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Dynamic Herd simulations



REDNEX

CowNex, a tool to assess nitrogen excretion and efficiency of a dairy cattle herd according management

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RedNex Final conference Paris 30th August 2013





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Context

- Competition on protein resources
 - Increase in cost
 - Interest to produce most of them (Farm self-sufficiency)
- **Nreactive** (Nitrogen cascade, Galloway 2004) has always many environmental impacts (climate change, eutrophication, acidification, health with small particles), and livestock is an important step in its transformation
 - 77% of ammonia emissions come from animal N excretion
- Farmers have an important responsibility in the use the protein



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Background and objective

- At cow level, on a daily basis:
 - N efficiency in dairy cows depends of the rumen balance of nitrogen and the efficiency of metabolizable protein (MP)
 - MP efficiency if a function of MP/NE of the diet, energy balance, essential AA content and milk yield.
- However, what are the main factors of N efficiency at herd scale according the type of dairy system and annual feeding management ?

→ **CowNex, a simple tool to estimate
N efficiency of a dairy herd**

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Plan

- Description of the modeling work
- Presentation of the CowNex Website
- Simulation of different model farms with different characteristics and feeding systems



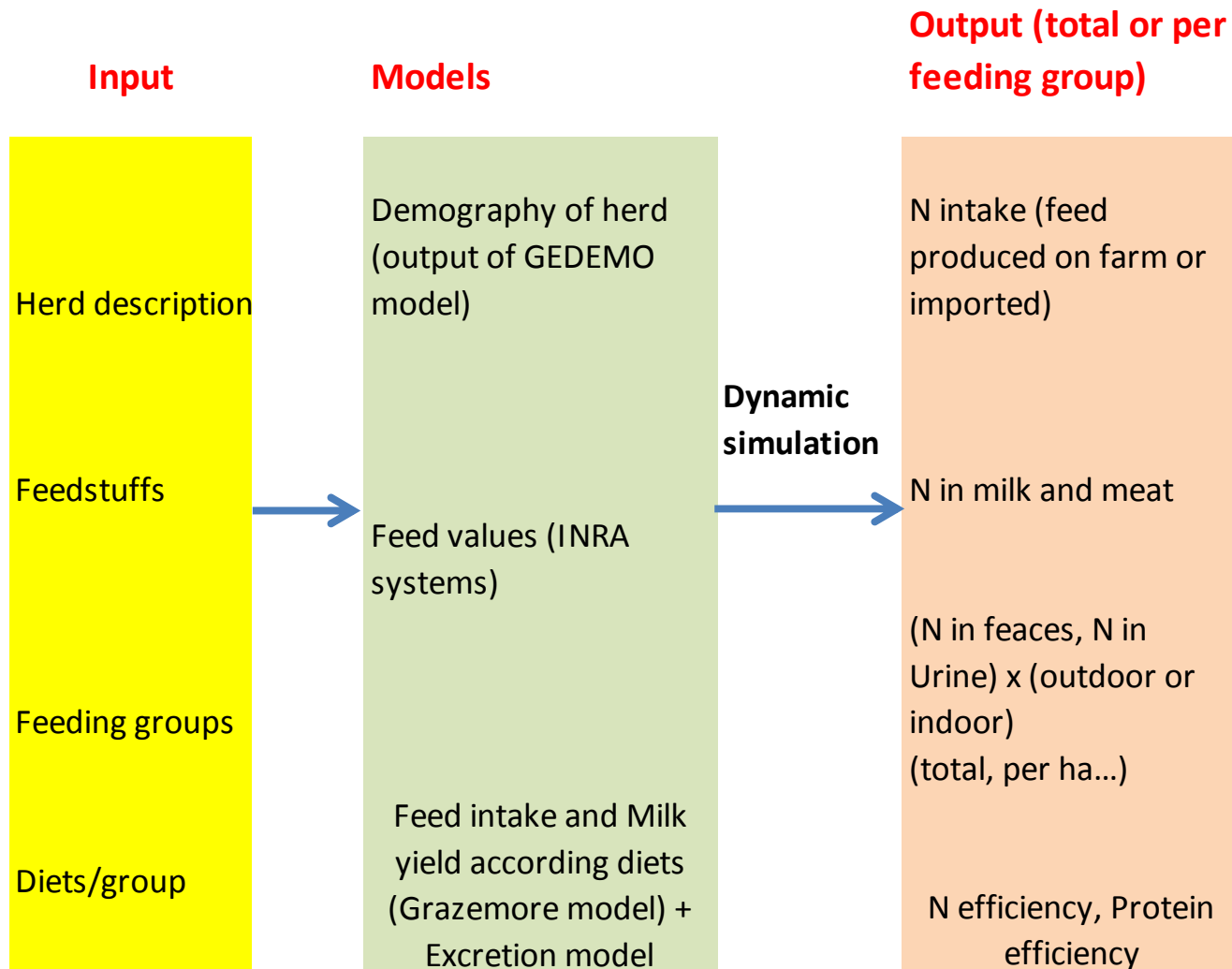
Objective of CowNex: Building a model predicting N excretion for a dairy herd over the year

- **Calculating N excretion from a dairy herd** according to the number of animals and the diets on a daily basis.
- **Merging animal sub-model** and **a herd demography structure** (number of heifers, dry cows and productive cows across the year and the feeding strategies for each category of animals).
- **The animal sub-model predicts N intake and urinary and faecal N** output on a daily basis using on farm available data.
- **N intake and N partition is predicted daily using the intake model developed during the GRAZEMORE project and other results of the RedNex project.**



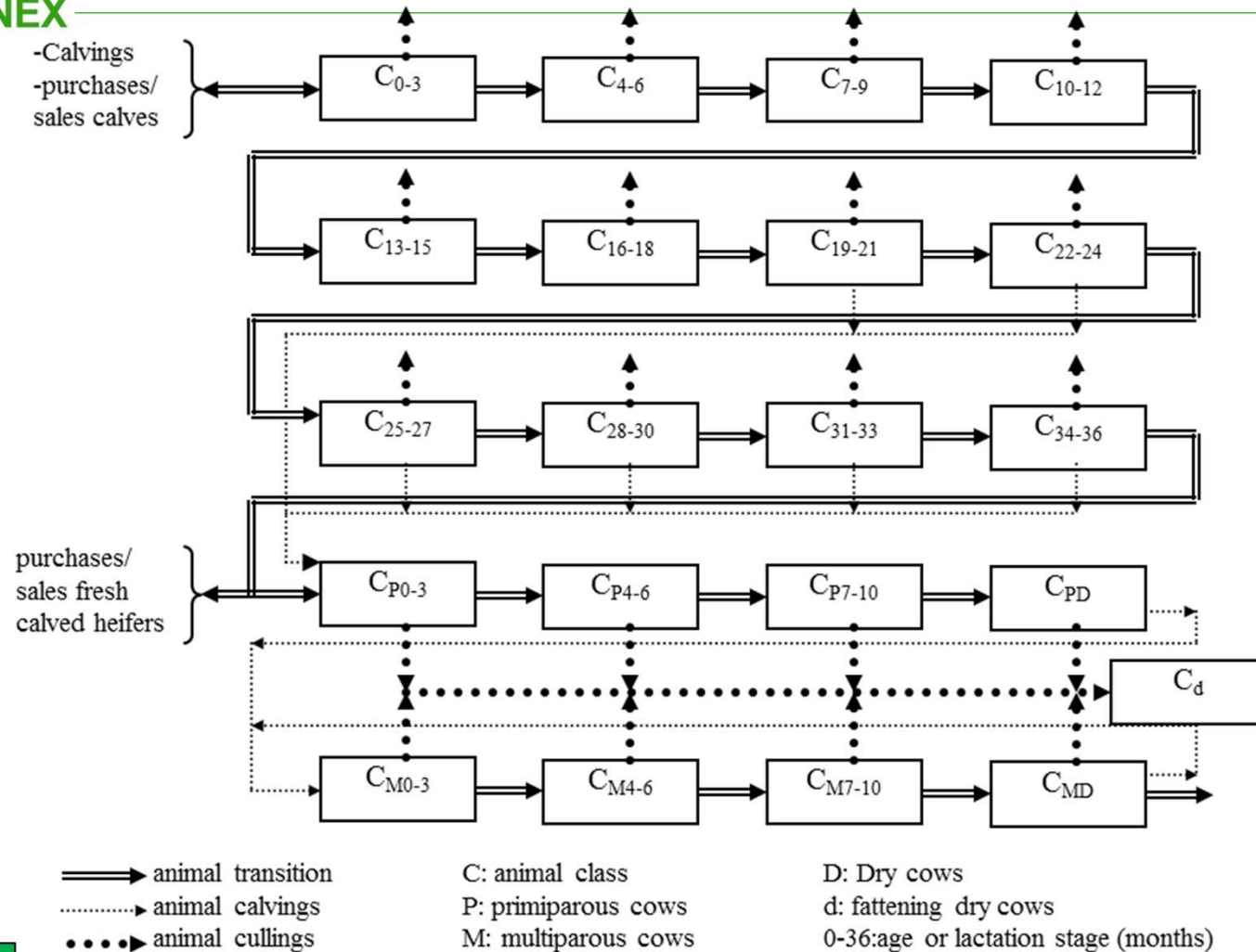
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General overview of CowNex



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A model to rebuild the dynamic structure of the herd



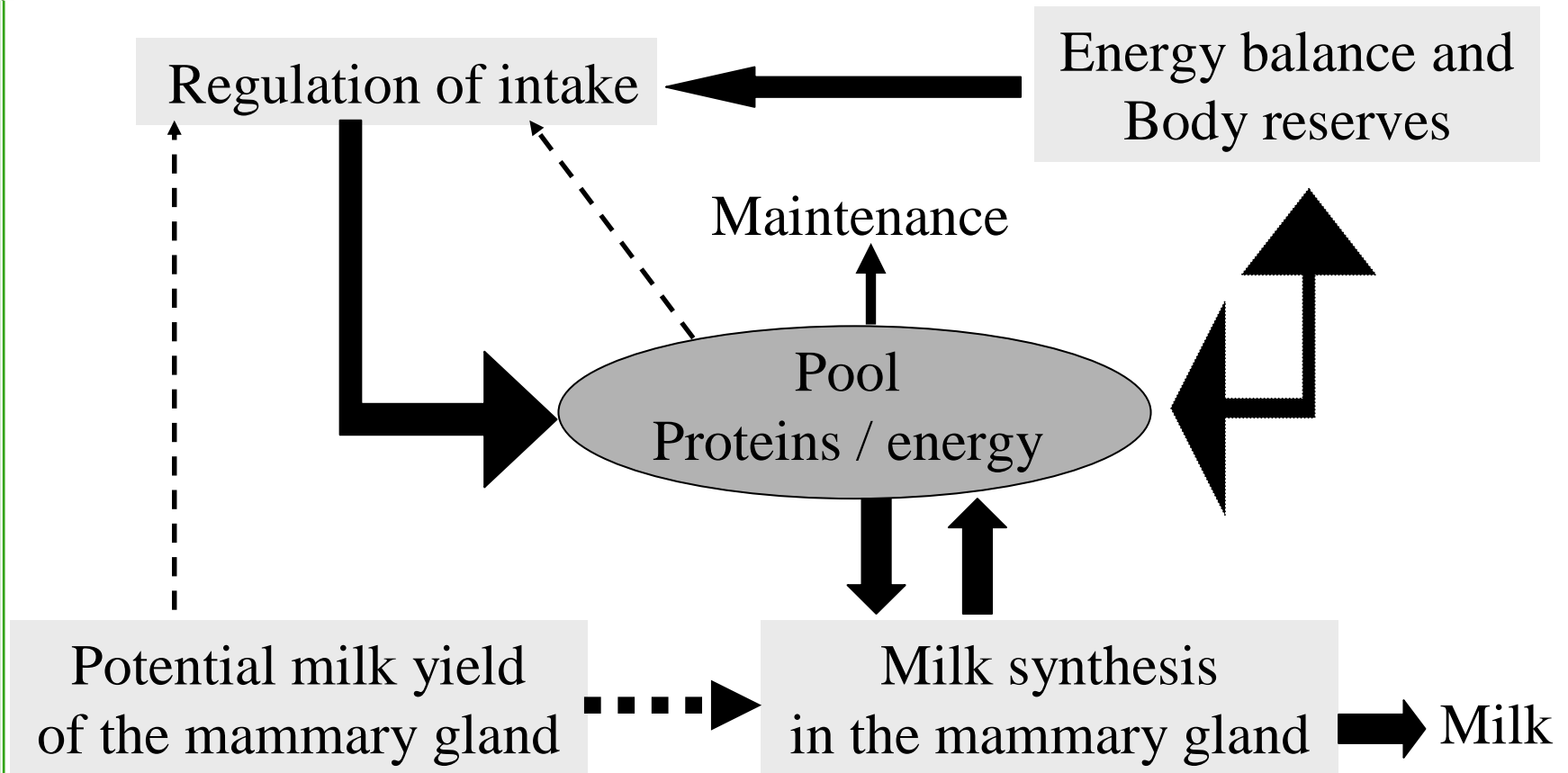
(Coquil et al)

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Intake Capacity and lactation of Grazin



(Faverdin et al, Grass and Forage Science, 2011)



REDNEX

The CowNex Website

Using the INRA modeling Record Platform



With the VLE modeling language




And the informatic skills of ULCO



Home First Step Herd Feed Feeding Groups Diet Plan Simulation

CowNex Simulator



The CowNex simulator is used to calculate protein synthesis and nitrogen excretion in dairy cattle herd, including heifers, depending on herd management.

It performs these calculations throughout the year and measures the impact of management changes, particularly nutrition, on the efficiency of nitrogen use by the herd and the release of fecal or urine nitrogen.

The amount of nitrogen to manage as manure is considered separately from the quantities directly returned to pasture.

© INRA - ULCO 2012 | [Credits](#)

Release 157

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Use of CowNex: different steps

- Describe the main characteristics of the herd : Herd
- Select the feedstuffs used to feed the herd during the year :
Feed
- Define the main groups of cattle gathering several classes of animal fed with the same diet during the year :
Feeding Groups
- Indicate for each feeding group the different diets offered during the year : Diet Plan
- Run the simulation to get results : Simulation

Simulation of feeding management of different model farms using survey data



Exemple of one model farm description (Institut de l'Elevage, 2011)

Type of farm

General description

Characteristics of forage used

Heifers: Example of feeding calendar

Elevages spécialisés lait de Plaine avec plus de 30% de maïs dans la surface fourragère hors Grand-Ouest

Ce système concerne 4,4 % des exploitations laitières françaises. Données 2007, issues de 41 exploitations des Réseaux d'élevage. Ces exploitations sont présentes en Picardie et Nord Pas-de-Calais (4), Haute-Normandie (2), Champagne-Ardenne et Alsace (8), Poitou-Charentes et Centre (15), Aquitaine et Midi-Pyrénées (14).

► CARACTÉRISTIQUES GÉNÉRALES DES EXPLOITATIONS

| | |
|-------------------------------------|---|
| Surface Agricole Utile (SAU) | 91,0 ha (± 45,5 ha) dont grandes cultures : 35,0 (± 24,5 ha) |
| Surface Fourragère Principale (SFP) | 55,5 ha (± 25,5 ha) dont surface en herbe : 30,0 ha (± 15,5 ha) |
| Taille du troupeau | 65,0 vaches laitières (± 26,5) représentant 71 % des UGB totales de l'élevage |
| Races | Prim Holstein (68 %) et 4 autres races pour les autres troupeaux |
| Quota de production | 495 100 L (± 199 700 L) référence MG : 39,5 g/L (± 6,5 g/L) |
| Quantité de lait produit | 7 710 Lvache (± 860 L) à TB de 41,3 g/L et TP de 33,3 g/L |

► LES FOURRAGES

Les fourrages conservés :
Les stocks fourrages sont importants : **4,7 t MS/UGB/an (± 0,8 t MS)**. Ils sont constitués aux 3/4 d'ensilage de maïs. Des résiduels (chêne, fenilages et foin) sont peu représentés. Ces fourrages conservés sont utilisés pendant l'hiver et durant la période estivale durant laquelle le pâturage n'est pas exploité dans plusieurs des régions concernées.

Le pâturage :
Les données proviennent de 6 exploitations de plusieurs régions parmi les 41 élevages des Réseaux. Une mise à l'herbe précoce, pour déprimage, à parfois lieu à mi-mars selon les régions. Au printemps les vaches pâturent de début-avril à début juin avec un complément de maïs ensilage de 2,5 kg MS/jour dans une exploitation sur deux (Aquitaine, Poitou-Charentes). Utiles les vaches pâturent de juillet à fin août-début septembre et reçoivent régulièrement du fourrage complémentaire en zones sèches (1,5 kg MS/jour) ; ceci n'est pas indispensable dans les régions mieux arrosées. À l'automne les troupeaux de régions à climat doux et humide (Haute-Normandie) peuvent pâturer de début septembre à fin-octobre ; le pâturage est alors accompagné d'ensilage de maïs (en moyenne 3,5 kg MS/jour).

► LES ALIMENTS CONCENTRÉS

Quantité totale de concentrés : 1 670 kg/vache (± 480 kg) soit 240 g de concentré/L de lait (± 60 g/L). Les aliments concentrés se répartissent en :
 > 12 % de matières premières prélevées sur l'exploitation et 88 % d'aliments achetés,
 > 82 % de matières premières distribuées (prélevées ou achetées) et 18 % d'aliments composés.

Les aliments composés représentent presque autant que les tourteaux parmi les aliments achetés : parmi les aliments composés ceux de type VL se répartissent à 50 % entre ceux de production à 16-22 % de protéines et 50 % de correcteurs protéiques à 40 % MAT.

Les coproduits sont présents à plus de 10 % dans ces élevages. Un quart des élevages utilisent de la pulpe de betterave (Picardie - Nord Pas-de-Calais) ou de la drêche de brasserie (Alsace).

► UN EXEMPLE DE CALENDRIER ANNUEL D'ALIMENTATION
« SYSTÈME EN CÔTEAUX SECS ARGILO-CALCAIRES - VALLÉES ET TERRASSES DU SUD-OUEST »

Concentrés 1 205 kg VL/an 170 g/L lait

1^{er} avril, 20 juin, 1^{er} novembre

Foin 570 kg MS, Pâturin 1280 kg MS, Ensilage d'herbe 1 040 kg MS, Ensilage de maïs 3 550 kg MS

Source : "Systèmes bovins laitiers du Sud-Ouest, Référentiels issus du collectif Optilait et des Réseaux d'élevage, 2007".

.../... Elevages spécialisés lait de Plaine avec plus de 30% de maïs dans la surface fourragère hors Grand-Ouest

Cows: Types and amount of concentrates used

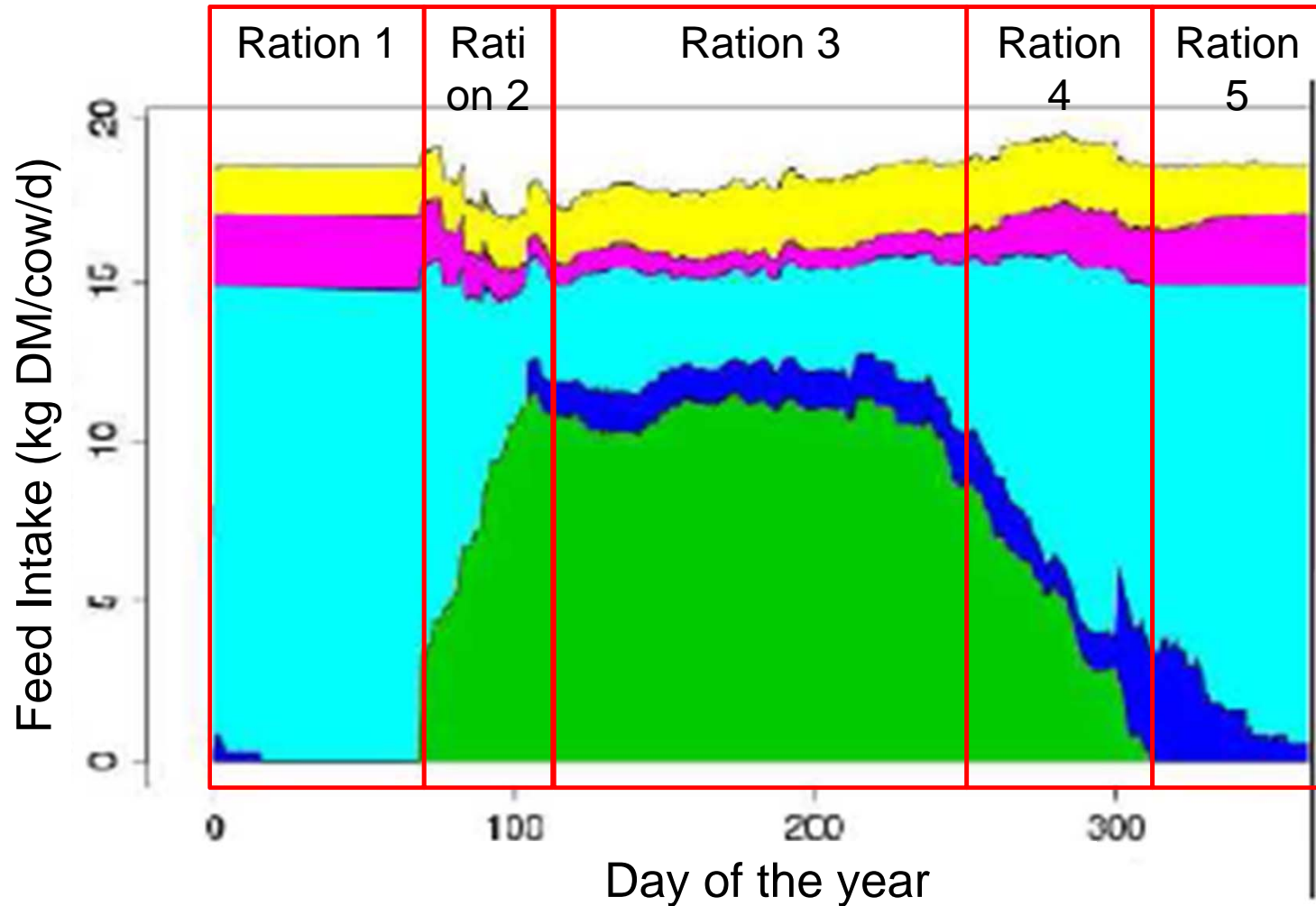
Cows : example of feeding calendar

15 diets of different model farms in different parts of France

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A complex description of the intake: simplification with a sequence of diet



Simulation using model farms to study N efficiency Protein selfsufficiency and emissions in different farming systems



1/ Translation of the feeding system description in CowNex to be consistent with global feed use data



2/ Simulation of the model farms and adaptation with CowNex

- Effect of age at first calving
- Comparison of model dairy farms
- Effect of protein supplementation on several model farms

Cows-Vaches

| | Diet 1 (75 Day) | | Diet 2 (60 Day) ✗ | | Diet 3 (88 Day) ✗ | | Diet 4 (76 Day) ✗ | | Diet 5 (62 Day) ✗ | |
|-------------------|-----------------|-----|-------------------|-----|-------------------|-----|-------------------|-----|-------------------|-----|
| | DM (kg/day) | % | DM (kg/day) | % | DM (kg/day) | % | DM (kg/day) | % | DM (kg/day) | % |
| FreshGrass | | 100 | | | | | | 100 | | 100 |
| MilkP-LaitP | | | | | | | | | | |
| MaizeS-EMais | | | 7 | | | 65 | | | | |
| Straw-Paille | | | | | | | | | | |
| SMB-Tt_Soja | | | 1 | | | 10 | | | | |
| Barley-Orge | 4 | | | | | 20 | 4 | | 4 | |
| Grass Silage | | | | | | | | | | |
| BRE | | | | | | | | | | |
| Foin | | | | 100 | | 5 | | | | |
| Total | 4 | 100 | 8 | 100 | 0 | 100 | 4 | 100 | 4 | 100 |
| Time outdoors (h) | | 20 | | 0 | | 0 | | 20 | | 20 |



Whole herd analysis : effect of age at first calving



- Virtual Farm with 100 cows high maize use, high producing cows (9700 kg milk) and group calving
- All heifers are reared with high replacement rate
- Replacement rate has little effect on N meat or milk efficiency

| Variable | 2 years | 3 years |
|---------------------|---------|---------|
| Cows | 100 | 100 |
| Heifers | 84 | 133 |
| Calves | 13 | 13 |
| Feed use (t/y) | 998 | 1199 |
| Conc use (t/y) | 195 | 203 |
| N intake (kg/y) | 24380 | 29399 |
| N Meat (kg/y) | 622 | 745 |
| N Milk (kg/y) | 5109 | 5119 |
| N Efficiency % | 23.7 | 20.0 |
| N milk efficiency % | 27.3 | 27.3 |
| N meat efficiency % | 9.9 | 6.3 |
| N Self sufficiency | 70.2 | 73.3 |



Example of 6 specialize dairy farms

- Farms of plain regions

| Forage system | West | Other regions |
|-------------------|---------------|---------------|
| >30% ha maize | Maize W | Maize E |
| 10%< ha maize<30% | Maize Grass W | Maize Grass E |
| >10% ha maize | Grass W | Grass E |



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Comparison of dairy systems

| | | OTHER REGIONS | | | WEST | |
|----------------------|---------|---------------|---------|---------|---------------|---------|
| Annual results | Maize E | Maize Grass E | Grass E | Maize W | Maize Grass W | Grass W |
| Total Diet DM (kg) | 7047 | 6756 | 6108 | 6791 | 6327 | 5732 |
| Total Diet N(kg) | 187 | 181 | 152 | 165 | 163 | 142 |
| CP annual diet | 166 | 168 | 156 | 152 | 161 | 155 |
| Milk (kg) /cow | 8169 | 7500 | 6334 | 7827 | 6786 | 5608 |
| Self sufficiency(DM) | 76% | 82% | 89% | 87% | 88% | 94% |
| Self sufficiency(N) | 49% | 57% | 78% | 67% | 73% | 79% |



Comparison of dairy systems

| | | OTHER REGIONS | | | WEST | |
|----------------------------|---------|------------------|---------|---------|------------------|---------|
| Annual results | Maize E | Maize Grass E | Grass E | Maize W | Maize Grass W | Grass W |
| N Milk (kg) | 44.2 | 40.6 | 32.5 | 42.3 | 37.8 | 30.4 |
| N Faeces (kg) | 61.8 | 62.0 | 54.2 | 59.5 | 56.3 | 52.0 |
| N Urine (kg) | 80.2 | 78.7 | 64.9 | 62.5 | 68.7 | 57.8 |
| N excreted (kg) | 142 | 141 | 119 | 122 | 125 | 110 |
| N Efficiency | 23.6% | 22.4% | 21.4% | 25.7% | 23.1% | 21.4% |
| Kg NH ₃ /T milk | 4.9 | 4.0 | 1.8 | 2.2 | 3.4 | 1.7 |
| % Controllable | 69% | 63% | 48% | 58% | 56% | 47% |

Impact of indoor protein supplementation on emissions



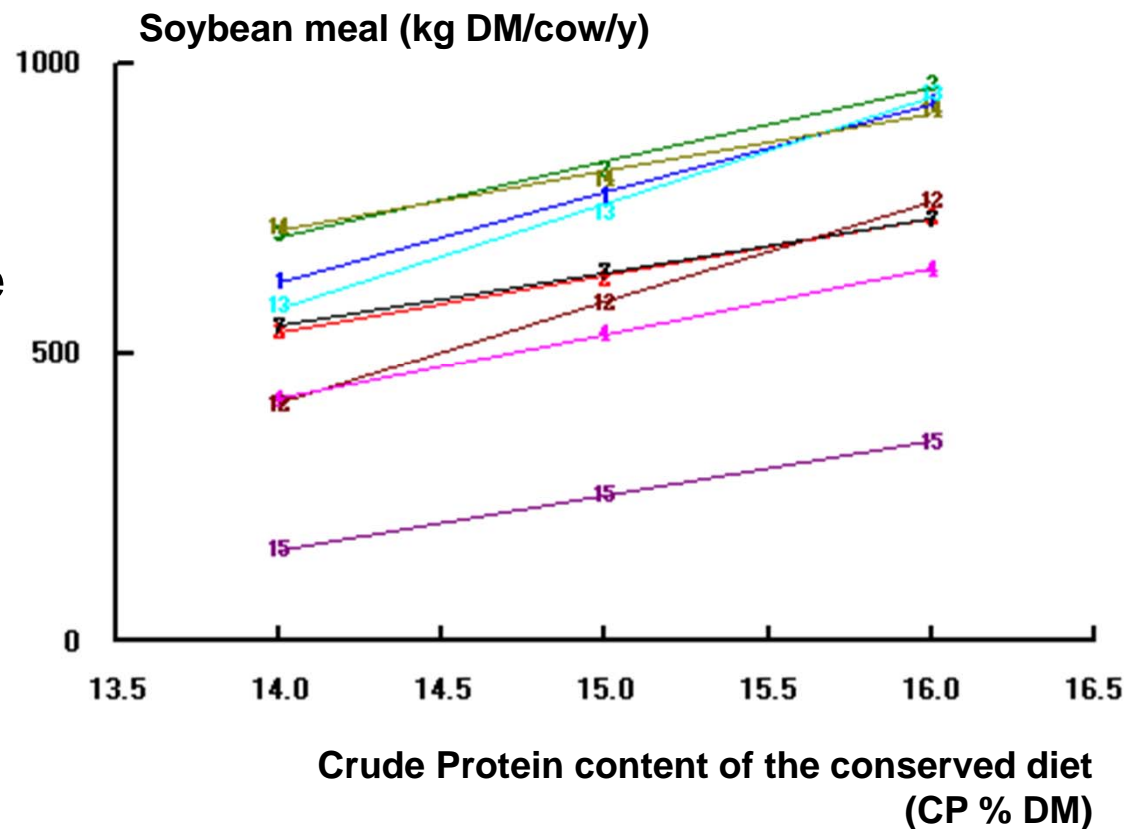
- Comparaison of different protein supplementations in dairy systems using large amount of soyabean meal (dairy specialized and crop-dairy systems). Calcul on dairy cows only.
 - 14% CP
 - 15% CP
 - 16% CP
- Collection of CowNex output to calculate NH_3 and N_2O emission using the EMEP/EEA european reference method and national database to describe housing and manure management systems

| | A | B | C | D | |
|----|-----------------------|-------------|-------------------|--------------|-----|
| 1 | equations/lots | Cows-Vaches | Heifers-GÃ©nisses | Calves-Veaux | Her |
| 14 | MaizeS-EMais N | 17.9361614 | 0 | 1.208880048 | |
| 15 | Straw-Paille N | 0 | 1.884728099 | 0 | |
| 16 | SMB-Tt_Soja N | 20.29854541 | 6.946569279 | 0 | |
| 17 | Barley-Orge N | 23.6938453 | 0 | 4.064640162 | |
| 18 | Grass Silage N | 0 | 7.538912283 | 0 | |
| 19 | BRE N | 0 | 0 | 0 | |
| 20 | Foin N | 10.00888089 | 0 | 0 | |
| 21 | Total Diet MS(input) | 7510.849093 | 3339.256725 | 547.5000218 | |
| 22 | Total Diet N(input) | 181.8897581 | 91.28261772 | 13.78824055 | |
| 23 | CP | 151.3558553 | 170.8513025 | 157.4 | |
| 24 | | | | | |
| 25 | N intake(dm) | 757036.8075 | 446261.8916 | 6956.097832 | |
| 26 | N intake(n) | 18333.11255 | 12199.10807 | 175.1823678 | |
| 27 | N produced(dm) | 732255.5584 | 435017.3779 | 4173.658699 | |
| 28 | N produced(n) | 16287.17263 | 11270.76101 | 67.00113432 | |
| 29 | N imported(dm) | 24781.24906 | 11244.51375 | 2782.439133 | |
| 30 | N imported(n) | 24781.24906 | 11244.51375 | 2782.439133 | |
| 31 | Self efficiency(dm) | 96.72654634 | 97.48028815 | 60 | |
| 32 | Self efficiency(n) | 88.8401933 | 92.39004155 | 38.24650572 | |
| 33 | | | | | |
| 34 | N Milk | 45.29550802 | 0 | 0 | |
| 35 | N Meat | 5.51291129 | 3.936631399 | 0.629798532 | |
| 36 | N Feaces | 67.68911106 | 25.50556371 | 3.854400153 | |
| 37 | N Urine | 67.34937134 | 61.42919758 | 2.921911558 | |
| 38 | Total Diet N (output) | 181.8897581 | 91.28261772 | 13.78824055 | |
| 39 | N Efficiency | 27.93363399 | 4.312575052 | 4.567649725 | |
| 40 | | | | | |
| 41 | totalExcretion | 13610.85815 | 11618.05582 | 86.09440244 | |
| 42 | Collectable feaces | 2572.289909 | 866.2873052 | 48.97092874 | |
| 43 | Collectable urine | 1597.906984 | 1249.659492 | 37.1234737 | |
| 44 | Collectable total | 4170.196893 | 2115.946797 | 86.09440244 | |
| 45 | Uncollectable feaces | 4250.260765 | 2542.303901 | 0 | |
| 46 | Uncollectable urine | 5190.400494 | 6959.80512 | 0 | |
| 47 | Uncollectable total | 9440.66126 | 9502.109021 | 0 | |
| 48 | % Controlable | 30.63875067 | 18.21257214 | 100 | |
| 49 | | | | | |

Relationship between the use of simulated soybean meal use per year and the protein content of the winter diet



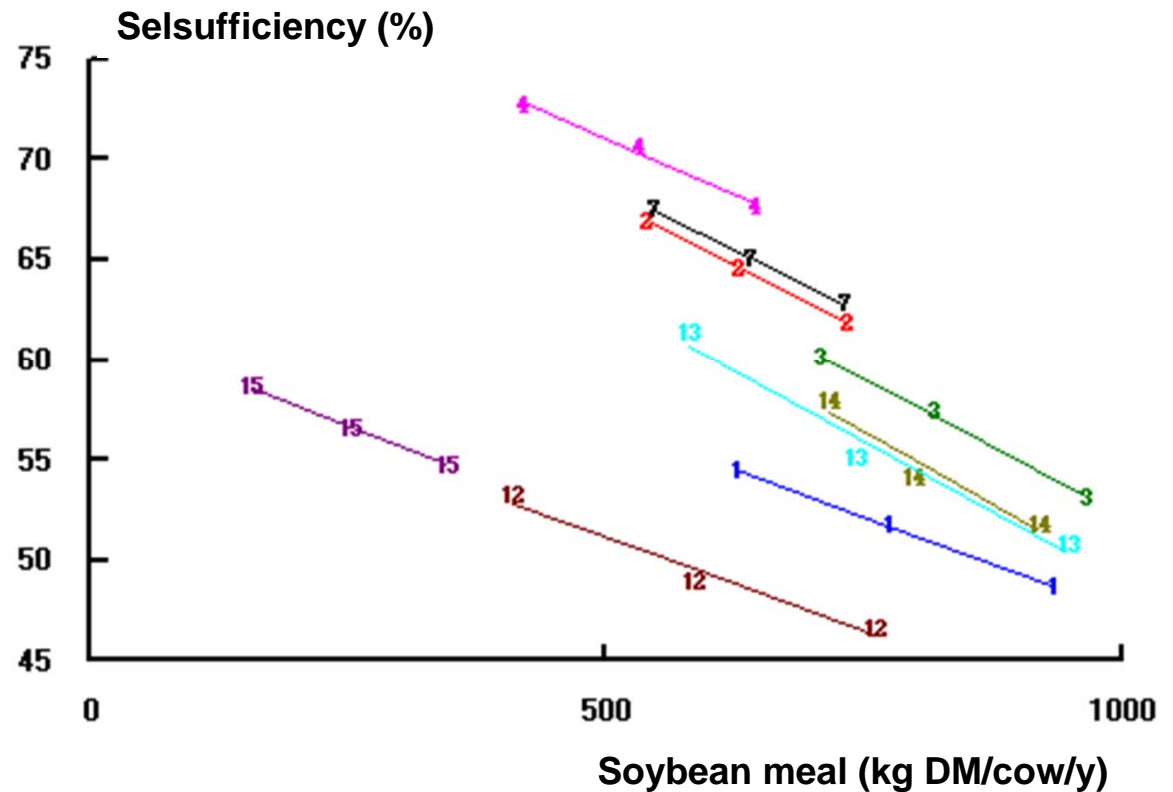
The soybean meal use increases of about 130 kg DM per 1 point more of crude protein in the conserved diets





Protein Dairy Farm selfsufficiency

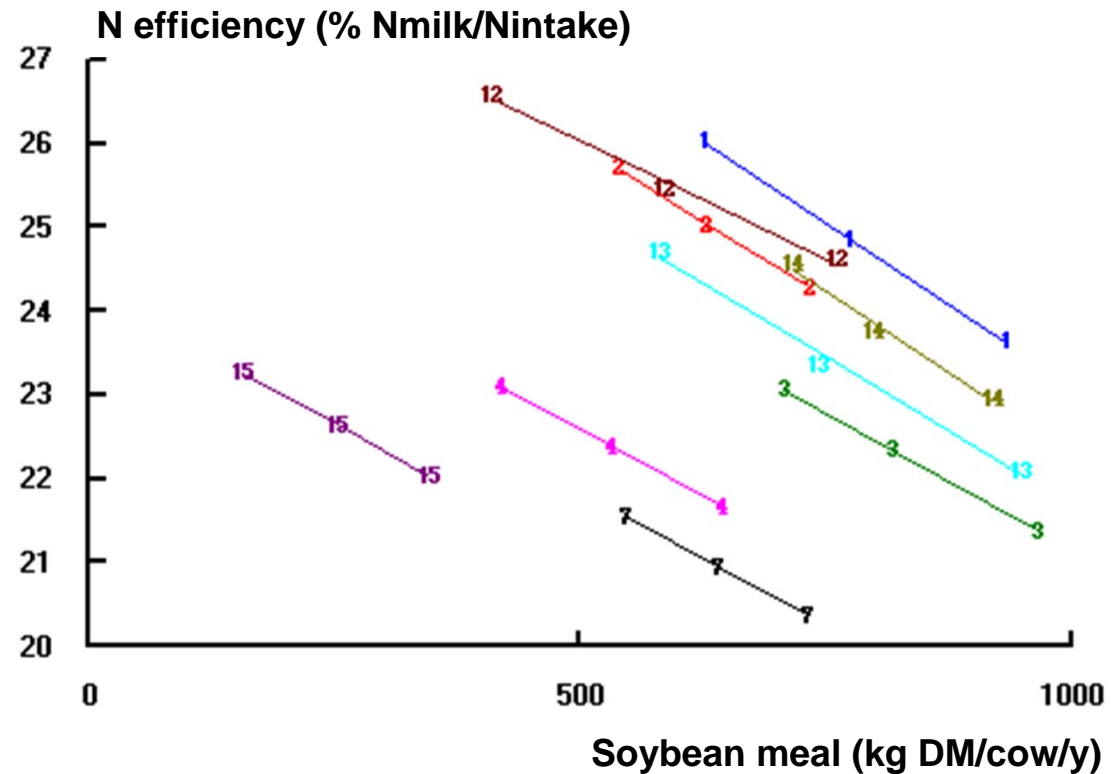
Protein Selfsufficiency of dairy herds decreases of 2.4 per 100 kg DM additional soybean meal.



Nitrogen efficiency decreases with nitrogen supplementation



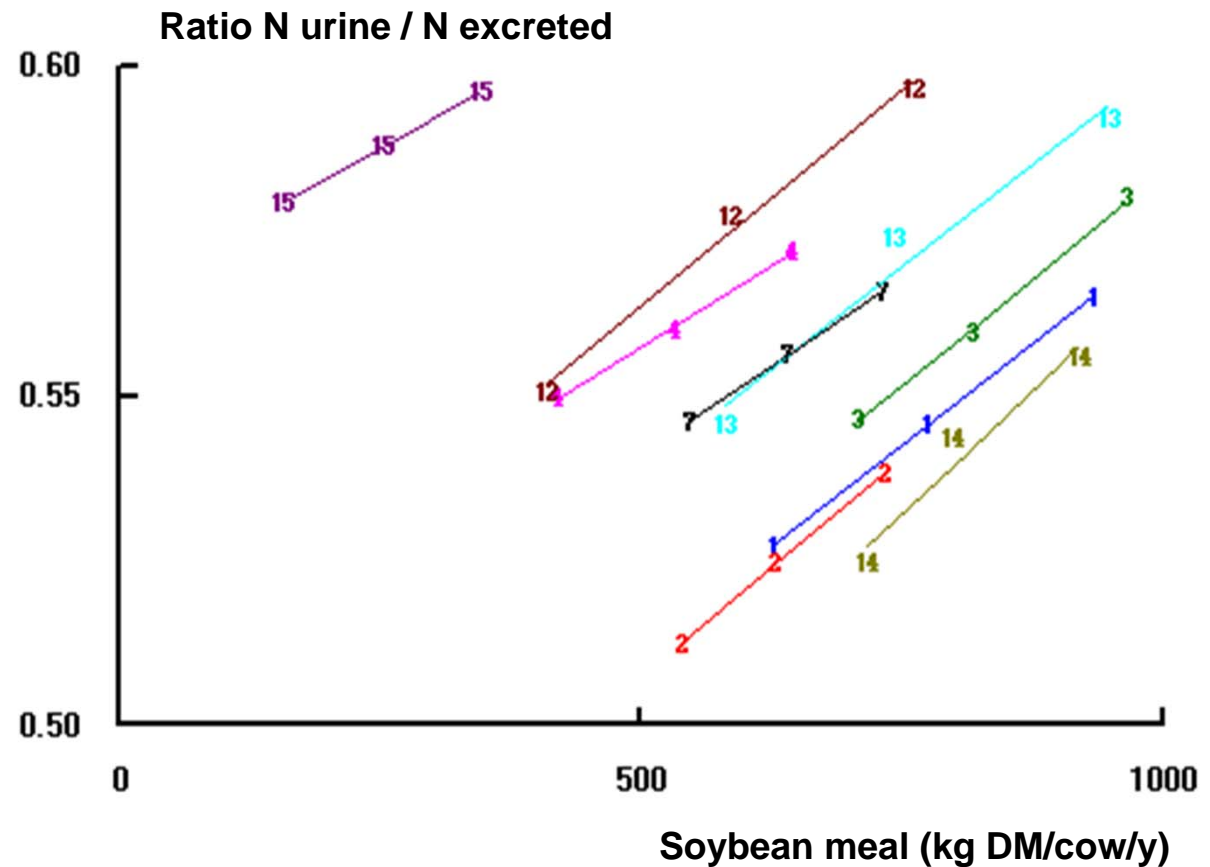
Efficiency of nitrogen utilization by the dairy cows decreases by 0.68 for 100 kg DM additional soybean meal, but varies largely with the farming system



The urine part of nitrogen excretion increases with protein supplementation



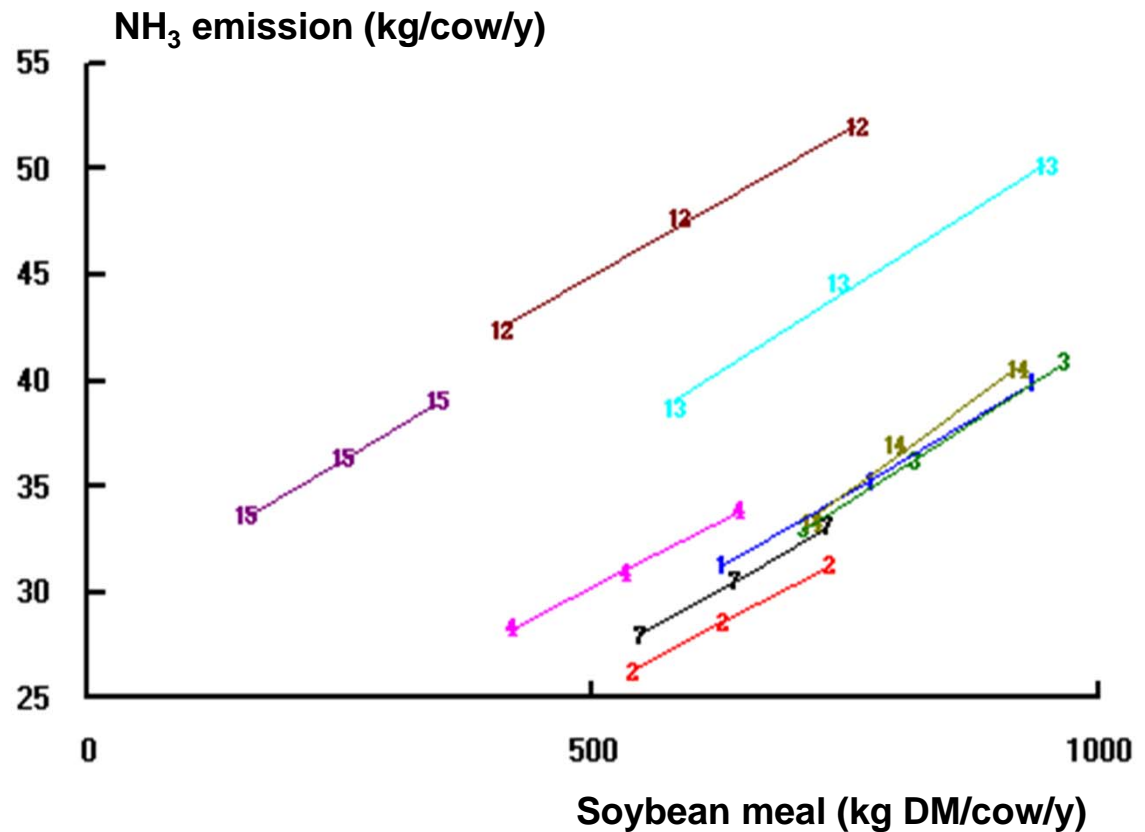
Urine N fraction increases of about 1.2 % with 100 kg DM additional soybean meal



Protein supplementation and ammonia losses



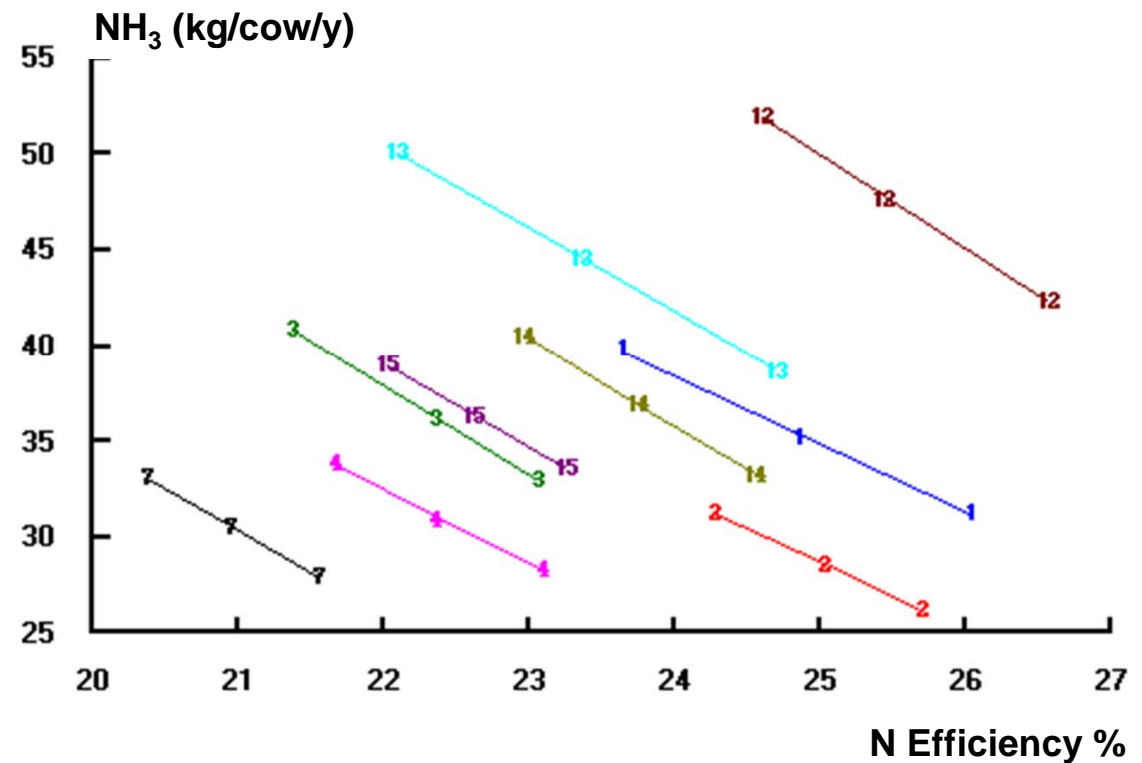
N ammonia increases of 2.9 kg per 100 kg DM Soybean Meal per cow per year, or 3.5 kg ammonia. (NH₃ emissions including manure spreading, inventory methods)





N efficiency and ammonia emission

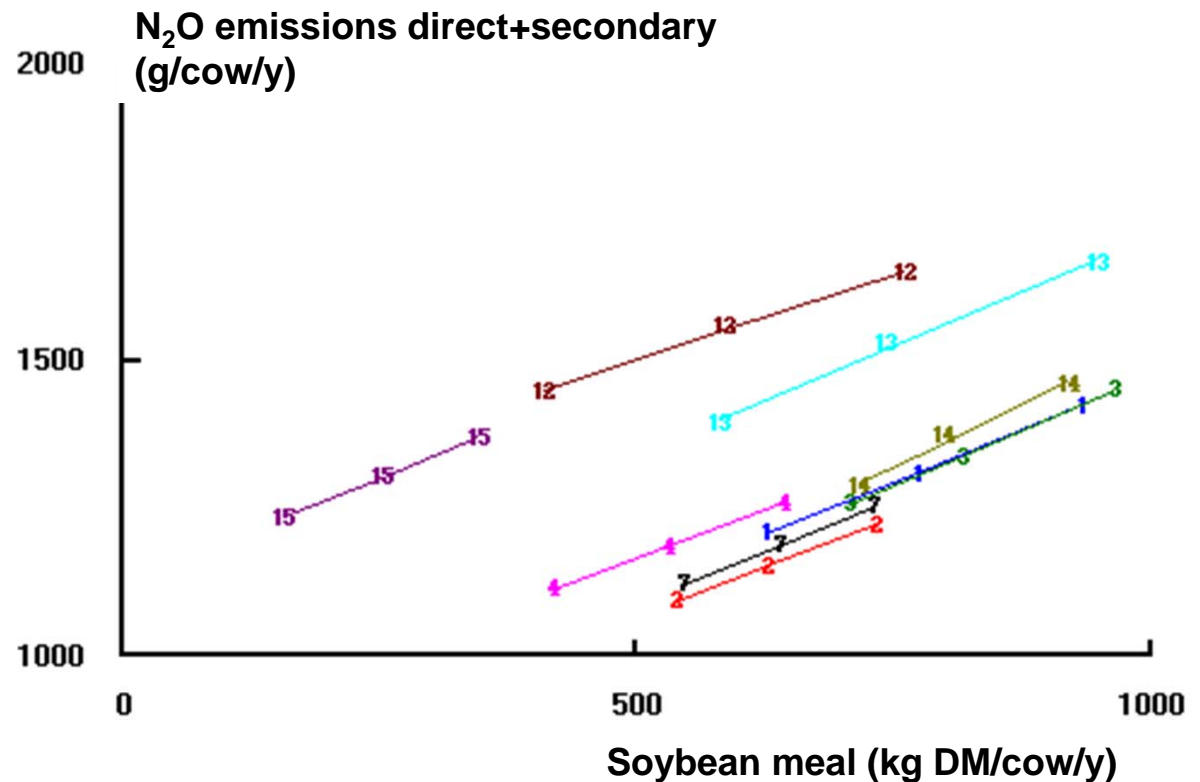
Ammonia emissions increases when N efficiency decreases within a system, but the relationship between farming systems is less clear, the time spent indoor being an important factor



Greenhouse gas emissions increases with protein supplementation



The GHG emissions increases of 70.5 kg CO₂ equivalent for 100 DM additional soybean meal due to an increase in N₂O emissions





Conclusions

- CowNex is a simple tool to assess quickly the efficiency of N use at herd level
- Increase age at first calving decrease N efficiency of meat
- If maize systems could theoretically better balance protein supplementation, it is not always observed in practice and they are less protein selfsufficient
- Protein supplementation is an important lever to control protein selfsufficiency, nitrogen excretion and environmental impacts of dairy farming system
- Time spent indoor increases the risks of ammonia emissions
- In many systems, there is economic and environmental benefit to pay attention to the protein supplementation



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Thank you for your
attention

It does not necessarily reflect its view and in no way anticipates the Commission's future policy in this area.

