

# Soil N balances and soil N dynamics under Irish dairy production systems



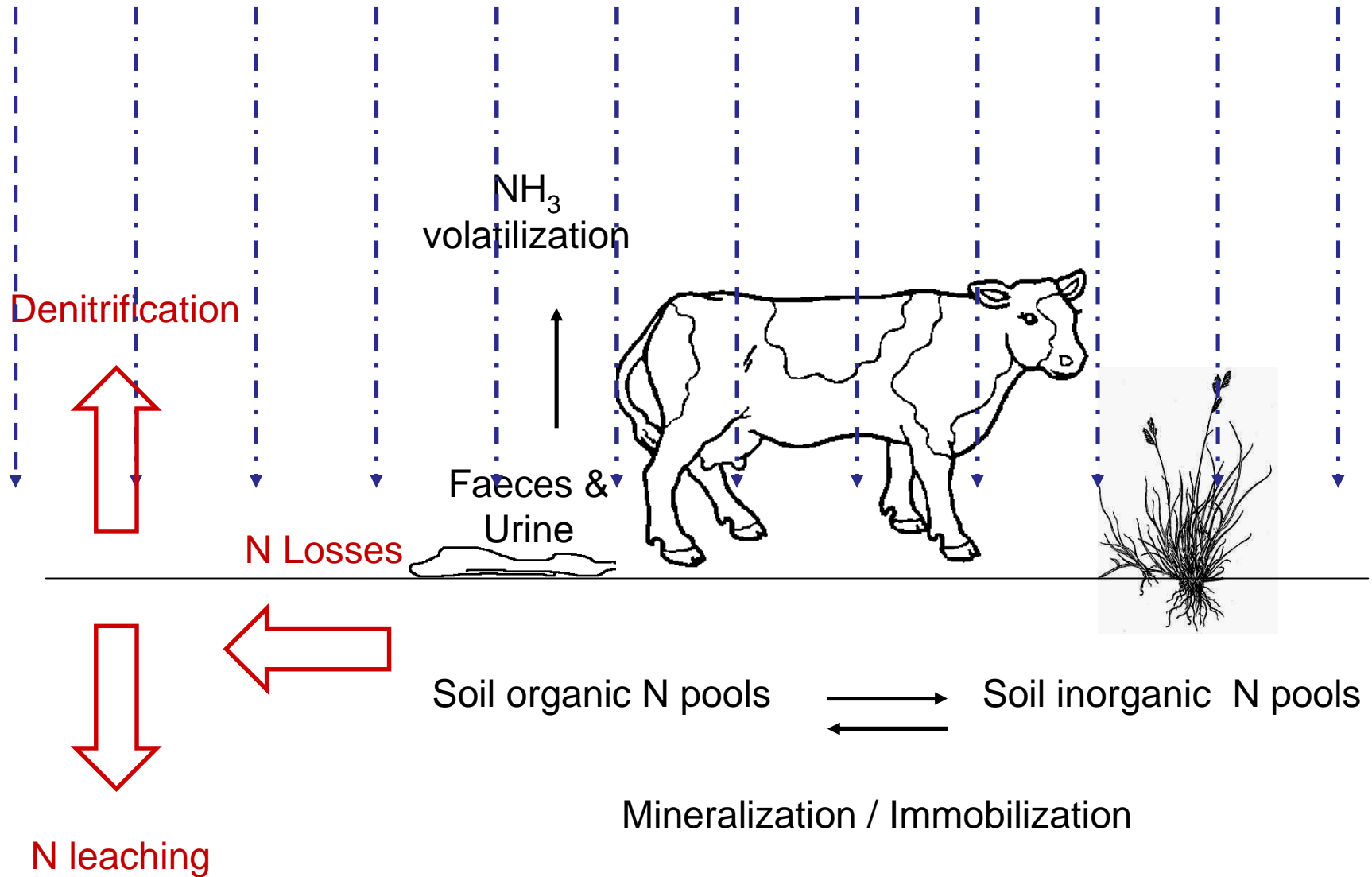
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# Background



# Objectives

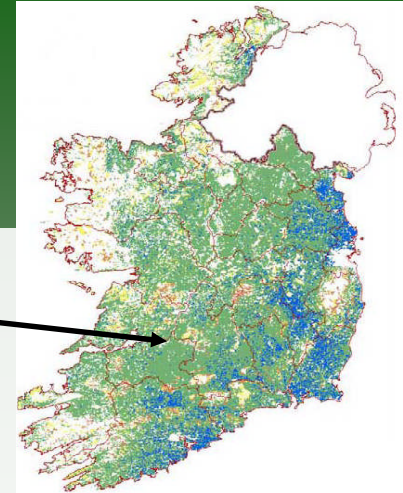
## Objectives:

- To quantify N losses through calculation of soil surface balances
- To evaluate the effect on soil soluble organic and inorganic content down to 0.9 m depth
- To determine the management and climatic factors affecting soil soluble N dynamics in a clay loam soil profile



# Site characteristics

- Solohead is a dairy research farm
  - Local climate: humid temperate oceanic (1018 mm, 9.8°C)
  - Growing season length: 305 days
  - Annual grass production rate: 11.5 t DM ha<sup>-1</sup>
  - Soils: Gleys (90%) and Grey Brown Podzolics (10%)
    - clay loam texture and low permeability
    - topsoil SOM, SOC and TN content was 6.48%, 4.48% and 0.48%
    - contain perched watertable (0 to 2.2 m bgl)
- => much of the farm remains seasonally wet, waterlogged or flooded due to impeded drainage





## Treatments: Dairy production systems

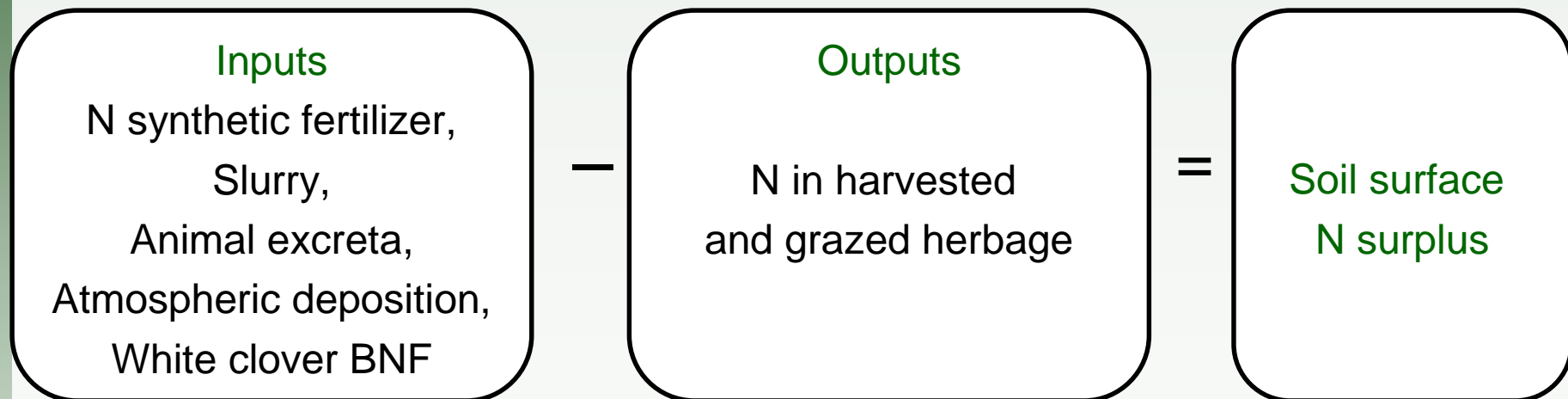
	Calving date	Stocking rate LU ha <sup>-1</sup>	Fertilizer N kg ha <sup>-1</sup>	Grazing season
Early spring calving with fertilizer (ES-100N)	17 <sup>th</sup> Feb	2.1	100	Feb – Nov
Early spring calving without fertilizer (ES-0N)	17 <sup>th</sup> Feb	1.6	0	Feb - Nov
Late spring calving without fertilizer (LS-0N)	17 <sup>th</sup> Apr	1.7 until 1 <sup>st</sup> Sept, then reduced to 1.2	0	Apr – Jan

# Methods



# Soil surface balances calculation

- Entries were chosen in correspondence with methodology of the OECD



- Surplus = ammonia volatilisation, denitrification, leaching losses + N accumulation into soil profile
- Balances were calculated for each paddock of the system for each year

## Quantities of :

- **Synthetic fertilizer and slurry** – recorded
- **N in animal excreta**- calculated as a difference between cows N intake and N output, accounting for a live weight change (Powell, 2006)
  - proportion excreted in each paddock estimated according a N° of grazing days
- **Atmospheric deposition** – measured using a rainfall collector *in situ*
- **White clover BNF in stolons, roots and stubble** estimated using a mechanistic model as described by Humphreys *et al.* (2008)
- **Herbage production** – pre-grazing and pre-harvesting herbage DM yields were measured by cutting four random strips at 5 cm
  - a subsample was freeze-dried, milled and analysed for N using LECO
  - **harvested and grazed herbage** - due to losses was estimated to be 90%



# Soil core sampling

- Soil BD - measured using the cylinder core method
- Soil cores for chemical analyses- taken 8 times during the study period
  - 15 cores per paddock taken using a hydraulic auger to a depth of 90 cm (0 to 30, 30-60, 60-90 cm)
  - bulked, crumbled and mixed to get a representative sample
  - subjected to extraction within an hour
- Extracts were obtained by shaking of soil with 2M KCl for three hours at a solution ratio of 2:1



# Soil core analyses

- Extracts were left to stand, filtered
  - analysed for Ammonium N,  
total oxidised N,  
and total soluble N
  - Soluble organic N = Total soluble N – Soluble inorganic N
- Results expressed on - DM basis using gravimetric soil moisture content or  
an area basis using BD data for each soil depth



# Statistical analyses

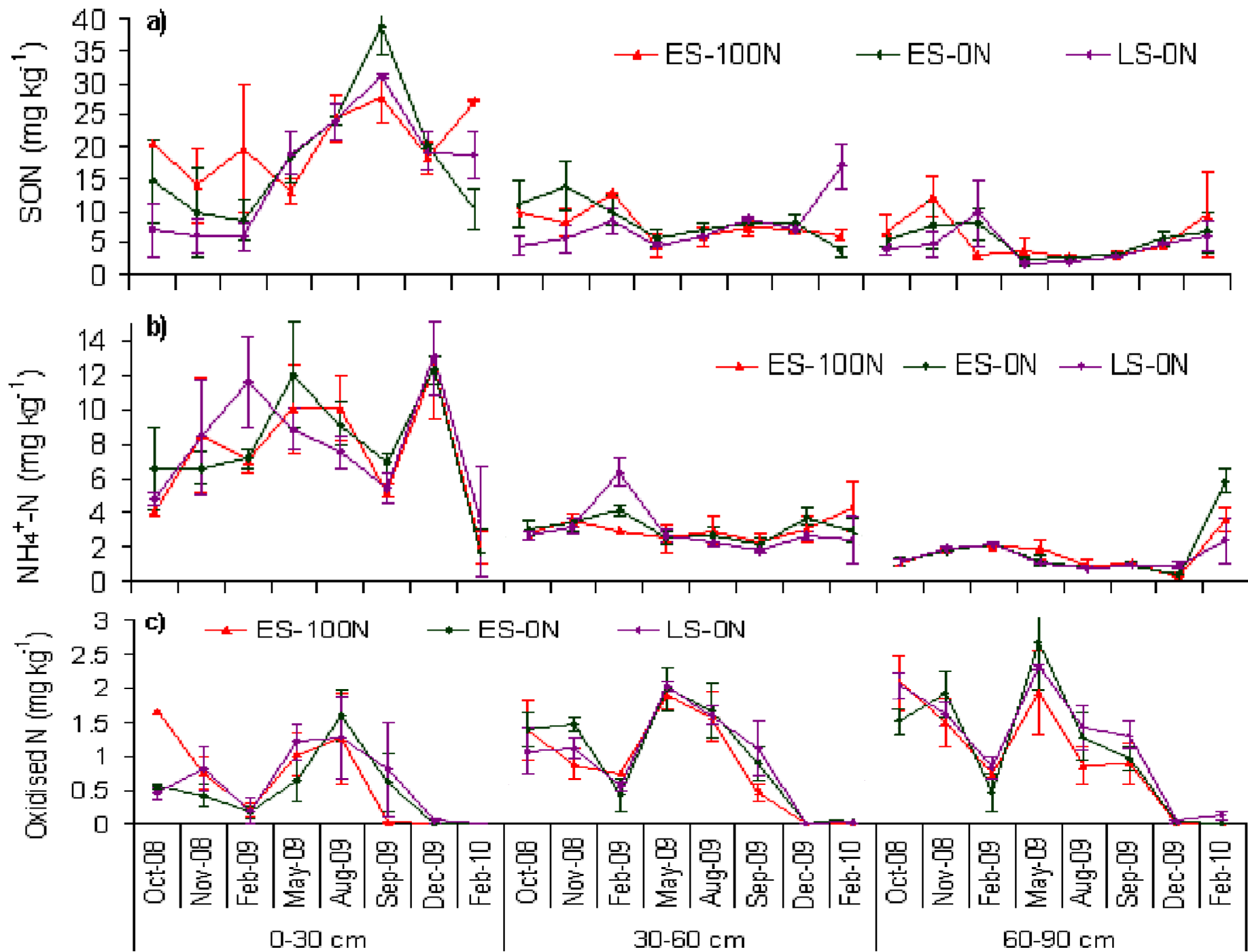
- Performed using SAS software
- The experimental unit of balances was a single paddock
- **N fluxes and N surplus** - two way analysis of variance (Proc Mixed)
  - fixed effects: system, year and system x year interaction
- **Soil N results** – three way analysis of variance (Proc Mixed)
  - fixed effects: system, sampling depth and their interaction
  - repeated measure: sampling date
- **Indicators affecting soil N** - using simple and multiple stepwise linear regression analyses (Proc Reg)

# Results

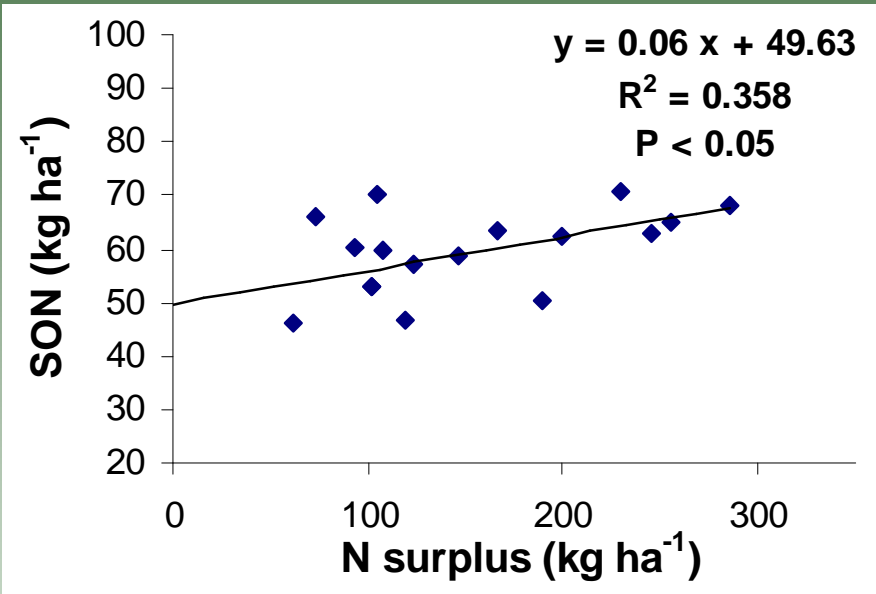
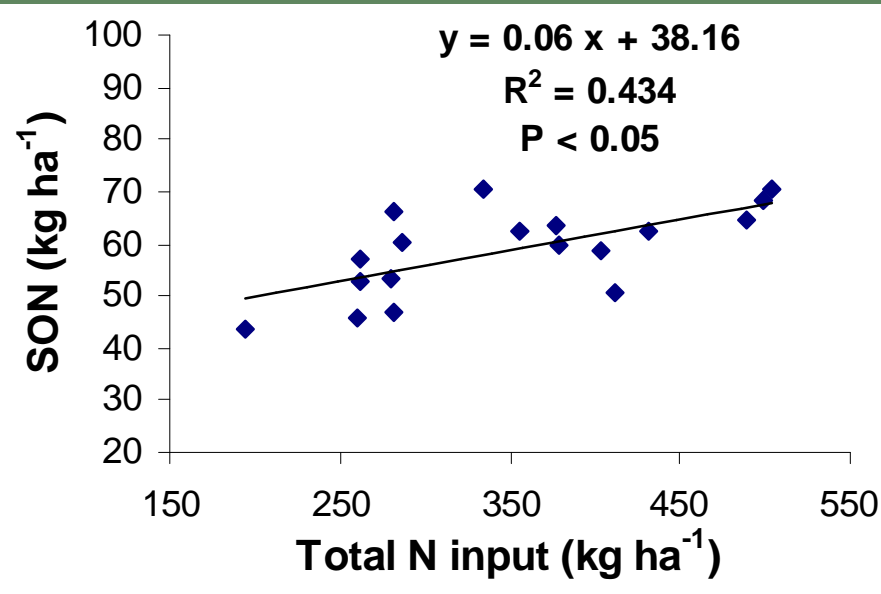


## Soil surface balances

<b>N flow (kg ha<sup>-1</sup>)</b>	<b>ES-100N</b>	<b>ES-0N</b>	<b>LS-0N</b>	System	Year	S x Y
<b>N input (kg ha<sup>-1</sup>):</b>						
N in synthetic fertilizer	100.0	0.0	0.0			
BNF	66.3 <sup>b</sup>	112.3 <sup>a</sup>	133.8 <sup>a</sup>	<0.05	NS	<0.05
N in excreta during grazing	119.2 <sup>a</sup>	95.2 <sup>ab</sup>	82.2 <sup>b</sup>	<0.05	NS	NS
N in slurry	109.1	109.0	103.0	NS	NS	NS
Atmospheric deposition	6.5	6.5	6.5			
total N input	401.2	322.8	325.2	<0.05	NS	NS
<b>N output (kg ha<sup>-1</sup>)</b>						
N in grazed grass	219.0 <sup>a</sup>	177.5 <sup>ab</sup>	147.2 <sup>b</sup>	<0.05	NS	NS
N in harvested grass	48.2	47.0	88.5	NS	NS	NS
N uptake by herbage	267.2	224.5	235.7	NS	NS	NS
N removed in herbage	240.5	202.0	212.2	NS	NS	NS
<b>N surplus (kg ha<sup>-1</sup>)</b>	160.7	120.8	113.0	NS	NS	NS
<b>N use efficiency (%)</b>	62.9	65.2	71.6	NS	NS	NS



# Factors affecting soils soluble organic N



# Factors affecting soil soluble inorganic N

Dependent variable (y)	Factor (x, z)	Relationship	Model R <sup>2</sup>	P value
Total oxidised N	gravimetric soil moisture (x)	$y = -0.01x + 1.77$	0.115	<0.05
	soil temperature (x)	$y = 0.12x - 0.30$	0.468	<0.0001
	rainfall (x)	$y = -0.18x + 1.62$	0.182	<0.001
	effective rainfall (x)	$y = -0.21x + 1.52$	0.353	<0.0001
	soil moisture deficit (x)	$y = 0.05x + 0.69$	0.270	<0.0001
	WFPS (x)	$y = -0.03x + 3.72$	0.279	<0.0001
Ammonium N	gravimetric soil moisture (x)	$y = 0.04x - 6.30$	0.717	< 0.0001
Soil inorganic N	gravimetric soil moisture (x) and soil temperature (z)	$y = 0.04x + 0.16z - 6.54$	0.699	<0.0001



# Conclusions

- BNF replaced an equivalent quantity of synthetic fertilizer so there was no difference in herbage production and potential for utilisation between the systems.
- The management of the systems resulted in a similar surplus and NUE, hence similar environmental pressure on an annual basis.
- The correlation between systems and N dynamics was difficult due to high buffering capacity of the soils.
  - Grazing over the winter had no effect on soil N dynamics.
- The grassland management factors influenced size of soil organic pool
- Soil inorganic N was mainly affected by the hydrological factors and soil temperature.

Thank you for your attention!