Dynamilk: a farming system model to explore the trade-offs between pasture, forage and milk production in grass-based systems

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INRA SCIENCE & IMPACT

Introduction:

Studied systems: dairy farming system based on grasslands located in mountain areas

- Geographical, soil and weather condition constraints
- Grassland based system

More sensitive to climatic change

⇨ Better forage and feed self-sufficiency

Possible plan of actions: Reinforce grassland utilization

- Dairy cattle management and strategies to optimize dairy cattle breeding
- Increasing the weight of grazing within the feeding system

Research hypothesis:

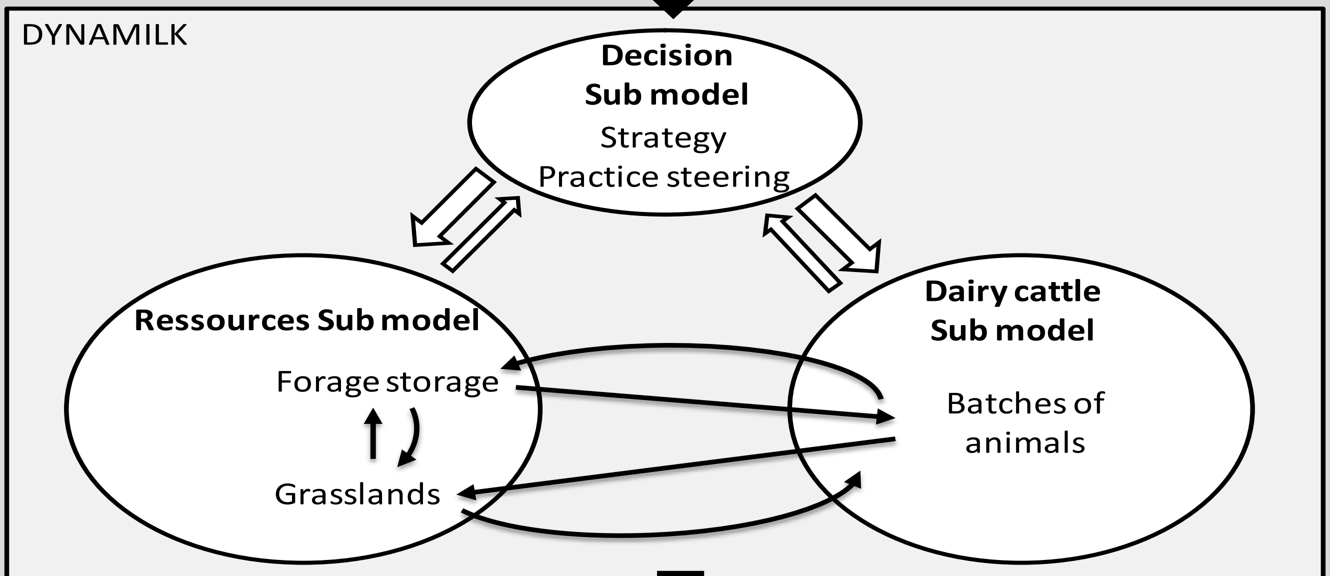
Dairy cattle need dynamics ⟺ match ⟺ Herbage supply dynamics

Improving the trade-offs and the robustness of the production system

Model description:

INPUTS

Paddocks characteristics	Weather data	Decision parameters (goals & steering)	Dairy Cattle characteristics



OUTPUTS

Biomass Digestibility Yields	Forage & grazing calendar Yearly assessment of forage ressources	Milk production Intake Energy balance

daily time step

Interactions between resources utilization and animals

Milk responses to grass-based diet variations

Simulations:

Hyp : a better match between animal needs and herbage offer

2 contrasted systems based on different dynamics of animal needs

(one produces milk based on forages, WINTER,

the other produces milk on grass, SPRING)

« classical » System Autumn & winter calving **"WINTER"**	**Effect of climatic variations 1995-2011**	System Spring calving **"SPRING"**

Main variables to analyze system performances:

- Milk yield
- Forage self-sufficiency (selling – purchases + Δ storage)/ LU
- Annual herbage yields and energy values of different kind of forages
- Annual biomass utilization rate of grasslands (on paddock grazed by dairy cows)

Simulations:

Scenario and systems presentation:

« classical » System Autumn & winter calving **WINTER**	System Spring calving **SPRING**

Data based on farm survey data – Massif Central (France) (Jacquot et al., 2010)

Field pattern :

Grasslands dominated by permanent pastures and productive grasses (Baumont et al., 2011)

Farm area ≈ 80 ha :
48% 1st cut, 17% grazing for dairy cows and 35% grazing for other batches

→

≈ 80 ha :
39% 1st cut, 26% grazing for dairy cows and 35% grazing for other batches

0,94 LU/ha

Decrease of first cut area in order to increase dairy cow grazings

Dairy cattle :

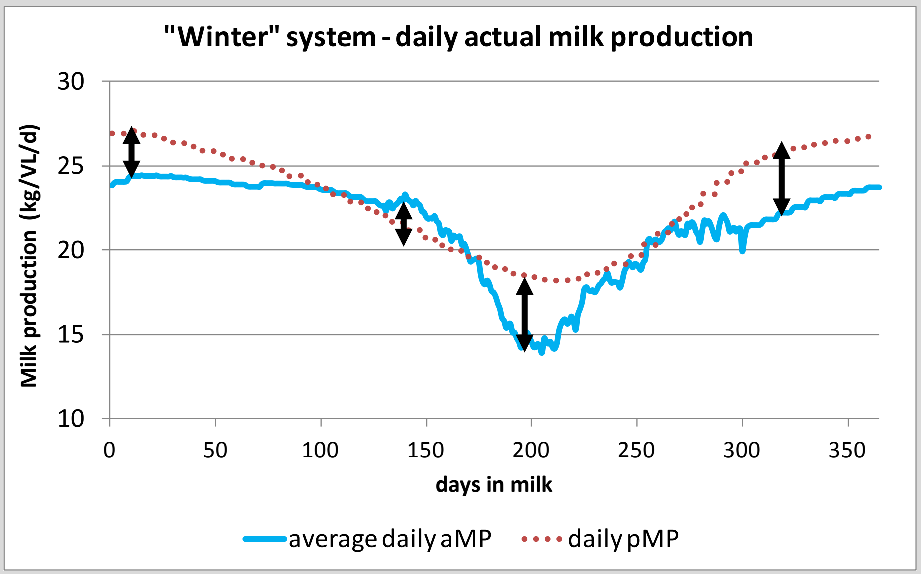
51 dairy cows
31% replacement rate
7000 kg/cow/year (potential yield)
1200 kg/cow/year feed concentrates
Age at the first calving : 3 year-old

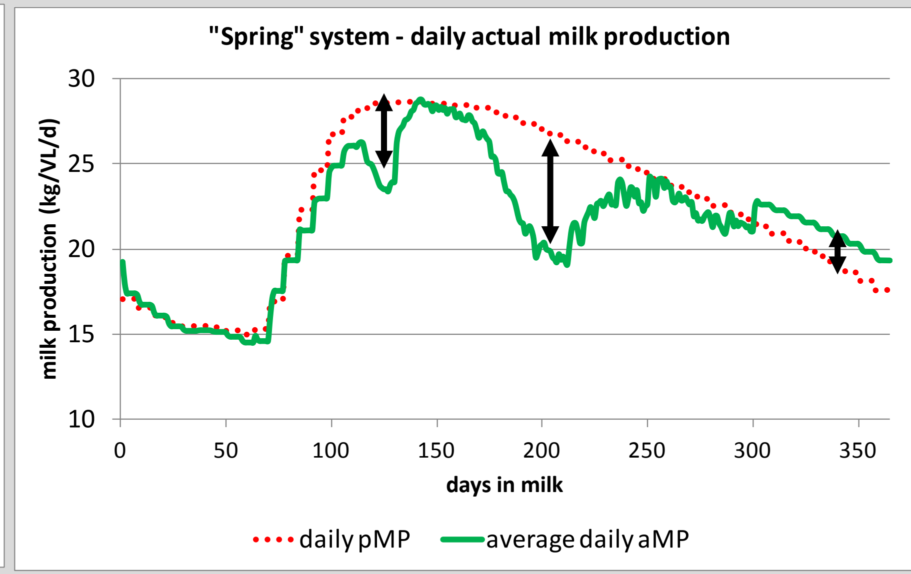
Simulation results:

Performance evolution between 1995 and 2011:

	"WINTER"	" SPRING"	ANOVA
Forage self-sufficiency (t DM/LU)	0,52 ± 0.51	0,34 ± 0.37	-
Purchased forage (t DM)	0 ± 0	1.1 ± 0.2.5	NS
Milk yield (kg/cow/year)	6 600 ± 78	6 759 ± 56	0,006

Self-sufficient systems for forages





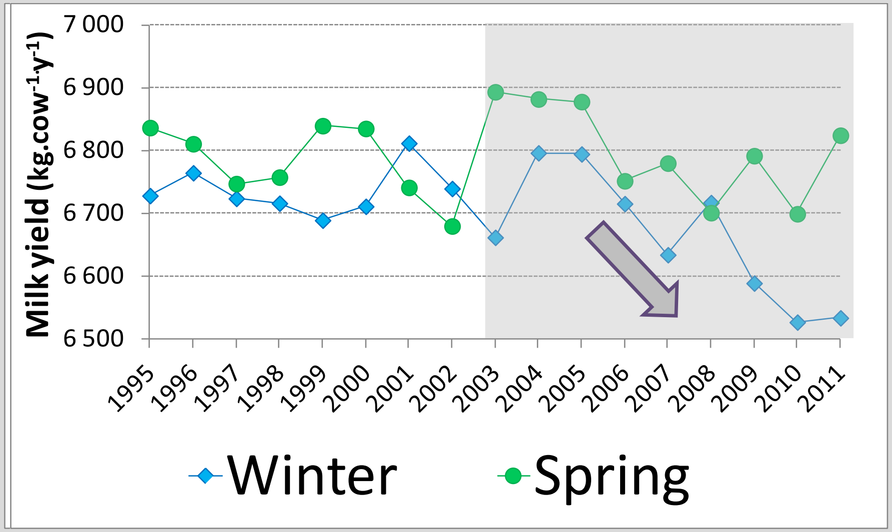
Δ (aMP – pMP) bigger for "WINTER" system than "SPRING"

("WINTER" : -1.47 / "SPRING" : -1.16 kg/cow/d)

Simulation results:

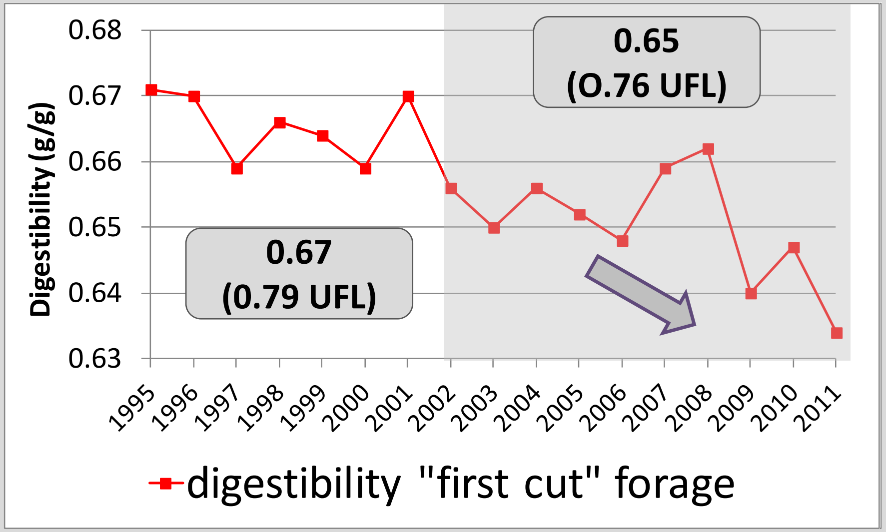
Performance evolution between 1995 and 2011:

	"WINTER"	" SPRING"	ANOVA
Milk yield (kg/cow/year)	6 600 œ78	6 759 œ56	0,006



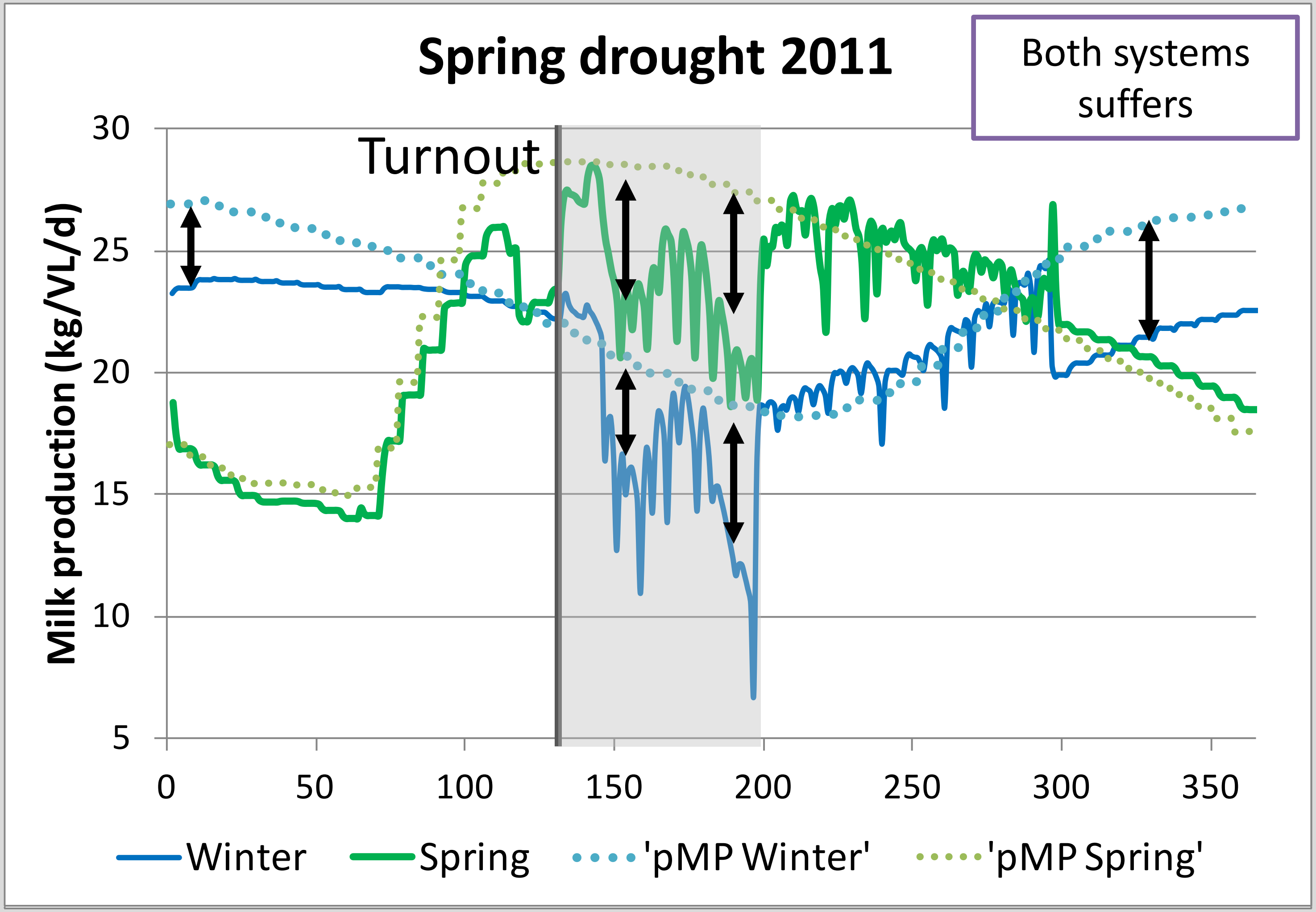
- "SPRING": a better stability of annual milk yields
- "WINTER": sensitive to forage quality

Correlations btw MP and digestibility:
"Winter": 0.47
"Spring" : 0.00



Simulation results:

Effect of a climatic event on milk performances:



Season:
Spring system is more sensitive to a spring draught

Δ(MP-pMP)
Δwinter = -2.39
Δ spring = -3.76

Year:
Still, spring system is closer to its pMP

Δ(MP-pMP)
Δwinter = -2.03
Δ spring = -1.08

Conclusions:

Simulations:

✓At a low stocking rate (0.94 LU/ha) and with productive grasslands, ***both systems are self-sufficient***

✓Spring system seems to be more resilient to climatic changes

⇨ a better match between animal needs and grass offer could be a relevant way to improve self-sufficiency through ***a better use of grass at grazing***

Dynamilk, a useful working tool to

Simulate interactions between grass resource dynamic and their utilization by dairy cattle

- Better understand ***system functioning and its performances***
- Analyze system evolutions on ***different times-steps*** (year, season and day)
- Better understand ***climatic events and/or effects of production changes on farming system***

⇨ -concentrate decrease on system performances
-stocking density increase on system performance



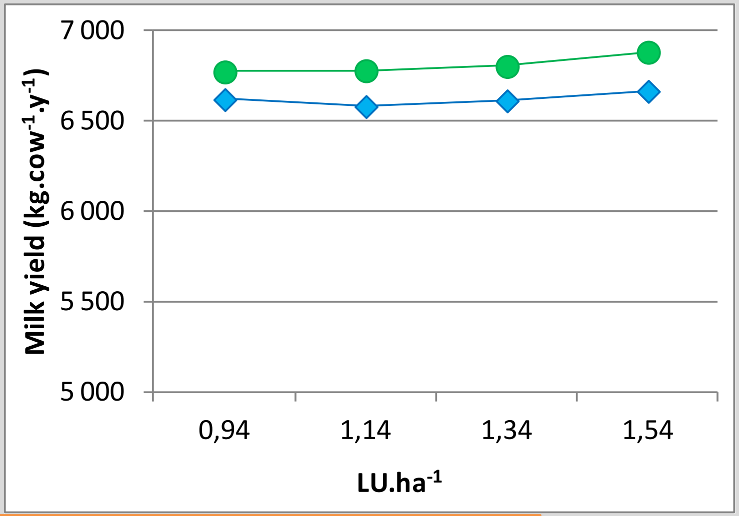

Thanks for your attention, please feel free to ask for more details!

A special thank to all persons who contributed to Dynamilk

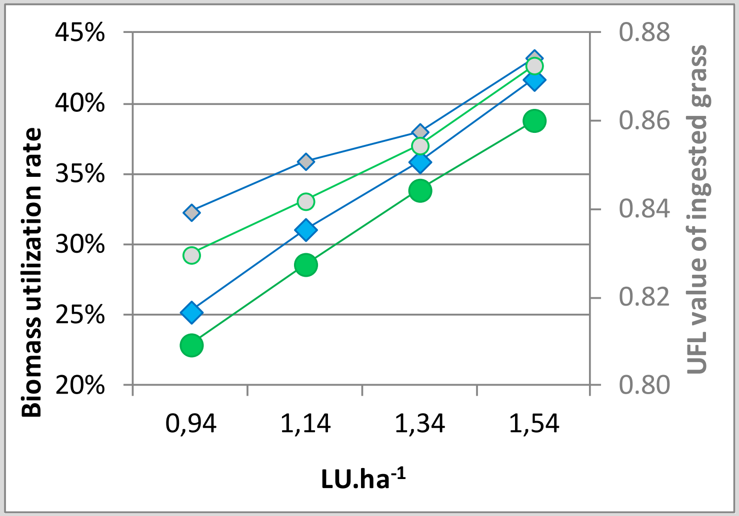



Simulation results:

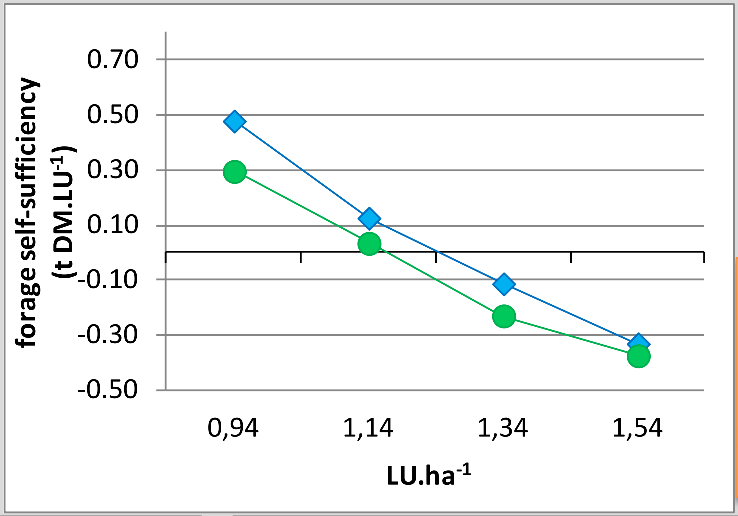
Increase of stocking density: 0.94 LU/ha (1.14 ⟶ 1.34 ⟶ 1.54)



AC
SC



- Stable milk yields
  - AC: +46kg.cow^{-1}.y^{-1}
  - SC: +109 kg.cow^{-1}.y^{-1}



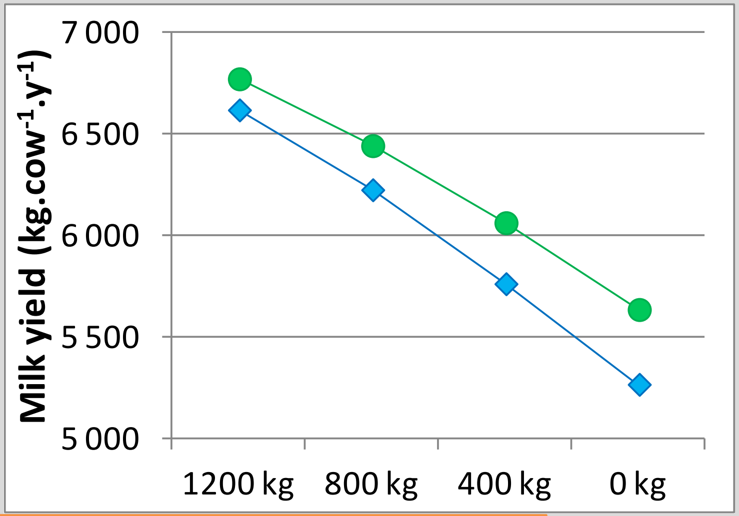
- Better utilization of grass offer
- Better quality of ingested grass

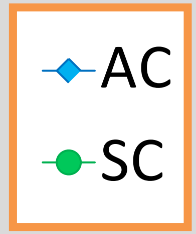
- breakdown of forage self-sufficiency

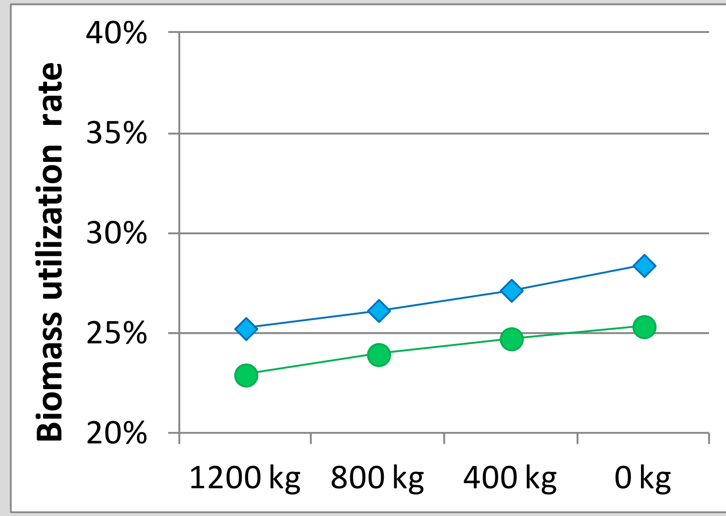
BUT balanced system until 62 cows for 81 ha

Simulation results:

Decrease of feed concentrates : 1200 kg/cow/year (800 ⟶ 400 ⟶ 0)

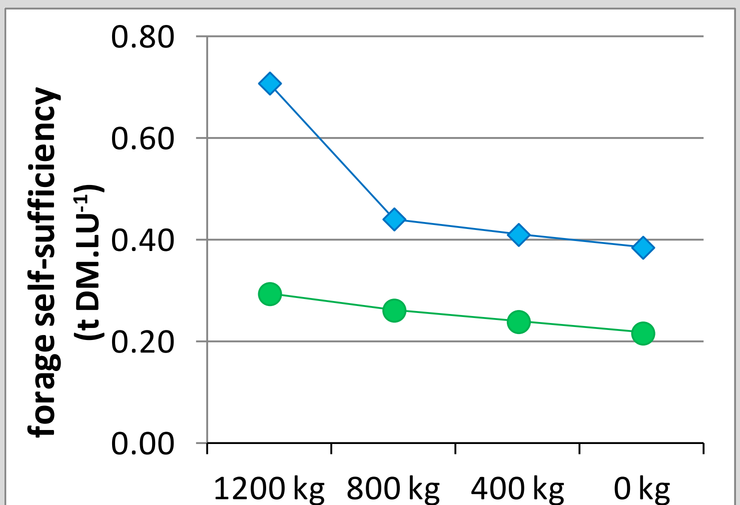






- Non-linear relationship
- kg of milk in less by kg of spare concentrates

AC : 0,90 to 1,17 kg milk/kg conc
SC : 0,83 to 1,05 kg milk/kg conc

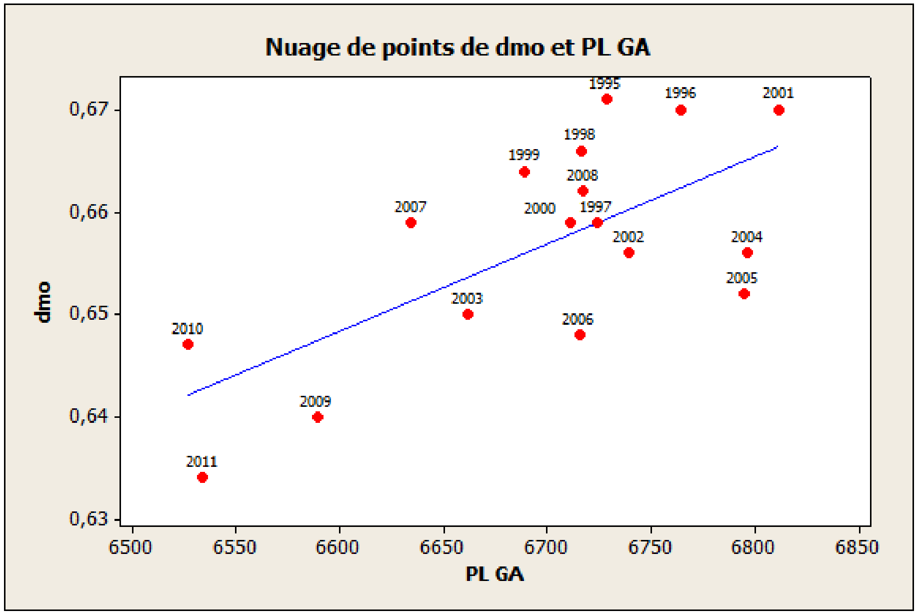


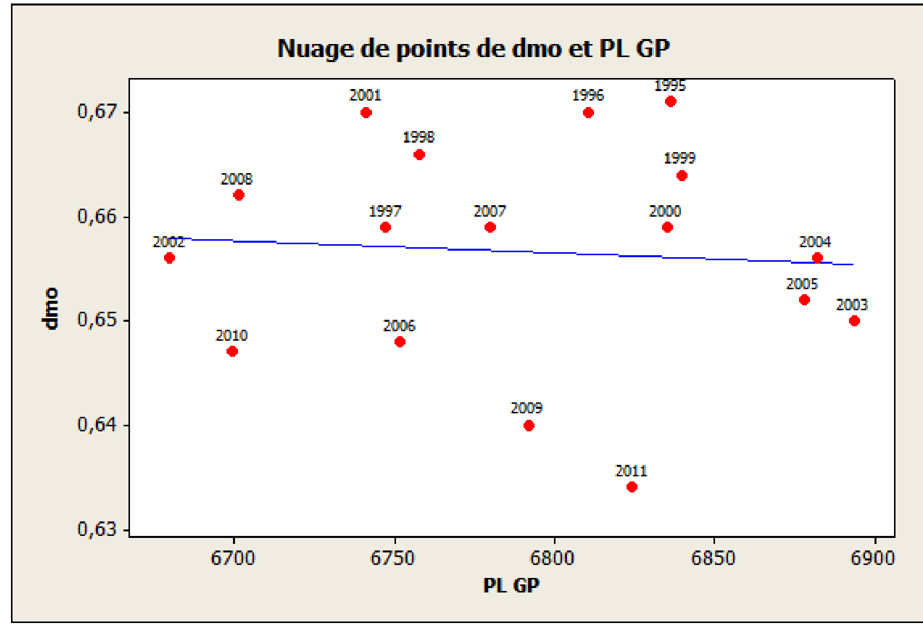
- A slight increase of grass utilization
(+3% for AC, +2% SC)

- Forage self-sufficiency still positive

Simulation results:

Rapport entre la dmo et la Plprod annuelle:





Correlation entre dmo et Plprod:

GA : 0.47

GP : 0.0

Moyenne réalisée sur les données de 1995-2011

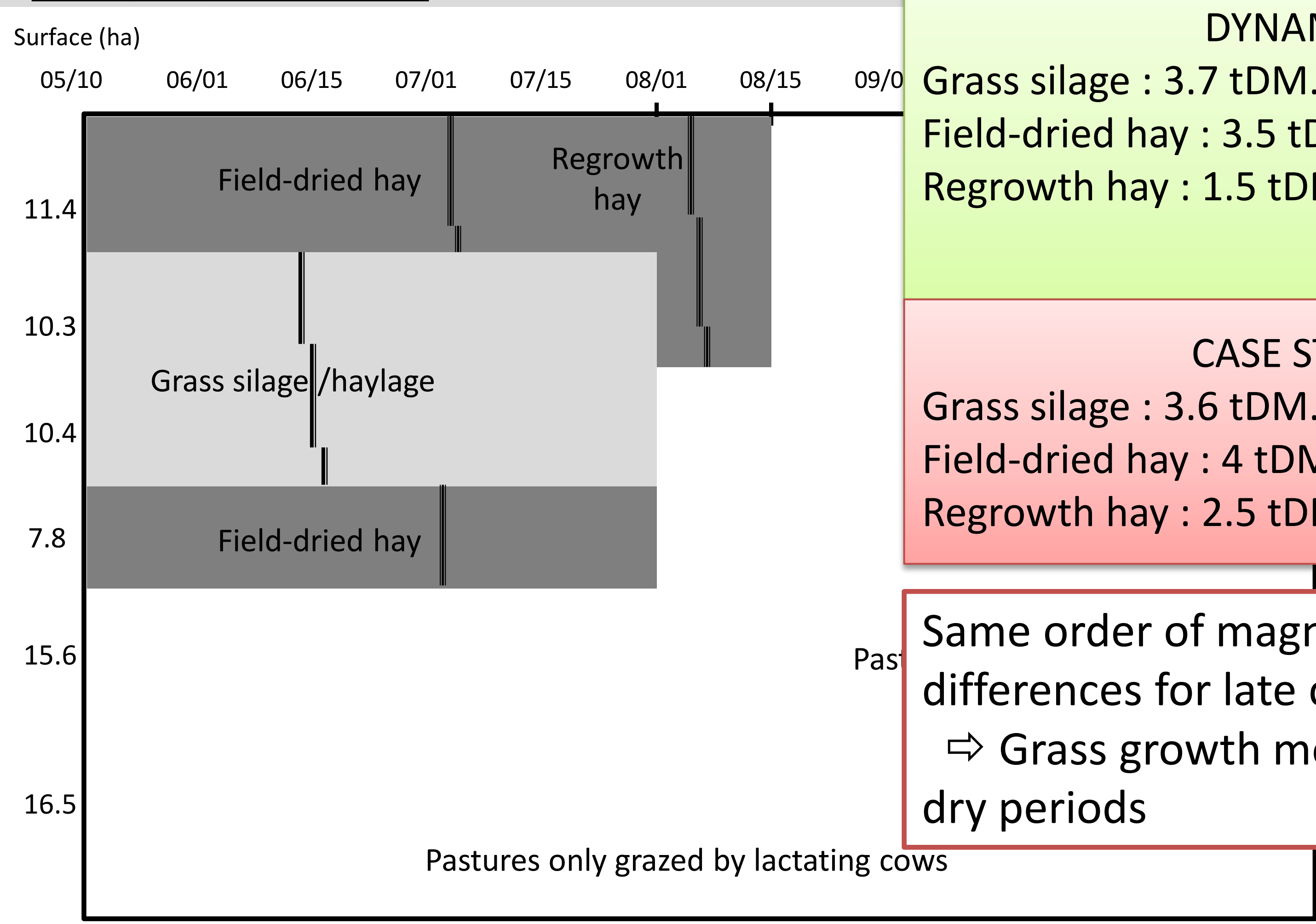
1rst cut (silage):
3.7 tDM/ha (0.80 UFL)

1rst cut (field-dried hay) :
3.5 tDM/ha (0.69 UFL)

Grazing:
“Winter” (13.7 kgDM/cow/day, 0.84 UFL)
“Spring” (15.0 kgDM/cow/day, 0.83 UFL)

Results: validation of Dynamilk

Forage system: cuts



DYNAMILK

Grass silage : 3.7 tDM.ha-1 *(3 - 4.4)*

Field-dried hay : 3.5 tDM.ha-1 *(2.3 - 4.7)*

Regrowth hay : 1.5 tDM.ha-1 *(0.7 - 2)*

CASE STUDY

Grass silage : 3.6 tDM.ha-1

Field-dried hay : 4 tDM.ha-1

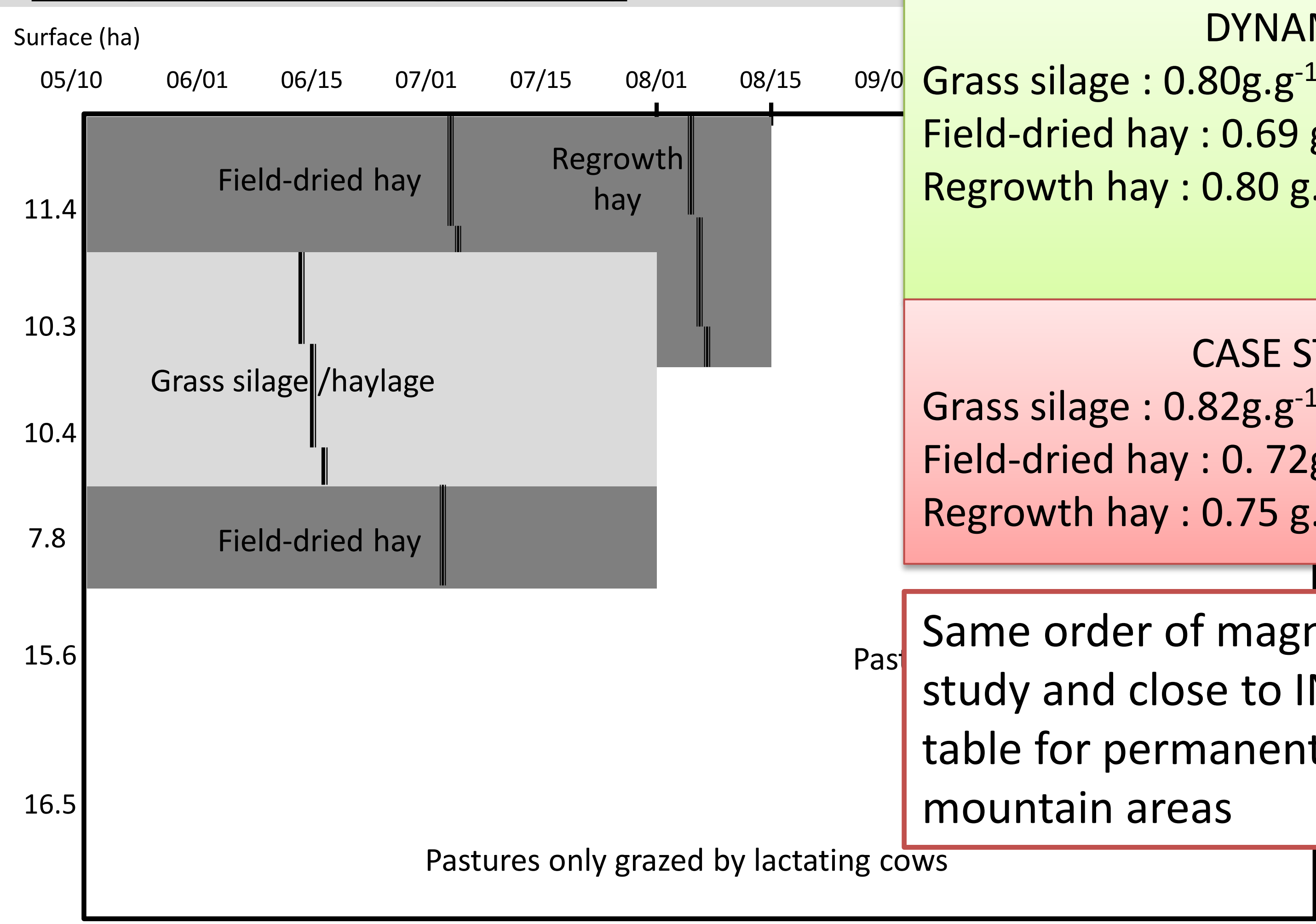
Regrowth hay : 2.5 tDM.ha-1

Same order of magnitude but slight differences for late cuts

⇨ Grass growth model is sensitive to dry periods

Results: validation of Dynamilk

Forage system: forage quality



DYNAMILK

Grass silage : 0.80g.g^{-1} *(0.76 – 0.83)*

Field-dried hay : 0.69 g.g^{-1} *(0.68 – 0.69)*

Regrowth hay : 0.80 g.g^{-1} *(0.75 – 0.83)*

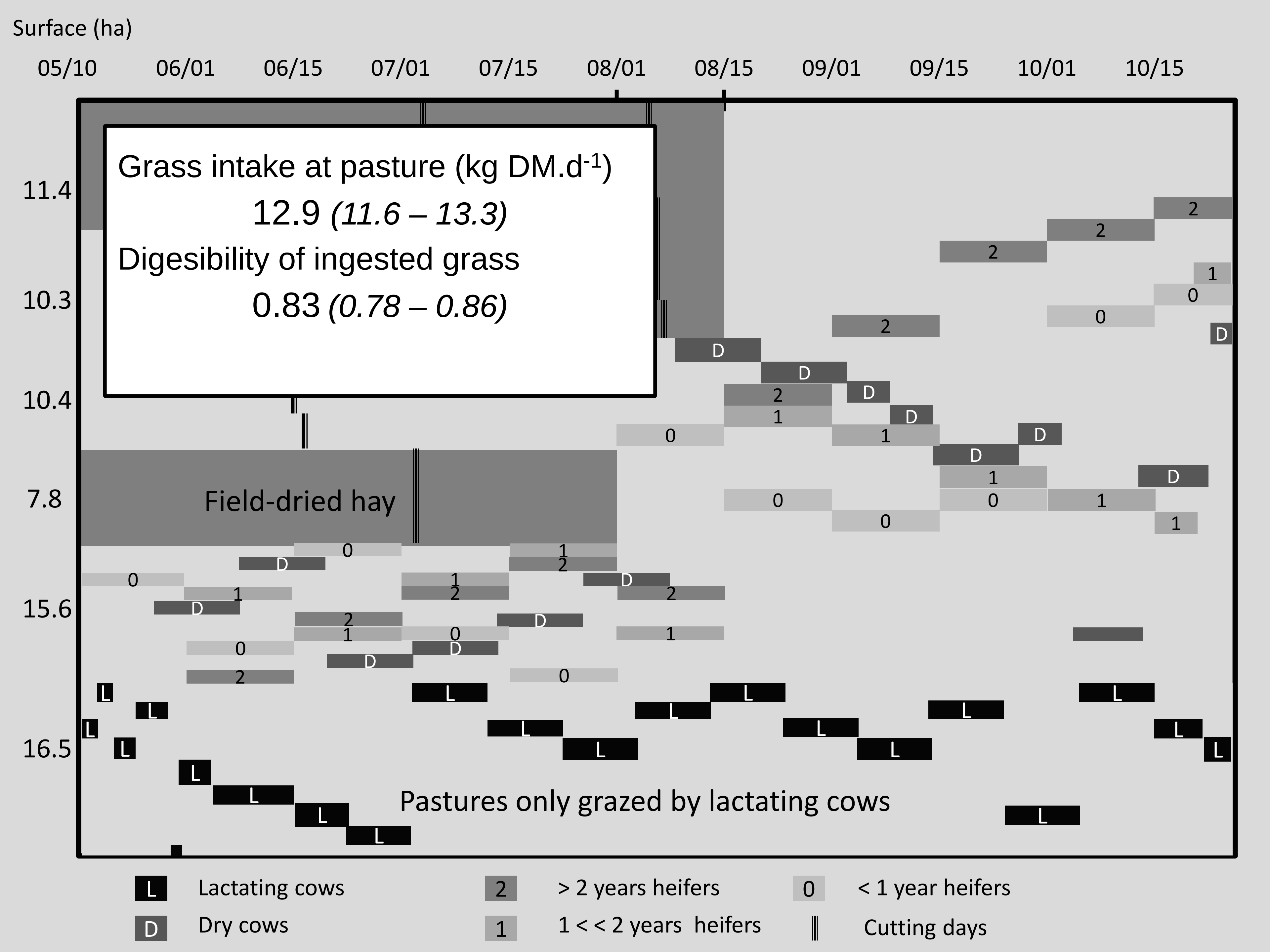
CASE STUDY

Grass silage : 0.82g.g^{-1}

Field-dried hay : 0. 72g.g^{-1}

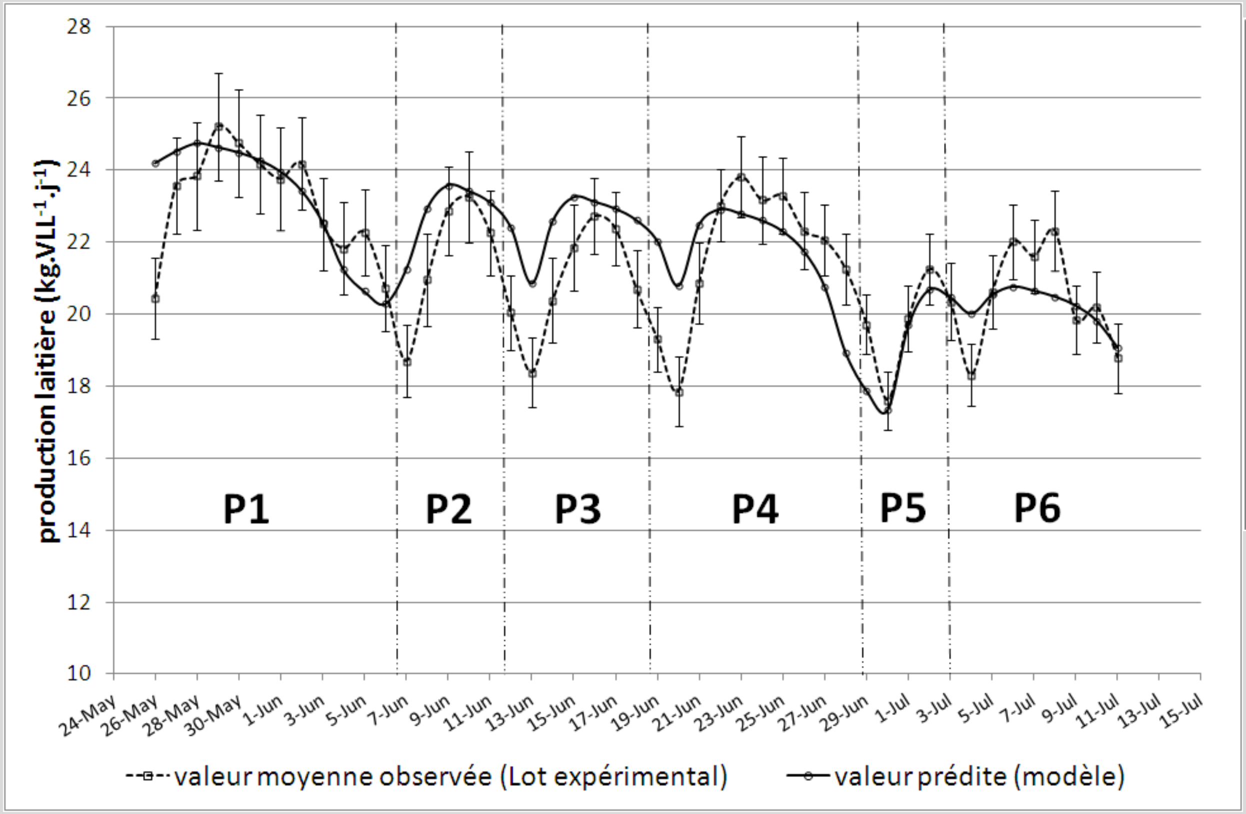
Regrowth hay : 0.75 g.g^{-1} -1

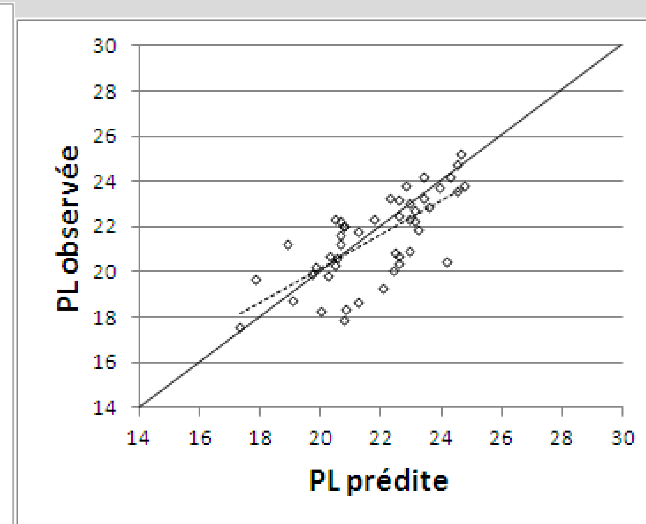
Same order of magnitude than case-study and close to INRA feed values table for permanent pastures in mountain areas


Surface (ha)
05/10
06/01
06/15
07/01
07/15
08/01
08/15
09/01
09/15
10/01
10/15
11.4
10.3
10.4
7.8
15.6
16.5
Grass intake at pasture (kg DM.d-1)
12.9 (11.6 – 13.3)
Digesibility of ingested grass
0.83 (0.78 – 0.86)
Field-dried hay
Pastures only grazed by lactating cows
L Lactating cows
D Dry cows
2 > 2 years heifers
1 1 < < 2 years heifers
0 < 1 year heifers
Cutting days

Validation sous-modèle troupeau

Enchainement de 6 parcelles entre le 24 mai et le 13 juillet





RMSD: 1.4 kg Plprod.VLL^{-1}.j^{-1}

Soit 6,5% de la PL moyenne

Biais et rotation minime

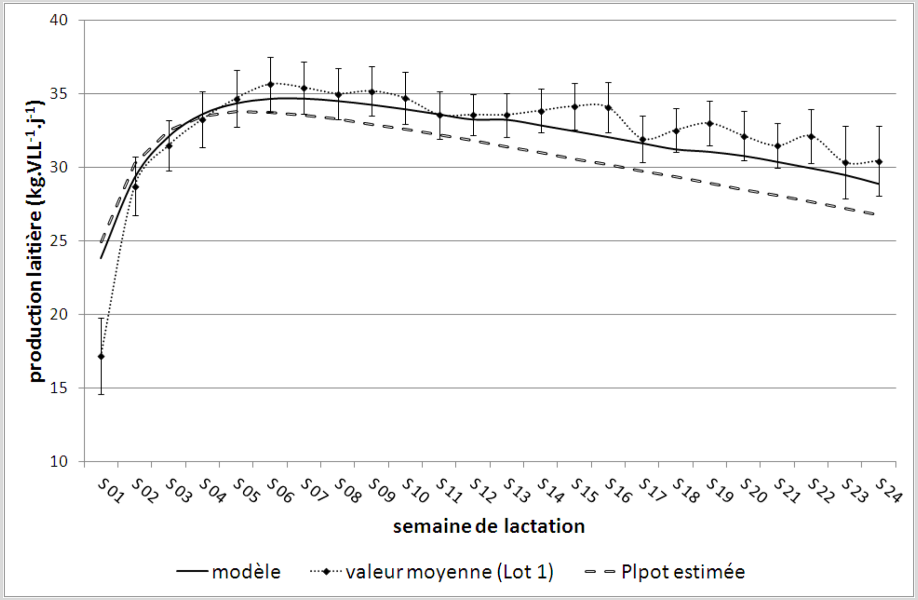
Manque de corrélations

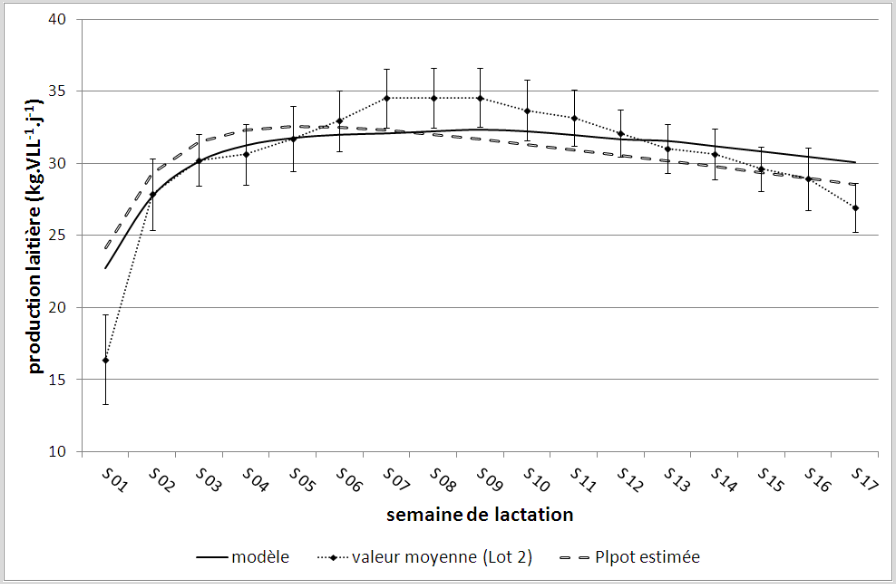
Structure model cohérente et prédiction correcte

Hyp:

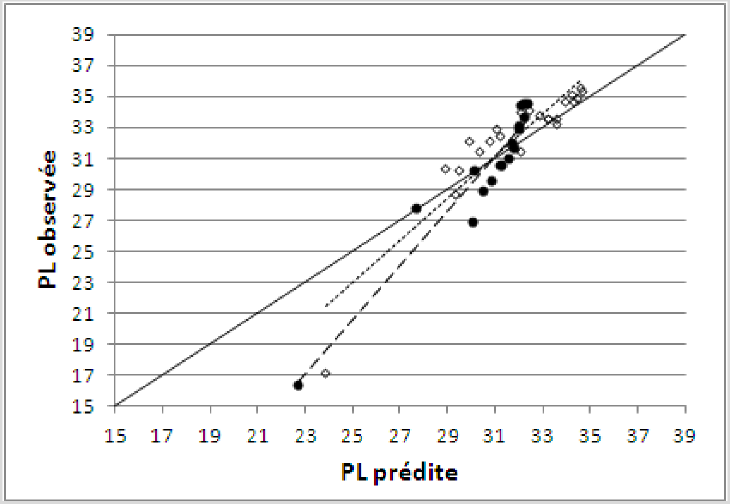
- Variabilité des PL observées (P4, P5, P6)
- Difficulté de paramétrage du couvert végétal à partir des données de biomasse à 5 cm et hauteur d'herbe

Validation sous-modèle troupeau - hiver





RMSD: 2.1 kg Plprod.VLL^{-1}.j^{-1}
Soit 5,6% de la PL moyenne



RMSD: 2.1 kg Plprod.VLL^{-1}.j^{-1}
Soit 6,8% de la PL moyenne

<u>Hyp</u>:
- 1ère semaine lactation
- Variabilité interindividuelle
- Estimation de la Plpot (lot 2)

Biais et rotation minime
Dispersion des données

Structure modèle cohérente et prédiction correcte