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

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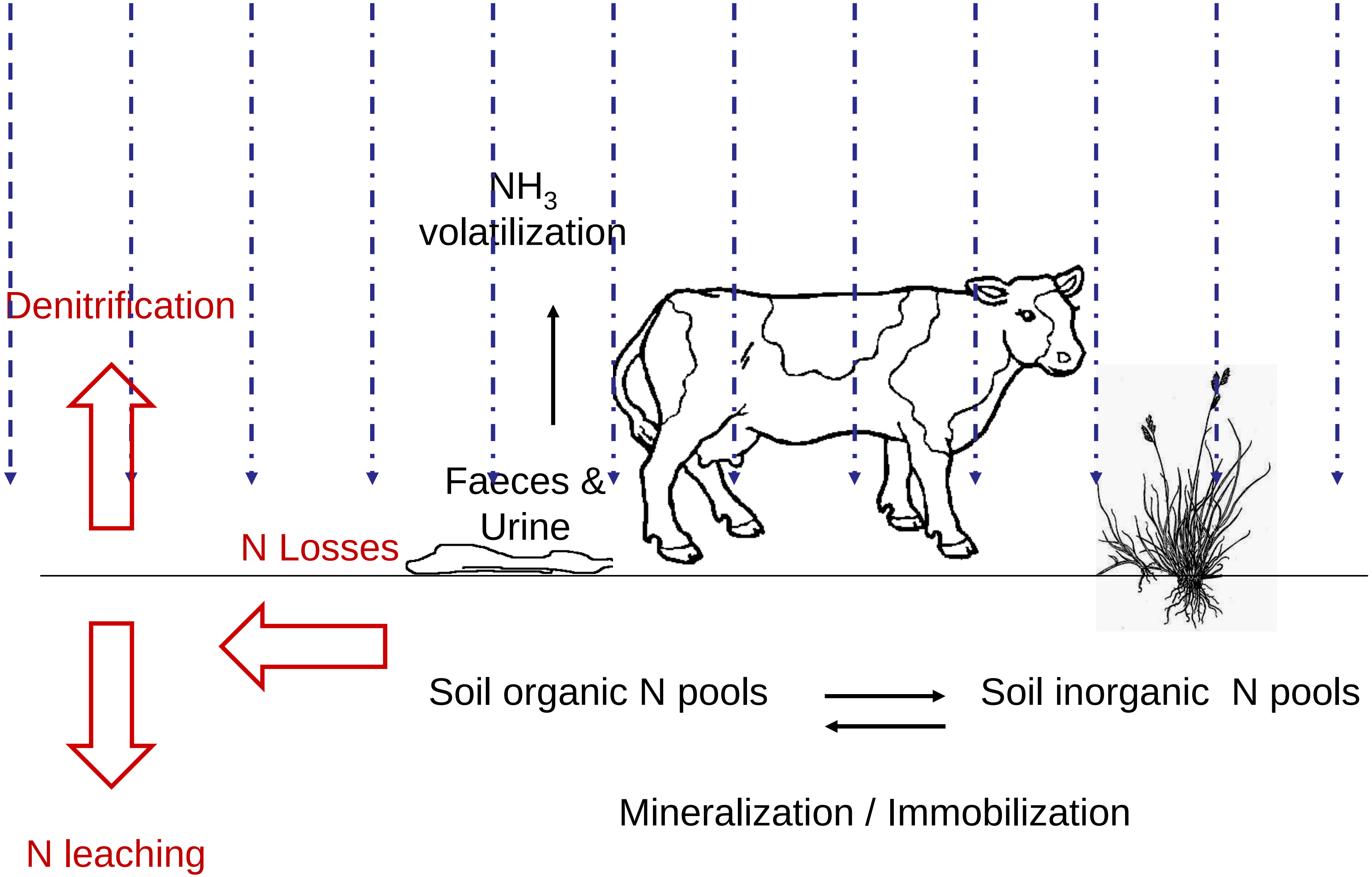
Background



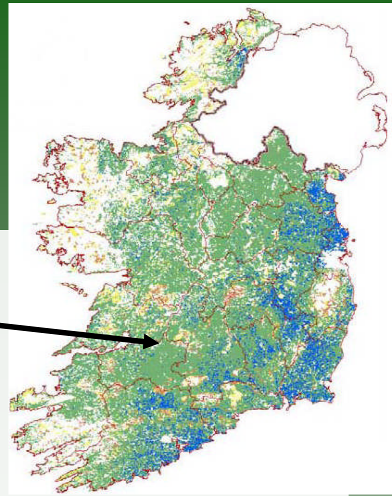
NH3 volatilization
Denitrification
Faeces & Urine
N Losses
Soil organic N pools
Soil inorganic N pools
Mineralization / Immobilization
N leaching

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^{-1}

- 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^{-1}	Fertilizer N kg ha^{-1}	Grazing season
Early spring calving with fertilizer (ES-100N)	17th Feb	2.1	100	Feb – Nov
Early spring calving without fertilizer (ES-0N)	17th Feb	1.6	0	Feb - Nov
Late spring calving without fertilizer (LS-0N)	17th Apr	1.7 until 1st Sept, then reduced to1.2	0	Apr – Jan

Methods

Soil surface balances calculation

- Entries were chosen in correspondence with methodology of the OECD

Inputs		Outputs		
N synthetic fertilizer, Slurry, Animal excreta, Atmospheric deposition, White clover BNF	−	N in harvested and grazed herbage	=	Soil surface N surplus

- 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

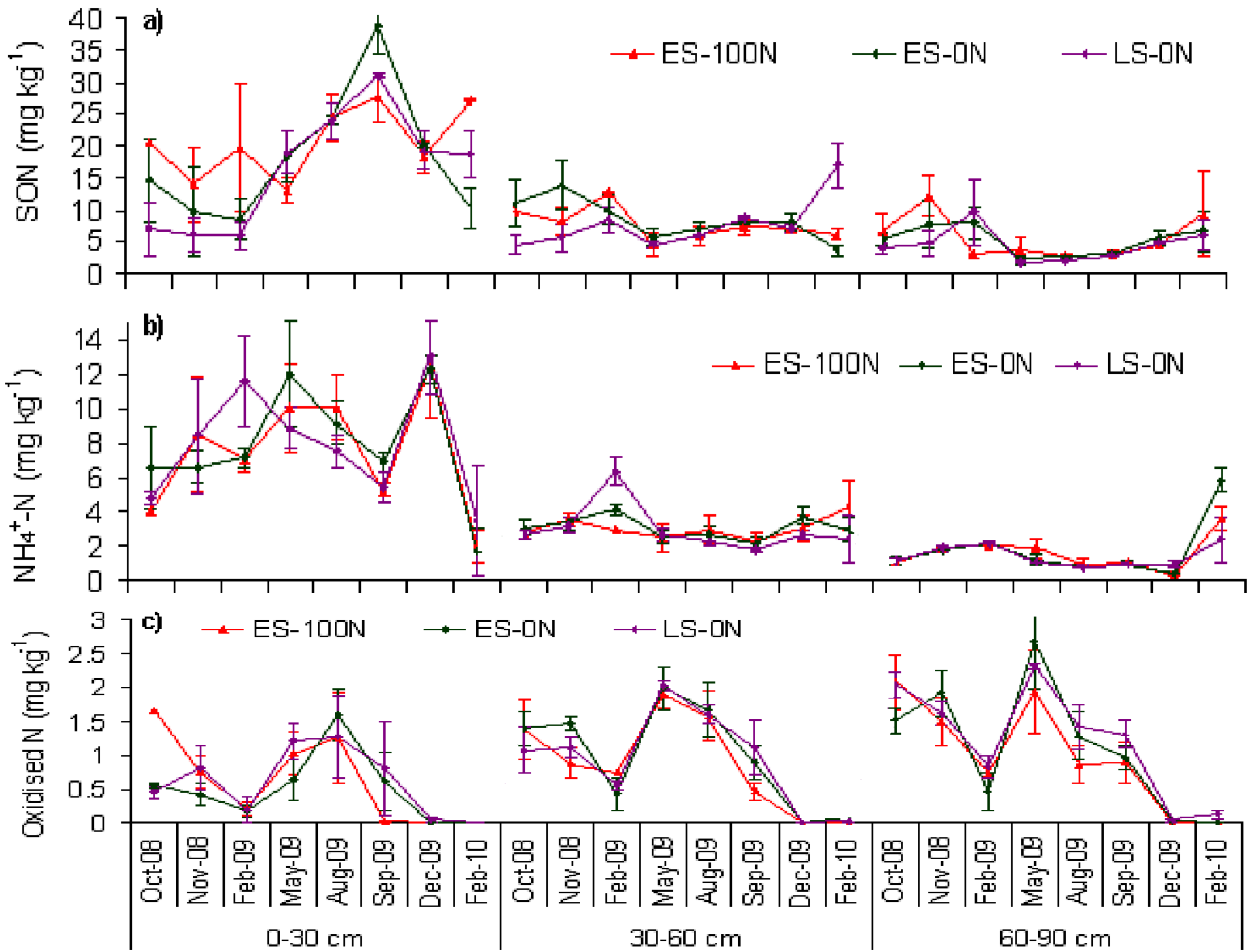
- Soil N results – three way analysis of variance (Proc Mixed)
- - fixed effects: system, sampling depth and their interaction
- - repeated measure: sampling date

- Indicators affecting soil N - using simple and multiple stepwise linear regression analyses (Proc Reg)

Results

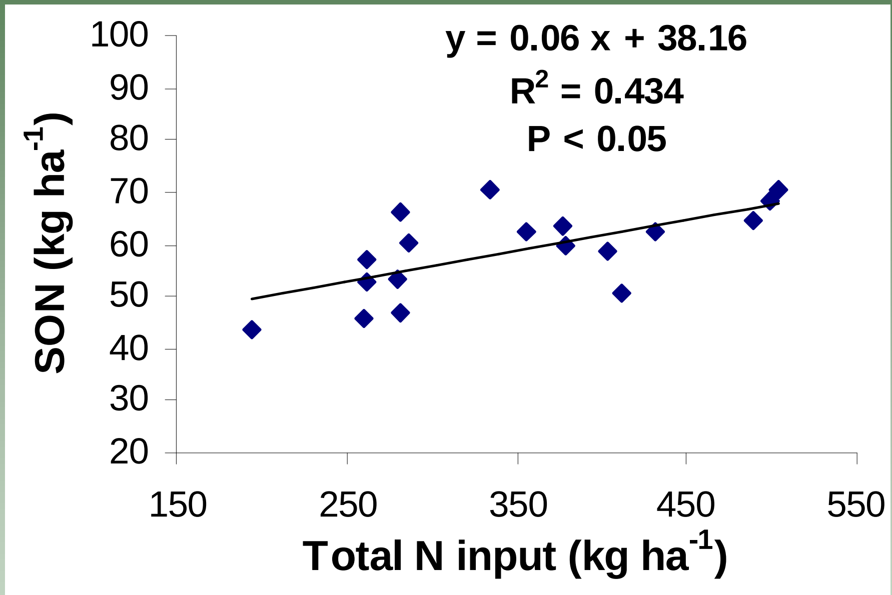
Soil surface balances

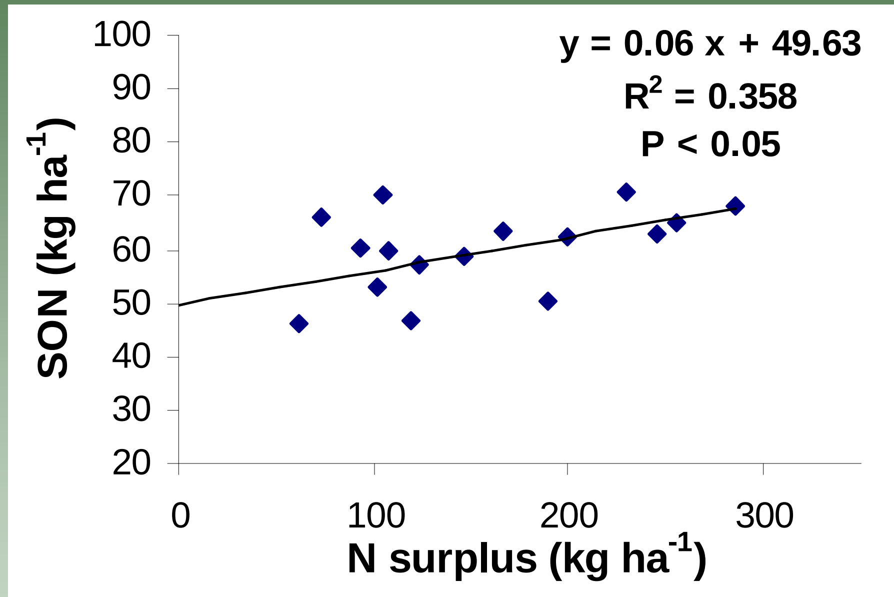
N flow (kg ha^{-1})		**ES-100N**	**ES-0N**	**LS-0N**	System	Year	S x Y
N input (kg ha^{-1}):							
N in synthetic fertilizer		100.0	0.0	0.0			
BNF		66.3 [b]	112.3 [a]	133.8 [a]	<0.05	NS	<0.05
N in excreta during grazing		119.2[a]	95.2 [ab]	82.2 [b]	<0.05	NS	NS
N in slurry		109.1	109.0	103.0	NS	NS	NS
Atmospheric deposition		6.5	6.5	6.5			
total N input		401.2	322.8	325.2	<0.05	NS	NS
N output (kg ha^{-1})							
N in grazed grass		219.0 [a]	177.5[ab]	147.2 [b]	<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
N surplus (kg ha^{-1})		160.7	120.8	113.0	NS	NS	NS
N use efficiency (%)		62.9	65.2	71.6	NS	NS	NS



a)
SON (mg kg-1)
ES-100N
ES-0N
LS-0N
b)
NH4+-N (mg kg-1)
c)
Oxidised N (mg kg-1)
Oct-08
Nov-08
Feb-09
May-09
Aug-09
Sep-09
Dec-09
Feb-10
0-30 cm
30-60 cm
60-90 cm

Factors affecting soils soluble organic N





Factors affecting soil soluble inorganic N

Dependent variable (y)	Factor (x, z)	Relationship	Model R^2	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!