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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 (CO_2) 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 CO_2 sequestration.




Hence, **environmental concerns** have been increased in order to reduce peat mining and use, and to obtain **sustainable substitutes** as potted substrates.

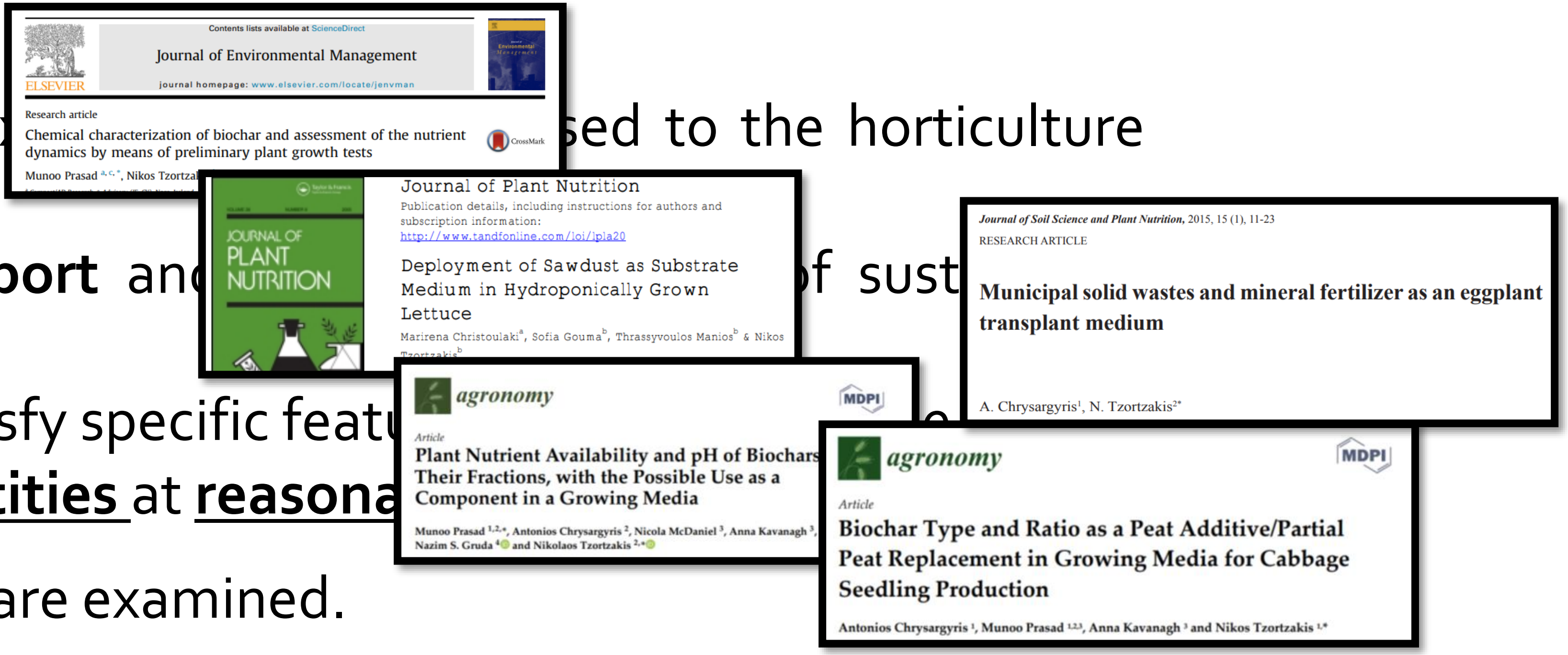
Approximately 14-20% of e… …sed to the horticulture sector.

Governmental policies **support** an… …f sust… peat alternatives.

These materials need to satisfy specific feat… **available** in **sufficient quantities** at **reasona**…

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


Contents lists available at ScienceDirect
Journal of Environmental Management
journal homepage: www.elsevier.com/locate/jenvman
Research article
Chemical characterization of biochar and assessment of the nutrient dynamics by means of preliminary plant growth tests
Munoo Prasad, Nikos Tzortzal…

Journal of Plant Nutrition
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lpla20
Deployment of Sawdust as Substrate Medium in Hydroponically Grown Lettuce
Marirena Christoulaki, Sofia Gouma, Thrassyvoulos Manios & Nikos Tzortzakis

Journal of Soil Science and Plant Nutrition, 2015, 15 (1), 11-23
RESEARCH ARTICLE
Municipal solid wastes and mineral fertilizer as an eggplant transplant medium
A. Chrysargyris, N. Tzortzakis

agronomy
Article
Plant Nutrient Availability and pH of Biochars … Their Fractions, with the Possible Use as a Component in a Growing Media
Munoo Prasad, Antonios Chrysargyris, Nicola McDaniel, Anna Kavanagh, Nazim S. Gruda and Nikolaos Tzortzakis

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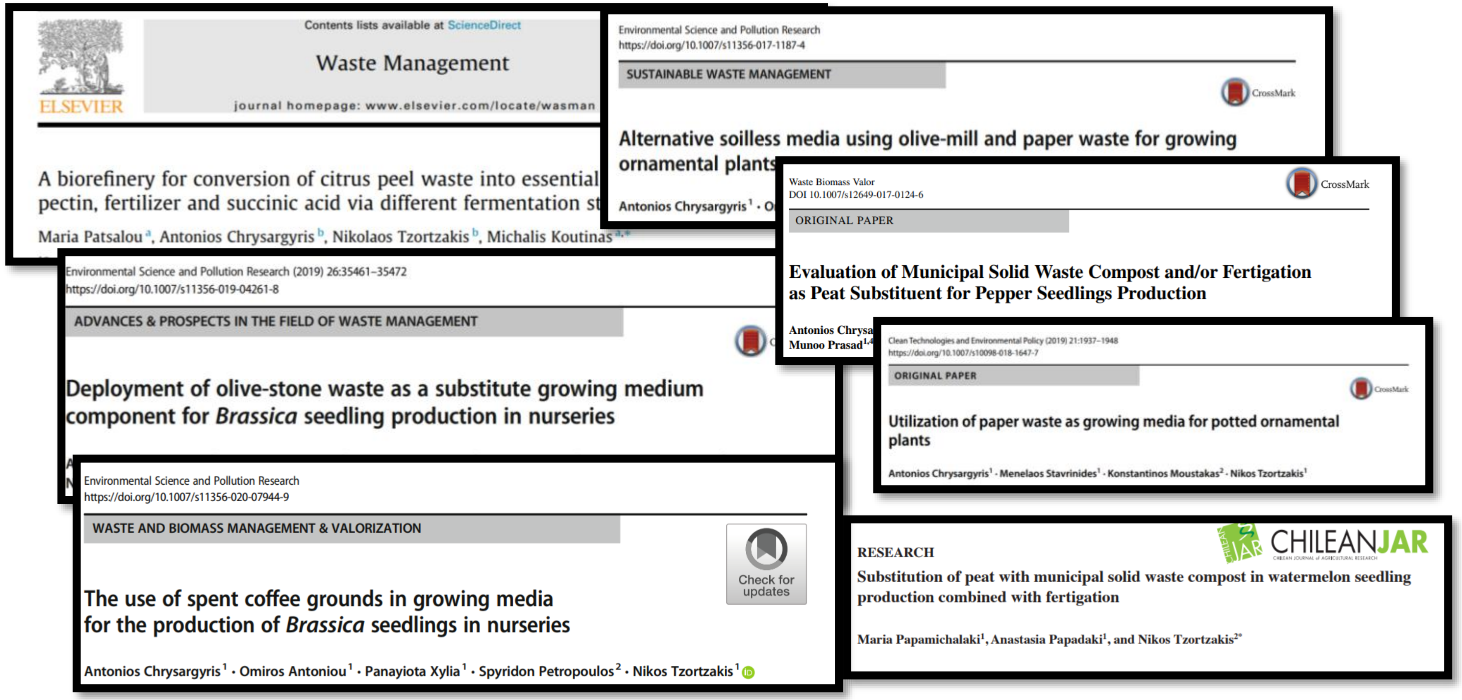
Article
Biochar Type and Ratio as a Peat Additive/Partial Peat Replacement in Growing Media for Cabbage Seedling Production
Antonios Chrysargyris, Munoo Prasad, Anna Kavanagh and Nikos Tzortzakis


Contents lists available at ScienceDirect
Waste Management
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A biorefinery for conversion of citrus peel waste into essential… pectin, fertilizer and succinic acid via different fermentation st…
Maria Patsalou, Antonios Chrysargyris, Nikolaos Tzortzakis, Michalis Koutinas

Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-017-1187-4
SUSTAINABLE WASTE MANAGEMENT
Alternative soilless media using olive-mill and paper waste for growing ornamental plants
Antonios Chrysargyris …

Waste Biomass Valor
DOI 10.1007/s12649-017-0124-6
ORIGINAL PAPER
Evaluation of Municipal Solid Waste Compost and/or Fertigation as Peat Substituent for Pepper Seedlings Production
Antonios Chrysa… Munoo Prasad

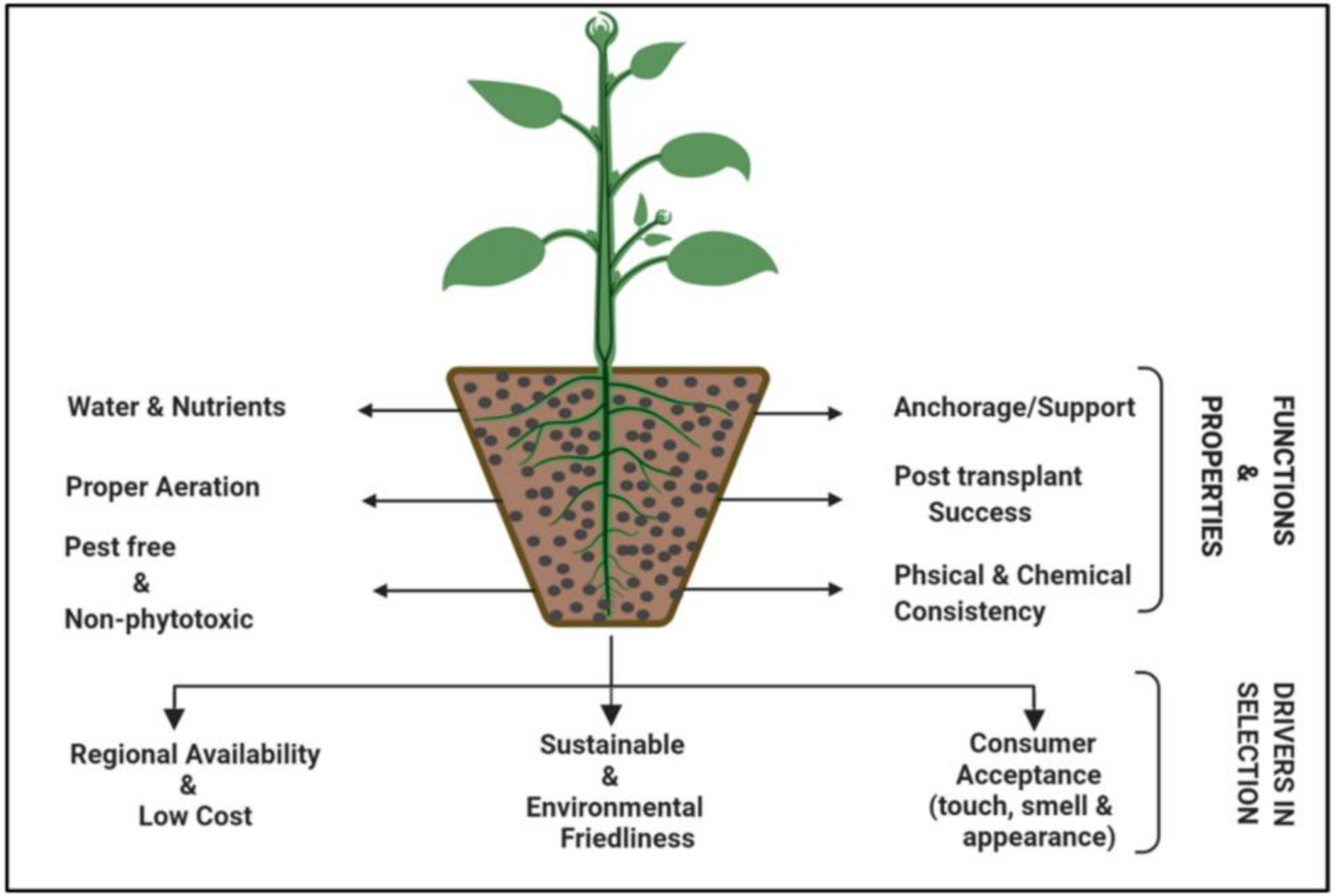
Environmental Science and Pollution Research (2019) 26:35461–35472
https://doi.org/10.1007/s11356-019-04261-8
ADVANCES & PROSPECTS IN THE FIELD OF WASTE MANAGEMENT
Deployment of olive-stone waste as a substitute growing medium component for *Brassica* seedling production in nurseries

Clean Technologies and Environmental Policy (2019) 21:1937–1948
https://doi.org/10.1007/s10098-018-1647-7
ORIGINAL PAPER
Utilization of paper waste as growing media for potted ornamental plants
Antonios Chrysargyris · Menelaos Stavrinides · Konstantinos Moustakas · Nikos Tzortzakis

Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-020-07944-9
WASTE AND BIOMASS MANAGEMENT & VALORIZATION
The use of spent coffee grounds in growing media for the production of *Brassica* seedlings in nurseries
Antonios Chrysargyris · Omiros Antoniou · Panayiota Xylia · Spyridon Petropoulos · Nikos Tzortzakis

CHILEANJAR
RESEARCH
Substitution of peat with municipal solid waste compost in watermelon seedling production combined with fertigation
Maria Papamichalaki, Anastasia Papadaki, and Nikos Tzortzakis

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

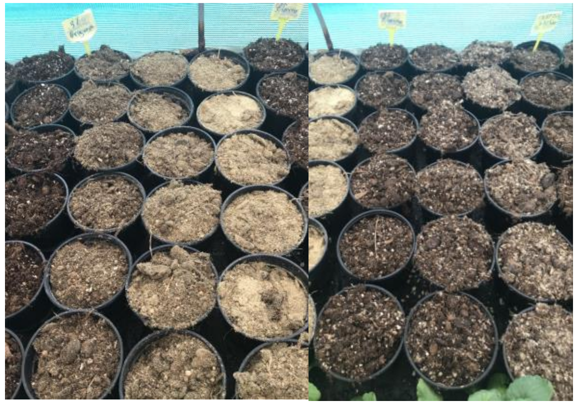
Material was collected from *Sideritis cypria* and *Origanum dubium* plantations

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 (H_2O_2, lipid peroxidation-MDA, SOD, CAT, POD).


5% ORIGIN.


5% ORIGIN.

Sonchus oleraceus

Origanum dubium

Sideritis cypria

5% 10% 20% 40%

Peat

Origanum dubium Boiss. residue (ODR),

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

Adding ODR → ↑ EC, pH, OM, N,K, P, bulk density

↓ Porosity and air filled porosity

Sideritis cypria residue (SCR)

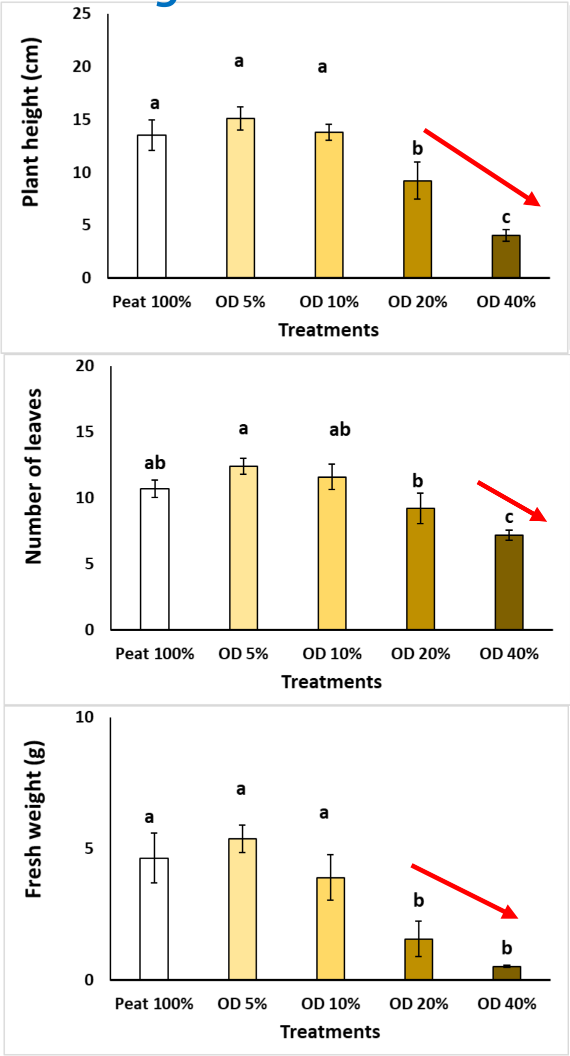
	Peat 100%	SCR 5%	SCR 10%	SCR 20%	SCR 40%	SCR 100%
pH	6.32 d	6.27 d	6.53 cd	6.91 b	7.54 a	6.71 bc
EC (mS/cm)	0.84 b	1.27 a	1.25 a	1.10 a	1.19 a	1.23 a
Organic matter (%)	72.39 b	77.64 b	75.38 b	75.22 b	76.11 b	92.80 a
Organic C (%)	41.99 b	45.03 b	43.73 b	43.63 b	44.15 b	53.83 a
C/N ratio	50.37 a	50.89 a	38.38 bc	36.34 c	30.05 d	42.57 b
N (g/kg)	8.35 c	8.87 c	11.41 b	12.04 b	14.73 a	12.66 b
K (g/kg)	2.03 f	3.12 e	4.20 d	6.32 c	8.75 b	14.60 a
P (g/kg)	1.13 c	1.39 bc	1.70 b	1.76 b	2.52 a	1.65 b
Ca (g/kg)	15.02 b	16.37 b	20.02 a	22.57 a	21.27 a	11.58 c
Mg (g/kg)	0.79 d	1.02 d	1.31 c	1.82 b	2.25 a	1.70 b
Na (g/kg)	0.97 e	1.03 e	1.20 d	1.65 c	2.03 b	5.79 a
Total porosity (% v/v)	84.97 ab	91.82 a	77.64 bc	69.00 cd	62.88 d	98.19 a
Air filled porosity (% v/v)	18.43 a	15.52 ab	14.29 ab	13.43 ab	9.62 b	17.14 ab
Bulk density (g/cm)	0.15 b	0.16 a	0.17 a	0.17 a	0.15 b	0.12 c
Container capacity (% v/v)	66.54 b	76.30 a	63.35 b	55.58 c	53.26 c	81.05 a

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

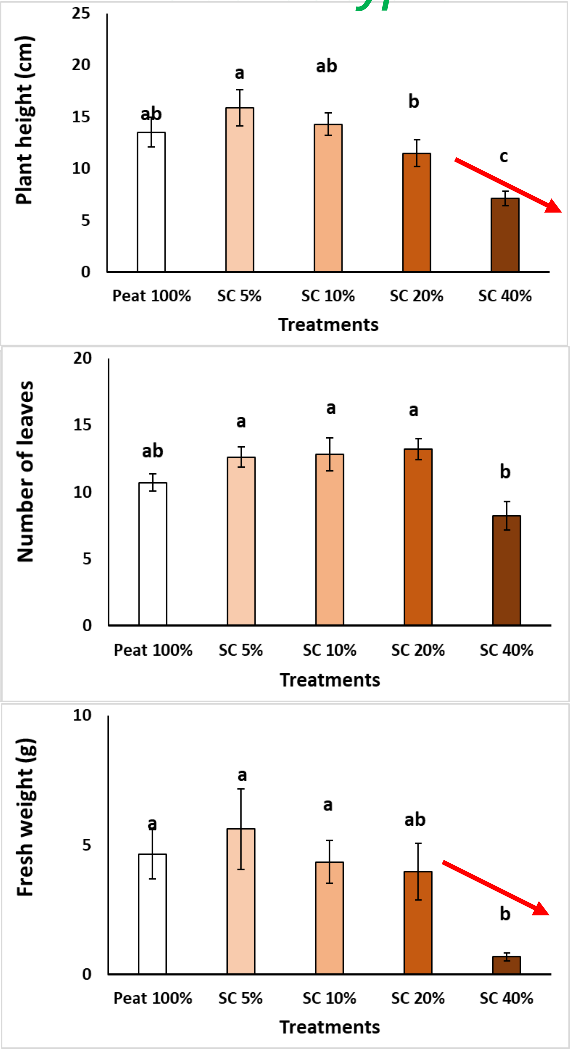
↓ Ca, Porosity, air filled porosity

Sonchus oleraceus (sowthistle)

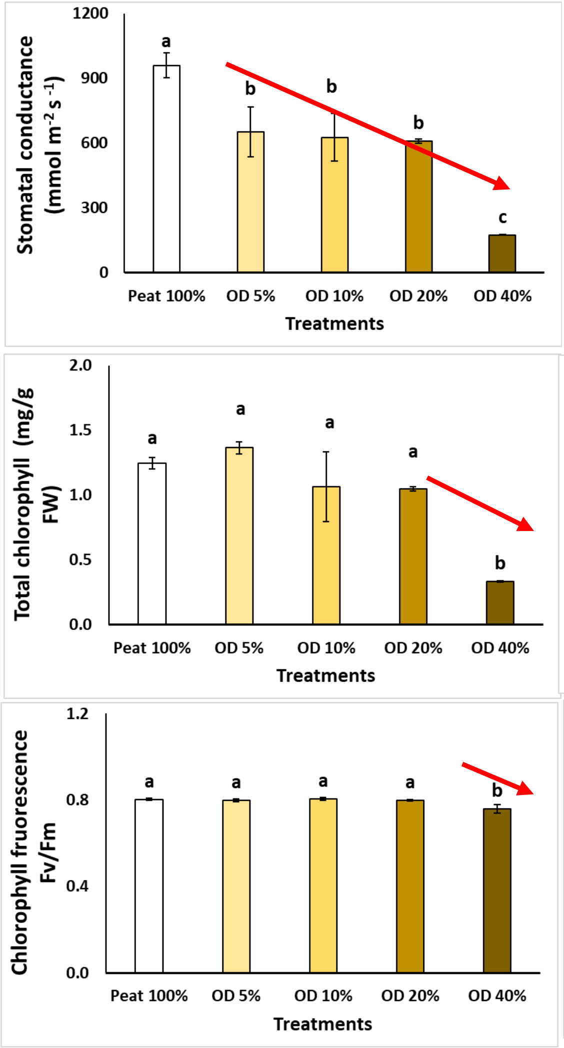
Origanum dubium



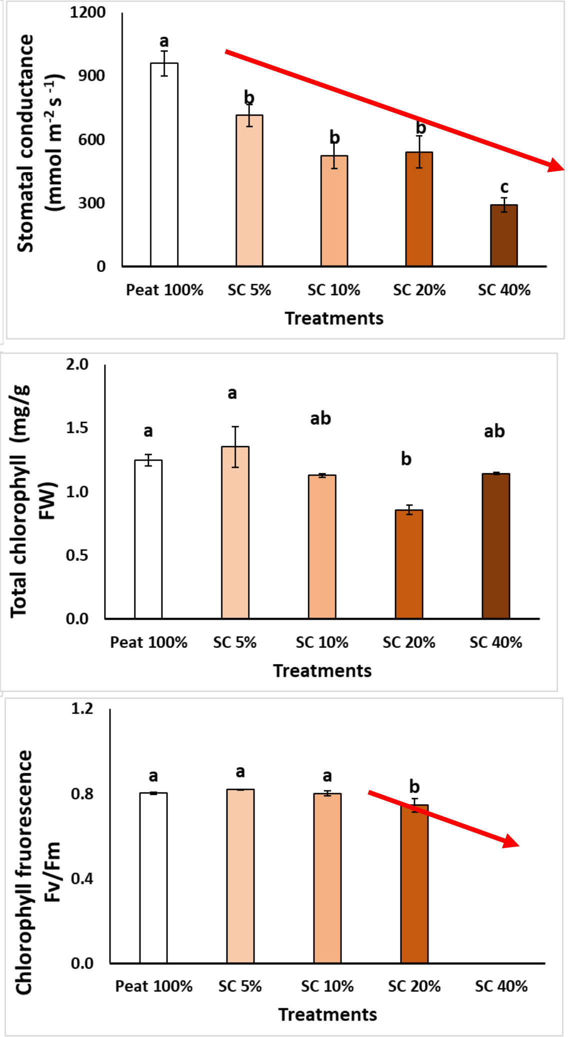
Sideritis cypria



Origanum dubium



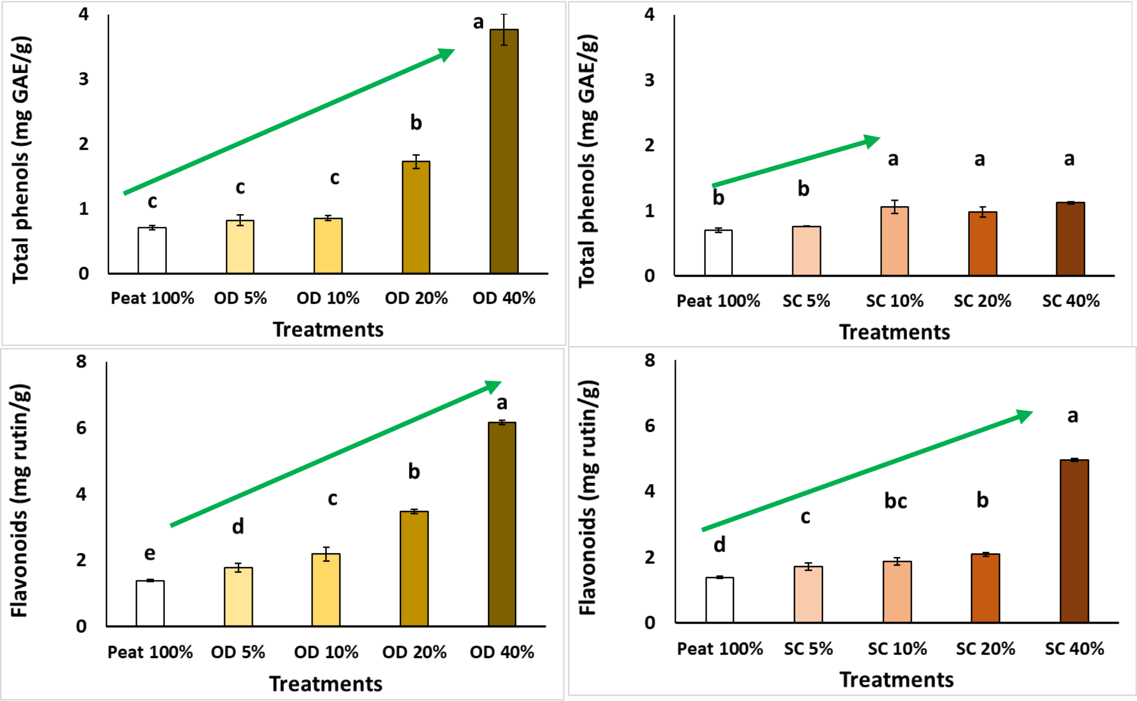
Sideritis cypria



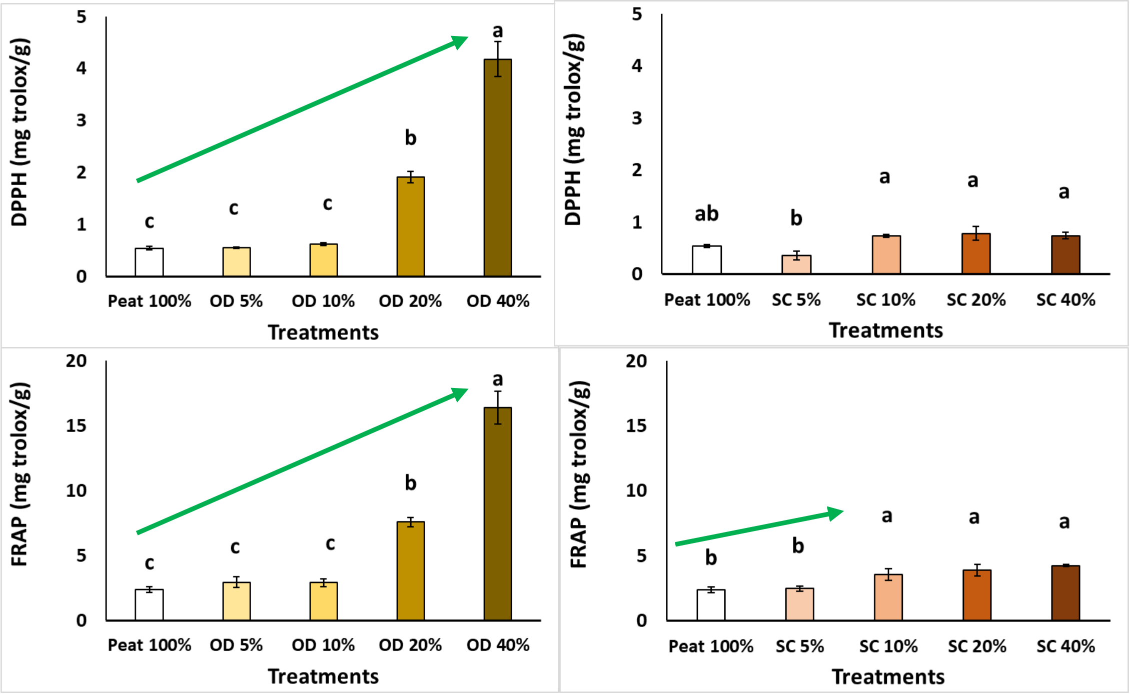
- High levels of OD and SC ➔ Plant growth and fresh biomass, and chlorophylls content
- Both residues ➔ leaf stomatal conductance

Sonchus oleraceus (sowthistle)

Origanum dubium   *Sideritis cypria*

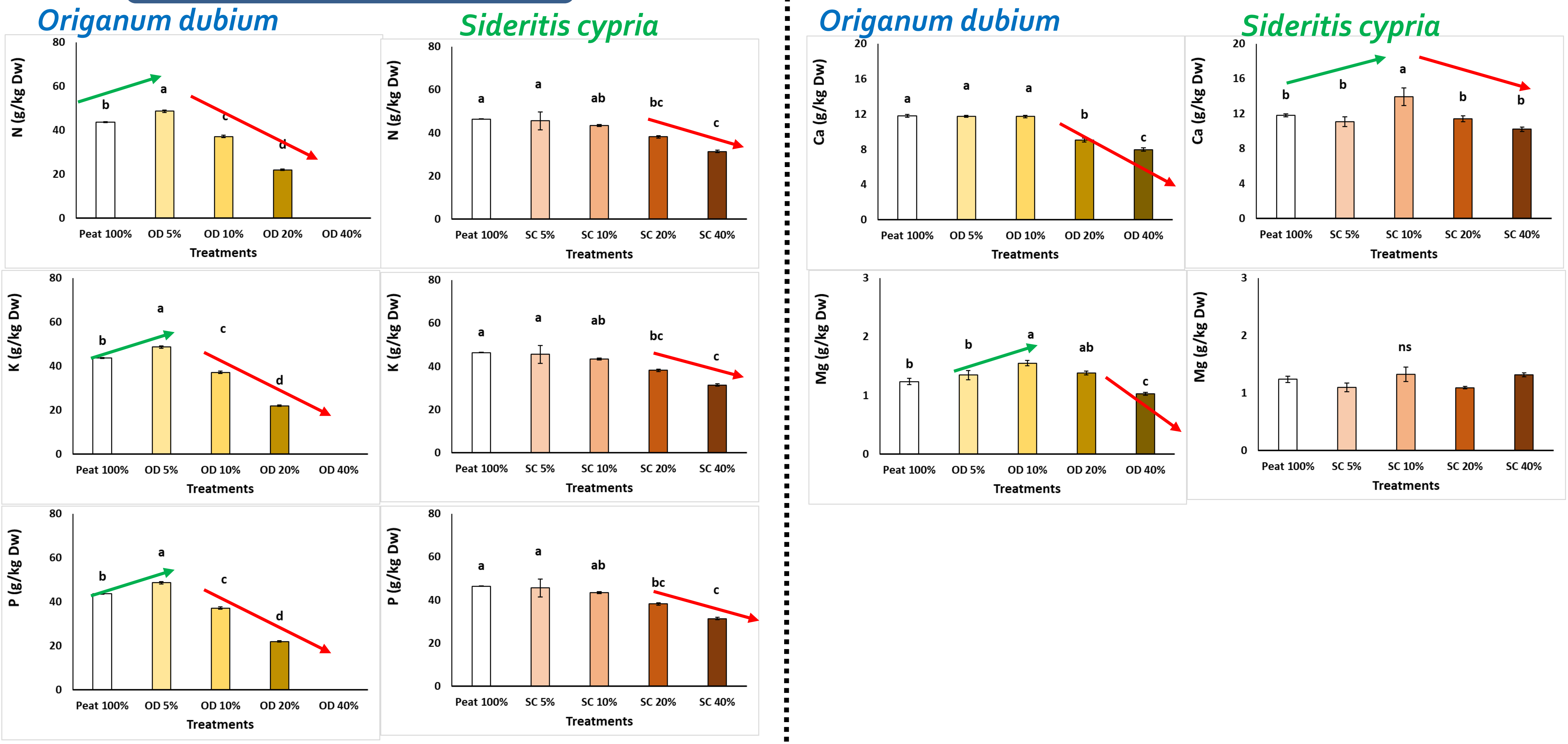


Origanum dubium   *Sideritis cypria*



- OD residues ➔ ↗ total phenols and flavonoids content as well as antioxidant capacity of sowthistle plants
- SC residues had lighter effects than the OD residues

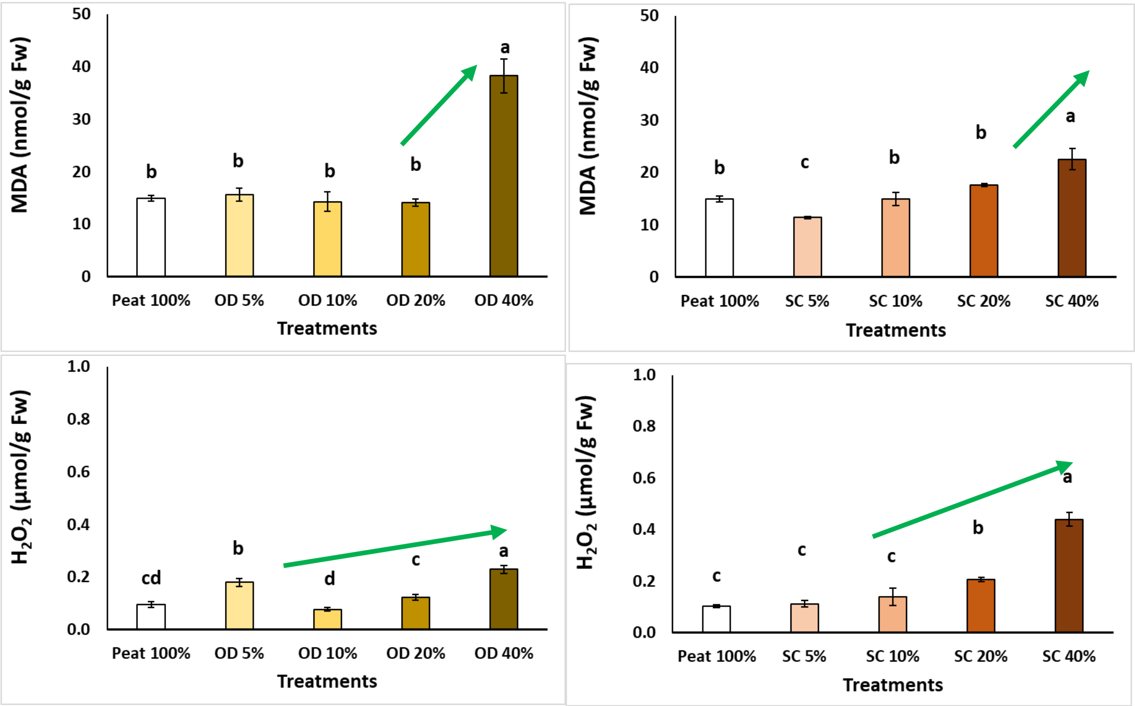
Sonchus oleraceus (sowthistle)



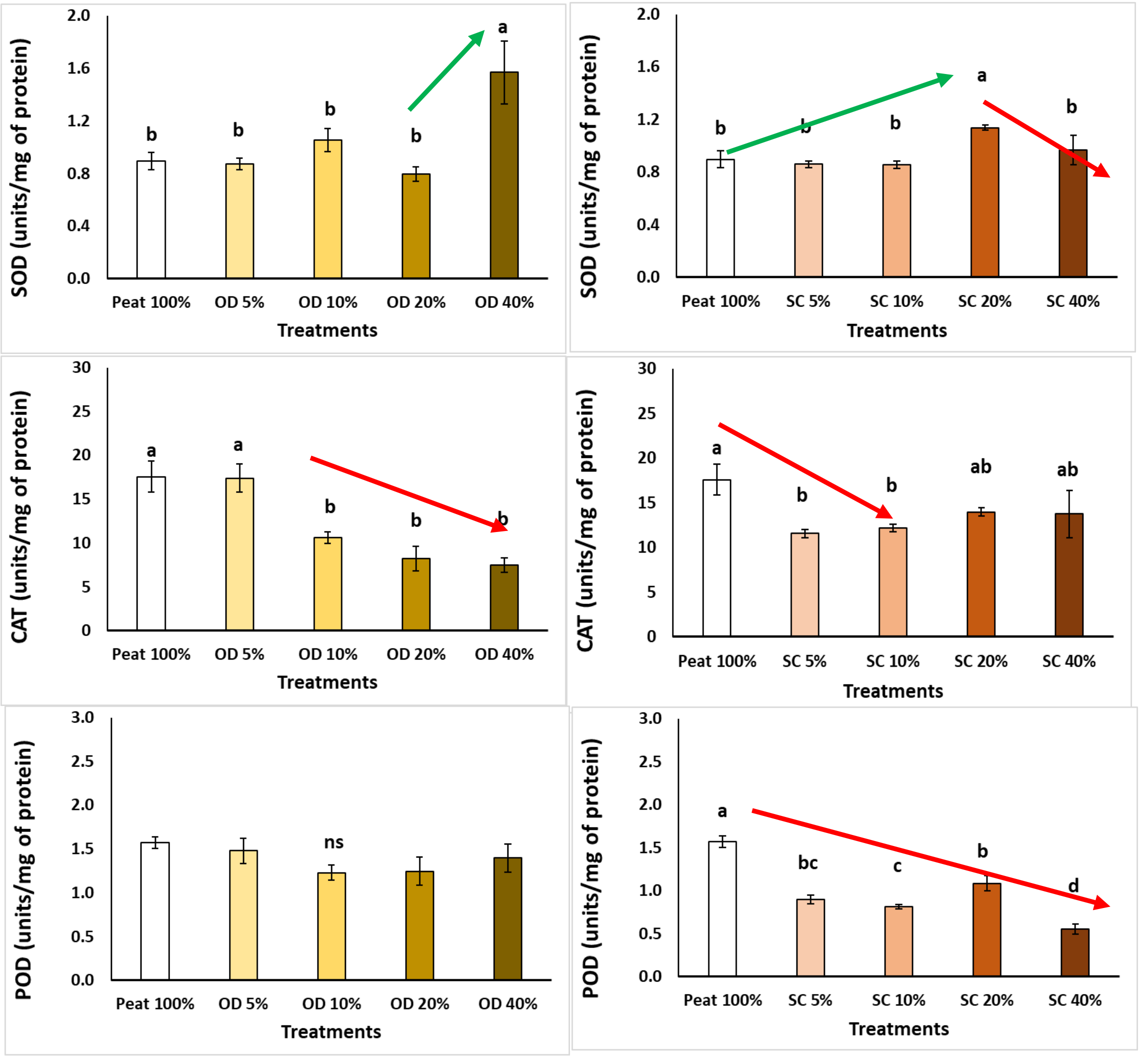
- Low levels of OD ➔ mineral accumulation while higher OD levels prevented the mineral accumulation in plant tissue.
- SC adding in the growing media had lighter effects than the OD residues on mineral accumulation in plants

Sonchus oleraceus (sowthistle)

Origanum dubium / *Sideritis cypria*



Origanum dubium / *Sideritis cypria*



- The 40% of OD ➔ ↗ MDA and H_2O_2, causing stress to plants, and initiated enzymes (SOD, CAT) antioxidant metabolism
- Increasing the levels of SC ➔ ↗ MDA and H_2O_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.

Sonchus sp.

Thank you for your attention

Any questions?

Financial support has been provided by PRIMA (ValueFarm project), a programme supported by the European Union with co-funding by the Funding Agencies RIF – Cyprus.