Vermicomposted olive oil wastewaters in horticultural practices

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Olive oil mill wastewaters

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Produced in large amount in short time during the traditional process of oil production

- Smelly
- low pH (3–5)
- high pollution load due to their high organic matter contents (organic acids, polyphenols)
- antibiotic and phytotoxic properties

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The disposal of OMW onto soil is possible only according to strict national technical regulations (Italian regulation 574; 11 November 1996).

50/80 m^3/ha year

It is not always possible for lack of areas with suitable characteristics

An alternative: **Vermicompost**

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Vermicompost

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A special composting process that involves the addition of earthworms to enhance the conversion and detoxification of different organic wastes.

Advantages

- Cost-effective
- Earthworms mix and give air to substrate under decomposition
- Earthworms ensure the continuous monitoring of material toxicity (bioindicators)
- Vermicompost is a stabilised humus-like product with high nutrient content, enzyme activities and hormon-like substances

Eisenia foetida

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Project between ***The Institute of Ecosystem Studies* (CNR, Pisa)** and ***San Giuliano Terme Municipality (Pisa)*** for "Recycling of olive oil wastewater"

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RESULTS:

Thesis:

Valorizzazione dei residui oleari mediante l'attivazione di un processo di umificazione in presenza di lombrichi (*Eisenia foetida*). *Laboratory scale*

Bioconversione di reflui oleari ad alto carico inquinante (acque di vegetazione) in vermicompost mediante un processo di lombricoltura con *Eisenia fetida* e piante (*Avena sativa*). *Laboratory scale*

Effetti del compost e del vermicompost derivanti da scarti agro-alimentari su colture orticole organico-biologiche. *Field scale*

Conference:

Uso in orticoltura di un vermicompost derivante da acque di vegetazione". Convegno nazionale Società Italiana della Scienza del Suolo" Il suolo: una risorsa primaria per l'uomo e per l'ambiente" Università degli studi di Perugia, 17-19 Giugno.

Articles in International journals:

Macci C., Masciandaro G., Ceccanti B. (2010). Vermicomposting of olive oil mill wastewaters. Waste management and research. 28, 738-739.

Masciandaro G., Macci C., Doni S., Ceccanti B. (2010). Use of earthworms (E. fetida) to control phytotoxicity and promote humification of prestabilised olive oil mill wastewater. Journal of the Science of Food and Agriculture 90, 1879-1885

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The study is aimed to:

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Evaluate the effect of OMW-vermicompost (obtained from OMW and cellulose materials in a six months pilot scale treatment), compared with a traditional municipal solid waste compost, on soil quality and fertility and on the growth of different horticultural species

The Vermicompost from OMW is suitable in organic farming

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Vermicomposted OMW (VC)

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- OMW was obtained from a local olive oil production plant (San Giuliano Terme, Pisa, Italy), which used a traditional discontinuous process for the extraction of olive oil

- 1 month of storage in tanks (n°574/1996)

- Adsorbtion on ligno-cellulosic material (1:1 v/v)

2 Settimane

- Addition of earthworms

Eisenia fetida

- 6 months vermicomposting process

Vermicompost

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Experimental Layout

Organic farm “Bonamici” San Giuliano Terme (Pisa)

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Horticultural species:

- *Allium porrum L.* (leek)

- *Brassica oleracea L.* var. botrytis (cauliflower)

- *Cichorium intybus L.* var. foliosum (chicory)

Treatments: 225kgN/ha

- Traditional municipal solid waste compost: 20t/ha
- OMW Vermicompost: 15t/ha
- Control without amendment

Field scheme

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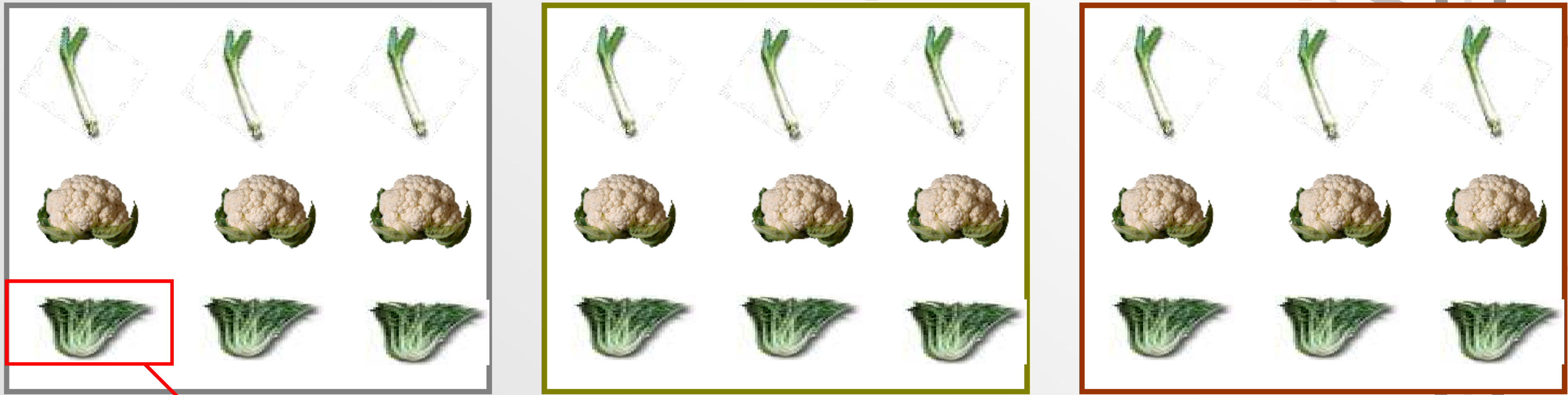
Experimentation in triplicate

Control | Vermicompost | Compost



Each plot 2mx1m

Soil sampling (0-15 cm) and plant biomass measurements 4 months after the plantation

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Chemical and biochemical properties of soil (S), compost (C) and vermicompost (VC)

	soil	VC	C
pH	7,5±0,7	7,7±0,4	7,7±0,5
Electrical Conductivity (mS/cm)	0,08±0,01	0,76±0,10	0,44±0,08
Total Organic Carbon (%)	2,5±0,4	29,7±0,7	25,3±0,3
Water soluble carbon (mg/kg)	579±38	2237±30	2457±38
Humic C (mg/kg)	8530±597	53814±3767	53676±3221
N total (%)	0,2±0,005	1,5±0,003	1,1±0,035
C/N		19,8±2,1	23,0±0,7
Ammonium (mg/kg)	2,4±0,1	6,1±0,3	13,5±1,7
Nitrate (mg/kg)	83±7,18	2564±178	432±26
Dehydrogenase activity (mg INTF/kg*h)	0,24±0,01	4,8±0,21	4,5±0,07
β-glucosidase (mg PNG/kg*h)	188±35	1087±45	183±7
Urease (mg NH_3/kg*h)	24±1,9	115±10,35	88±6,16
Phosphatase (mg PNF/kg*h)	339±4,1	1471±133	355±40
Protease (mg NH_3/kg*h)	39±1,95	58±3,48	26±1,82

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Amendment Italian regulation 75/2010

	pH	Organic Carbon (%)	Humic Carbon (%)	Organic N	C/N
Ammendante compostato misto	6-8,5	>25	>7	Norg≥ 80% dell'N tot.	<25
Ammendante torboso compostato	-	>30	>7	-	<50
Ammendante compostato verde	6-8,5	>30	>2,5	Norg≥ 80% dell'N tot.	<50
Ammendante vegetale verde non compostato	6-8,5	>40	-	Norg≥ 80% dell'N tot.	-
Vermicompost da letame	≤8	-	-	Norg≥1,5%ss	<20

Amendments used in this field experiment

Compost (C)	***7,7***±0,5	***25,3***±0,3	5,4±0,3	96%	***23,0***±0,7
OMV Vermicompost (VC)	***7,7***±0,4	***29,7***±0,7	5,4±0,4	87%	***19,8***±2,1

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Analysis

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➢ Plants: → Biomass weight

➢ Soil:

Chemical

- Total Organic Carbon
- Total N
- water soluble carbon
- nitrates
- ammonium

Biochemical

- Dehydrogenase
- β-glucosidase
- protease BAA
- Urease
- Phosphatase

Statistical analysis

- Principal component analysis

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RESULTS

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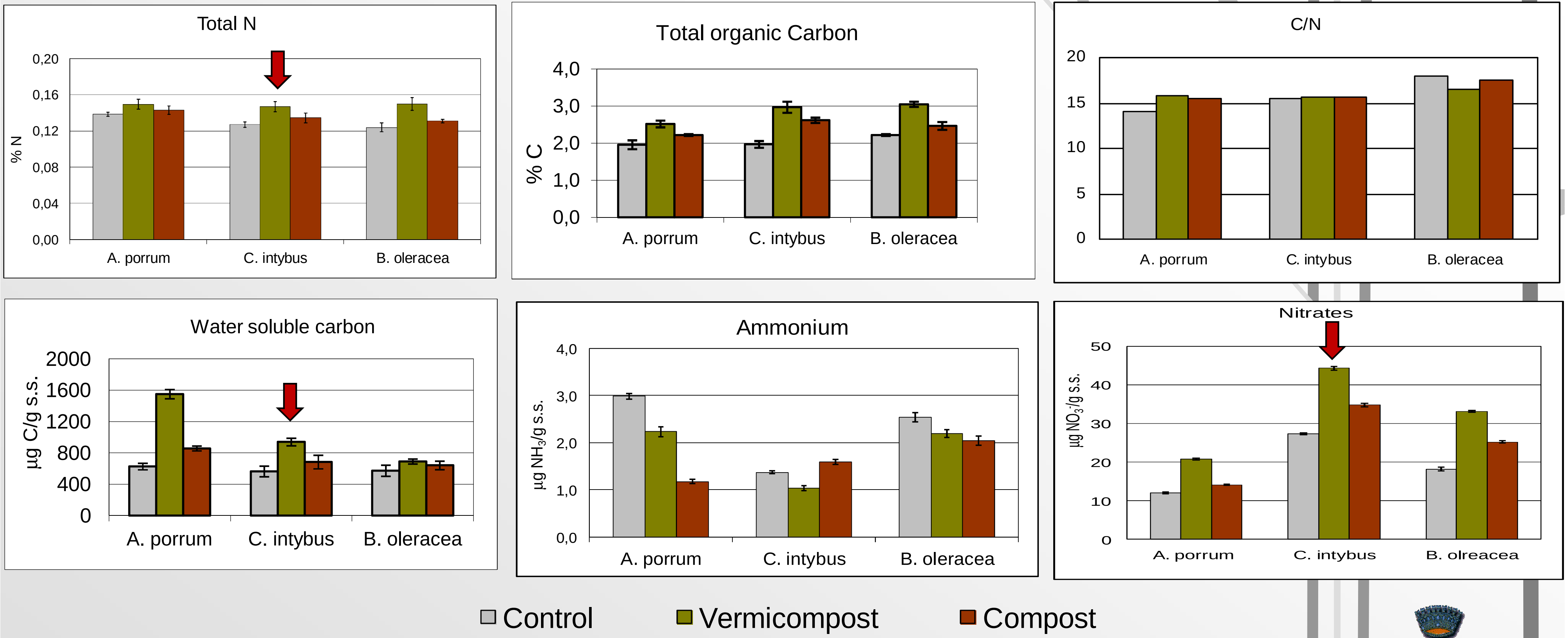
Soil results: Chemical parameters



Increase in nutrient content in treated soils;
More emphasized in vermicompost treatment

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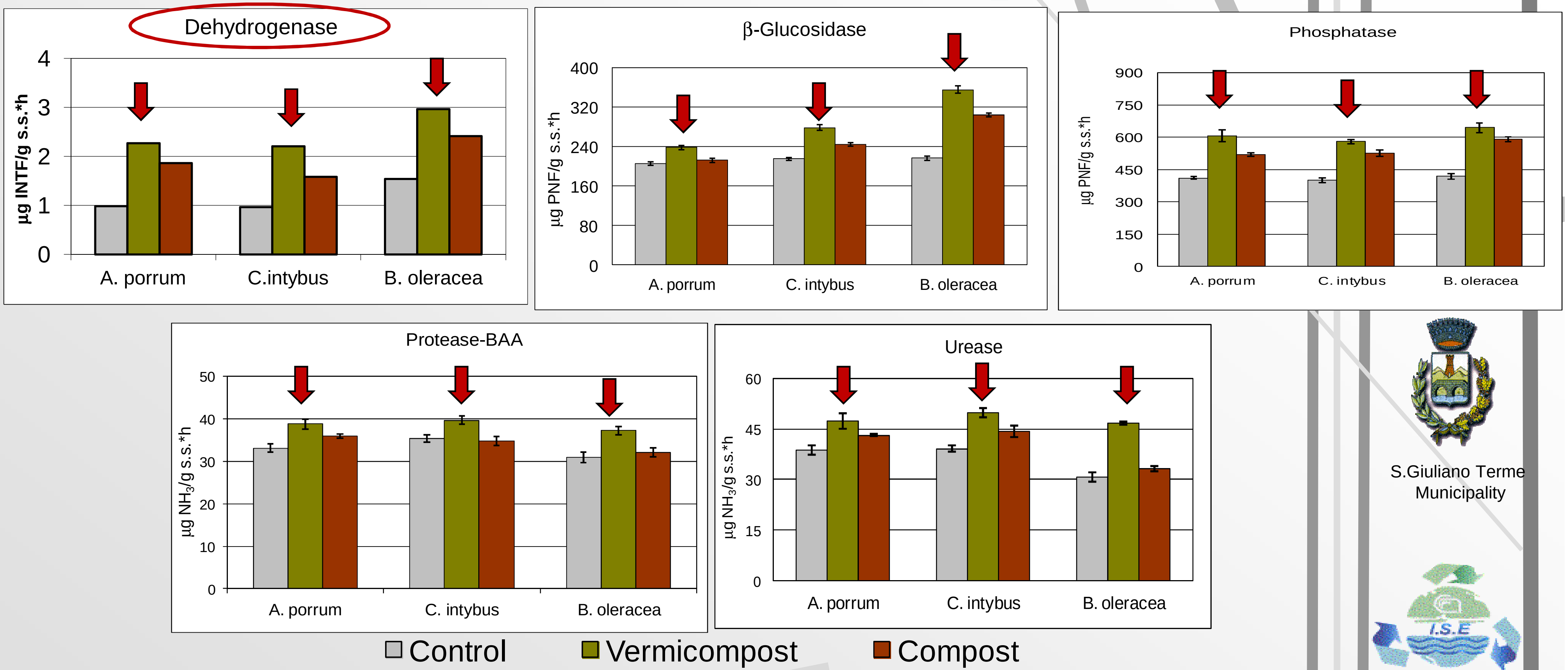
Soil results: Biochemical parameters



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The availability of nutrients (C and VC) stimulated soil microbial metabolism, resulting in an increase in enzyme activities related to C and P cycles

VC stimulates more nitrogen cycle with respect to C

Dehydrogenase, indicator of total microbial activity, increased in VC vs. Control of 100-130% in VC vs. C of 20-40%

✓Heavy metals in Compost and Vermicompost lower than Italian regulation limits (75/2010)

	Cd (mg /Kg)	Cu (mg /Kg)	Zn (mg /Kg)	Ni (mg /Kg)	Pb (mg /Kg)
Compost regulation limits	<1.5	< 230	<500	<100	<140
Vermicompost	0,564	63,5	187	65,1	65,1
Compost	0,469	60,4	178	89,5	77,6

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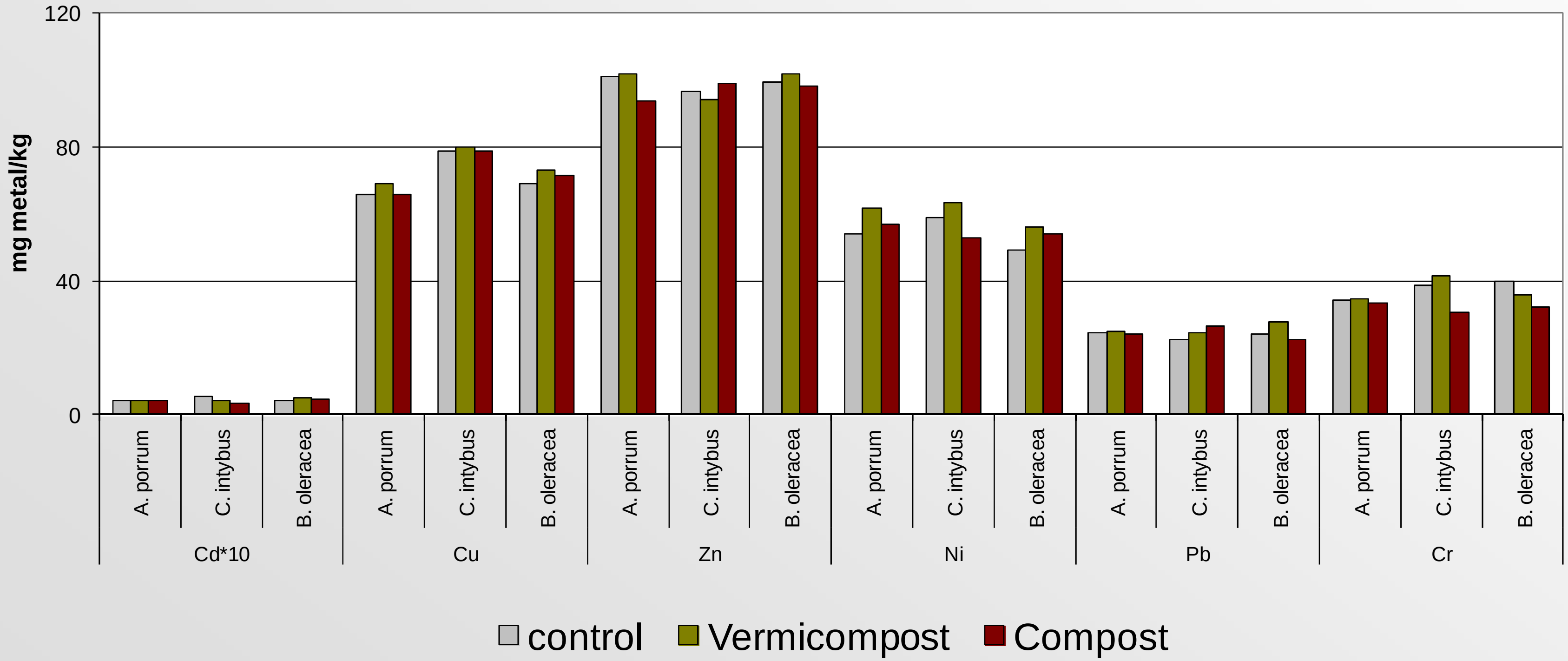
Heavy metals in soil



✓No relevant variation in soil heavy metals in the different treatments

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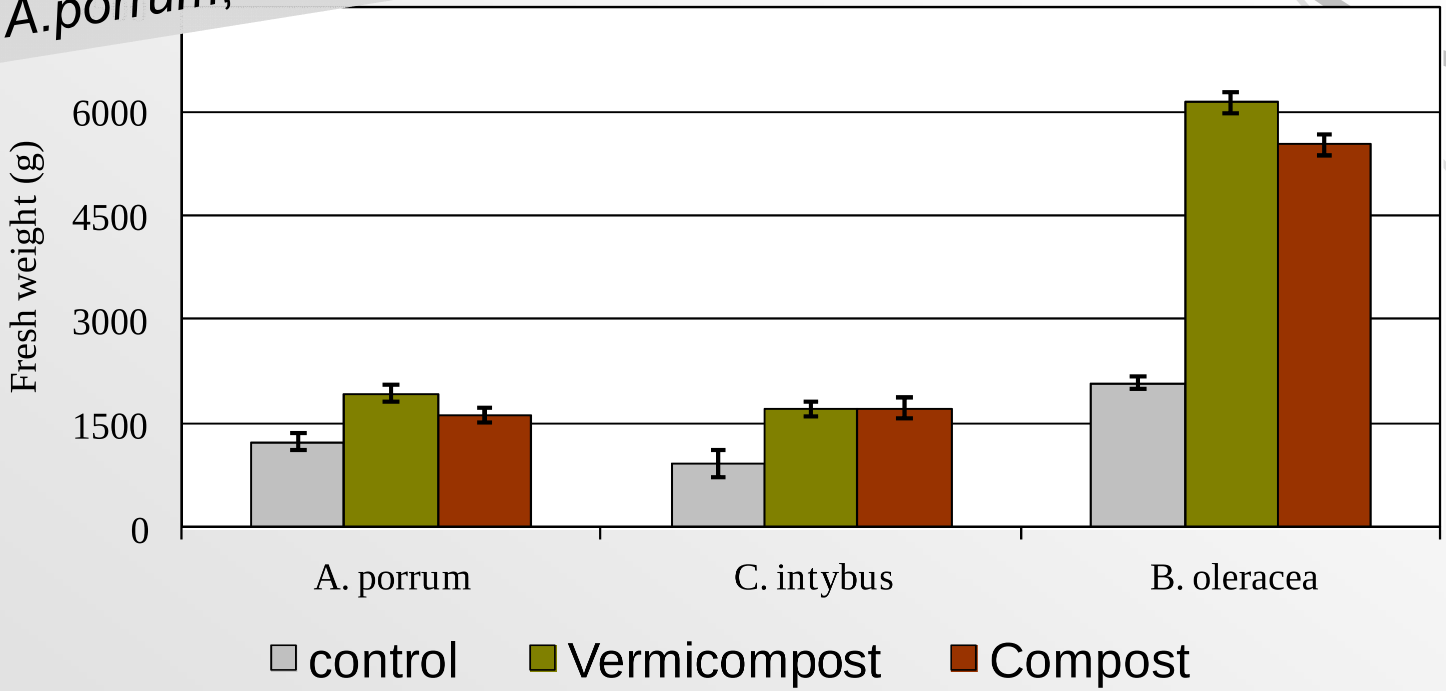
Plant biomass

Biomass increase in VC vs. Control
58% *A.porrum*, 88% *C.intybus*; 193% *B.oleracea*



Biomass increase in VC vs.C:
28% *A.porrum*, 30% *B.oleracea*

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Principal Component Analyses

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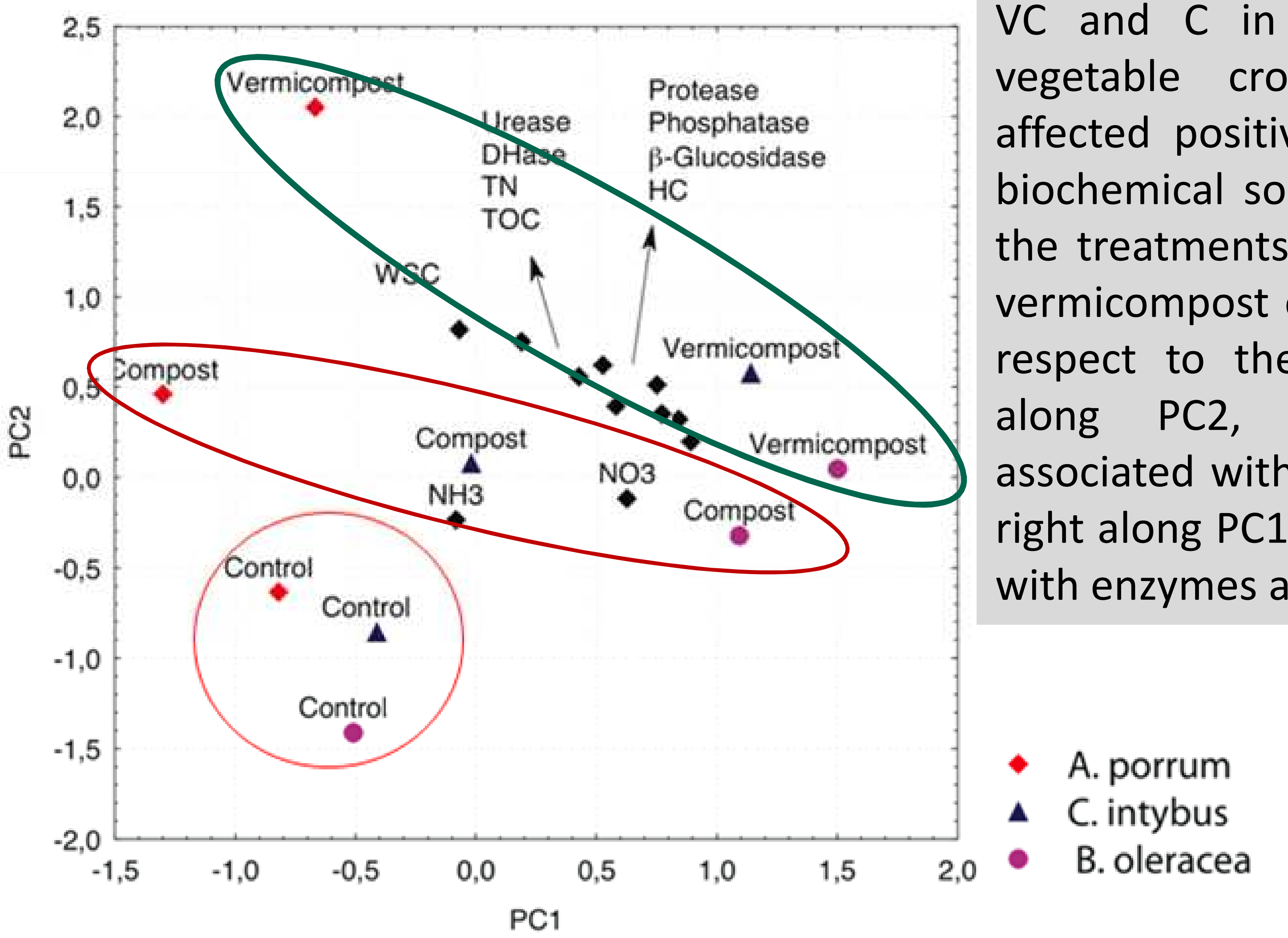

VC and C in presence of all the vegetable crops investigated had affected positively the chemical and biochemical soil characteristics, since the treatments, and in particular the vermicompost one, were shifted with respect to the control on the top along PC2, which was mainly associated with nutrients, and on the right along PC1, which was associated with enzymes activities.

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Conclusions

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Vermicomposting process could be an alternative technology for the management of OMW, transforming a polluted and phytotoxic matrix into a non-toxic and value-added product that could be used as organic fertilizer

Vantages:

- Economic: Vermicompost permits to save money with respect to mineral fertilizer
- Ecological:

i) improvement soil chemical fertility
ii) activate the metabolic processes (increase in hydrolitic enzymes and dehydrogenase activity) expressing the soil biochemical fertility
iii) stimulate plant biomass yield.

This OMW derived vermicompost is suitable to be used in organic farming at field scale

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