Compressed Coir as Substrate in Ornamental Plants Growing – Part I: Physical Analysis

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Abstract

Physical characteristics of peat and coir briquets were measured in laboratory. Coir and peat briquets (JIFFY-7) of different sizes (22 and 38 mm) were studied. The physical analysis included: particle density, dry bulk density, water retention and sample volume at different suctions. The samples volumes at different suctions were measured by coating the samples in paraffin and weighing them in air and water. As for particle density, dry bulk density, and pore volume, only minor differences were observed between coir and peat for both 22-mm and 38-mm briquets. Briquets did not shrink and volume remained the same at all suctions analyzed (0, 2, 4, 6, 8, 10, 50, and 100 cm). The greatest difference in air filled porosity as a function of the suction levels was verified between 38-mm peat and coir. At 0-cm suction, the air filled porosity was the same for both 38-mm peat and coir. At 5-cm suction the difference started to increase, and peaked at 10-cm suction. Air filled porosity was three times as large in 38-mm coir briquets as in peat, and twice as large in 22-mm coir briquets as in peat briquets. Water contents at low suctions in peat and coir were the same. Water availabilities for peat and coir were different. Twenty-two-mm peat briquets presented large amounts of unavailable water (58.9%) and low water buffering capacity (3.1%), and did not differ significantly from 38-mm briquets.

INTRODUCTION

Artificial substrates are used worldwide in seedlings production (Salvador and Minami, 2001). In Europe, peat-based substrates are the most common ones. Jiffy-7 briquets, which are made from sphagnum peat and other materials, have been widely used for many years (Gislerød, 1982).

Potential peat substitute materials must present adequate and known physical characteristics, be available in large quantities and also be economically viable (Salvador and Minami, 2002). Coir has been recognized as an acceptable peat substitute, being a renewable resource with no ecological drawbacks to its use (Verdonck et al., 1983; Meerow, 1994; Awang and Ismail, 1997; Nogueira, et al., 1997; Prasad, 1997; Stamps and Evans, 1997; Konduru et al., 1999; Shinohara et al., 1999). Coir is the name given to the mesocarpic fibrous material from coconut fruits (Cocos nucifera L.). It is produced in countries such as Sri Lanka, India, The Philippines, Indonesia, Mexico, Costa Rica and Guyana, and is of great interest to large substrate companies in Europe and North America.

Stamps and Evans (1997) reported that coir presents several characteristics that are similar or superior to peat. According to Meerow (1994), some coir qualities are high water retention capacity, excellent drainage, easy water absorption, slow decaying, adequate pH, electrical conductivity and cationic exchange capacity. It is free from

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pathogens and weed propagules, besides being a renewable resource that does not harm the environment.

Awang and Ismail (1997), studying the difficulty of obtaining good quality soil-based substrates in Malaysia, mentioned that coir is one of the most viable materials in soilless substrate production in tropical countries. Stamps and Evans (1997) observed that coir is an excellent alternative to peat in *Dieffenbachia maculata* crop. Meerow (1994), comparing the use of peat and coir in *Pentas lanecolata* and *Ixora coccinea* crops, observed that plants cultivated in coir were superior considering all evaluated characteristics. Blom (1999) observed that roses cultivated in coconut fiber showed an increase of 9.3% in the amount of fresh matter and of 8.5% in the number of flower stems, when compared to those cultivated in rock wool. Van Labeke and Dambre (1998) demonstrated that coconut fiber could substitute rock wool in gerbera growing.

The compressed peat briquets are widely used for propagation, especially for *Euphorbia* and *Pelargonium*. The air/water ratio does influence both the number of roots per cutting and the time to rooting. This effect is different from species to species. Jiffy is going to make briquets of coir in addition to peat and would like to know the physical characteristics as well as possible for this new material used in compressed form. If the physical characteristics is different between peat and coir this makes it possible to marked this as different products, if not, other factors will decide which of this material will be used in the further development.

**MATERIAL AND METHODS**

**Substrates**

Jiffy-7 briquets made of two different components, peat and coir, in two different sizes, 22 and 38 mm diameters, were analyzed. Jiffy-7 briquets are made from compressed peat and/or coir encased in a biodegradable net, and show pH around 5.3 (Gislerød, 1982).

Peat briquets are composed of a mixture of peat (85%) and coir (15%). Briquets with diameter 22 mm and length 7 mm, when saturated in water give cylinders with diameter 24 mm and length 45 mm, and briquets with diameter 38 mm and length 8 mm when saturated give cylinders with diameter 41 mm and length 48 mm.

Coir briquets are made of coir only. Briquets with diameter 22 mm and length 7 mm, when saturated in water give cylinders with diameter 29 mm and length 39 mm, and briquets with diameter 38 mm and length 8 mm when saturated give cylinders with diameter 41 mm and length 42 mm.

**Laboratorial Analyses – Physical Parameters**

1. **Saturation of Briquets.** Dried briquets were weighed and separated according to their dry weight (Wd). For each suction, briquets showing the same dry weight were saturated with deionized water in a vacuum chamber. After a 48-hour soaking, the weight at saturation was measured (Ws).

2. **Briquets Volume.** The briquets volume (Vs) was assessed using the paraffin method. Briquets were first tied up with a thread and then immersed in melted paraffin twice, in the case of 22-mm briquets, or four times, in the case of 38-mm briquets, until they were completely coated. After being weighed without paraffin (Weight at x cm Suction – Wx), briquets were weighed with the paraffin coat (Weight with Paraffin – Wp). A metal ring was installed around the rings to keep them totally immersed in water (Fig. 1) (Weight with Paraffin and Ring – Wpr), and after immersion they were weighed once more (Weight with Paraffin and Ring in Water – Wprw). The metal ring (without sample) was weighed out of water (Ring Weight in Air – Wra) and than immersed under water and weighed again (Ring Weight under Water – Wrw). The sample volume was calculated as follows:
Sample volume ($V_s$) = \[
\frac{[(W_{pr} - W_{prw}) - (W_{ra} - W_{rw})]}{\rho_w} - \frac{[(W_p - W_x)]}{\rho_{paraffin}}
\]

$\rho_w$ = density of water  
$\rho_{paraffin}$ = density of paraffin

3. Briquets Particle Density. Particle density values were assessed through the alcohol method. Alcohol soaks organic matter better than water due to its lower surface tension. Twenty samples, 10 peat and 10 coir samples, of dried 38-mm briquets were used in all.

The alcohol method consisted of weighing up measuring-flasks (100 cm$^3$) (Flask weight – $W_f$), adding 10g dry substrate to the flasks (Flask weight with substrate – $W_{fs}$), filling up the flasks with alcohol 70% to 100cm$^3$ volume and placing them in a vacuum chamber for 24 hours. After that, flasks were filled up with alcohol again and weighed (Flask weight with substrate and alcohol – $W_{fsa}$). Finally, the flasks filled with alcohol were weighed ($W_{fa}$). The alcohol density was 0.8863 g/cm$^3$.

Particle density ($P_d$) was calculated as follows:

\[
P_d = \frac{\rho_{alcohol} (W_{fs} - W_f)}{(W_{fs} - W_f) - (W_{fsa} - W_{fsa})}
\]

Particle density was also calculated using the dry bulk density and the pore volume as follows:

Particle density ($P_d$) = $\frac{Dbd}{(1 - Pv)}$.

4. Soil Water Retention. Water volumes at different suctions were measured in sandbox with a hanging water column (Eijkelkamp). The 38-mm briquets were analyzed at suction levels of 0, 2, 4, 6, 8, 10, 20, 50, 80 and 100 cm, while 22-mm briquets were analyzed at suction levels of 0 and 10 cm. Ten replicates were measured at each suction level. Samples were placed in a sandbox and weighed after equilibrium was attained at each suction level (Weight at $x$ cm Suction – $W_x$, where $x = 0, 2, \ldots, 100$).

5. Definitions. Easily available water, available water, water buffering capacity, unavailable water, air filled porosity and solid parts were determined as follows.

Easily available water (Eaw) = $Wv_{10} - Wv_{50}$  
Available water (Aw) = $Wv_{10} - Wv_{100}$  
Water buffering capacity (Wbc) = $Wv_{50} - Wv_{100}$  
Unavailable water (Uw) = $Pv - Wv_{100}$  
Air filled porosity (Af) = $Pv - W_{10}$  
Air content at $x$ cm suction (Ac) = $Pv - W_{vx}$, where $x = 0, 2, 4, 6, 8, 10$  
Solids (So) = 100 – $Pv$

6. Statistics. The obtained data were analyzed with the statistic software SANEST from the Federal University of Pelotas – Brazil. The analyses performed were the ANOVA and Tukey test. Ten coir and ten peat/coir samples were separately evaluated for each suction level and for each briquet size.

RESULTS AND DISCUSSION

Particle Density

The particle density measured through the alcohol method was lower than the estimated particle density using pore volume and dry bulk density values (Table 1). Coir particle density values determined through the sandbox and the alcohol methods were 1.68 (± 0.12) and 1.57 (±0.06) g/cm$^3$, respectively, while the peat particle density determined through the same methods were 1.69 (±0.14) and 1.57 (±0.04) g/cm$^3$. 

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Data determined through the alcohol method are in greater agreement with the results from other authors, who reported coir particle densities to be around 1.5 g/cm³ (Nogueira et al., 1997). Therefore, the values of particle density, pore volume and air filled porosity considered in this study, as well as for the calculation of water amounts in the substrates were the ones obtained through the alcohol method. Only minor differences were observed between coir and peat (Table 02) for both 22-mm and 38-mm briquets.

**Dry Bulk Density**

Only minor differences were observed between coir and peat dry bulk density values (Table 02) for both 22-mm and 38-mm briquets, with higher values been verified in 22-mm briquets.

**Pore Volume**

Results for peat and coir differed very little for both 22-mm and 38-mm briquets (Table 2). The pore volume values for both substrates were between 92 – 93 vol%. In other investigations, coir pore volume values were between 93 and 96% (Nogueira et al., 1997; Prasad, 1997; Vendonck, 1983; and Van Labeke, 1998).

**Water Content at Different Suction Levels (or the Water Retention Curve)**

Water contents at low suction levels were the same for peat and coir up to 5-cm suction, when water content differences started to increase (Fig. 3). Water contents in coir decreased from 88.5 to 82.7%, a 5.8% difference, with the increase in suction levels from 6 to 10 cm. However, water contents in peat did not differ, with a decrease of only 0.4%, from 89.4 to 89.0%, for the same suction levels. The difference in water content for peat and coir between 10 and 100-cm suction levels remained practically the same (Fig. 4). Easily available water increased in 38-mm peat briquets, but did not vary significantly along with the size in coir briquets (Table 2). Available water contents were greater in 38-mm briquets for both coir and peat briquets, with no differences being verified between them when considering 38-mm briquets. The lowest available water content was verified in 22-mm peat briquets. A large amount of unavailable water (58.9%) and a low water buffering capacity (3.1%) were observed in 22-mm peat briquets.

**Air Filled Porosity**

A great difference in air filled porosity was observed between peat and coir briquets after 4 cm suction (Fig. 2). For 38-mm briquets, air contents at suction levels between 0 and 4 cm had no significant differences, but from a 5 cm suction level, coir briquets began to show higher aeration than peat briquets. The difference in aeration between peat and coir, which was 1.3% at 6 cm suction, increased to 2.1% and 6.7% (the greatest difference) at 8 and 10 cm suctions, respectively. Air filled porosity was three times as great in 38-mm coir briquets (10.6%) as in peat briquets (3.9%), and twice as great in 22-mm coir briquets (6.2%) as in peat briquets (3.4%). The greater aeration in coir briquets at 5-cm suction level allows cuttings of species demanding greater aeration for rooting like begonias, and which do not develop roots appropriately in peat-based substrates, to be grown in this substrate.

**Shrinkage**

The results (Fig. 5) did not evidence any significant changes in the samples volume at different suctions (0, 2, 4, 6, 8, 10, 50, and 100 cm).

**CONCLUSION**

As for particle density, dry bulk density, and pore volume, only minor differences were observed between coir and peat for both 22-mm and 38-mm briquets. Briquets did not shrink and volume remained the same at all suctions analyzed. Air filled porosity was three times as large in 38-mm coir briquets as in peat, and twice as large in 22-mm coir briquets as in peat briquets. Water contents at low suctions in peat and coir were the
same. Water availabilities for peat and coir were different. Twenty-two-mm peat briquets presented large amounts of unavailable water (58.9%) and low water buffering capacity (3.1%), and did not differ significantly from 38-mm briquets.

ACKNOWLEDGEMENTS
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Literature Cited
Table 1. Dry bulk density, particle density, pore volume and air content in 38-mm, peat and coir, briquets obtained through different methods.

<table>
<thead>
<tr>
<th></th>
<th>Sand box method</th>
<th>Alcohol method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coir</td>
<td>Peat</td>
</tr>
<tr>
<td>Dry bulk density (g/cm³)</td>
<td>0.106 (0.04)</td>
<td>0.112 (0.04)</td>
</tr>
<tr>
<td>Particle density (g/cm³)</td>
<td>1.68 (0.12)</td>
<td>1.69 (0.14)</td>
</tr>
<tr>
<td>Pore volume (%)</td>
<td>95.8 (1.7)</td>
<td>93.5 (0.8)</td>
</tr>
<tr>
<td>Air filled porosity (%)</td>
<td>13.1 (1.6)</td>
<td>4.5 (0.8)</td>
</tr>
</tbody>
</table>

(1) Standard deviation

Table 2. Physical parameter analyses on peat and coir briquets of different sizes.

<table>
<thead>
<tr>
<th></th>
<th>22 mm</th>
<th>38 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coir</td>
<td>Peat</td>
</tr>
<tr>
<td>Dry bulk density (g/cm³)</td>
<td>0.127 a</td>
<td>0.126 a</td>
</tr>
<tr>
<td>Particle density (g/cm³)</td>
<td>1.64 a</td>
<td>1.73 a</td>
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<tr>
<td>Pore volume (%)</td>
<td>91.6 a</td>
<td>92.7 a</td>
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<tr>
<td>Air filled porosity (%)</td>
<td>6.2 a</td>
<td>3.4 b</td>
</tr>
<tr>
<td>Water content at 10 cm suction (%)</td>
<td>85.4 b</td>
<td>89.3 a</td>
</tr>
<tr>
<td>Easily available water (%)</td>
<td>34.4 b</td>
<td>27.3 b</td>
</tr>
<tr>
<td>Water buffering capacity (%)</td>
<td>3.6 a</td>
<td>3.1 a</td>
</tr>
<tr>
<td>Available water (%)</td>
<td>38.0 a</td>
<td>30.4 b</td>
</tr>
<tr>
<td>Unavailable water (%)</td>
<td>47.4 b</td>
<td>58.9 a</td>
</tr>
<tr>
<td>Solids (%)</td>
<td>8.4 a</td>
<td>7.3 a</td>
</tr>
</tbody>
</table>

Means displayed horizontally and followed by different letters differ between them by Tukey test for means at 5% probability level.

Figures

Fig. 1. Scheme of the briquets volume using the paraffin method
Fig. 2. Air content in 38-mm, peat and coir, briquets at low suction.

Fig. 3. Water content in 38-mm, peat and coir, briquets at low suction.
Fig. 4. Water content in 38-mm, peat and coir, briquets at 0-100 cm suction.

Fig. 5. Shrinkage in 38-mm, peat and coir, briquets.