Life Cycle Assessment of wheat production: Influence of nutriment intake

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Introduction: What is the impact of fertilizers? Which is the best strategy? The aim of this study is NOT to compare organic vs conventional agriculture but to compare the manure based vs the mineral based fertilizers: therefore the amount of phytosanitary product is the same in all the scenarios.

Wheat:
- An important cereal with a lot of applications in the feed and food industries (e.g. starch production)
- Growing context of biobased products, a better understanding of the impact of its production is needed, using Life Cycle Assessment (LCA)
- Primary data are taken from Agrybalise [1] , backround data from Ecoinvent using Simapro (excluding infrastructure and long term emissions).
- Impact assessment method: *ReCiPe 2016 Midpoint (H)* [2]

Several scenarios *Functional unit = 1 kg of wheat produce in France*

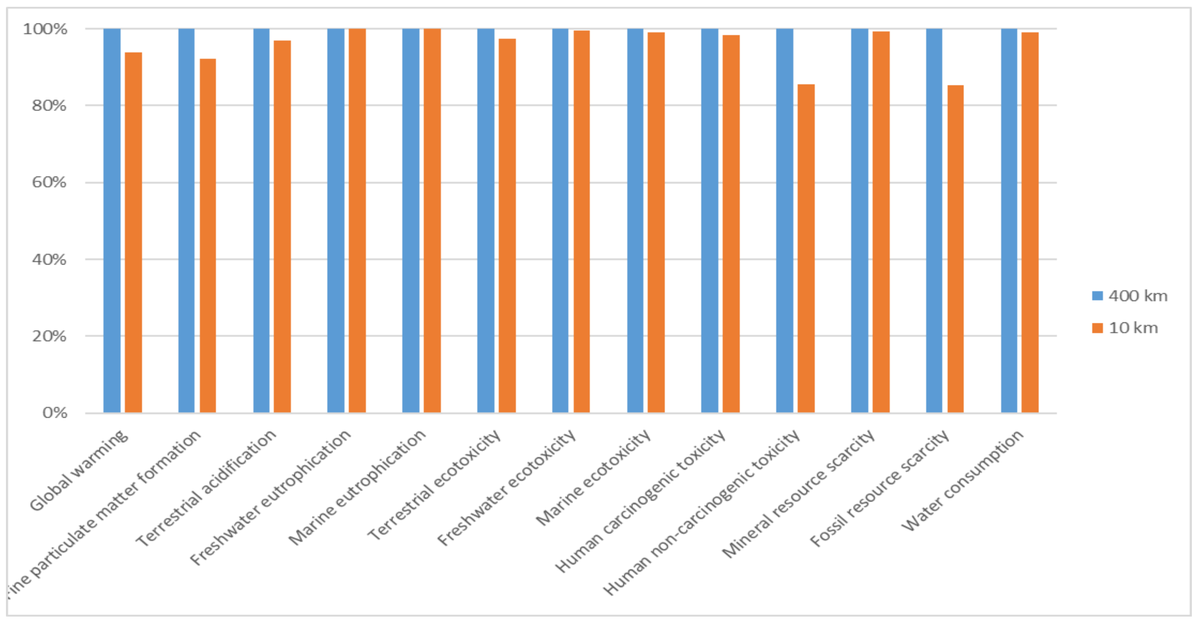
Scenario 1: "Conventional": mix between livestock manure and mineral fertilizers – based on Agribalyse data [1]
Scenario 2a: Maximal use of organic fertilizers based on the European nitrate directive (i.e. : 170 kg of N from organic fertilizers)
Scenario 2b: Maximal use of organic fertilizers based on the European nitrate directive exception for region with high livestock (i.e. : 250 kg of N from organic fertilizers)
Scenario 3: 100% mineral fertilizers
Scenario 4: Intermediate scenario: All the P provided by organic fertilizer – excess of K – N needs completed by minerals fertilizers
Scenario 5: 100% mineral fertilizers with measure to improve the NUE (nitrogen use efficiency): use of inhibitor and precision farming technologies: Reduction of N_2O emissions (-38 %), NH_3 emissions (-70%) and NO_3 emissions (-50%)

Amount of fertilizers:
- Calculate to be equivalent to the conventional case (using mineral fertilizers equivalent (MFE) for the organic fertilizers)
- N equivalent always equal, in some case excess of P and K.

Same yields

Theses scenarios are extreme scenarios, not representative of agricultural practices (except the conventional) but have been selected to allow a good understanding of the impact of fertilizers. Several discussions with agronomist experts have been conducted to validate the hypothesis.
Some sensitivity analysis have been conducted on the conventional case. Example: distance transport for organic fertilizers (base case: 10 km – alternative case: 400 km)

	Convetionnal	Manure (170 kg N/ha/yr)	Manure (250 kg N/ha/yr)	Mineral	Inter-mediate	Mineral - improved NUE	Unit
Yields (t/ha)			7100			7266	kg/yr
Straw			4297			4398	kd DM
% Of straw remove			52				%
N-fertilizer. as N	163	117	93	167	150	152	kg/ha
P-fertilizer. as P_2O_5	25	0	0	33	0	33	kg/ha
K-fertilizer. as K_2O	42	0	0	64	0	64	kg/ha
Applied organic	1.90	22.95	33.75		7.92		ton/ha
N in organic (total)	11.12	170.00	250.00		58.66		kg/ha
P_2O_5 in organic (total)	6.78	95.63	140.64		33.00		kg/ha
K_2O in organic (total)	11.88	260.15	382.57	0	89.77	0	kg/ha
N in organic (mineral equivalent)	4.14	50.03	73.58		17.27		kg/ha
P_2O_5 in organic (mineral equivalent)	7.92	95.63	140.64		33.00		kg/ha
K_2O in organic (mineral equivalent)	21.54	260.15	382.57		89.77		kg/ha
Herbicide application			0.46				kg/ha
Pesticide application			0.90				kg/ha
Fungicide application			0.65				kg/ha
Total N mineral equivalent. as N	167	167	167	167	167	>167	kg/ha
Total P mineral equivalent. as P_2O_5	33	96	141	33	33	33	kg/ha
Total K mineral equivalent. as K_2O	64	260	383	64	90	64	kg/ha
NUE	77	68	65	78	74	87	%



Results

Climate change :

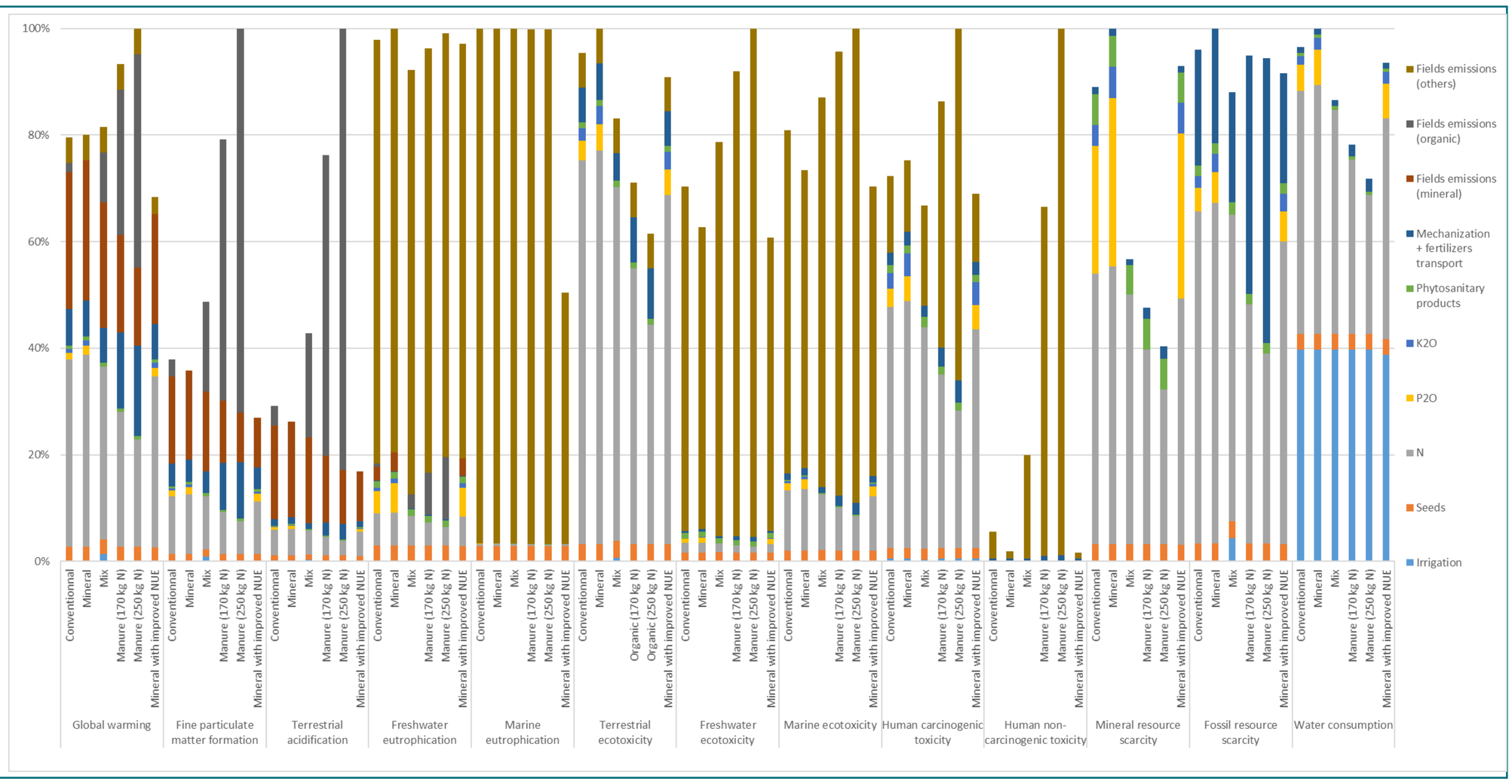
- <u>Nitrogen fertilizers</u>
  - Production: non negligible contribution
  - Use: N_2O emissions: large contribution

But N_2O emissions related to organic fertilizers are larger for the same amount of nutriments.

➔ Scenario with mostly organic fertilizers perform worst

➔ Measures to improve NUE: impact reduction

Toxicity categories: Large contribution of <u>heavy metals emissions</u> (larger for organic fertilizers). But differences < uncertainties on these categories



Conclusions

- The aim of this study is to compare several strategies for nutriments intake by wheat in France context. France have the particularity to have a conventional agriculture with large yield and efficient use of fertilizers.
- Except in mineral resources scarcity, the mineral based fertilizers case always preforms better or the differences are too small to be significant. The technique to reduced the NUE allows a reduction of the impact.
- These scenarios have been defined with great care but some assumptions are heavy such as keeping the yield constant in the first scenarios. More, a lot of things are not characterized by this study, such as the contribution of the non-mineral part of the organic fertilizers, the impact of organic fertilizers on soil quality, the influence of a crop rotation, the possible environmental impact of organic fertilizers production (considered as a waste from livestock production). Nevertheless, this study is a first step to a better understanding of the influence of different fertilizers strategies.

[1] ADEME, "L'outil Agribalyse," 2014. [Online]. Available: http://www.ademe.fr/expertises/produire-autrement/production-agricole/passer-a-laction/loutil-agribalyse.
[2] M. Goedkoop, R. Heijungs, M. Huijbegts, A. De Schryver, J. Struijs, and R. van Zelm. 2009. ReCiPe 2008 : A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. Ruimte en Milei. 132 p.

30th SETAC EUROPE Annual meeting, May 3rd – 7th 2020