Nutrient availability and greenhouse gas emissions from bio-based fertilizers under controlled conditions

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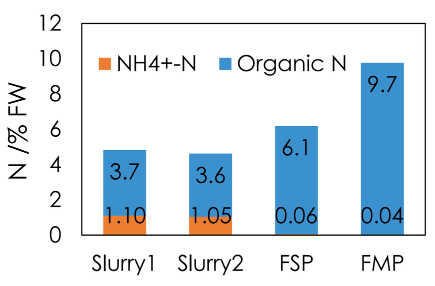
Introduction

- Sustainable agriculture is essential for addressing global food security and climate change, driving interest towards bio-based fertilizers (BBFs) derived from organic waste like fishery waste and by-products. These fertilizers can promote nutrient recycling by transferring nutrients from the fishery industry to agriculture.
- This study investigates the effects of fishery waste-based BBFs on plant growth, nutrient uptake, and GHG emissions under control conditions. The preliminary results highlights the potential of these fertilizing products in achieving spinach yields comparable to that of synthetic fertilizers and presents a holistic view of their potential agronomic performance and environmental impact when applied in the field.

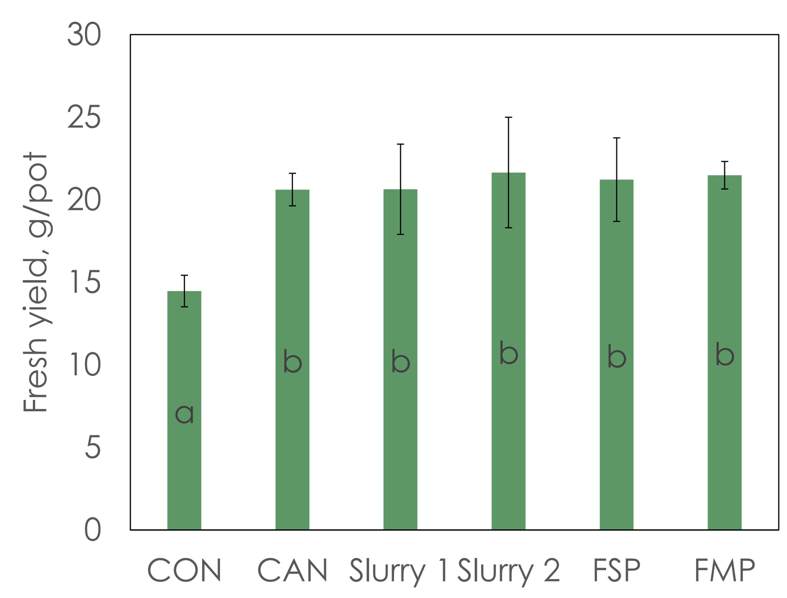
Fertilizer composition



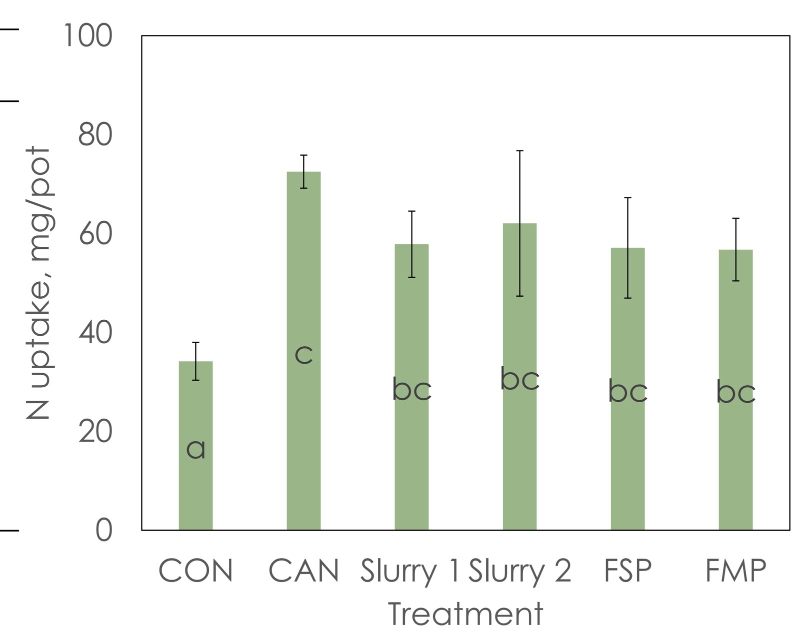
Biobased fertilizer	Unit	Hydrolysate	Chitin-rich N fertilizer	Fish sludge pellet	Fish mix pellet
Abbreviation		Slurry1	Slurry2	FSP	FMP
pH-H_2O	-	5.78 ± 0.01	5.80 ± 0.01	6.15 ± 0.01	6.17 ± 0.03
DM	%	42.1 ± 1.71	42.3 ± 0.17	94.4 ± 0.2	94.5 ± 0.11
OM	%DM	82.5 ± 0.21	82.9 ± 0.11	82.5 ± 0.4	71.1 ± 0.72
TN	%	4.82 ± 0.17	4.62 ± 0.03	6.19 ± 0.07	9.77 ± 0.22
NH_4^+-N	g kg^{-1}	11.0 ± 0.09	10.5 ± 0.09	0.62 ± 0.06	0.38 ± 0.05
NO_3^--N	g kg^{-1}	<0.002	<0.002	<0.002	0.007 ± 0.002
TC%	%	28.4 ± 1.2	27.9 ± 0.6	39.3 ± 0.6	36.5 ± 0.8
C/N	-	5.88	6.04	6.35	3.73

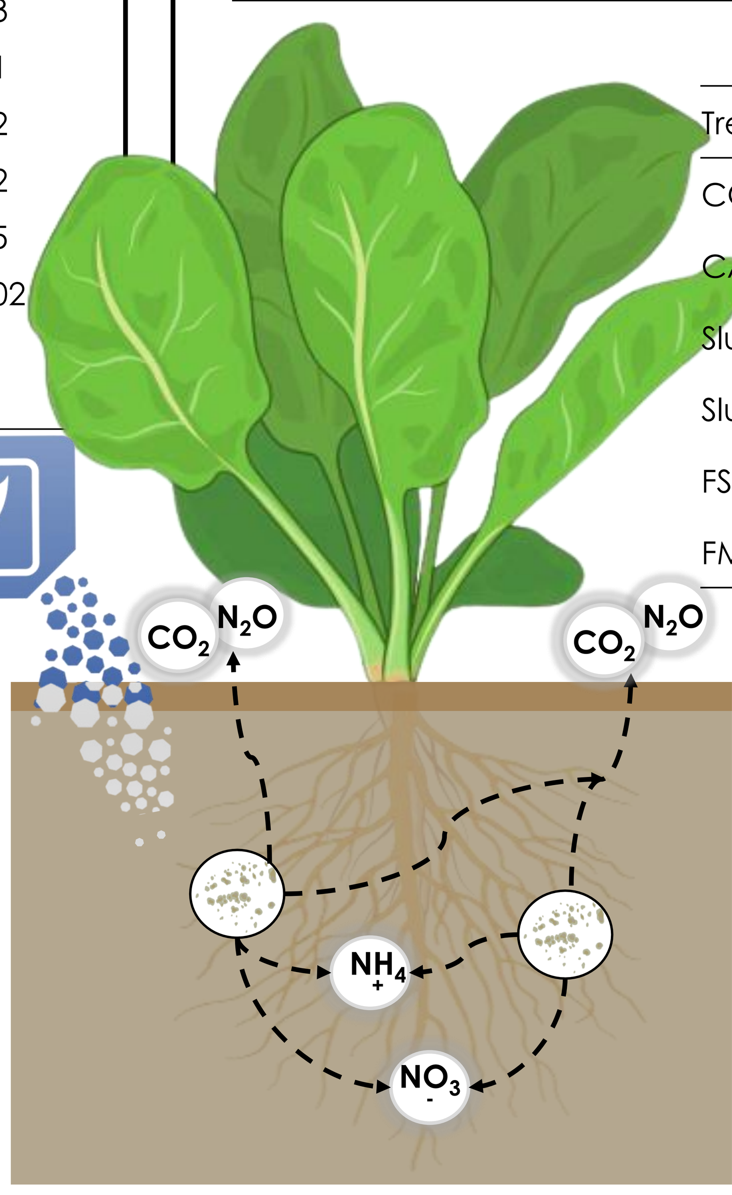
Nutrient availability in pot experiment

Information	
Plant	*Spinacia oleracea*
Growth period	60 days
N demand	200 kg ha^{-1}
Soil water content	50% WFPS
Watering	3 times week^{-1}
Reference	Calcium ammonium nitrate (CAN)

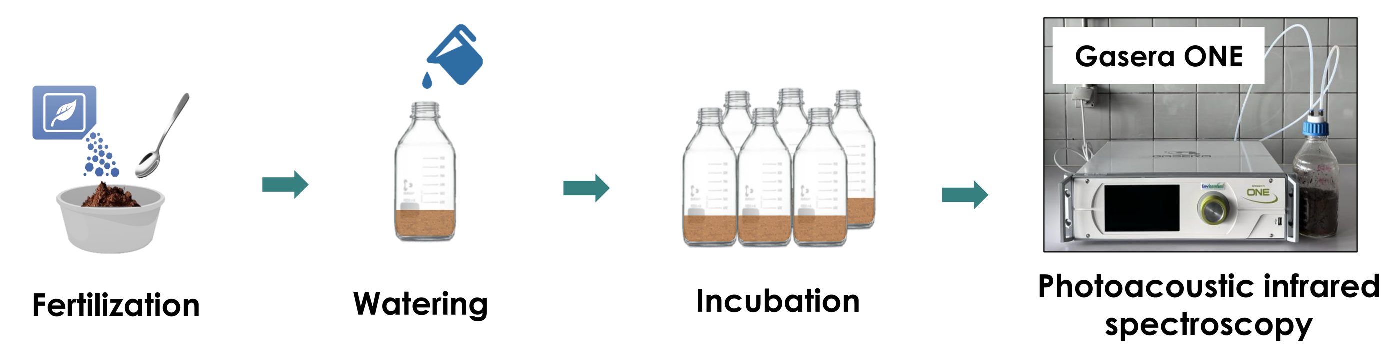


Treatment	NUE
CON	
CAN	0.64 ± 0.06b
Slurry_1	0.40 ± 0.11ab
Slurry_2	0.47 ± 0.25ab
FSP	0.39 ± 0.17ab
FMP	0.38 ± 0.11ab

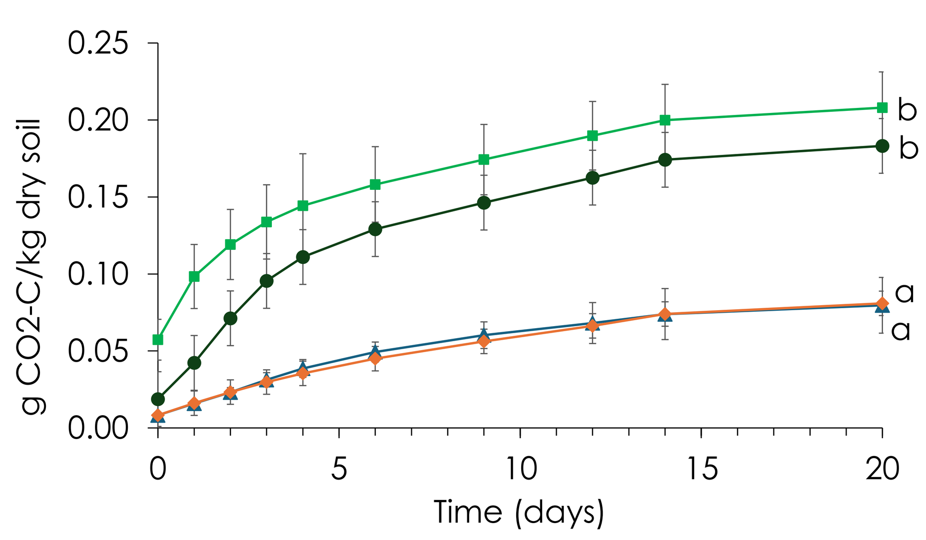


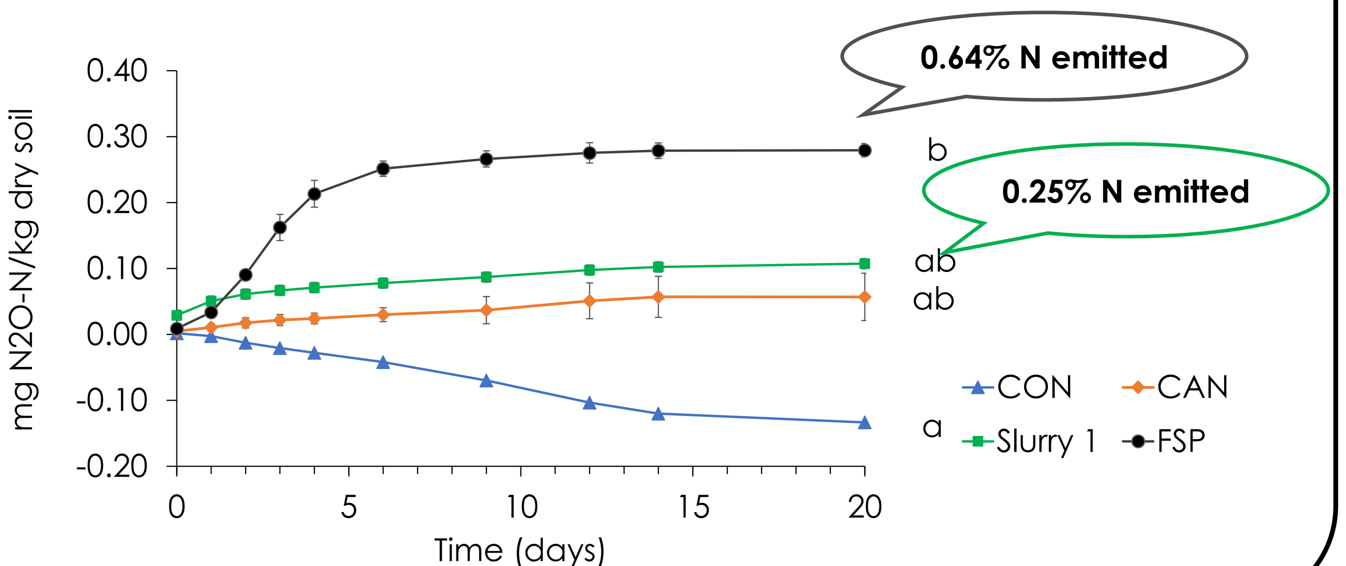


GHG emission via microcosm setup



Cumulative gas emission:





Calculations

- Nutrient use efficiency (NUE):

$$NUE = \frac{Nuptake_{fertilizer} - Nuptake_{control}}{N_{applied}}$$

- Gas emission flux:

$$Flux = \frac{\Delta gas}{\Delta t} \times \frac{P \times M \times n}{R \times T} \times \frac{V}{W}$$

where Flux is the elemental flux released as a gas, in µg kg^{-1} h^{-1}; $\frac{\Delta gas}{\Delta t}$ is the slope of the linear regression of gas concentration against time; P is the pressure in the cell (0.838 atm); M is the molar mass of the element (e.g., 14 for N); n is the number of atoms of the element in the gas (e.g., 2 N in N_2O); R is the ideal gas constant (0.08206 L atm mol-1 K-1); T is the average atmospheric temperature (293 K); V is the total volume of the headspace, tubing, and analyzer cell (1.14 L); and W is the weight of the dry soil in the microcosm (0.26 kg).

Conclusion

- This study demonstrates that BBFs derived from fishery waste can achieve spinach yields (20.6-21.7 g/pot) comparable to those obtained with synthetic fertilizer CAN (20.6 g/pot). Based on their NUEs, BBFs have the potential to (partially) replace the synthetic fertilizer CAN, with replacement values ranging from 0.59 to 0.73.
- Despite their benefits, the FSP and Slurry1 treatments can cause higher CO_2 and N_2O emissions, indicating the need for careful management to balance nutrient supply with environmental sustainability in future applications.

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