Consiglio Nazionale delle Ricerche
ISPA
ISTITUTO DI SCIENZE DELLE PRODUZIONI ALIMENTARI

75th EAAP Annual Meeting, 2024
Florence 1-4 September

Session 25: Project session ADVAGROMED

Insect frass and poultry manure: a novel circular economy approach for sustainable vegetable production in Mediterranean regions.

The PRIMA project ADVAGROMED experiences.

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Sustainable agriculture: why?

Post-green revolution intensification of agriculture has resulted in **soil degradation** in the form of compaction, erosion, **loss of organic matter**, pesticide contamination, **loss biodiversity,** increased soil salinization and waterlogging

Sustainable agriculture systems are able to restore soil quality by the use of organic fertilizers, biopesticides and crop rotation.

Organic fertilizers represent a source of plant nutrients and their use improve the soil organic matter content.

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ADVAGROMED WP4 – Use of insect frass and poultry manure in sustainable agricultural processes

To evaluate the use of insect frass and poultry manure as organic fertilizers for local crops to enhance agro-biodiversity.

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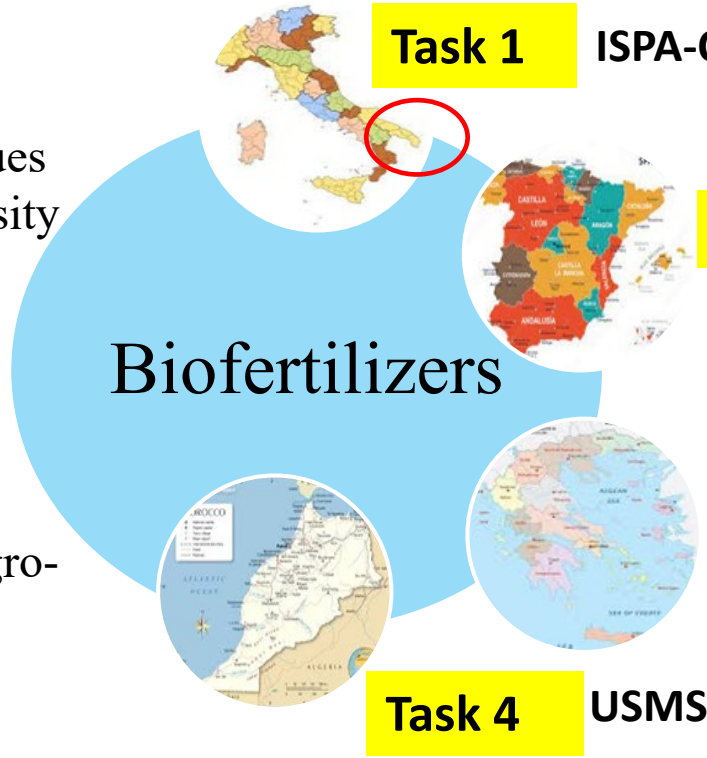
The WP 4 is performed in 5 tasks (1-4 agronomic case studies)

Common approach

- Sustainability of agricultural techniques
- Local agro-biodiversity approach

Differences

- Agro-environmental context (locations/agro-ecosystems)
- Local crop varieties
- Frass used



Task 1 **ISPA-CNR** supported by UNITO; Italy

Task 2 **SERIDA** Spain, supported by IO, Portugal

Task 3 **UTH**, Greece

Task 4 **USMS**, Morocco

Task 5

DIL, Germany; supported by UNITO, UTH, IO, SERIDA, USMS, CNR;

Impact analysis and consumer acceptance

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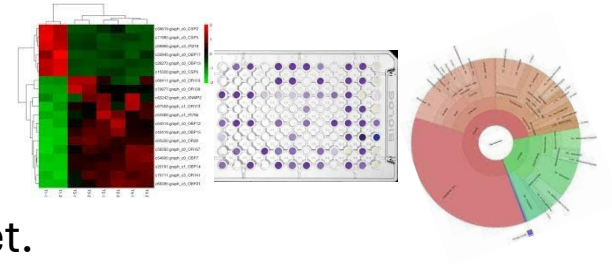
Step 1 – Physico-chemical and microbiological (bacterial and fungal population) characterization: frass, poultry manure, and soil. (carried on by CNR, UTH, SERIDA, USMS).

Essential for a correct use as organic fertilizers



The content of macro and microelements is closely dependent on the insect's diet.

Macro and micro-nutrient content of the Tenebrio and Hermetia frass.

Macronutrient content in different batches of *Tenebrio molitor* L. and *Hermetia illucens* L. frass.

	Ca	K	Mg	P
	g/kg of dry weight			
Tenebrio				
Batch1	4.5	37.6	11.2	32.9
Batch2	2.6	27.7	9.0	22.3
Batch3	5.1	27.6	9.5	22.4
Hermetia				
Batch1	7.0	40.6	8.2	22.3
Batch2	48.4	19.7	6.8	10.9

Mean of three independent analysis,

Nitrogen and anions content in *Tenebrio molitor* L. and *Hermetia illucens* L. frass.

	N_{tot}	NO_3	SO_4	Cl
	g	mg		
	/kg of dry weight			
Tenebrio	22.04	429	2659	3797
Hermetia	19.1	165	2226	4647

Mean of three independent analysis.

Mineral content in different batches of *Tenebrio molitor* L. and *Hermetia illucens* L. frass.

	Al	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Na	Ni	Sr	Pb	Zn
	mg/kg of dry weight														
Tenebrio															
Batch 1	95.8	5.1	23.3	<lod	<lod	0.8	20.9	312.9	260.7	2.2	3044	2.5	14.9	4.7	137
Batch 2	54.2	6.2	23.4	0.5	0.2	0.5	16.3	387.6	226.6	1.1	306	2.8	16.8	5.2	135
Batch 3	58.3	20.1	25.6	0.4	1.5	0.8	18.0	220.0	232.7	1.8	115	3.6	20.6	6.1	137
Hermetia															
Batch 1	601	5.7	22.3	<lod	<lod	2.27	18.48	724	106.21	2.44	381.3	3.62	27.4	5.00	115.56
Batch 2	5764	64.6	50.0	0.4	4.0	11.1	50.2	4210	214.7	2.2	2435	8.6	25.1	8.4	168.3

Mean of three independent analysis; <lod =< detection limit.

(Data by CNR-ISPA)

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Physico-chemical characteristics of the poultry manure from *Pita Pinta* chicken fed with *Hermetia illucens* (HI) larvae.

	Total N (%N)	Total Ca (%CaO)	Total K (%K2O)	Total Mg (%MgO)	Total P (%P2O5)
5%	3.59	10.51	2.14	1.00	3.11
10%	3.25	12.25	2.30	1.15	3.36

Data from dry samples.

	Total B (mg/kg)	Total Cu (mg/kg)	Total Fe (mg/kg)	Total Mn (mg/kg)	Total Mo (mg/kg)	Total Na (%NaO2)	Total Zn (mg/kg)
5%	18.8	32.0	627	337	3.64	0.62	390.7
10%	18.2	34.8	751	410	1.81	0.58	407.7

Data from dry samples.

(Data by SERIDA)

Step 2 - Preliminary tests on plants

(carried on by CNR, UTH, SERIDA, USMS)

To evaluate potential phytotoxic effects of insect frass and poultry manure in environmental controlled conditions.

Incubation experiments

Laboratory

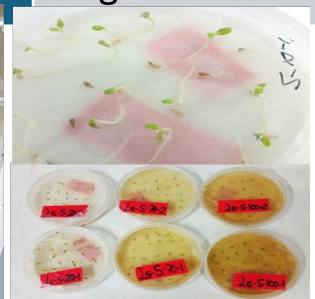
With **frass** (Control, 0.25%, 0.5%, 0.75%, and 1% soil); Two **soils**: (a) Velestino, and (b) sandy

With **chicken manure** (Control, 2.5%, 5%); Two **soils**: Velestino, and Larissa (sandy) soils

Germination test
Plant growth test in pots

Greenhouse

Vegetable species tested: (**Brassica** oleracea var. Viridis, **Lactuca** sativa and **Phaseolus** vulgaris var. Verdina).



Agronomic trials

Growth chamber

to assess the effects of increasing rates of insect frass on physiology and agronomic performances of local varieties of **rapini** and **tomato**.

Ex.: Use insect frass as a substitute for chemical fertilization for growing rapini and mizuna.

Treatments:

- Peat (**+ chemical fertilization**) common agronomic practices
- Hermetia frass:peat (50:50 w/w) **Without chemical fertilization**
- Tenebrio frass:peat (50:50 w/w) **Without chemical fertilization**

Experimental Design: randomized block with 3 replications


Hermetia frass


Tenebrio frass

Ctr – 100% Peat

Hermetia frass:peat (50:50 w/w)

Tenebrio frass:peat (50:50 w/w)

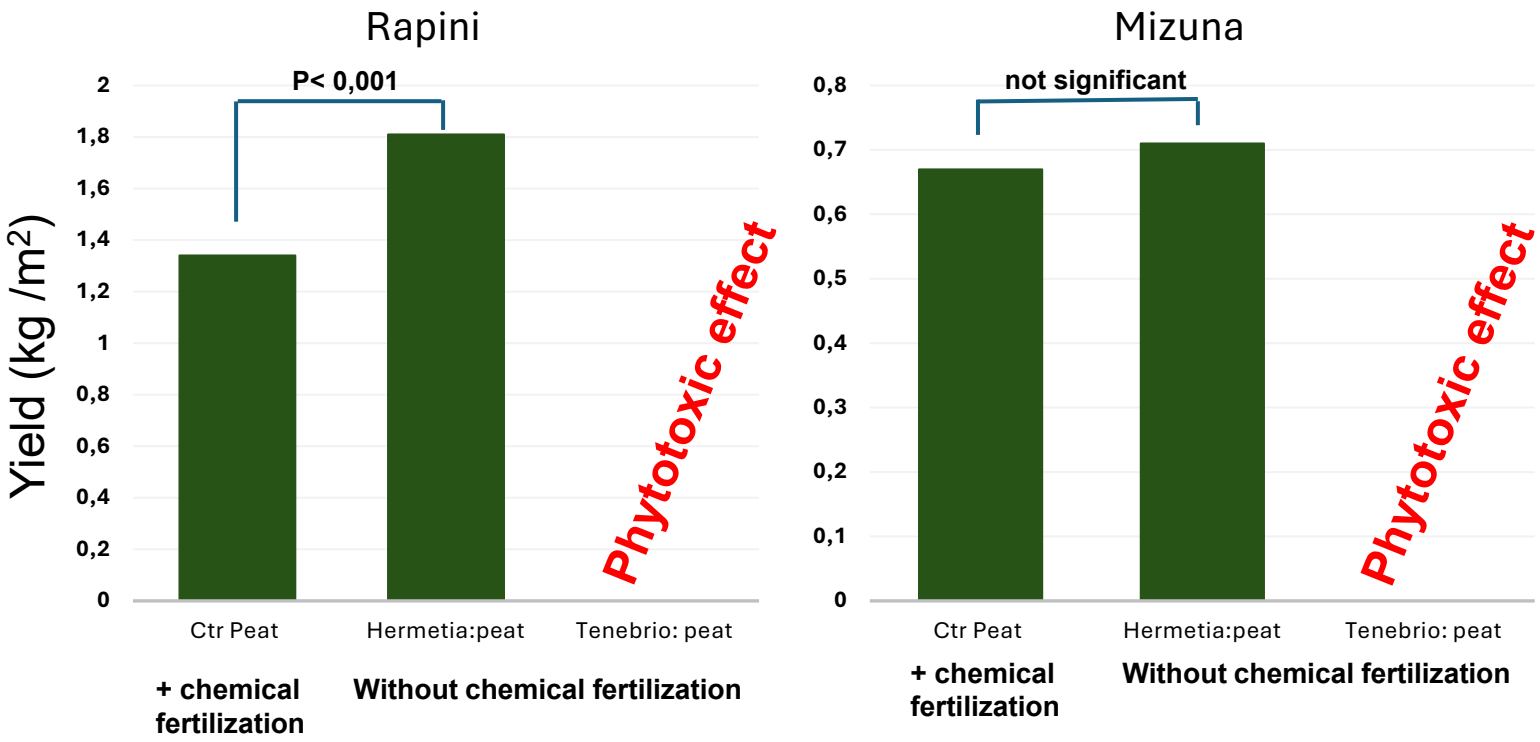
Phytotoxic effect

(+ chemical fertilization)

Without chemical fertilization

Mizuna microgreens (*Brassica rapa* L.)

Crop performance



Data are expressed as mean (n = 9).

Step 3 - Agronomic trials

(carried on by CNR, UTH, SERIDA, USMS across Italy, Greece, Spain, and Morocco)

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CNR, UNITO - Italy

Open field agronomic trials*	
Tomato: spring-summer period 2023	First trial was performed growing the local variety "Regina"
Brassica: autumn-winter period 2023-2024	Second trial was performed using local variety of rapini cv. "Novantina".
Tomato: spring-summer period 2024	Third trial was performed growing the local variety "Regina".

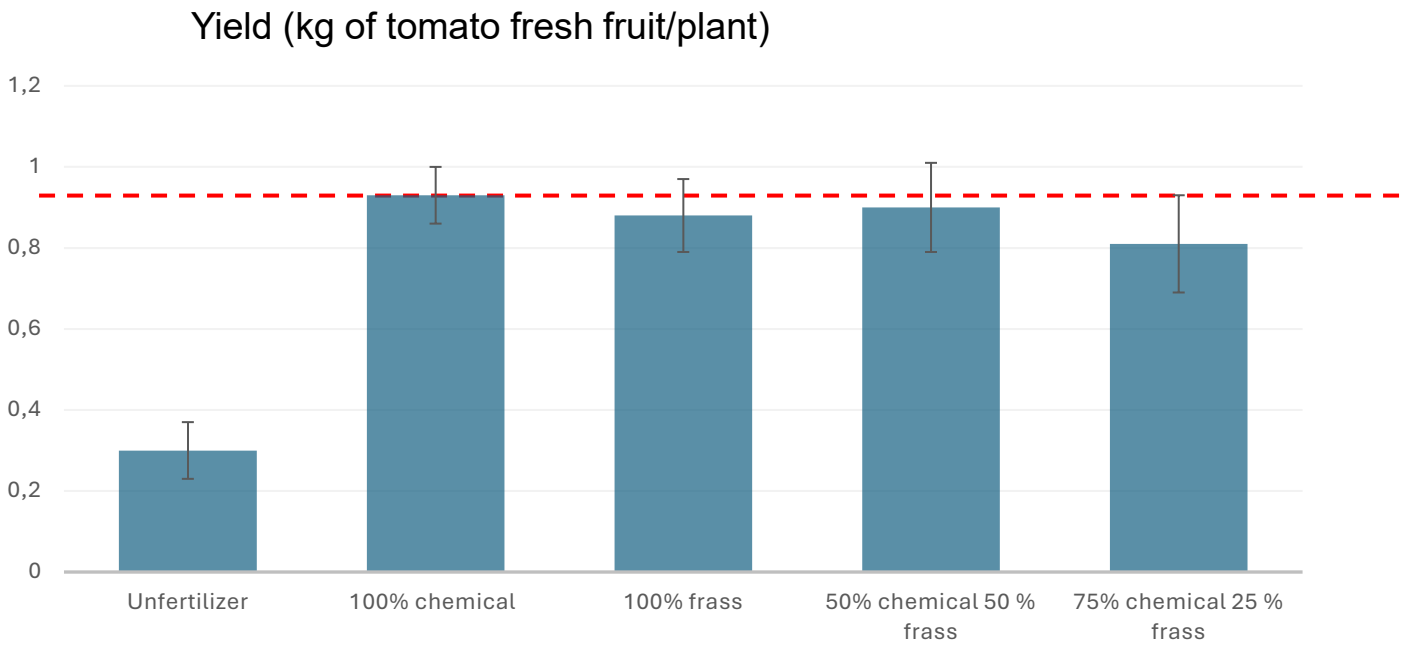
9 treatments arranged in a randomized block design with three replication. Tenebrio molitor frass and poultry manure used as biofertilizers

***The same experimental design and plot placement is maintained to assess a possible residual fertilization effect of TM frass and poultry manure.**

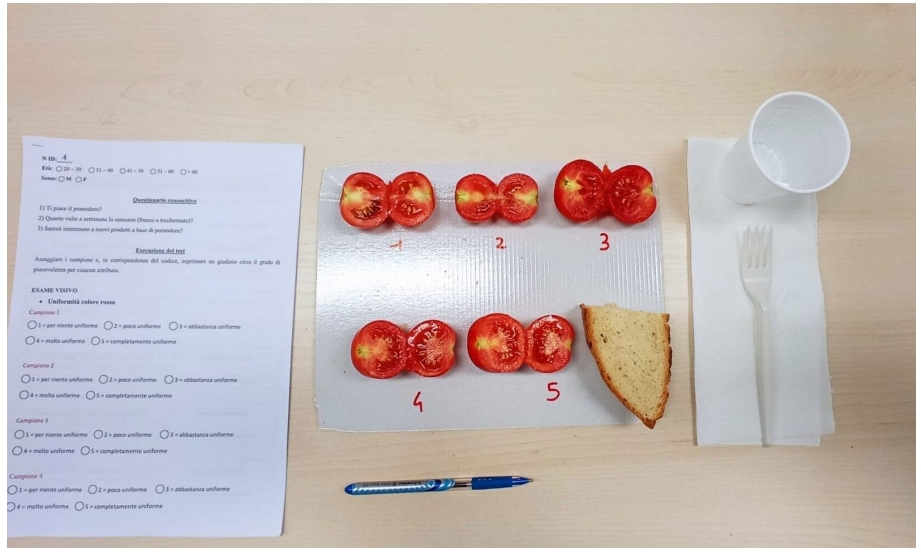
Treatments		
T1	**T2**	**T3**
100% chemical	100% frass	100% organic
T4	**T5**	**T6**
100% poultry	75% chem 25% frass	50% chem 50% frass
T7	**T8**	**T9**
75% chem 25% poultry	50% chem 50% poultry	Control

Rate of Nitrogen (N) fertilizer as reference: 130 kg/ha according to Apulia region Official Bulletin n. 38 31/03/2022

Crop performance and nutritional quality



Panel test



In tomatoes, the use of TM frass did not result in variations in the following nutritional parameters: color, ° Brix, titratable acidity.

UTH - Greece

UNIVERSITY OF THESSALY

Open field agronomic trials on pepper and eggplant local varieties	Period: Spring – Summer 2023 Two local varieties of pepper, *Capsicum annuum* cvs. **Bachovitiki and Florinis** grown in two soils (a medium-to-heavy textured soil & a sandy one) in 15 L pots in outdoor conditions.	Period: Spring-Summer 2024. Two local varieties of eggplants, **Tsakoniki and Langada,** grown using the same treatments and soils, and the same set of growth and functional measurements will be performed.
	Frass and poultry manure were added at increasing rates and compared with two control treatments (positive control represented by commercial chemical fertilizers; negative control: no inputs).	

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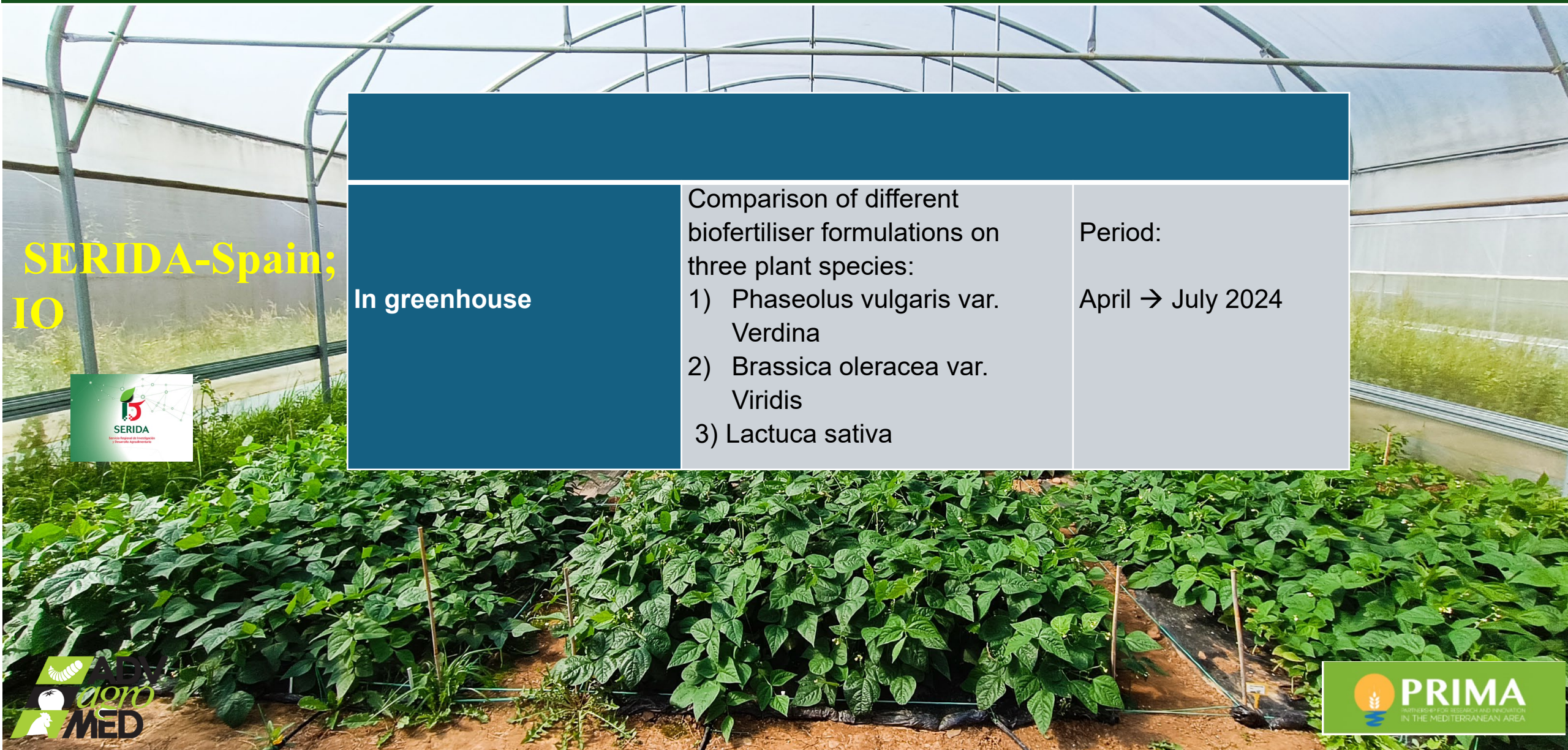
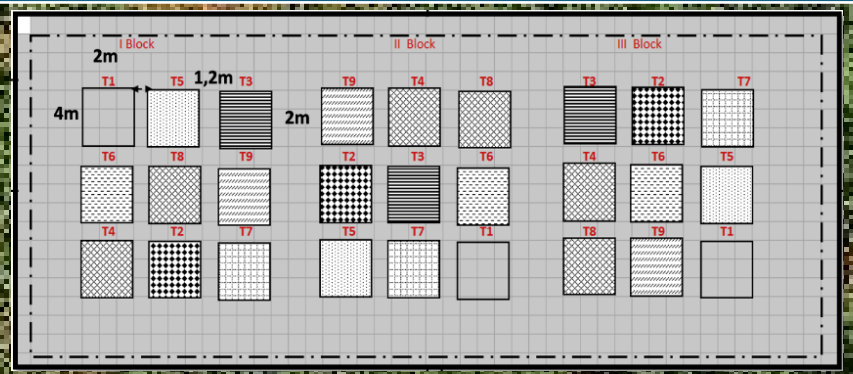


SERIDA-Spain; IO

In greenhouse	Comparison of different biofertiliser formulations on three plant species: 1) Phaseolus vulgaris var. Verdina 2) Brassica oleracea var. Viridis 3) Lactuca sativa	Period: April → July 2024

USMS - Morocco

Open field	Period: Autumn – Summer 2023 Plant species: barley, local variety "Beldi"	Period: Spring – Summer 2024 Plant species: local variety of onion.
Doses of insect frass (Hermetia illucens) and poultry manure. Total 9 experimental thesis set up as a randomized block design with 3 replications.		



Experimental design of field trials
9 treatments (3 replications):
T1: NC (0t/ha).
T2: PC (~219 Kg/ha).
T3: 5,8 t/ha of insect frass.
T4: 2,85 t/ha of insect frass.
T5: 1,42 t/ha of insect frass.
T6: 11,4 t/ha of insect frass.
T7: 5t/ha of poultry manure.
T8: 2,5t/ha of poultry manure.
T9: 5t/ha,

DIL supported by UNITO, CNR, SERIDA, IO, UTH, USMS

Data collection for environmental and economic impacts analysis and consumer acceptance of insect-based agricultural practices

Collection of experimental trials data through questionnaires.

Datasets for

- Insects rearing
- Poultry rearing
- Slaughterhouse
- Agricultural practices

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Conclusions

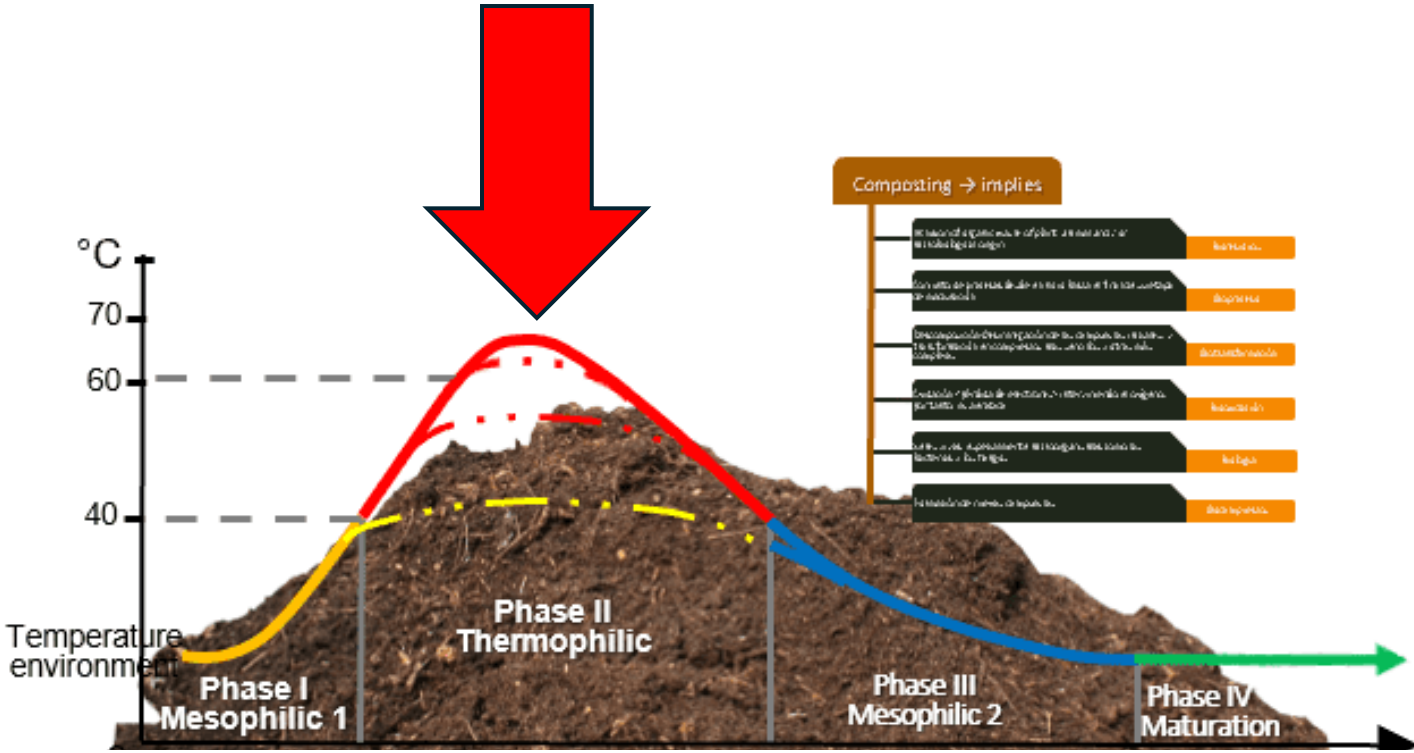
Insect frass and poultry manure, as organic fertilizer, could replace mineral fertilizers for growing a variety of vegetables. No significant differences in yield or quality were observed compared to the control (chemical fertilizer).

Tenebrio frass may exhibit phytotoxic effects at high application rates (high quantity of N in the form of NH4??????)

Thank you

Alternative to thermal treatment in an oven (70 °C 1 h, as stated by UE 2021/1925)

Considering the increasing cost of energy, we are actively working on the development of an alternative method for sanitizing insect frass.



Improving distribution

Powder

Pellet

Fertigation

The transformation into pellets makes distribution easier and more precise compared to a powdery product.

Solution of frass applied through irrigation (organic fertigation).