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GHG emissions, production and economics of typical French beef and dairy farms in 2035: will GHG emissions be reduced?

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Introduction

- The French low carbon national strategy targets a reduction of 12% of agricultural emission in 2028 relative to 2013 and of 50% between 1990 and 2050.

- Agricultural sector =19% of national emissions ; bovine sector = 60% of the French agricultural sector

➢ How this sector may evolve? Will mitigation objectives be met ? What policies should be implemented to prepare the future?

Overview of the Global project

- The Gesebov project has investigated the joint evolution of the dairy and beef cattle sectors in horizon 2035

Definition of coherent, contrasted and plausible scenarios in focus groups

Story telling : drivers, main production changes

National level :

Assumptions regarding milk and beef production

Breakdown of cattle headcount into ≠production systems // technologies

Estimation of GHG emissions with "Climagri"

Farm level :

Simulation of the impacts of the main drivers of scenarios on the evolution of typical dairy and suckler cow farms

MATERIAL AND METHOD OF THE FARM LEVEL STUDY

1) The simulation model : Overview

<u>Model inputs</u> : prices and policy, farm resources, range of available production technologies

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<u>Bioeconomic model (Orfee)</u>

Optimisation of the number and type of animals, crop allocation, animal diets, buildings and machinery

To maximize : net revenue

Under constraints : resources (land, labour, buildings), biology (energy and protein requirements, herd, demography), regulations..

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<u>Model outputs</u> : Herd and crop productions, input consumption, revenue, GHG emissions..

1) The simulation model : GHG Calculation

- CH_4 Enteric fermentation *(Sauvant and Noziere, 2016)* = f (digestible organic Matter, Dry matter intake / Liveweight, share of concentrate feeds, rumen protein balance), Dejection : f(non digestible organic matters) (Eugène et al, 2012).
- N_2O Manure management (IPCC Tier2-3) = *f(N excreted, manure storage),* Managed soils (IPCC tier 1) = *f(N spreading, Grassland renewal, crop residues, N Leaching)*
- CO_2 Indirect: f (fuel consumption, input purchased)

Carbon storage *(Soussana et al, 2010) :* perm. grasslands 570 kg C/ha/year, annual crops destock 160 kg C/an/year

- Biophysical Allocation per kg of liveweight or milk (Agribalyse)

2) Calibration / validation

- DATA used :
  - Farm type referential from Inosys Reseaux d'élevage and inra farm network (forage management, fertilization and yield, animal production, concentrate feeds, economic results, sometimes : fuel consumption, labour)
  - Technical publications from extension services (Arvalis, Idele, Chambre d'Agriculture, RMT..)
- Calibration (adaptation of technical parameters) / validation in 2 steps :
  - Optimisation with fixed herd size / composition and crop activities for the refenrence year
  - For the period 2008-2013 : 'full' optimisation

Scenarios

	S1 'Trend '	S2 'Produc-tion +'	S3 ' Grass+'	S4 ' GHG- '
Context	Low economic growth	End of the economic crisis	Environemental awareness	Strong policy to reduce GHG
Consumption	Continuing decline (-12%)	Increase (+10%)	Fall back upon quality (-10%)	decrease (-20%)
Production *Milk* *Meat*	+ 36% + 6%	+ 60% +16%	+ 7% - 14%	- 21% - 32%
Systems : *geog concentration* *Farm enlargement* *Mechanisation* *Prod / LSU*	+ + + +	++ ++ ++ ++	- - - - - - -	- = + -/+

+ S1bis , S2bis with strengthened environmental strategy (improvement of practices, including GHG mitigation options)

Drivers of scenarios selected

B0	Baseline price (average 2008-2013)
S1-S4	- Prices =B0 (standard milk = 335€/ton, charolais culled cow = 3.5 €/kg carc, wheat =187€/t), fuel and fertilizers: B0 x1.4 - First calving three month younger possible, free calving periods, - Same breeds as S0 + Holstein Friesian 2035 : milk yield +30%, liveweight +3.5%, fed indoors - Mixture of cereal_protein crops, alfalfa - Increase of fertilisation efficiency (+10%) - Crop intensitiy : organic / intetrated / conventional / intensive
S2	Labor productivity x2
S3	Organic farming with 10% max. of concentrate feed (organic milk price x 1.2, beef carcass price x1.15, lean animals x 1, crop price ≈ x 2)
S4	Tax on net carbon emission (40€/ t)

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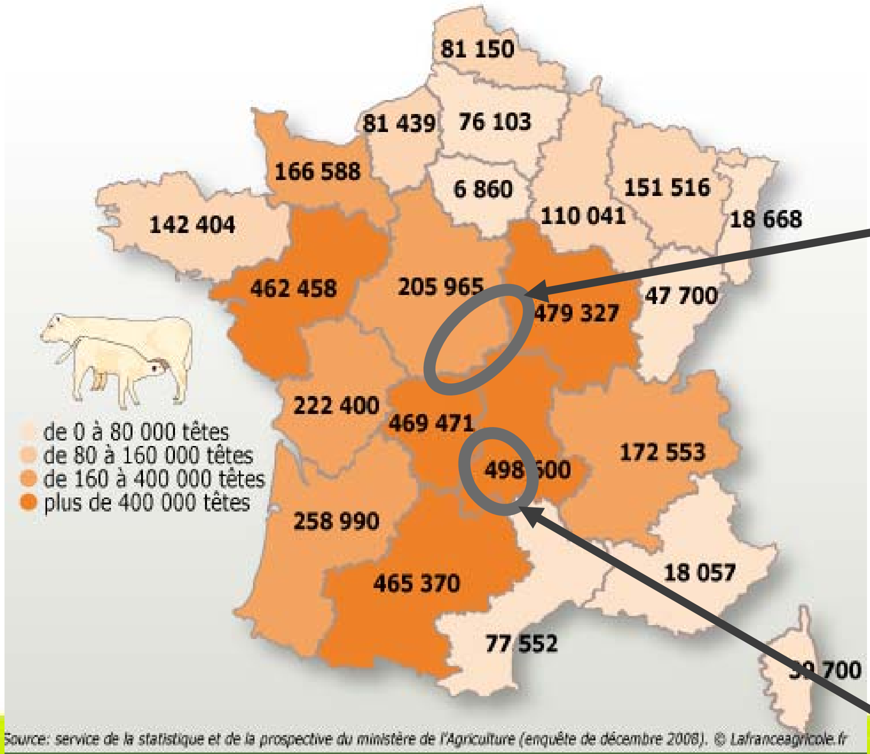
2/ Case studies: 2 Suckler Cow farms



SC_Crops

251 LSU : young bulls, heifers 33m, culled cows - Charolais

280 ha : 67% Permanent Grassland, temporary grasslands, 4% corn, 29% cash crops (wheat yield :65q)

SC_Grass

86 LSU: weanlings, culled cows, Salers and Crossbred

87 ha : 100% grassland

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2/ Case studies: 2 Dairy farms

DC_Grass

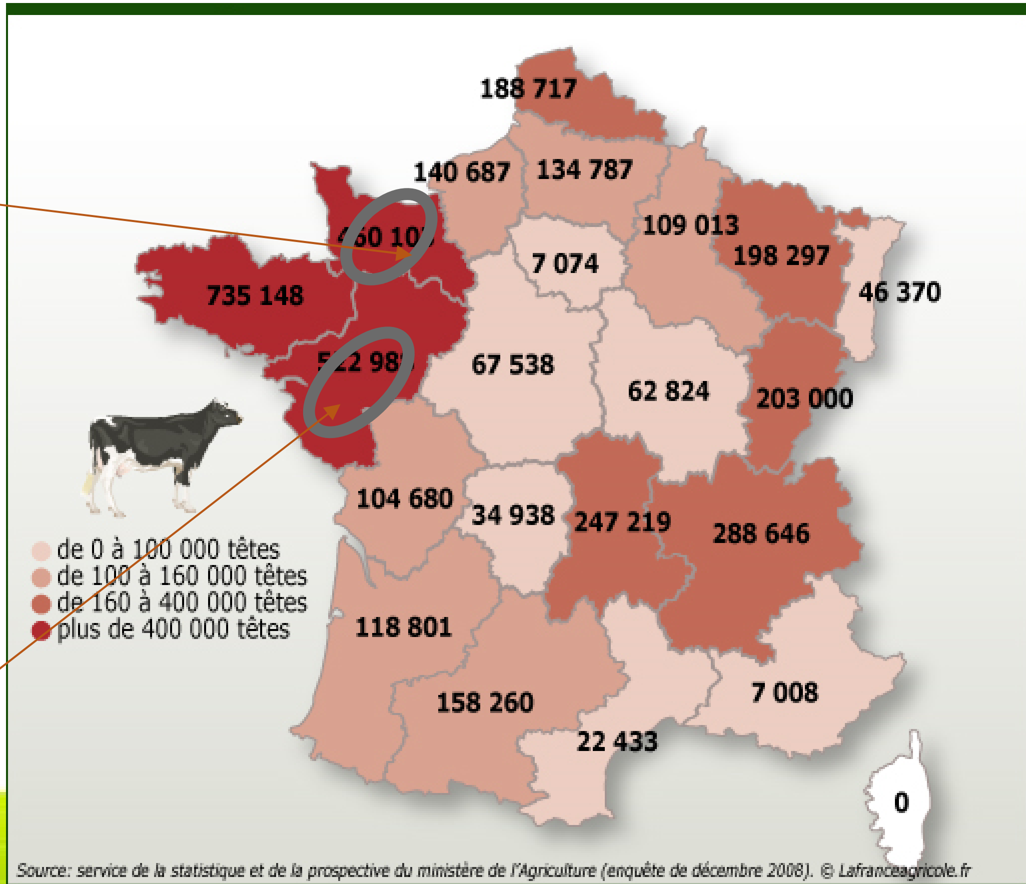
36 DC : 5700 L milk /DC - normande

55 ha : 100% permanent grasslands

DC_Crops

50 DC : 7800 L milk /DC – Hostein Friesian

61 ha : 61% temporary grasslands, 21% corn, 18% cash crops (cereal yield: 70q)



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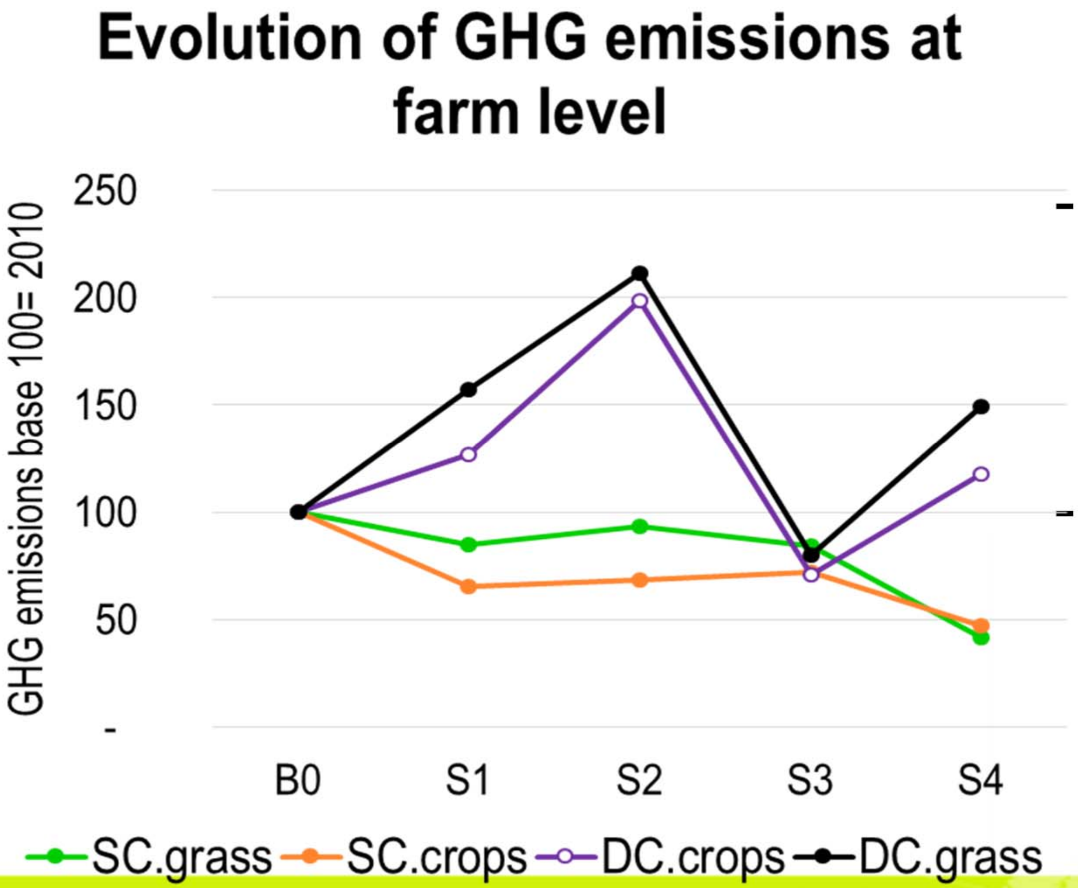
RESULTS

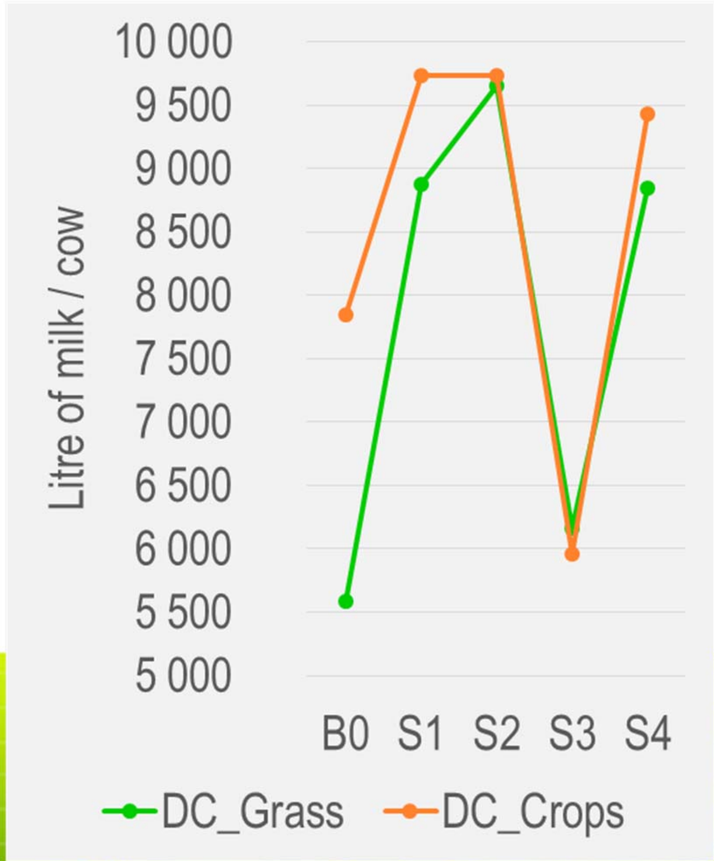
1/ Global GHG emission and production at farm level



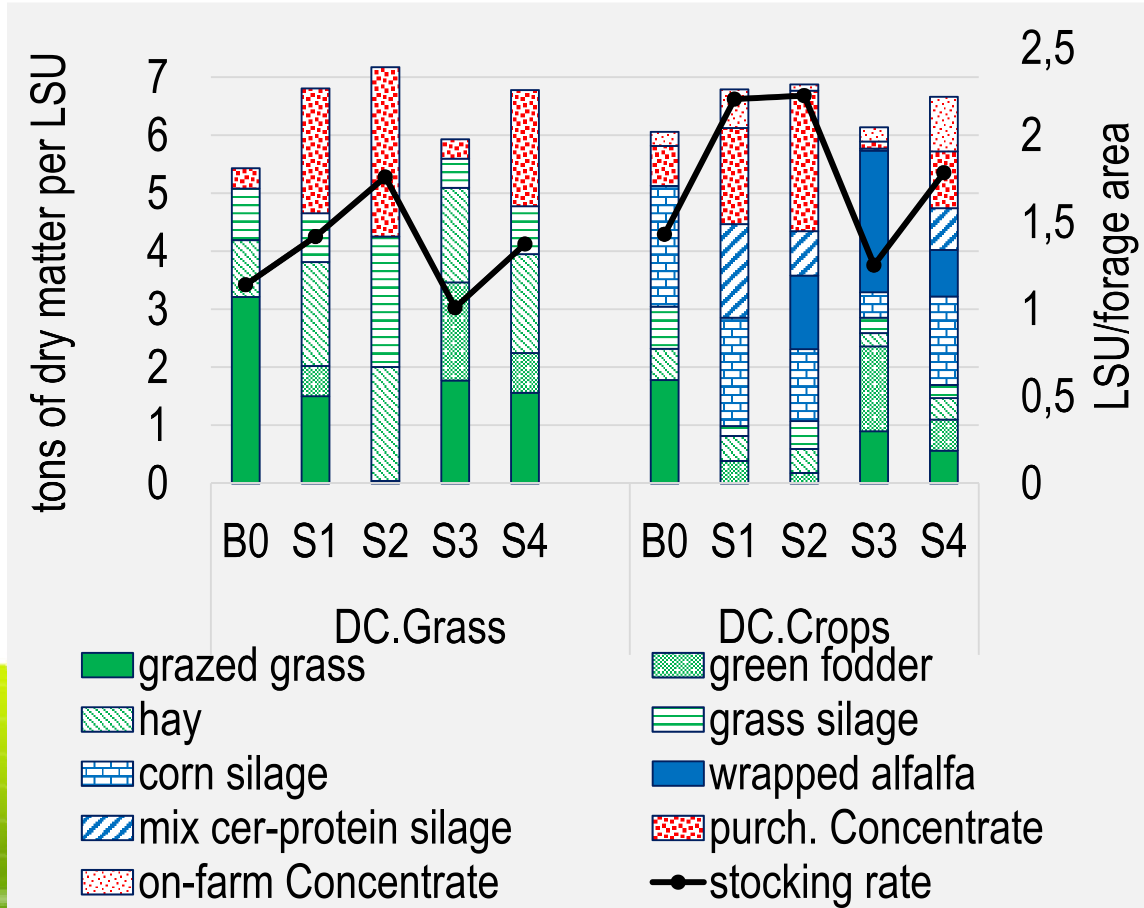
- Milk and GHG ↑ in dairy farms (S2 : ++ S3 : --)
- Beef production and GHG ↓ suckler cow farms (S4 :- -)

2/ GHG emission efficiency and production technology for Dairy farms

- Milk yield



- Feeding system and stocking rate



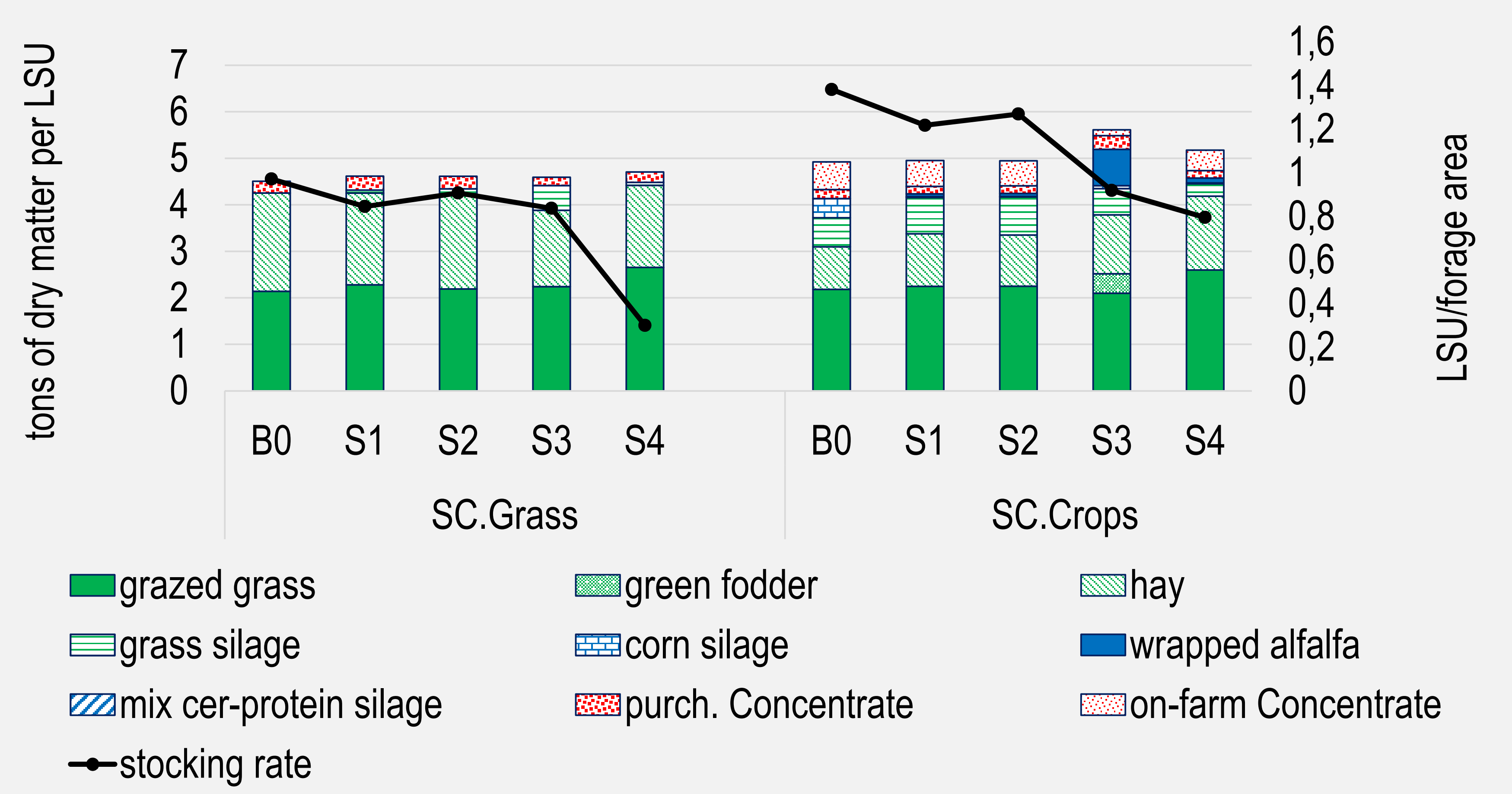
2/ GHG emission efficiency and production technology

		B0	S1	S2	S3	S4
DC_grass	Gross CO_2e/ kg milk	0.89	0.75	0.73	0.72	0.75
	Net CO_2e/ kg milk	*0.55*	*0.57*	*0.60*	*0.38*	*0.56*
DC_crops	Gross CO_2e/ kg milk	0.73	0.66	0.65	0.73	0.65
	Net CO_2e/ kg milk	*0.68*	*0.65*	*0.64*	*0.65*	*0.60*

- S1 and S2 : increase in milk yield ↓ GHG emissions
- S3 : in DC_grass, GHG emissions could also be efficiently reduced by↓ input consumptions and stocking rate
- S4≈S1

2/ GHG emission efficiency and production technology: suckler cow farms

- Feeding system and stocking rate



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2/ GHG emission efficiency and production technology: suckler cow farms

		B0	S1	S2	S3	S4
SC_Grass	Kg CO_2e/kglw	***14.8***	***14.2***	***14.2***	***13.4***	***15.2***
	Net CO_2e /kglw	*7.28*	*5.69*	*6.48*	*5.34*	*-3.23*
SC_Crops	Kg CO_2e/kglw	***15.0***	***13.4***	***13.6***	***12.9***	***13.2***
	Net CO_2e/*kglw*	*12.2*	*10.1*	*10.4*	*9.1*	*8.8*

- S1 : ↓ emissions by 4-10%
- S2 : higher intensification per ha without animal productivity gain → slight ↑of CO_2e
- S3 : Lowest emissions
- S4 : very low stocking rate → carbone storage >> GHG emissions for SC_Grass

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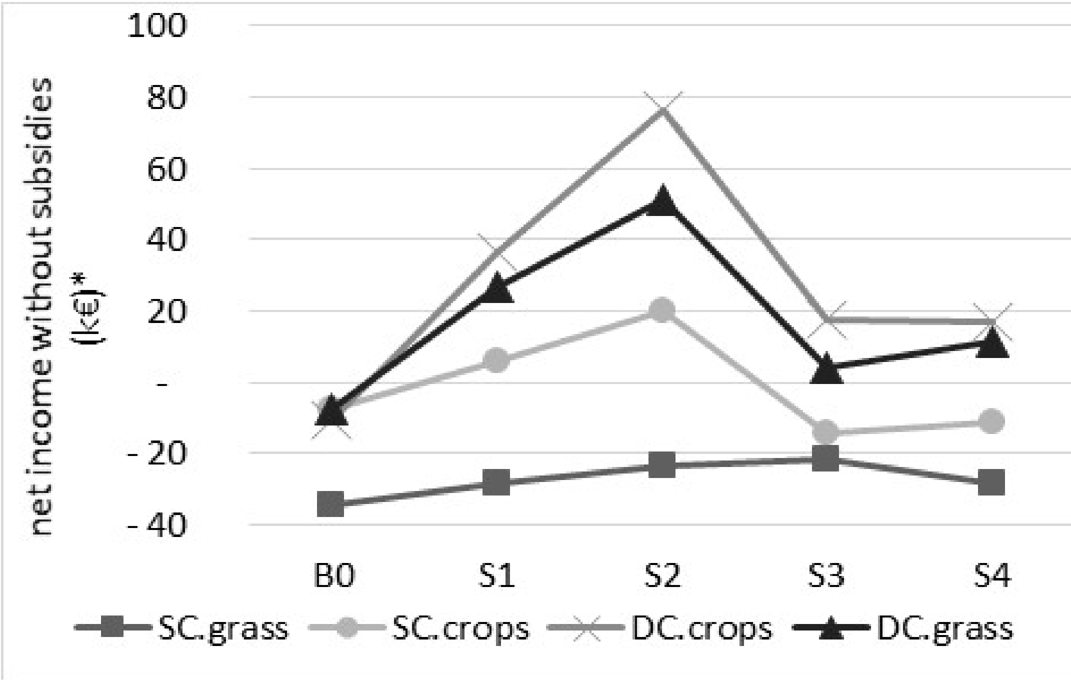
2/ Economic results (after salaries, without subsidies)



- Net income raises in S1 thanks to technological progress
- S2 is the most favorable to producers' net income
- Net income are close between scenarios S3 and S4

DISCUSSION & CONCLUSION

Summary of objectives and methodology

- Objectives were 1) to simulate which technologies would be adopted by some typical suckler cow and dairy farms according to scenarios 2) to assess whether evolution of GHG emissions per unit of product and per farm are compatible with climate change mitigation objectives.

- A Single farm level model to simulate a large range of cattle farming system with a focus on production intensification as a driver of GHG emissions

Main results of simulations at farm level

- In the future dairy farms are likely to increase their production per hectare while suckler cow farms would reduce it

- GHG emissions per unit of milk and meat (without C storage) would be reduced thanks namely to an increase in milk yield, younger age at first calving, spring calving and legumes fodders

- the most favorable scenarios for the reduction of GHG emissions level involve
  - the development of organic farming for suckler cow farms and grass based dairy farm
  - The introduction of a tax on GHG emissions for dairy farms with annual crops.

Limits

- Not all mitigations strategies have been included (biogas plant, lipid in animal diets etc.)→GHG mitigation options could be even more improved
- Simulations have been made with current prices while uncertainties are very important
- Impacts of risks on production decisions have not been considered →could limit production specialisation and intensification
- Repercussions of these scenarios on global food consumptions and GHG emissions?

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Would GHG emissions be reduced in French beef and dairy farms in 2035?

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