Exploring Medicinal and Aromatic Plant residues after distillation as a peat substitute component in growing media for *Sonchus oleraceus* production

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Peat is the dominant potting medium material

The major component of substrates for potted plant production due to the **appropriate physical properties** (low bulk density, high porosity and water holding capacity) and the high cation exchange capacity (CEC).

**Peatlands**: an ecosystem containing accumulated, partially decomposed organic matter, under anaerobic and waterlogged conditions.

Spread from arctic to tropical regions, occupying 3% of the earth’s land area. More than 90% of all known peatland area is found only in 6 countries (Russia, Canada, USA, Finland, Sweden, and Indonesia).
Why to substitute peat?

Peatlands are highly fragile ecosystems with a great ecological value, representing important carbon dioxide (CO2) sinks.

The increasing use of peat in horticulture has derived in a quick depletion of wetlands, determining the loss of a non-renewable resource which plays a key role in CO2 sequestration.

Hence, **environmental concerns** have been increased in order to reduce peat mining and use, and to obtain **sustainable substitutes** as potted substrates.
Approximately 14-20% of extracted peat is released to the horticulture sector. Governmental policies support and encourage the use of sustainable peat alternatives. These materials need to satisfy specific features and be available in sufficient quantities at reasonable cost. Several alternatives to peat are examined:

- Olive mill wastes
- Grapes mill waste
- Paper waste
- Compost
- Biochar
- Sawdust
- Coffee waste
- Citrus peel waste
- Bark
- Sewage sludge
Characters of an ideal potting media

Agarwal et al, 2021
Main objective of the study

The aim of this study was to evaluate the residues derived from the extraction of essential oils from medicinal/aromatic plants, as a potential ingredient in the substrate mixtures for the successful cultivation of wild edible vegetables (*Sonchus oleraceus*- sowthistle).

The medicinal plants used in this study are endemic to Cyprus species (*Origanum dubium* and *Sideritis cypria*).
Production of the tested materials

Material was collected from *Sideritis cypria* and *Origanum dubium* plantations

Material was then dried and chopped

Subjected to hydro-steam distillation for EO extraction

The material was dried again and milled

Preparation of substrate mixtures with peat, in different ratios

Mixtures in different ratios in pots

Sowthistle plants in pots
Experimental design of the plant cultivation and analysis

• 5 different ratios of each material (*S.* cypria SC and *O.* dubium OD) were prepared (0%, 5%, 10%, 20% and 40%, in peat).

• *Sonchus* plants were produced from seeds and transplanted at the stage of 3rd leaf.

• At the end of the cultivation, a series of plant growth and physiology parameters were assessed, and the mineral status of the plants.

• The tested materials and the substrate mixtures were evaluated for their physicochemical properties at the beginning and at the end of the experiment.

• Plants were irrigated according to their needs. No additional fertigation was applied, or any other plant protection product.
Experimental layout..................

Measurements:

- **Physicochemical properties of the growing media** (pH, EC, O.O., minerals (N, K, P, Na, Ca, Mg), total porosity, air filed porosity, bulk density etc).

- **Plant growth** (plant height, leaf number, fresh and dry plant weight).

- **Physiological** (chlorophylls, total carotenoids, leaf stomatal conductance, leaf fluorescence).

- **Minerals** (N, K, P, Ca, Mg with AAS, IC and Kjeldahl).

- **Antioxidants** (polyphenols, flavonoids and antioxidant activity- FRAP, DPPH).

- **Damage index and antioxidant enzymes** (H₂O₂, lipid peroxidation- MDA, SOD, CAT, POD).
Sonchus oleraceus

Origanum dubium

Sideritis cypria

Peat
*Origanum dubium* Boiss. residue (ODR),

<table>
<thead>
<tr>
<th></th>
<th>Peat 100%</th>
<th>ODR 5%</th>
<th>ODR 10%</th>
<th>ODR 20%</th>
<th>ODR 40%</th>
<th>ODR 100%</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.32 b</td>
<td>6.39 b</td>
<td>6.31 b</td>
<td>6.63 b</td>
<td>7.51 a</td>
<td>5.95 c</td>
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<tr>
<td>EC (mS/cm)</td>
<td>0.84 c</td>
<td>1.14 bc</td>
<td>0.89 bc</td>
<td>1.12 b</td>
<td>1.70 a</td>
<td>1.92 a</td>
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<tr>
<td>Organic matter (%)</td>
<td>72.39 cd</td>
<td>73.03 c</td>
<td>73.30 c</td>
<td>70.16 d</td>
<td>76.92 b</td>
<td>92.80 a</td>
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<tr>
<td>Organic C (%)</td>
<td>41.99 cd</td>
<td>42.37 c</td>
<td>42.52 c</td>
<td>40.70 d</td>
<td>44.62 b</td>
<td>53.83 a</td>
</tr>
<tr>
<td>C/N ratio</td>
<td>50.37 a</td>
<td>42.91 b</td>
<td>40.92 b</td>
<td>26.22 c</td>
<td>28.34 c</td>
<td>51.21 a</td>
</tr>
<tr>
<td>N (g/kg)</td>
<td>8.35 c</td>
<td>9.88 b</td>
<td>10.52 b</td>
<td>15.54 a</td>
<td>15.78 a</td>
<td>10.51 b</td>
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<tr>
<td>K (g/kg)</td>
<td>2.03 d</td>
<td>3.86 c</td>
<td>3.97 c</td>
<td>4.70 c</td>
<td>7.36 b</td>
<td>13.46 a</td>
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<tr>
<td>P (g/kg)</td>
<td>1.13 c</td>
<td>1.61 bc</td>
<td>1.73 b</td>
<td>1.92 b</td>
<td>2.62 a</td>
<td>2.83 a</td>
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<tr>
<td>Ca (g/kg)</td>
<td>15.02 b</td>
<td>21.52 a</td>
<td>17.62 b</td>
<td>20.41 a</td>
<td>20.51 a</td>
<td>7.66 c</td>
</tr>
<tr>
<td>Mg (g/kg)</td>
<td>0.79 e</td>
<td>1.51 d</td>
<td>1.51 d</td>
<td>2.23 c</td>
<td>3.29 a</td>
<td>2.68 b</td>
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<tr>
<td>Na (g/kg)</td>
<td>0.97 c</td>
<td>1.13 b</td>
<td>1.19 ab</td>
<td>1.17 ab</td>
<td>1.32 a</td>
<td>1.22 ab</td>
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<tr>
<td>Total porosity (% v/v)</td>
<td>84.97 a</td>
<td>72.68 b</td>
<td>77.19 ab</td>
<td>53.32 c</td>
<td>48.60 c</td>
<td>69.87 b</td>
</tr>
<tr>
<td>Air filled porosity (% v/v)</td>
<td>18.43 a</td>
<td>10.48 b</td>
<td>9.14 b</td>
<td>7.90 b</td>
<td>5.51 b</td>
<td>1.57 c</td>
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<tr>
<td>Bulk density (g/cm)</td>
<td>0.15 c</td>
<td>0.17 bc</td>
<td>0.17 b</td>
<td>0.17 b</td>
<td>0.18 b</td>
<td>0.29 a</td>
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<tr>
<td>Container capacity (% v/v)</td>
<td>66.55 a</td>
<td>62.21 a</td>
<td>68.05 a</td>
<td>45.41 b</td>
<td>43.08 b</td>
<td>68.31 a</td>
</tr>
</tbody>
</table>

Adding ODR ➔ EC, pH, OM, N, K, P, bulk density

Porosity and air filled porosity
**Sideritis cypria** residue (SCR)

Adding SCR ➔ pH, EC, N, K, P, bulk density

![Image of Sideritis cypria residue](image)

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Sonchus oleraceus (sowthistle)

- High levels of OD and SC ➔ Plant growth and fresh biomass, and chlorophylls content
- Both residues ➔ leaf stomatal conductance
Sonchus oleraceus (sowthistle)

- OD residues ➔ total phenols and flavonoids content as well as antioxidant capacity of sowthistle plants
- SC residues had lighter effects than the OD residues
- Low levels of OD ➔ mineral accumulation while higher OD levels prevented the mineral accumulation in plant tissue.
- SC adding in the growing media had lighter effects than the OD residues on mineral accumulation in plants.
• The 40% of OD ➔ MDA and \( \text{H}_2\text{O}_2 \), causing stress to plants, and initiated enzymes (SOD, CAT) antioxidant metabolism
• Increasing the levels of SC ➔ MDA and \( \text{H}_2\text{O}_2 \), activating enzymes antioxidant metabolism
Conclusions

- Production of EOs ends up with an amount of waste plant material (residues), that it needs to be managed.

- Based on our results, the materials under evaluation *Origanum dubium* and *Sideritis cypria* residues, could be used up to 10% and 20%, respectively, in the substrate mixture, as a peat substitute, for the successful cultivation of sowthistle plants.

- The produced plants exhibited the same or in cases improved features compared to the controls, even without additional fertigation.

- Further improvement of the growing media’s properties (i.e. aeration) is needed to ensure adequate yield.

- Additional research (i.e. fertigation, mix of the materials) could provide useful data towards the exploration of such residues.

- MAP residues derived from the distillation process, can be explored further for a partially peat substitution, producing plants with added nutritional value and increased antioxidant compounds.
Thank you for your attention

Any questions?

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