CLAUDIO MONDINI

Short term effect of novel bio-based fertilisers from fruit and vegetable residues on soil functioning

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RUSTICA Demonstration of circular bio-based fertilisers and implementation of optimized fertiliser strategies and value chains in rural communities

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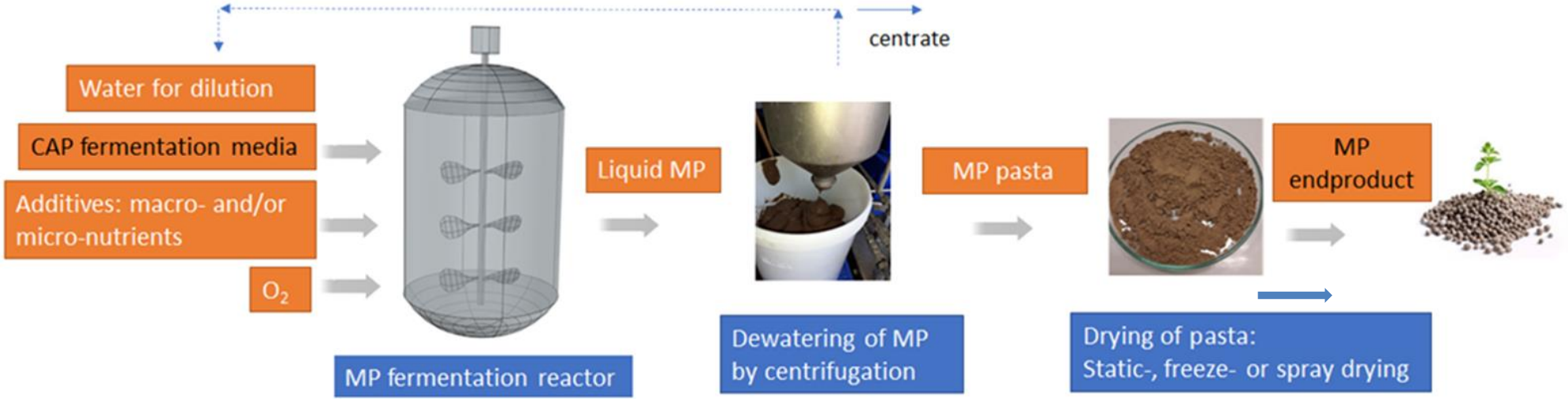
The H2020 RUSTICA project aims to provide a technical solution to convert organic residues from the fruit and vegetable sector into novel bio-based fertilisers (BBF) of high quality that address the needs of modern agriculture

https://rusticaproject.eu

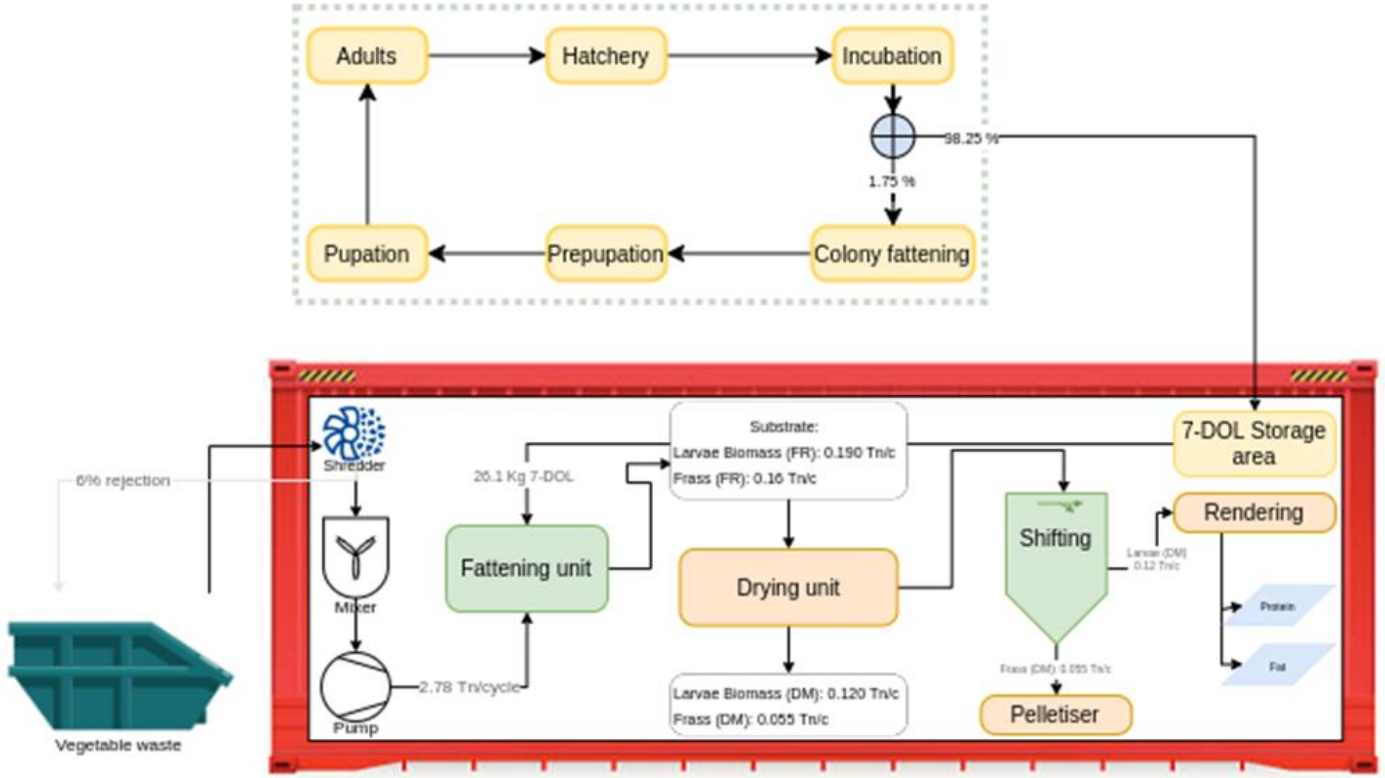
The technical solution consists of different conversion processes recovering nutrients and organic matter from fruit and vegetables and leading to novel bio-based fertilisers

Microbial cultivation



Bio-based fertiliser: microbial biomass

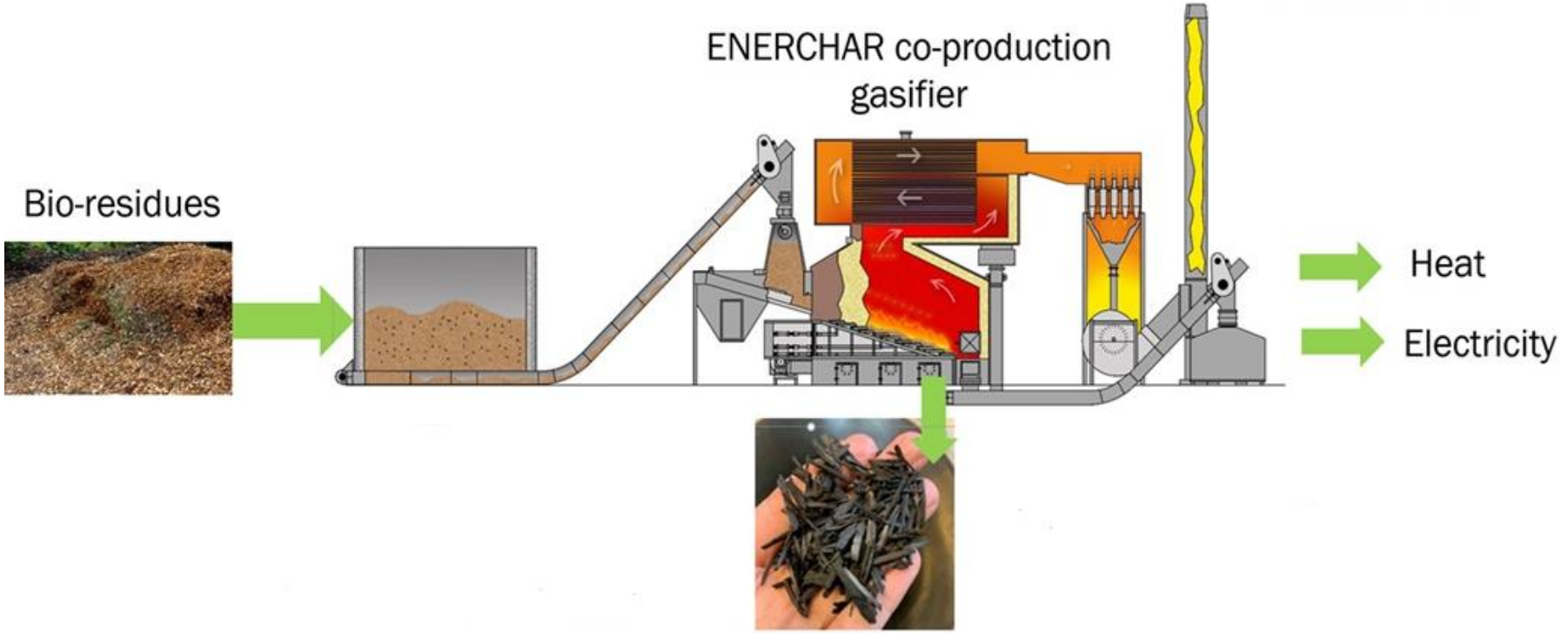
Insect breeding



2 bio-based fertilisers:

- insect frass (IF): a mixture of insect dropping (manure) and the remaining of fruit and vegetables residues
- Insect biomass (IB): body of the insect larvae

Pyrolysis



Pyrolysis: thermochemical conversion of biomass in an oxygen-limited environment

Bio-based fertiliser: biochar

Aim of the study

The impact of novel bio-based fertilisers on soil functioning is very little known

Bio-based fertilisers can affect the soil and the environment in different, unpredicted and undesired ways

Soil quality is crucial for the sustainability of circular food chains

An exhaustive assessment of the effects of bio-based fertilisers on soil quality is needed for their full valorisation and the sustainability of fruit and vegetable residues recycling into the soil

Particularly relevant is the impact of bio-based fertilisers on soil C and N dynamics, nutrients availability, microbial status and climate change.

Specific aim:

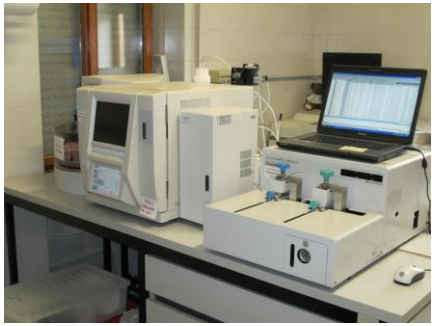
Evaluation of 18 different samples of microbial biomass, insect biomass, insect frass and biochar for:

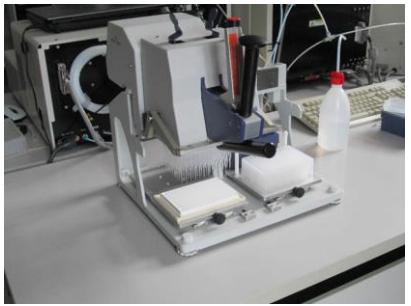
- Stability to decomposition in soil
- Impact on soil functioning:
  - ✓ C and N mineralisation
  - ✓ nutrient availability
  - ✓ microbial biomass content
  - ✓ N_2O emissions

BBF characterisation

Standard methods for:

- Dry and organic matter content
- Organic C, Total N
- Water soluble C, N, NO_3^- and NH_4^+
- pH
- Electrical conductivity
- Oxygen uptake ratio (OUR)
- Total nutrients
- Total heavy metals





Materials and methods

BBF soil addition (laboratory incubations)

Incubation

30 days
40% WHC
20 °C

GHG emissions (GC) (every 6 h)

- K_2SO_4-extractable OC and N
- K_2SO_4-extractable nutrients (NO_3^-, NH_4^+, P)
- Olsen P
- soil microbial biomass C and N

After 2, 7 and 30 days

Analyses

BBF characterisation

Average chemical composition of BBF: microbial biomass (n = 5), insect biomass (n = 3), Insect frass (n = 6) and biochar (n = 4)

Bio-based fertiliser	Dry matter	Organic matter	C_{org}	N	C_{org}/N	WSC	WSN	$N\text{-}NO_3^-$	$N\text{-}NH_4^+$	pH	EC	OUR	P total	K total	Mg total	Ca total	Mn total	Zn total	Cu total
	%	%	%			mg/g		µg/g			dS/m	mmol O_2 /kg OM/h	g/kg				mg/kg		
Microbial biomass	91	77	39	9.9	4	51	14	14	41	7.2	5	92	17	14	4	65	60	56	44
Insect biomass	95	95	53	7.1	7	48	11	25	6	6.2	4	35	5	8	2	6	53	38	5.3
Insect frass	82	70	39	2.5	19	27	4	21	49	8.1	8	34	8	36	7	35	130	81	47
Biochar	70	74	65	1.1	64	2	0.1	2	2	9.7	5	1	4	28	5	14	276	183	33

WSC: water soluble C; WSN: water soluble N; EC: electrical conductivity; OUR: oxygen uptake ratio

Biochar: very stable (very low OUR, WSC and WSN), high organic C and pH

Insect frass: high K content, intermediate stability

Microbial and insect biomass: high N content (9.9 - 7.1%), highly degradable

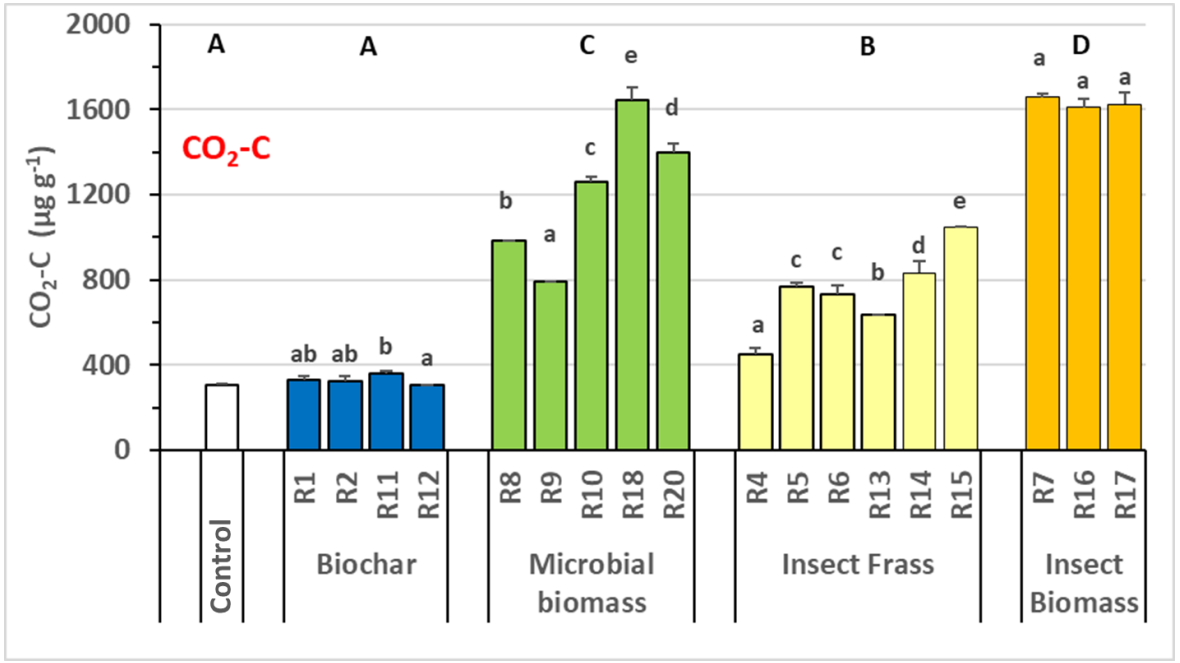
biochar

insect frass

microbial biomass

insect biomass

BBF soil addition



CO_2 respiration

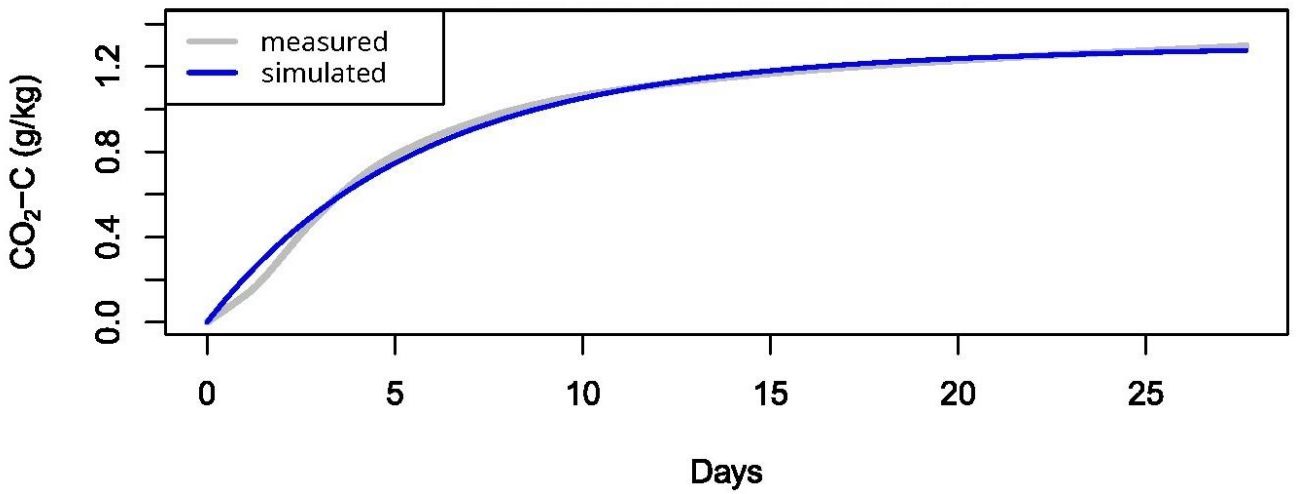
The percentages of added C mineralised after 30 days were 0.8, 25, 47 and 53% for biochar, insect frass, microbial biomass and insect biomass, respectively

Considering CO_2 emissions and chemical characterisation, bio-based fertilisers can be ranked as follows in terms of stability to degradation:

Biochar >> insect frass > microbial biomass = insect biomass

BBF soil addition

Exogenous organic matter (EOM) pool parameters estimation for long term soil C modelling



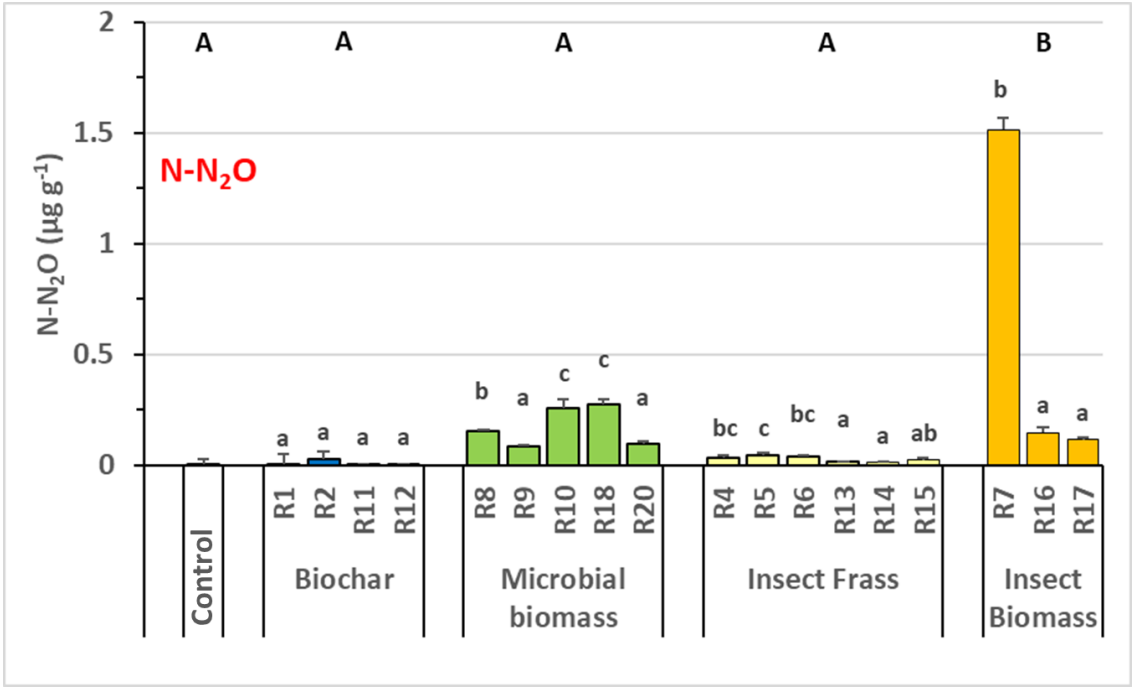
Fitting of measured cumulative respiration curves with respiratory response simulated by RothC soil C model (modified for amended soil) for estimation of partitioning factors and decomposition rates of EOM pools

This would enable to enhance the accuracy of long-term simulation of SOC dynamics in amended soil

Poster: *Modelling long-term impact of novel biobased fertilizers on soil organic matter storage from laboratory short-term C mineralization" – ID Web 136427*

Session: 131145 - Dynamics and functions of soil organic matter under new and traditional amendments

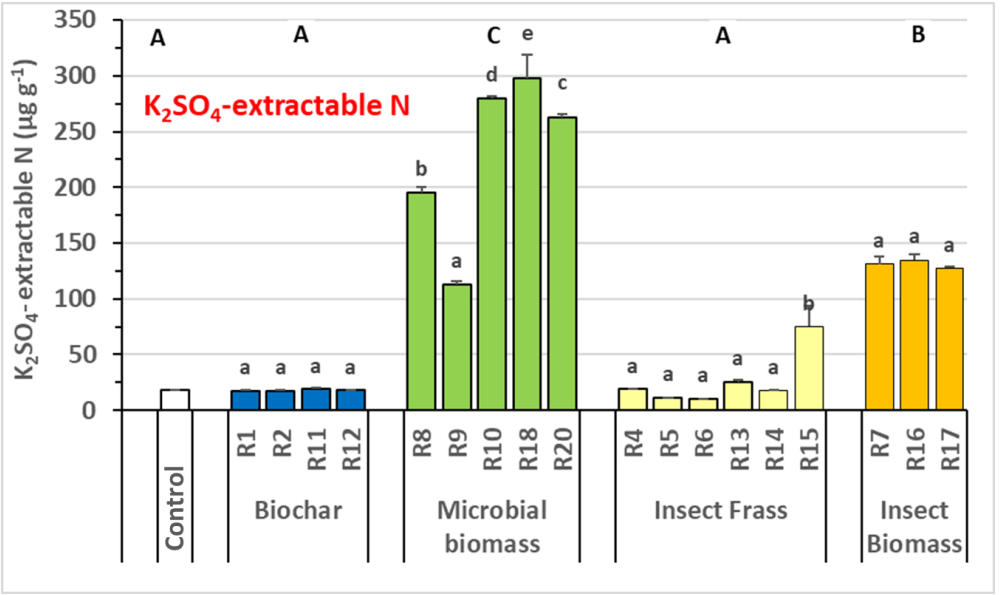
BBF soil addition



N_2O emissions

The different degree of stability is reflected by N_2O emissions, as higher levels are observed in soil treated with more degradable bio-based fertilisers (insect and microbial biomass).

BBF soil addition



Available N

Microbial and insect biomass:

44 and 34 % of added N, respectively.

Nitrate was on average 45% of K_2SO_4-extractable N.

Biochar and insect frass:

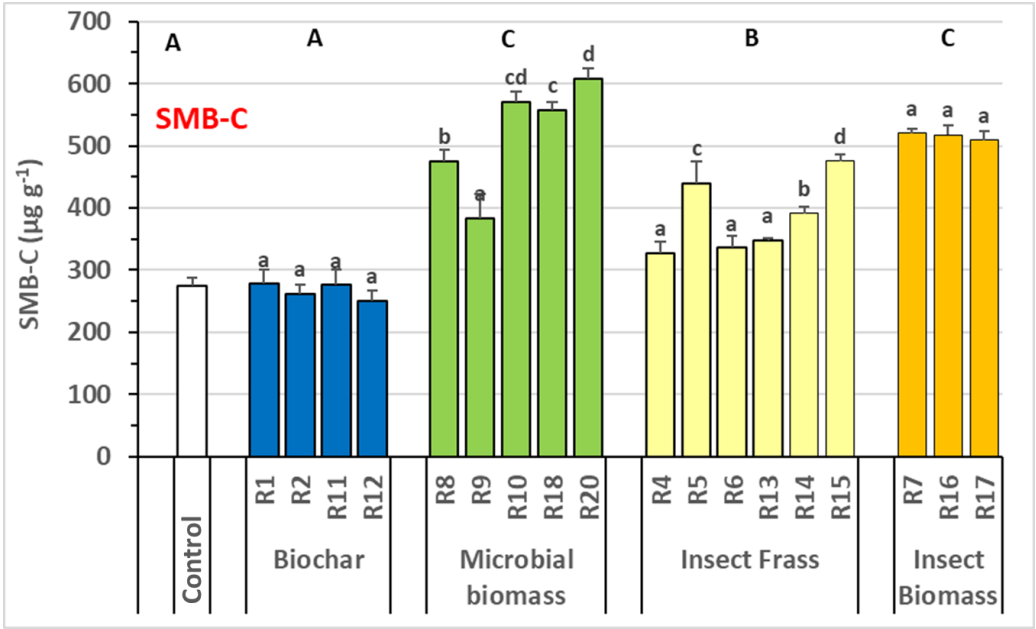
no significant effect on short term N availability.

BBF soil addition

Soil microbial biomass C

- *Biochar* had no effect
- A significant increase was recorded for *microbial and insect biomass*
- An intermediate behaviour was recorded for *insect frass*

The content of microbial biomass C reflects the level of degradability of the bio-based fertilisers



Conclusions

The highly variable physico-chemical characteristics and properties of bio-based fertilisers resulted in a distinct impact on soil quality

Bio-based fertilisers require a specific management

Bio-based fertilisers can be fully valorised to fulfil specific soil functions:

Microbial and insect biomass

high N content, fast OM mineralization and release of significative amounts of nutrients can increase N_2O emissions → **mineral fertilisers substitution**

Insect frass

degradable to an extent maintaining biological activity, but still showing some persistence in soil → **maintenance of soil quality and functioning**

Biochar

high recalcitrance to decomposition in soil → **soil C sequestration and climate change mitigation**

Conclusions

- This study underlines the importance of the assessment of the impact of bio-based fertilisers from different fruit and vegetable residues and conversion processes on soil quality and climate relevant C and N dynamics.

- Such evaluation is necessary to identify appropriate managements that enhance their potential and avoids negative agronomic and environmental effects.

- Among these strategies, blending bio-based fertilisers with contrasting properties may represent an effective option to fully exploit the potential of these materials, resulting in innovative fertilisers with multiple functionalities that are an effective alternative to usual fertilising products.

Thank you for your attention