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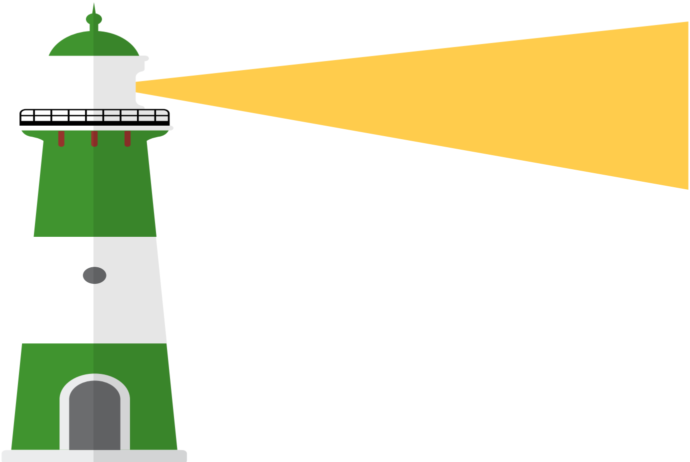
Transition towards a more carbon and nutrient efficient agriculture in Europe

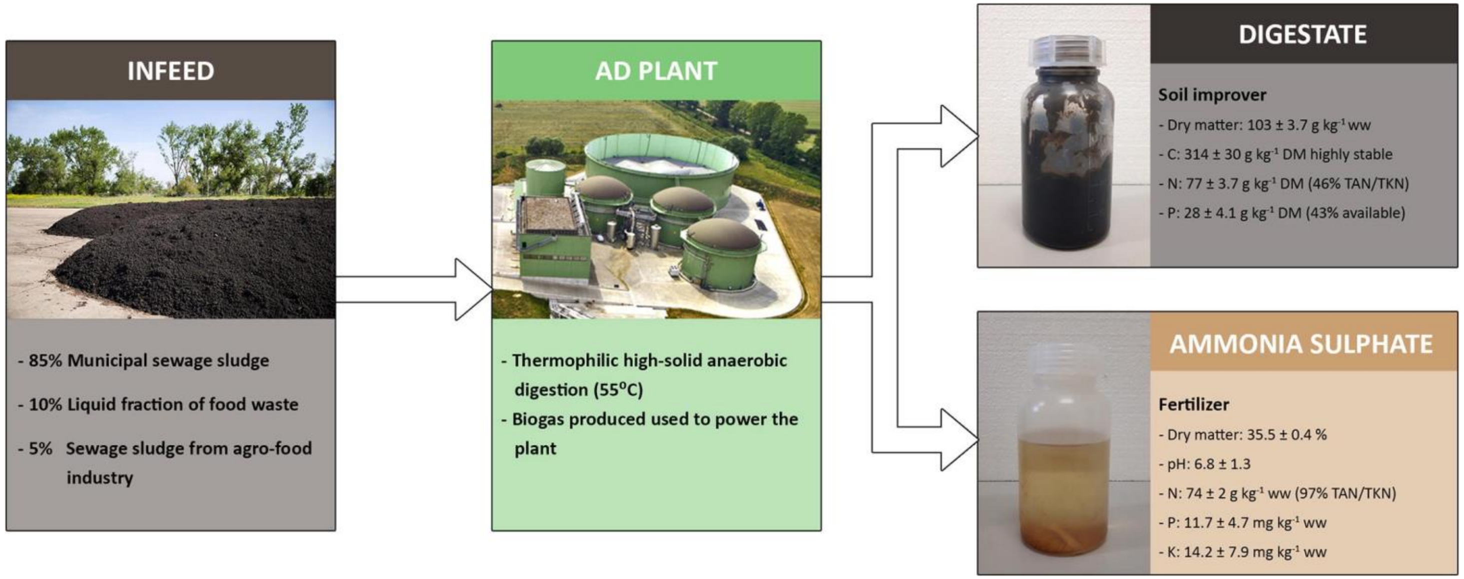


Using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of it

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Description of the solution

Anaerobic digestion plant with stripping system active since 2016 (TRL 9).
Waste treated: 70’000 tons per year (sewage sludge of urban wastewater).
5’000 ha cultivated land, rice mainly.



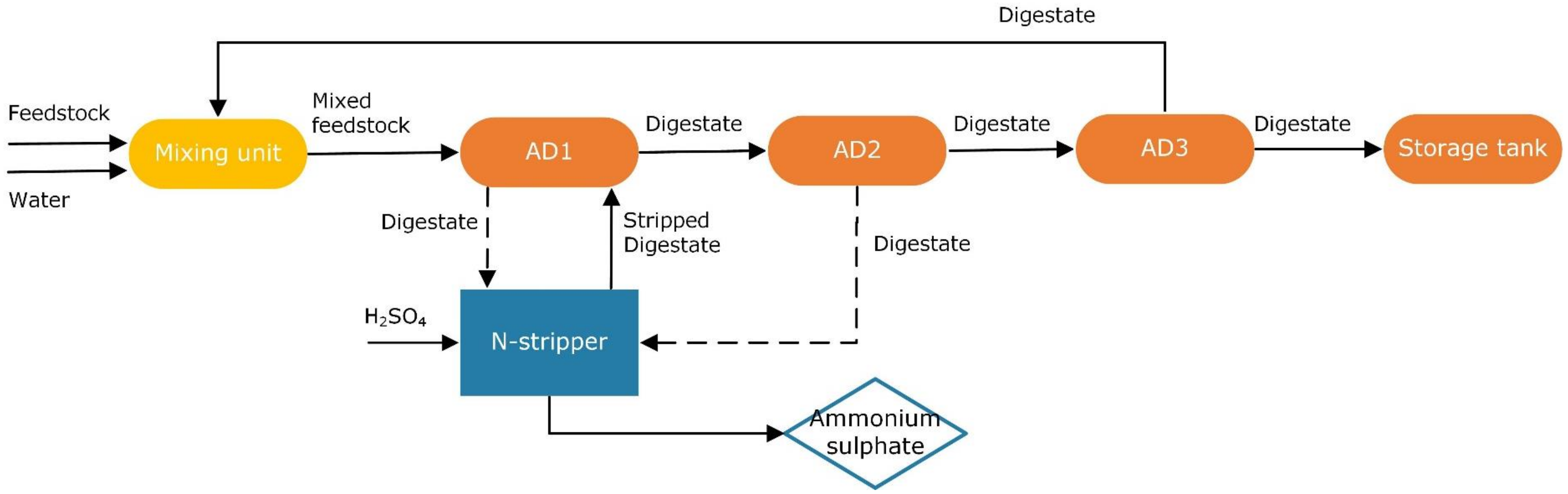
Details about products composition in:

Thermophilic anaerobic digestion as suitable bioprocess producing organic and chemical renewable fertilizers: A full-scale approach

Author: Pigoli et al.

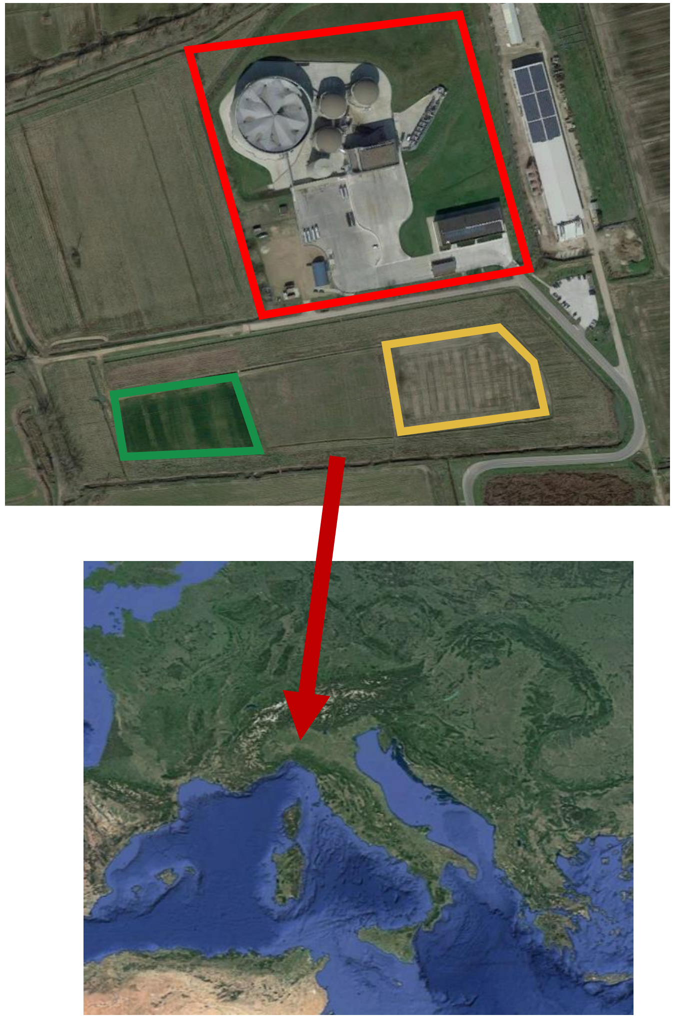
DOI:
https://doi.org/10.1016/j.wasman.2021.02.028

Description of the solution



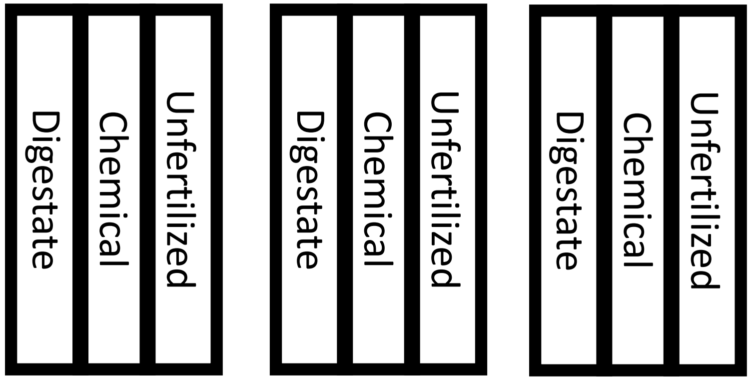
Experimental fields

- Anaerobic digestion plant
- **2 experimental fields**: wheat and rice
- **3 treatments**: Chemical, Digestate, Non-fertilized control
- Low N digestate injection at 10 cm
- **3 years** of experimentation
- Minimum tillage techniques
- Precision agriculture techniques (N stress remote optical sensing, GPS mapping)



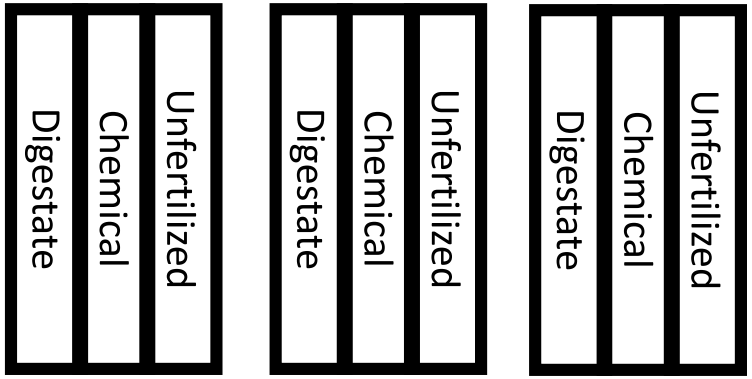
Experimental plan

Rice



Plots	Fertilizer	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})
Digestate (D)	Digestate (pre-sown)	125	104
	Ammonium sulphate	35	
Chemical (C)	Urea (pre-sown)	125	
	Triple superphosphate		50
	Ammonium sulphate	35	

Wheat



Plots	Fertilizer	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})
Digestate (D)	Digestate (pre-sown)	185	146
Chemical (C)	Urea (pre-sown)	185	

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Data available at April 2022

- Changes in soil characteristics after three years
    - pH
    - Available P
    - Total N
    - Total organic carbon

- Gaseous emissions
    - Odour emissions during spreadings
    - Ammonia emissions after spreadings
    - GHG emissions during the crop season

- Agronomic performances
    - Yield

Changes in soil characteristics in three years

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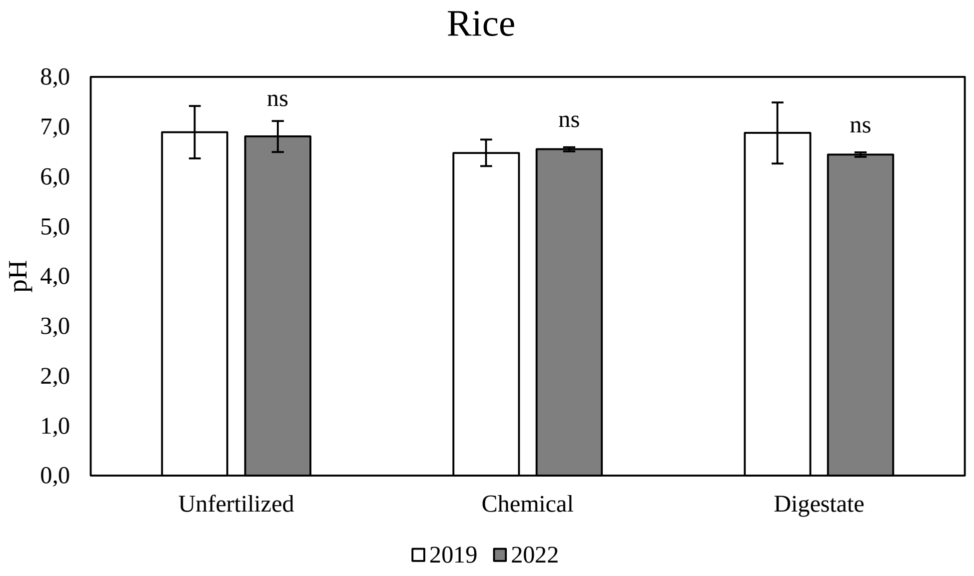
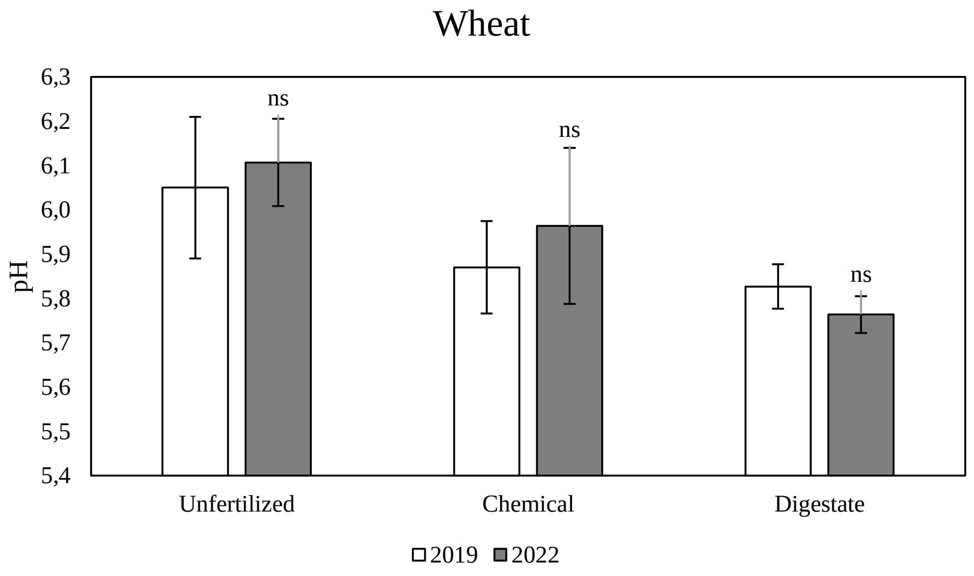
Changes in soil pH: 2019 vs 2022





No changes after three crop seasons

t test between 2019 and 2022 values:
*: *p*<0.05; **: *p*<0.01; ***: *p*<0.001; ns: no significant differences

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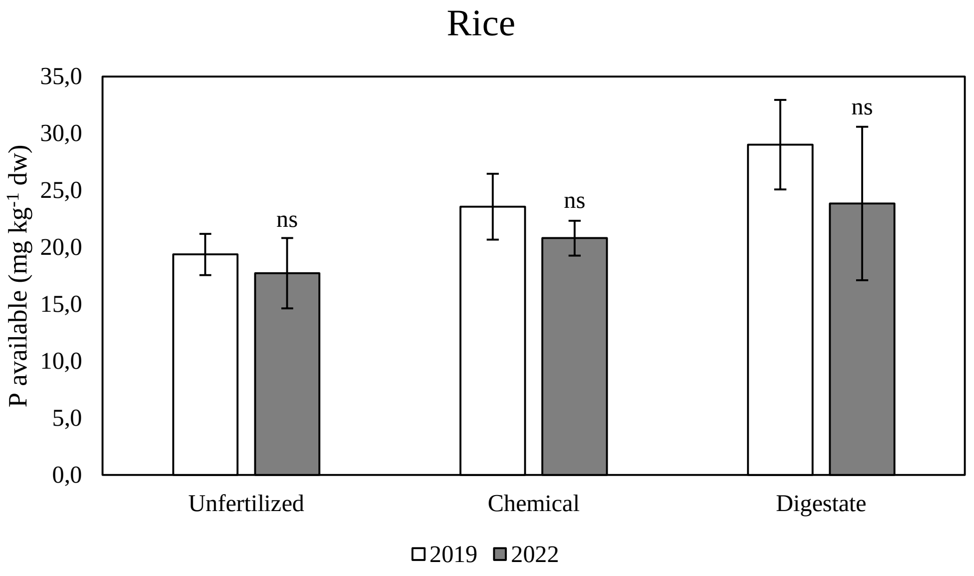
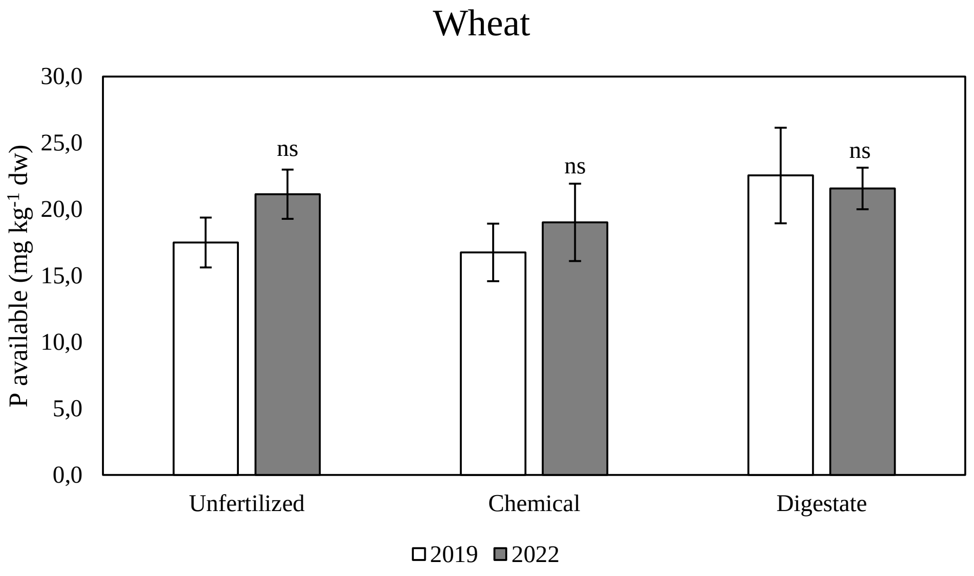
Changes in soil available P: 2019 vs 2022

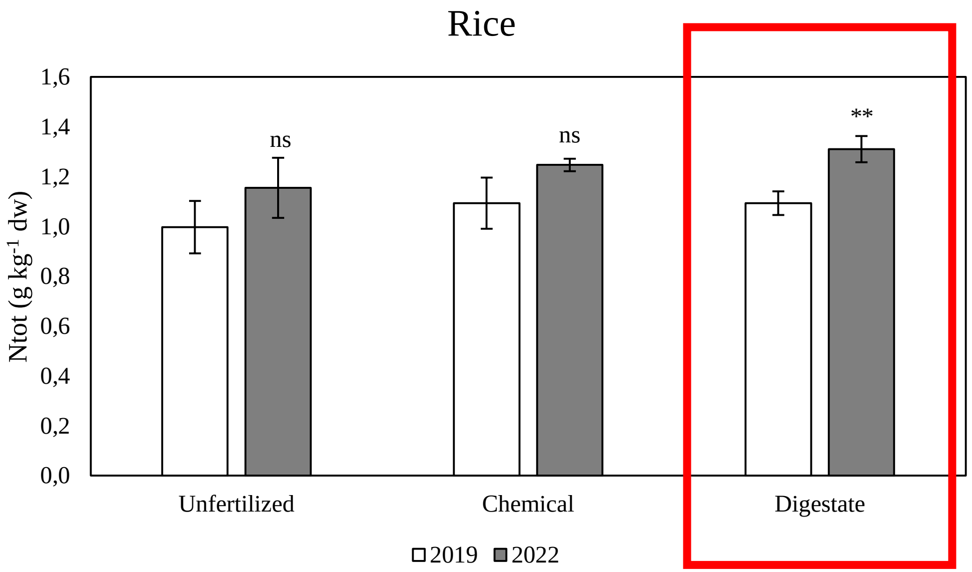




No changes after three crop seasons

t test between 2019 and 2022 values:
*: p<0.05; **: p<0.01; ***: p<0.001; ns: no significant differences

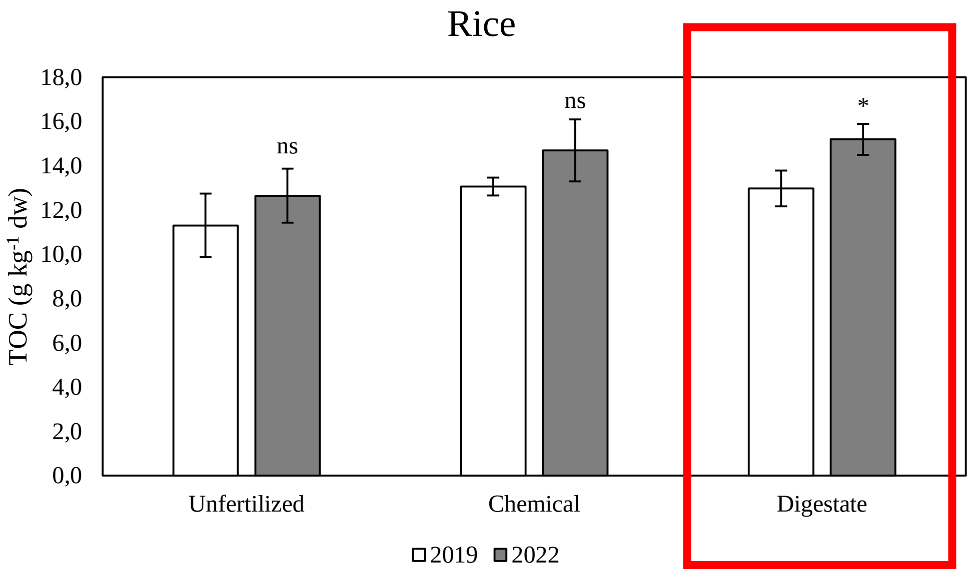
Changes in soil total N: 2019 vs 2022

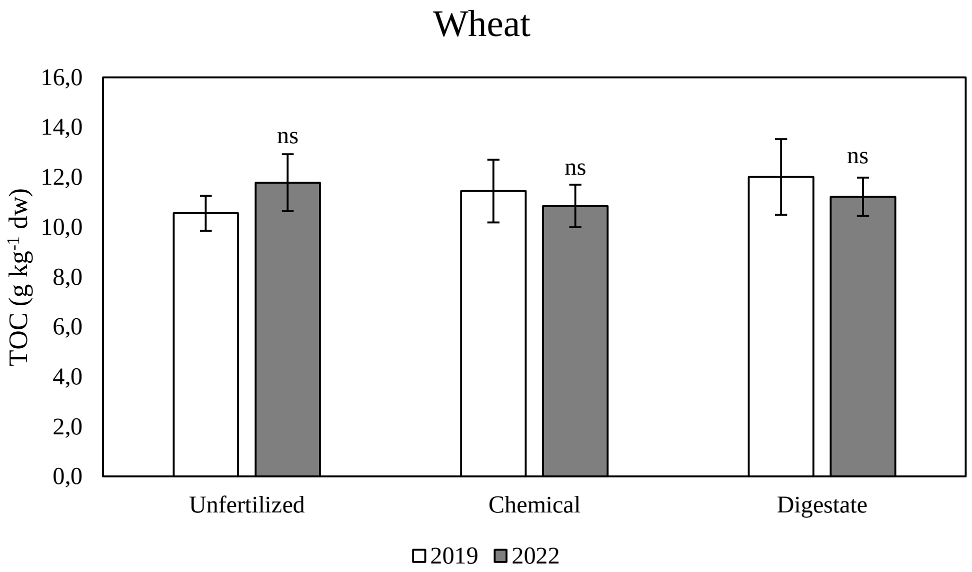


In rice field, the use of digestate resulted in an increase in the total N content in the soil

t test between 2019 and 2022 values:
*: *p*<0.05; **: *p*<0.01; ***: *p*<0.001; ns: no significant differences

Changes in soil total organic carbon: 2019 vs 2022





In rice field, the use of digestate resulted in an increase in the total organic C content in the soil

t test between 2019 and 2022 values:
*: p<0.05; **: p<0.01; ***: p<0.001; ns: no significant differences

Gaseous emissions from rice field

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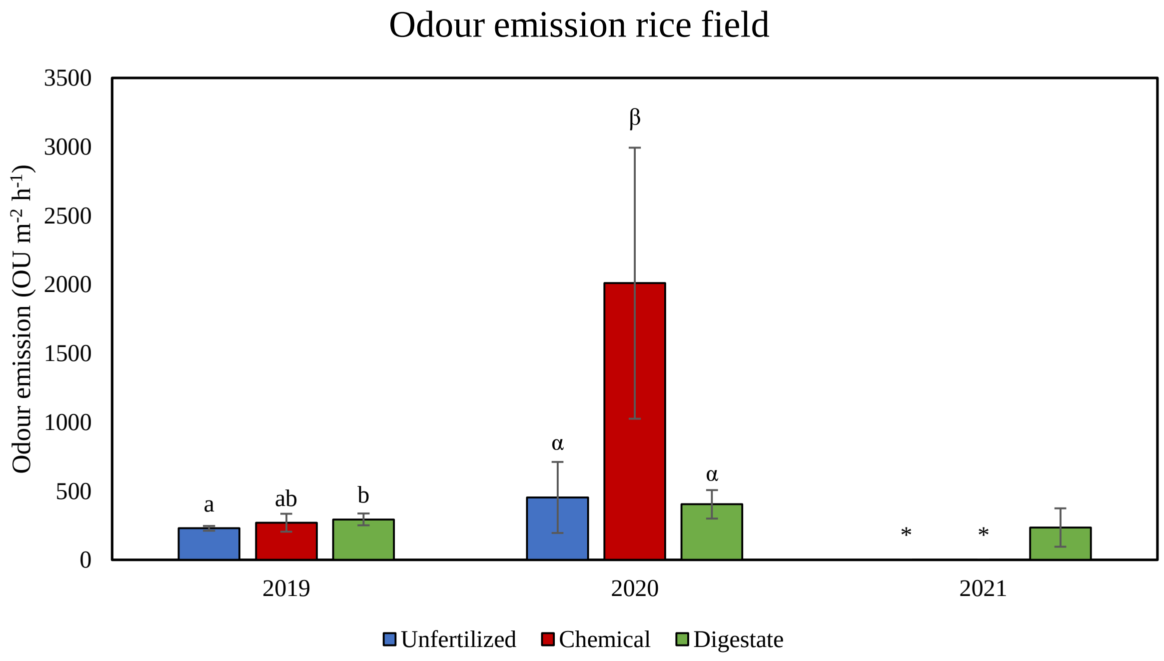
Gaseous emissions: odour emissions during spreading



Strong annual variability

AVERAGE 2019 – 2020 - 2021

	Odour emission ($OU\ m^{-2}\ h^{-1}$)
Unfertilized	342 ± 159 a
Chemical	1140 ± 1231 a
Digestate	311 ± 86 a

Letters (a-b-c; α-β-γ) are referred to one-way ANOVA analysis ($p<0.05$; Tukey post-test).
*: value under detection limits

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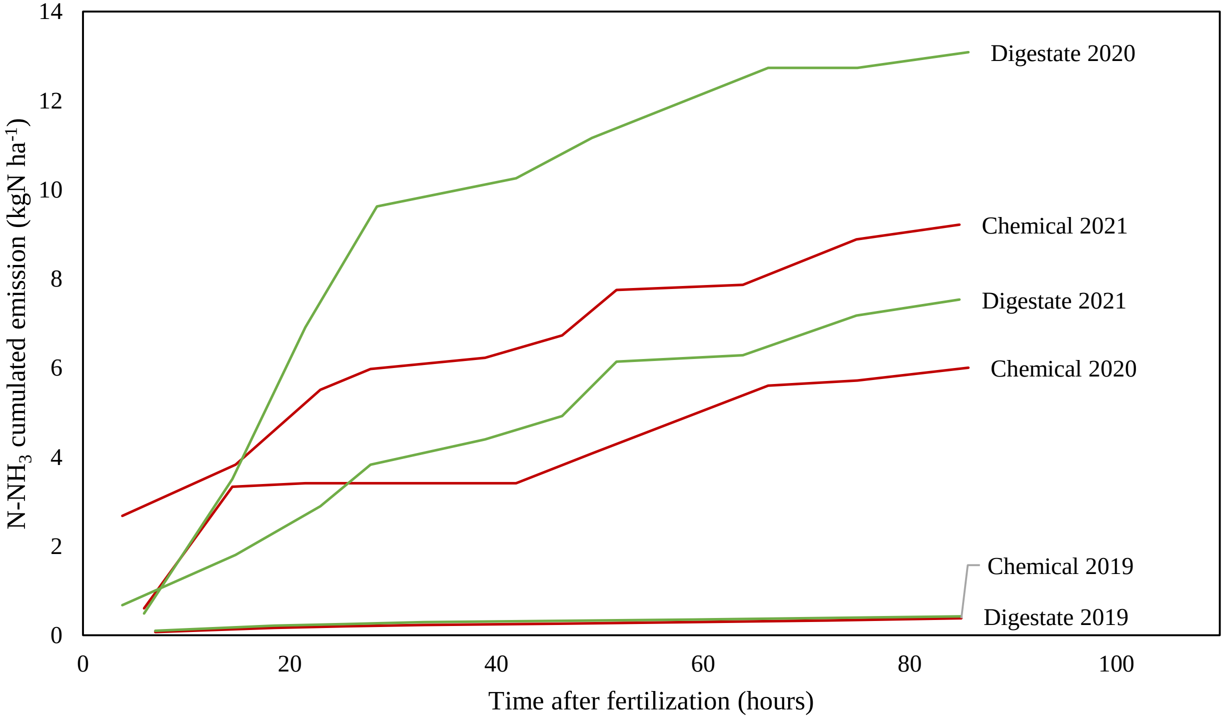
Gaseous emissions: ammonia after spreading



Campaign	Fertilizer	Total cumulated ammonia emission (kg N ha^{-1})	Loss of NH_3 (%Ntot)	Loss of NH_3 (%TAN)
2019	Digestate	0.50	0.40%	0.65%
	Chemical	0.46	0.36%	0.36%
2020	Digestate	13.09	10.47%	16.89%
	Chemical	6.01	4.81%	4.81%
2021	Digestate	7.54	6.03%	9.73%
	Chemical	9.22	7.37%	7.37%
Average	Digestate	7.04 ± 6.31 a	5.63% ± 5.05 a	9.09% ± 8.14 a
	Chemical	5.23 ± 4.43 a	4.18% ± 3.55 a	4.18% ± 3.55 a

Letters (a-b-c) are referred to one-way ANOVA analysis ($p<0.05$; Tukey post-test).

Gaseous emissions: GHG during crop season

35 measurements in open field in 12 months
6 replies per treatment

Fertilizer	Total nitrogen dosed (kgN ha^{-1})	Total N_2O emitted (kgN ha^{-1})	Total CO_2 emitted (kgC ha^{-1})	Total CH_4 emitted (kgC ha^{-1})
Unfertilized	0	1.19 ± 0.57 a	6727 ± 2071 a	-0.02 ± 3.97 a
Chemical	160	4.5 ± 2.9 ab	8543 ± 3054 a	-1.08 ± 0.31 a
Digestate	160	9.02 ± 4.36 b	9934 ± 687 a	-0.54 ± 0.33 a

No differences between chemical and digestate, but strong variability

Agronomic performances

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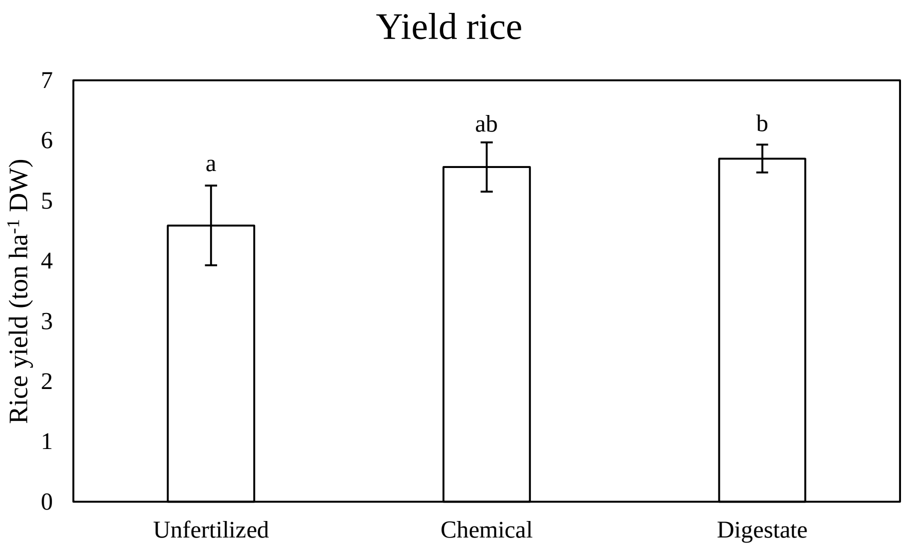
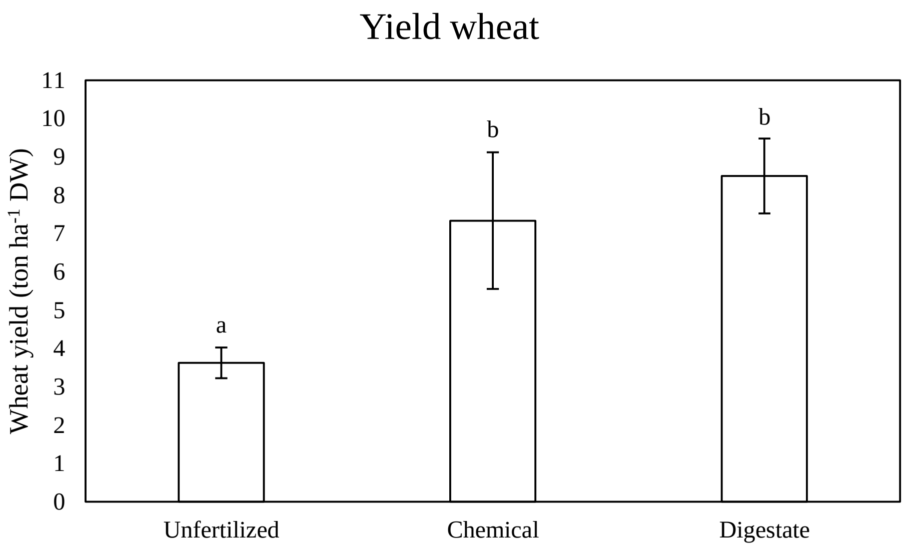
Agronomic performances: Yield



Average of 2019 and 2020 crop seasons



Data of 2019 crop season

No yield differences between chemical and digestate treatments

Letters (a-b-c) are referred to one-way ANOVA analysis ($p<0.05$; Tukey post-test).

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Discussion

- After three crop seasons, an **accumulation of total N and organic carbon** was observed in soils fertilized with digestate, but only in paddy fields. The available P content and pH did not change.

- Atmospheric emissions from the paddy field were highly variable from year to year. On average, **no significant differences** were found between the use of chemical fertilizer and digestate for odours, ammonia and GHG emissions.

- The yields obtained **using digestate were similar to those obtained using urea**, both for rice and wheat.

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Thank you very much

www.nutri2cycle.eu

Twitter: #Nutri2Cycle

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