Nitrogen excretion and ammonia emissions in dairy cows fed low-N fresh grass and maize silage

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EMIGRAZE project

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Introduction

- **Dairy farm sustainability =**

↘ environmental impacts
N losses as water and atmospheric pollution sources
(Castillo *et al.*, 2000; Lesschen *et al.*, 2011)

↗ feed self-sufficiency

} More forage in dairy cow diet

Fresh grass = Low-cost on-farm feed, interesting feeding value, grasslands = environmental services

(European Environment Agency, 2019; Delaby *et al.*, 2020)

BUT availability and composition variable along the year

Frequently associated with conserved forages

 + 

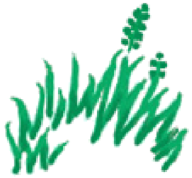
Fresh grass + Maize silage → Effects on cow N utilisation and losses ???

What are the effects of increasing maize silage proportion in
a fresh grass diet on cow nitrogen excretion, efficiency and NH_3 emissions ?

Material & Methods – Dietary treatments and feeding

Four maize silage proportions in a fresh grass (ray-grass) diet

Treatments

	
0 %	100 %
17 %	83 %
34 %	66 %
51 %	49 %

(DM basis)

7 lactating Holstein cows, Latin square **4 diets** x 3 periods of 3 weeks

WITHOUT concentrate

Individual indoor feeding, in tie stall
Fresh grass cut daily, accessible during the day (8 am to 6 pm)
Maize silage accessible during the night (6 pm to 8 am)

→ **% of each feed**: check daily

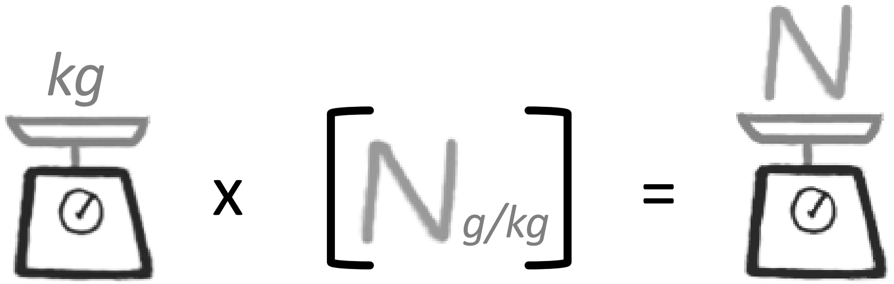
***Ad libitum* feeding** (> 10% of refusals), at least one *ad libitum* feed:

"if the maize proportion in the ingested diet was insufficient, maize silage was *ad libitum* and fresh grass distribution was restricted"

Material & Methods - Measurements

Measurements for each cow:

- Feed intake
- Milk production
- Faeces and urine excretion (total collection)



→ **Nitrogen concentration:** Feeds, refusals, milk, faeces, urine

→ **N intake, N in milk, faecal and urinary N excretion** (g/day)

→ **N efficiency** = N milk (g/day) / N intake (g/day)

Slurry reconstitution: mixing faeces and urine in proportion to their excretions

→ **Total ammonia nitrogen (TAN)**

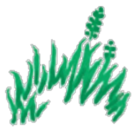
→ **Potential NH_3 emission estimated** from the **TAN excretion x 0.24**

(emission factor for dairy cattle housing, for slurry, EMEP/EEA national inventory guidelines 2019)

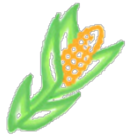
Low to very low-N diets affecting intake and milk production

	Maize silage % in the diet (DM basis)				
	0	**17**	**34**	**51**	RSD
Diet CP concentration (g/kg DM)	107[a]	99[b]	92[c]	85[d]	4.1
	Low →			**Very low**	

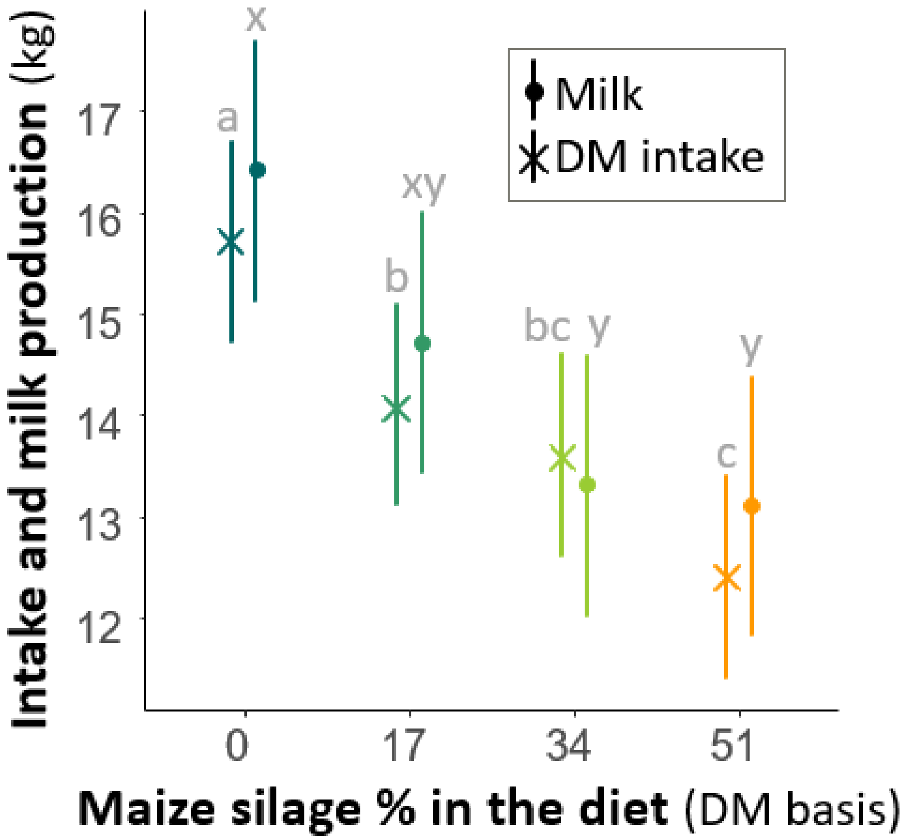
Different letters per row = significative difference with *P*<0.05; RSD= residual standard deviation



Very low grass crude protein (CP) concentration



With increasing % of maize silage without protein-rich concentrate

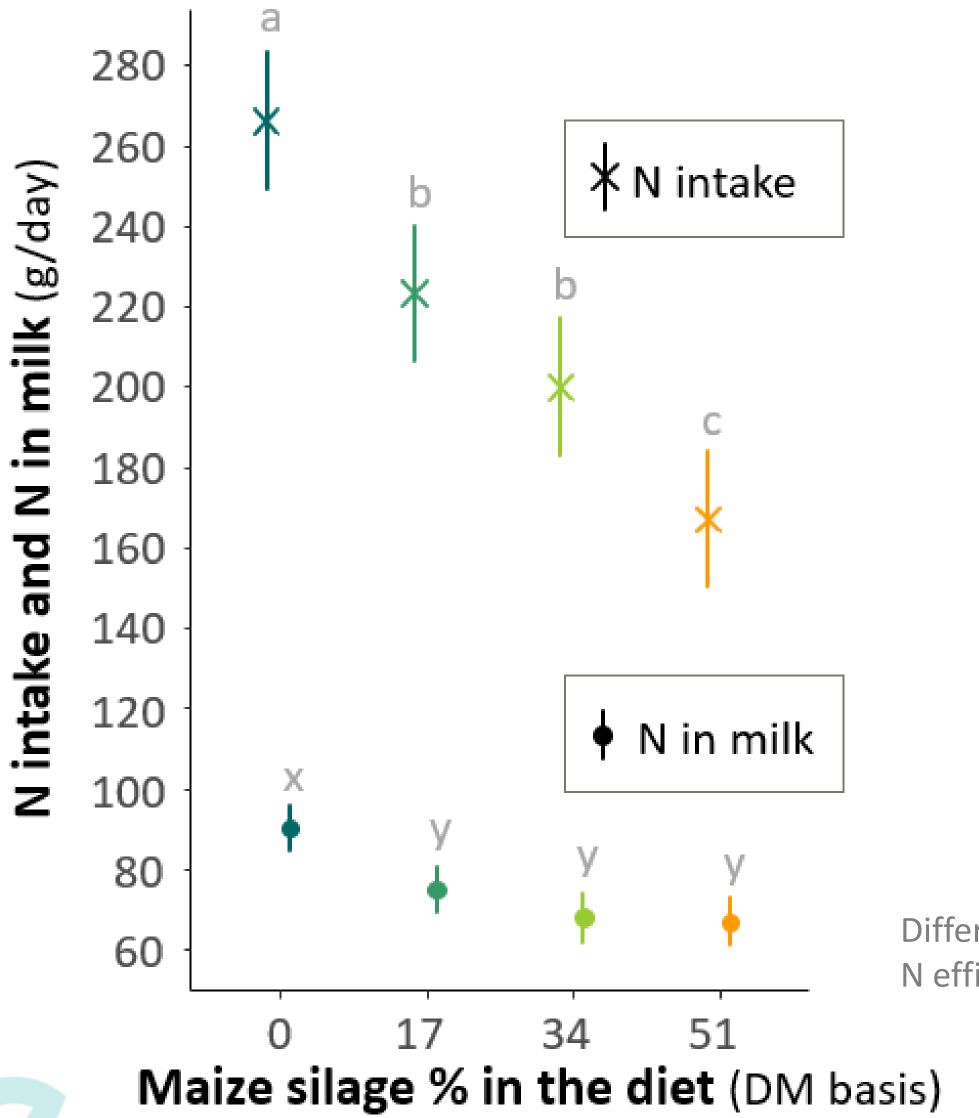


a, b, c = *P* value intake < 0.05 ; x, y = *P* value milk < 0.05

With ↗ maize silage proportion:

- Intake ↘, due to diet CP concentration ↘ (Faverdin *et al.*, 2003)
- Milk ↘, due to intake ↘

Nitrogen in milk and efficiency



a, b, c = *P* value N intake < 0.05 ; x, y = *P* value N milk < 0.05

With ↗ maize silage proportion:

- N intake ↘
- N milk ↘ quadratically
- N milk ↘ less than N intake

	Maize silage % in the diet (DM basis)				
	0	17	34	51	RSD
N efficiency (%)	33^{a}	33^{a}	34^{a}	40^{b} **+ 6%**	2.9

Different letters per row = significative difference with *P*<0.05; RSD= residual standard deviation
N efficiency = N milk / N intake

Nitrogen excretion and partition

	Maize silage % in the diet (DM basis)					
	0	17	34	51	RSD	
Faecal N (g/day)	103^{a}	90^{b}	87^{b}	75^{c}	7.2	↘
Urinary N (g/day)	68^{a}	60^{b}	53^{b}	44^{c}	5.5	↘
N excreted (g/day)	171^{a}	150^{b}	140^{b}	119^{c}	8.0	↘
Urinary N as % of N excreted	40	40	38	38	3.0	=

Different letters per row = significative difference with *P*<0.05; RSD= residual standard deviation

+ 10% of maize silage in the diet =

N intake
- 20 g N/day

Urinary N
- 4.8 g N/day

Faecal N
- 5.4 g N/day

With ↗ maize silage proportion:

- Faecal N ↘, due to DM intake ↘
- Urinary N ↘, due to N intake ↘

(Castillo *et al.*, 2000; Peyraud and Delaby, 2006; Spanghero and Kowalski, 2021)

Total ammonia N (TAN) excretion and NH3 emission

	Maize silage % in the diet (DM basis)					
	0	17	34	51	RSD	
TAN excreted (g/cow/day)	34.9[a]	26.3[ab]	24.2[b]	22.6[b]	6.46	↘
NH3-N emissions (g/cow/day) TAN × 0.24*	8.4[a]	6.3[ab]	5.8[b]	5.4[b]	1.55	↘

Different letters per row = significative difference with $P<0.05$; RSD= residual standard deviation
* Emission factor for dairy cattle housing, for slurry, European Environment Agency, 2019)

- TAN excreted and NH3-N emissions ↘ with ↗ maize silage proportion
- Very low NH3-N emissions (emission range ≈ 10 to 210 g/cow/day) (Hristov *et al.*, 2011; Bougouin *et al.*, 2016)
- TAN excreted in slurry ≈ **20% of N excreted** in faeces + urine
  EMEP/EAA estimates TAN in slurry as **60% of N** in faeces + urine

→ Overestimation of TAN by EMEP/EEA methodology for low-N diet ?

Edouard *et al.*, 2019: **TAN in slurry = 40 and 80% of N in faeces + urine**
for diets with low CP concentration (120 g/kg DM) vs high CP concentration (180 g/kg DM)

Conclusion

- ↗ **maize silage %** in unusually low-N grass diets induced **very N-deficient diets** on which **N efficiency was ↗** and **losses** to the environment **were minimal**

  We tested atypical diets for which cow responses were poorly known

- **TAN excreted as % of N excreted** in faeces and urine was **overestimated for very low-N diets** by actual national inventory guidelines.

  This estimation can be improved, considering the protein concentration of the diet

Ferreira M., Delagarde R., and Edouard N., 2022, Nitrogen flows in dairy cows fed various proportions of low-N fresh grass and maize silage, *In: Grassland Science in Europe: Grassland at the heart of sustainable food systems, European Grassland Federation*, 27, 566-568

Thank you for your attention !

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