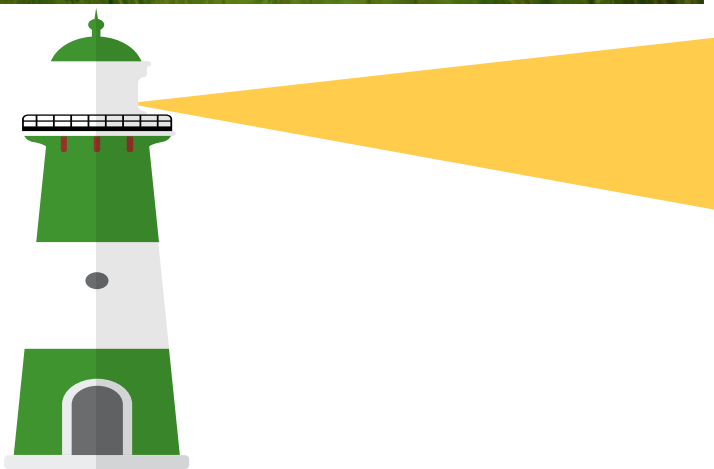




Nutri2Cycle

Transition towards a more carbon and nutrient efficient agriculture in Europe



The substitution of the mineral fertilizers with the biological fertilizers to optimize the organic carbon storage in soil and the NP cycling



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

The substitution of the mineral fertilizers with the biological fertilizers to optimize the organic carbon storage in soil and the NP cycling : two application cases in France



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Closing nutrient loops

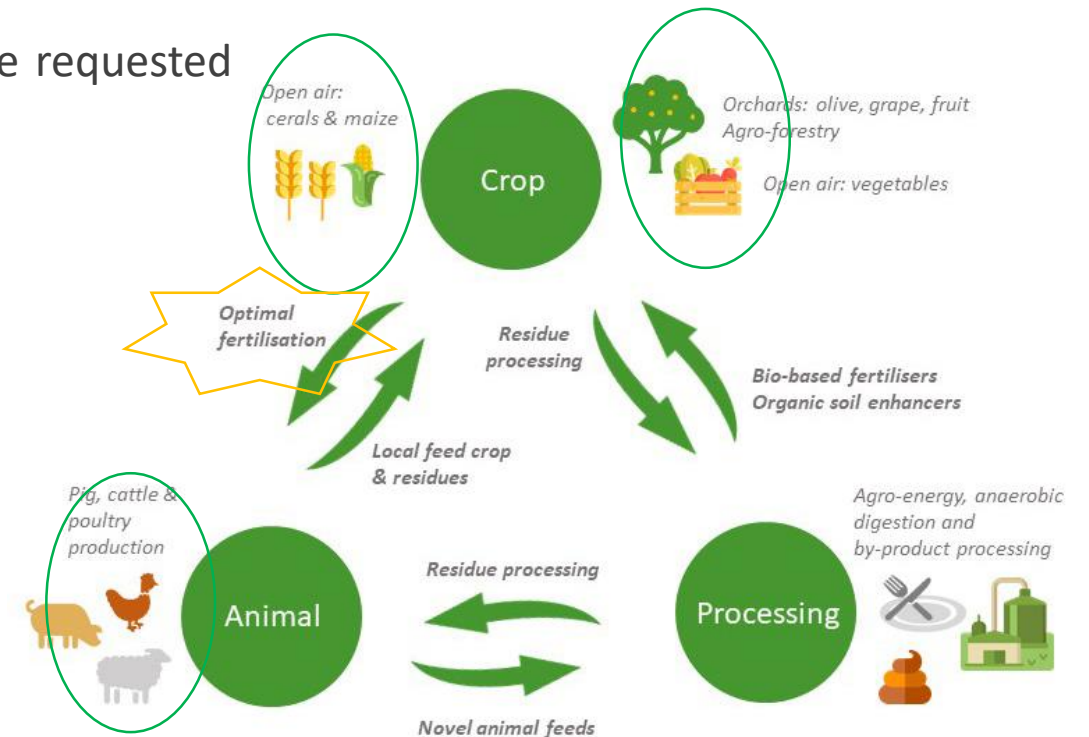
During the design of the project, two kinds of farm system were requested for our participation :

- ➞ a farm combining livestock and agroforestry
- ➞ a farm with perennial crops in organic farming

Opportunity ...

... to study from the perspective of circular economy

- ➞ The level of organic residus/effluents recovery
- ➞ The keys steps for changing from recycling to fertilisation



About agriculture in Charente-Maritime...



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The Nouvelle Aquitaine (New Aquitania - NA) region represents 9% of the French population, 15% of France's territory (8 484 000 ha) and 15% of its Utilised Agricultural Land (UAL – 4 235 000 ha).

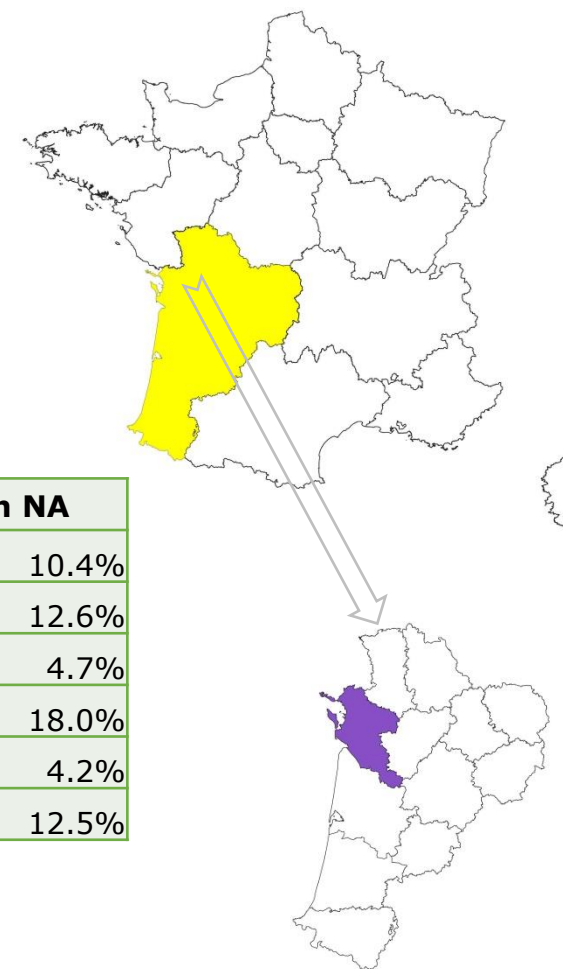
The department (district) of Charente-Maritime is one among the 12 of Nouvelle Aquitaine.

About 7000 agricultural holdings take up 64% of space in Charente-Maritime :

- 1600 specialized in arable crops (112 ha of mean area);
- 1725 specialized in vineyard, mainly for Cognac production;
- 970 in a mixed crop-livestock system;
- 370 specialized in livestock farming.

Land use in Charente-Maritime

	1000 ha	% in NA
UAL	442	10.4%
Arable crop	341	12.6%
Grassland	46	4.7%
Vineyard	41	18.0%
Forestry area	122	4.2%
Urban area	100	12.5%



(Bibliographic source : charente-maritime.chambre-agriculture.fr - AGRESTE, 2017)


French background of agronomic recycling



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According to a study commissioned by the Ministry of Agriculture and published in November 2020 :

	Stock (10 ⁶ tons FM)	Agronomic recycling	
		Direct spreading	After composting
Livestock effluents	122.6	88.90%	10.30%
Fermentable part of household waste	0.93	-	54.00%
Green wastes	4.69	-	60.40%
Food wastes	0.2	-	14.40%
Urban sewage sludges	4.24	41.80%	31.20%
Food processing sludges	10.8	45.60%	1.90%
Other sludges	8.8	18.30%	3.90%

 The agronomic recycling of residues - with or without treatment - is already a common practice in France.

The challenge is to move from recycling to optimal fertilization

Description of the solution



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Our proposal :

To organize a demonstration operation with two farms as partner

- ➔ The EARL (exploitation agricole à responsabilité limitée - private limited farming company) "Manicot" with Goose livestock (4500/year) and arable crops (93 h) including an agroforestry plot
- ➔ The EARL "Le Petit Bois – la ferme de l'Orée" combining organic arable crops (105 ha) and organic vineyard for Cognac production (25 ha)



Our purpose :

To monitor the recycling of effluents/residues in each farm – slurry and manure for Manicot farm and oilseed cake for Le Petit Bois farm – to find the conditions for their optimal use as organic fertilizers.



Farmers as partners : innovative people



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The farmers who have agreed to participate in N2C are remarkable for

- their project dynamics,
- their will for progress,
- their wish to innovate.

We can already find in their exploitation innovative characteristics:

- ✓ transformation on the farm,
- ✓ direct sale in short circuit,
- ✓ Numerous crops in rotation,
- ✓ production of biomass energy

...



« Manicot » farm : direct sale and sunflower for tractor



« Le Petit Bois » farm : from soil to bottle

Demonstration methodology



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For the both demonstration sites, we have foreseen a similar monitoring protocol :

1. Characterization of the organic residues to recycle;
2. Soil characterization before, after and if possible during the demonstration;
3. Data acquisition during the crop growing with remote-sensing, manual sensor and vegetal samples (if possible);
4. Interpretation of the residues fertilising behaviour and balance sheet of CNP elements during the crop development using the modelling tool STICS.



Demonstration work at Manicot farm : the agroforestry plot



The plot followed in demonstration - 8 ha – has an agroforestry area with agroforestry - in form of hedges - and an open-field area.

We have monitored 3 years of use of the two kinds of effluents on this plot : goose slurry and goose solid manure.

The plot was driven with only mineral fertilisation until our demonstration.



Demonstration work at Manicot farm : from 2019 to 2021



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The testing device divides the plot into four areas:

1. A strip as agroforestry area with spreading of slurry (2 years) and with mineral fertilization;
2. B strip as agroforestry area with spreading of solid manure, of slurry and with mineral fertilization;
3. C area as agroforestry area with only mineral fertilization;
4. D area as the "conventional" open field control with mineral fertilization

	2019	2020	2021
Crops	Winter Wheat	Corn	Corn
A	Goose slurry + mineral fertilization	Mineral fertilization	Goose slurry + mineral fertilization
B	Mineral fertilization	Goose manure + mineral fertilization	Goose slurry + mineral fertilization
C	Mineral fertilization	Mineral fertilization	Mineral fertilization
D	Mineral fertilization	Mineral fertilization	Mineral fertilization



Demonstration work at Manicot farm : data and results about effluents



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The contents of NPK elements in fresh matter are quite low: less than 0.5% per element.

☞ These effluents cannot claim the qualification of fertilizer.

The evaluation of slurry and manure stocks was difficult: no traceability. By crossing different information :

- 145 m3 of slurry
- 25 tons of manure

Effluents	Slurry			Solid manure	units
	05/02/2019	17/12/2020	Mean	05/02/2019	
DM	3.5	2.2	2.85	19.1	% FM
OM	2.18	1.78	1.98	11.02	% FM
	62.55	79.56	71.055	57.71	% DM
Total N	0.18	0.13	0.155	0.45	% FM
	5.2	5.9	5.537	2.36	% DM
Mineral N	0.04	0.06	0.05	0.05	% FM
	1.18	2.72	1.95	0.24	% DM
Organic N	0.14	0.07	0.105	0.4	% FM
	4.03	3.04	3.535	2.11	% DM
P2O5	0.11	0.1	0.105	0.24	% FM
	3.07	4.66	3.865	12.58	% DM
K2O	0.1	0.1	0.1	0.46	% FM
	2.93	4.62	3.775	24	% DM

Demonstration work at Manicot farm : data and results about soils



Indicator levels are generally quite good. Agroforestry shows a positive effect on biological indicators

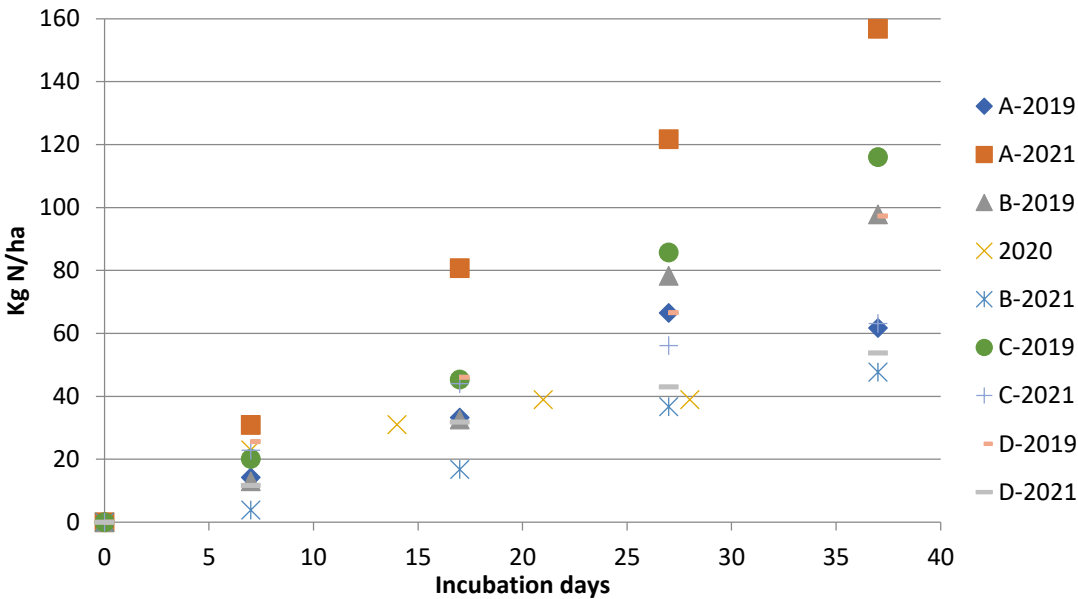
	A		B		C		D	
	2019	2021	2019	2021	2019	2021	2019	2021
OM(%)	2.6	2.9	3.2	3.4	2.8	3.1	4	2.9
Total N (%)	0.169	0.215	0.178	0.231	0.171	0.184	0.202	0.175
C/N	9.1	7.8	10.5	8.5	9.3	9.8	11.4	9.7
CaO (g/kg)	16.49	17.39	16.08	18.78	18.56	18.77	16.91	18.18
P ₂ O ₅ JH (g/kg)	0.315	0.318	0.277	0.476	0.507	0.438	1.482	0.596
K ₂ O (g/kg)	0.572	0.51	0.524	0.584	0.679	0.542	1.447	0.808
MgO (g/kg)	0.249	0.263	0.245	0.331	0.333	0.315	0.443	0.354
Na ₂ O (g/kg)	0.035	0.056	0.031	0.062	0.034	0.049	0.038	0.045

Evaluation of the nitrogenous fertility of the soil: from mineralization kinetics data we compute of the quantity of mineralized nitrogen in kg/ha.

Our observations :

- slurry inputs seem to have increased the mineralization potential,
- manure input seems to have a significant nitrogen immobilizing effect.

Waiting for more data about C storage.

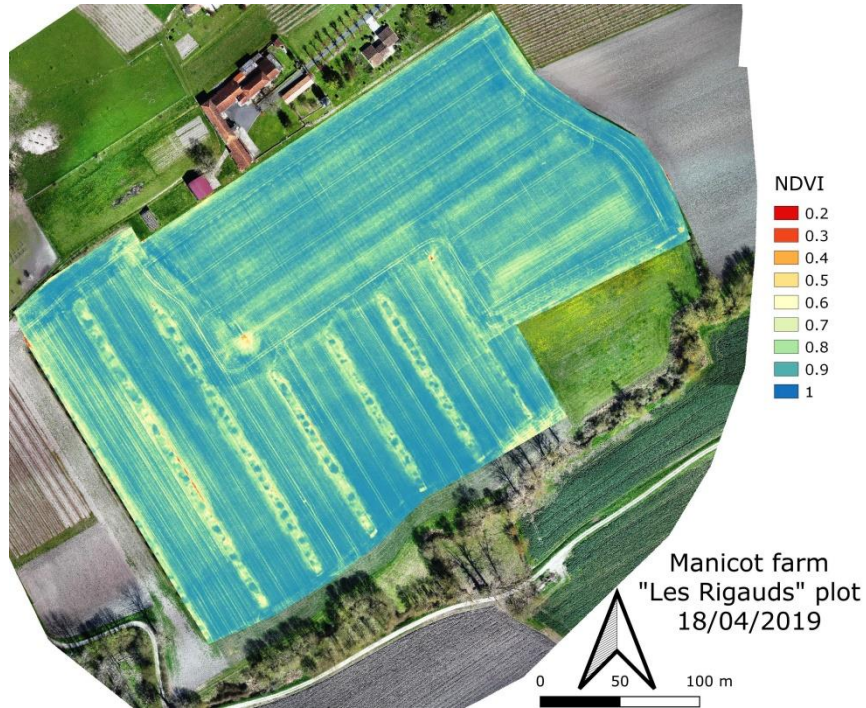


Demonstration work at Manicot farm : crops monitoring

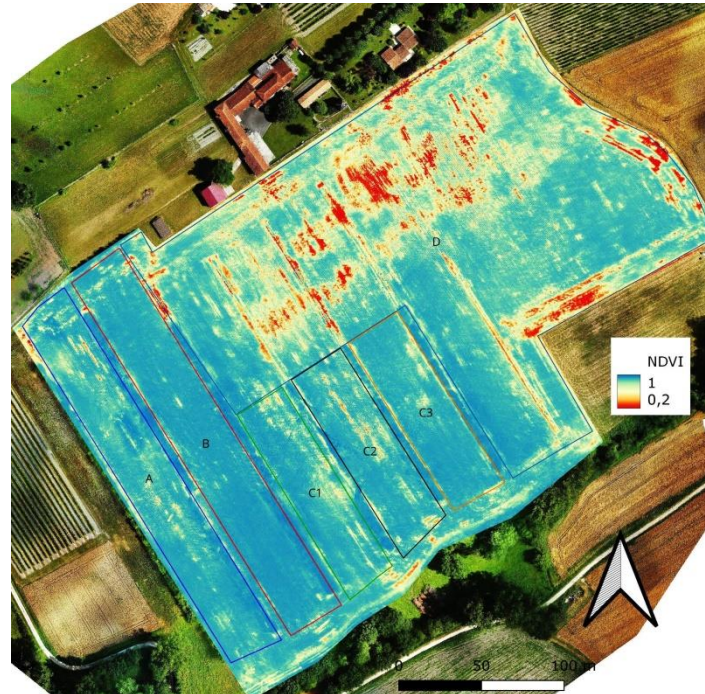


Remote sensing data allowed us to regularly monitor crop development over 3 years.

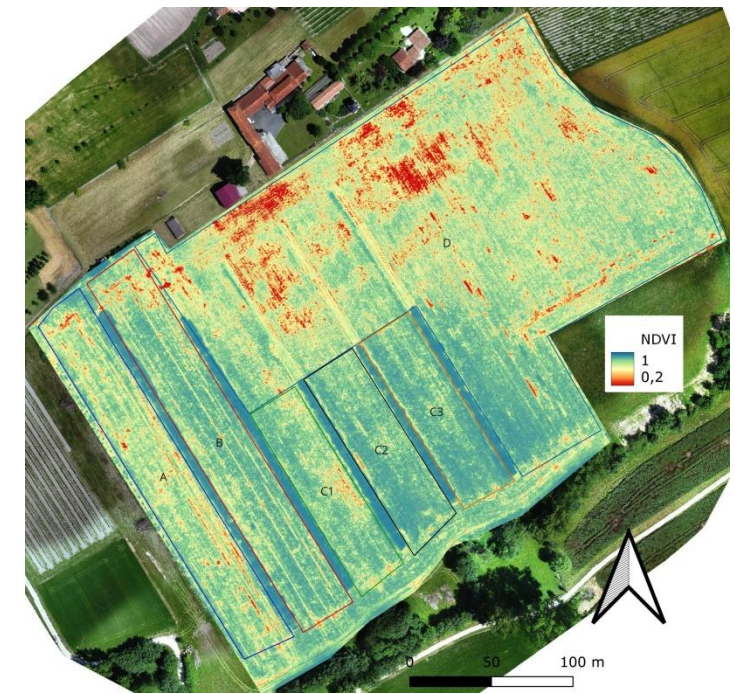
Our observations : no depressive but rather positive effect of the presence of agroforestry on crop development and little obvious effect of organic inputs in addition to mineral fertilization.



Map for wheat crop on 18/04/19



Map for corn crop on 29/06/20



Map for corn crop on 05/07/21

Demonstration work at Petit Bois farm : organic vineyard



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- Because of difficulties for farmers to organize their fertilization workshop, we only drove one year of monitoring - 2021 - until now.
- Plot in organic vines divided into 3 zones with spreading of
 - Oil-cake (Oca) from the farm
 - Market compost for organic farming (Co)
 - A mixture “50% oil-cake/50% compost”



Demonstration work at Petit Bois farm : data and results about oil-cake



Parameters	Value	Unit
Dry matter (DM)	86.90	% Fresh Matter (FM)
Mineral matter	18.65	
Organic matter	68.20	
C/N	9.60	-
Total N	3.54	% FM
Mineral N (NH ₄ + NO ₃)	0.019	
Organic N	3.52	
P ₂ O ₅	1.62	
K ₂ O	1.10	
CaO	0.50	
MgO	0.53	
Na ₂ O	0.01	

The contents of NPK elements in fresh matter is enough to be considered as a nitrogen fertiliser : more than 3 %.
Levels for P and K are quite interesting.

The evaluation of stock is difficult: no traceability.

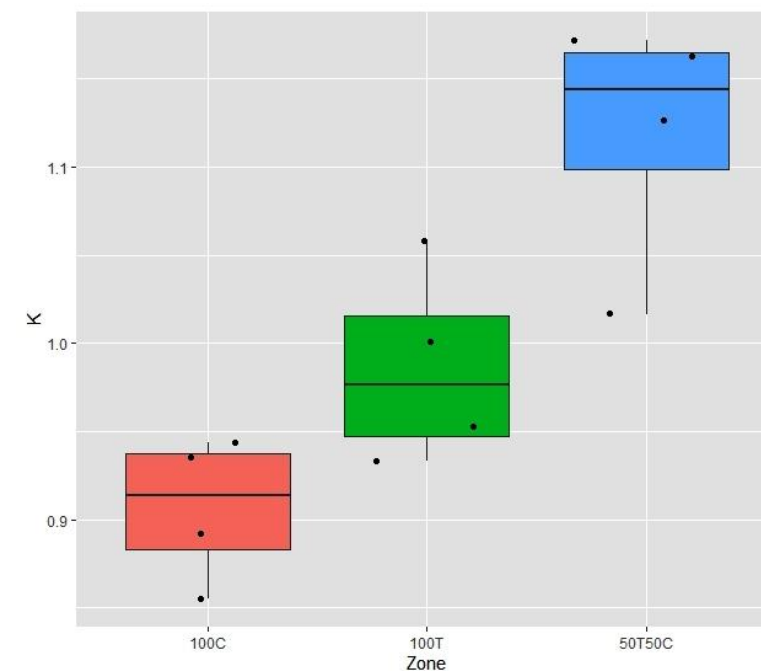
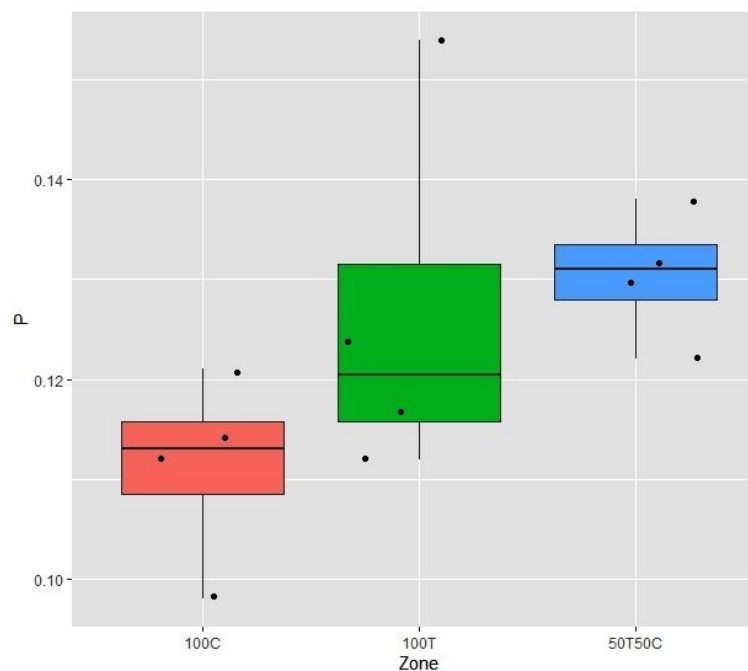
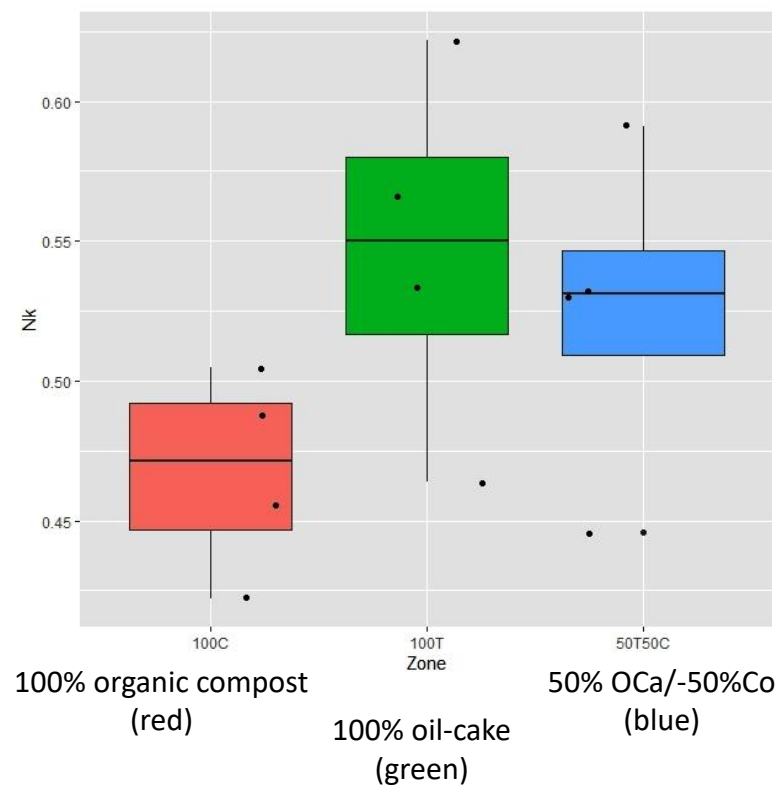


Demonstration work at Petit Bois farm : first results



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Analysis of the content of elements on grape berries for each of the 3 spreading areas in september 2021



Demonstration of the real efficiency of oil-cake compared to market compost for each of the macronutrients

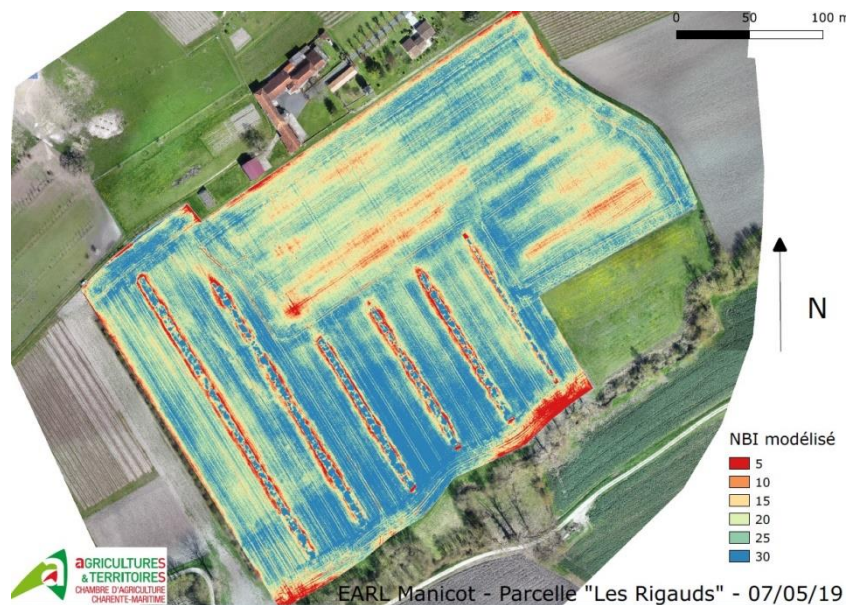
Demonstration in connection with farmers management



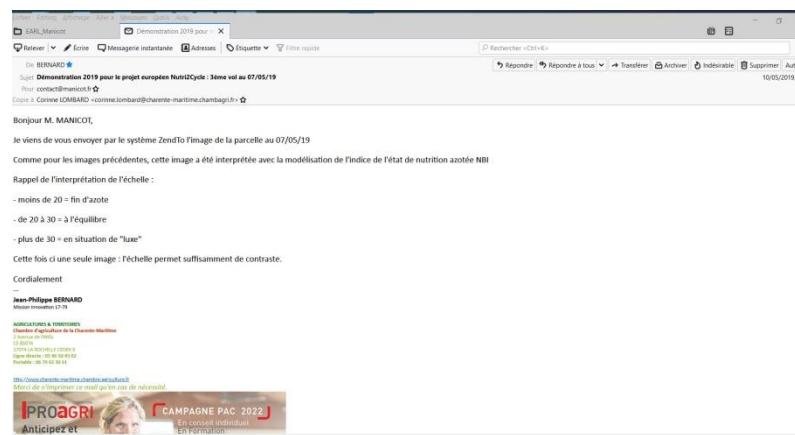
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Our demonstration work is linked with the farmers practices : we have sent regularly the feedbacks to the farmers to explain our action and the results they can use.

The main bottleneck : to provide the advice just in time to be useful... not always feasible with the innovative tools (lack of references).



Videoconference with Mrs CROC from « Petit Bois » farm on 23/08/21



Remote sensing map and e-mail for explanations sent to « Manicot » farm after the data taking on 07/05/19

To substitute mineral fertilizers with biological fertilizers : first “bottom up” feedback



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After 3 years of working together, we noticed :

➡ *the main challenge to increase the use of organic effluents as fertilisers is the balance between agronomic properties of the effluents and the importance of the fertilization workshop within the farm's organization.*

- ⇒ For the “Petit Bois” farm, in organic farming, fertilisers are rare and expensive : the demonstration of agronomic properties is a real opportunity for the farm organisation.
- ⇒ For the “Manicot” farm, effluents are not enough rich and the fertilisation workshop is not so priority - compared to the breeding workshop or to the food transformation workshop : no real interest yet for changing their fertilisation practices.

It was before Russian crisis and increase by 4 for fertilisers price...

Next steps for the demonstration operation



Already some opportunities to present N2C project and the first results of demonstration:

- ➡ *Open days at Manicot farm in November 2019 for farmers and general public;*
- ➡ *Presentation with a poster during the 15th Soil and plant analysis and fertilization management conference of COMIFER (French Committee for the Study and Development of sustainable Fertilization) in november 2021*
- ➡ *Presentation during the last French NTF workshop on 14/01/22*

But still some work to do :

- ⇒ Pedagogic approach of carbone storage on agroforestry plot with Manicot farmers
- ⇒ Another year of testing oil-cake with “Petit Bois” farm
- ⇒ Presentation of our demonstration first results to farmers groups during the second half year 2022 to introduce the set up of the new regulation about fertilisers





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