PRIFYSGOL ABERYSTWYTH UNIVERSITY

IGER

IBERS

Sefydliad y Gwyddorau Biolegol, Amgylcheddol a Gwledig

Institute of Biological, Environmental and Rural Sciences

Genetic Improvement of Forage Crops for Climate Change Mitigation

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Plant Breeding and Genetics Programme

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IBERS Animal Science

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Livestock and Grasslands

- Grazing plus feedcrops= 30% ice free land
- Meat and Milk Production
- Ecosystem services
- Environmental disbenefits: ‘long shadow’

Livestock’s Long Shadow FAO 2006

Genetic Improvement

- **Successful**
- **Cost Effective**
- **Cumulative impact**
- **High uptake**
- **Accessible and at little or no additional cost to farmer**
- **Complementary to other approaches (management, animal breeding)**

Greenhouse gas emissions from N fertiliser production and use

- Haber-Bosch process produces 100Mt artificial N/yr
- Emissions of 41Mt CO_2/yr
- N_2O emissions 1.25% applied N
- For N used to produce feedcrops for livestock: 0.2Mt/yr
- Soybean and pulses: 0.2M/t
- Forage legumes:0.2Mt/yr?
- Also : nitrate leaching to water, ammonia emissions, energy use on farm

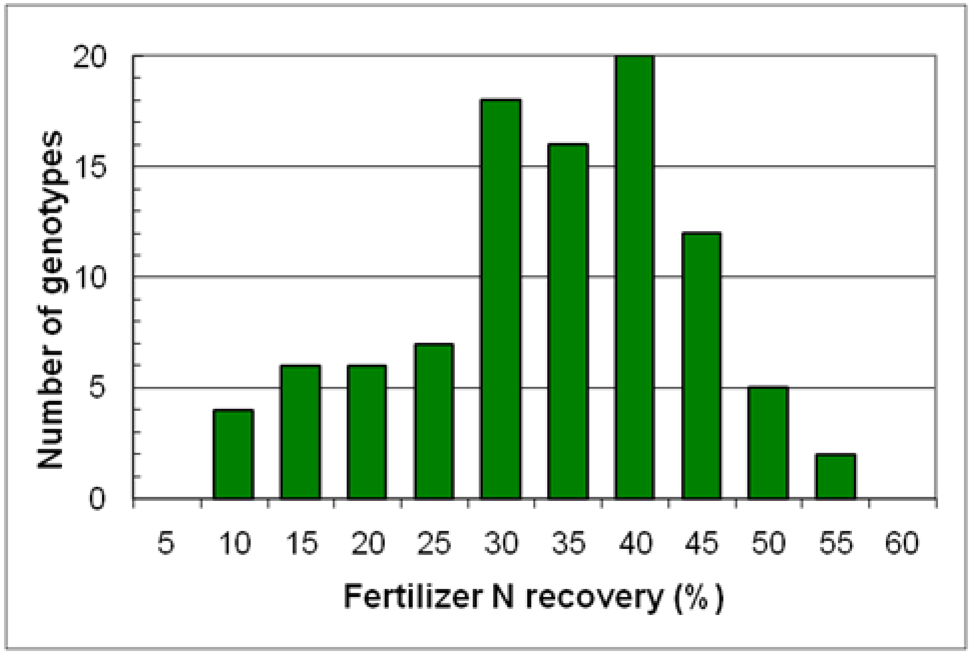
Key Requirements

- Increased Nitrogen Use Efficiency(NUE soil-plant)

- Greater use of legumes BUT more efficient use of fixed N (.150kgN/ha/yr)

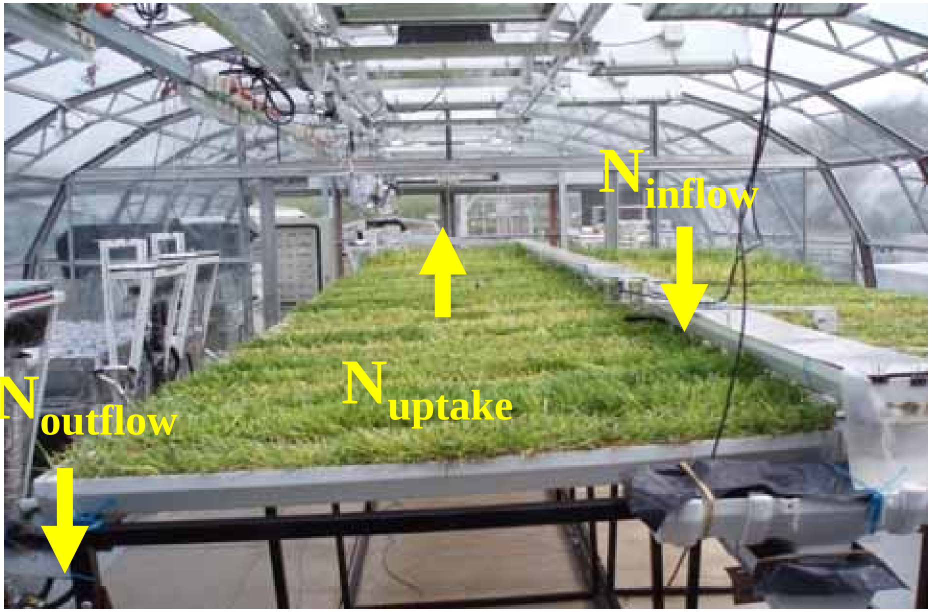
Screening systems

NUE in sand-box swards



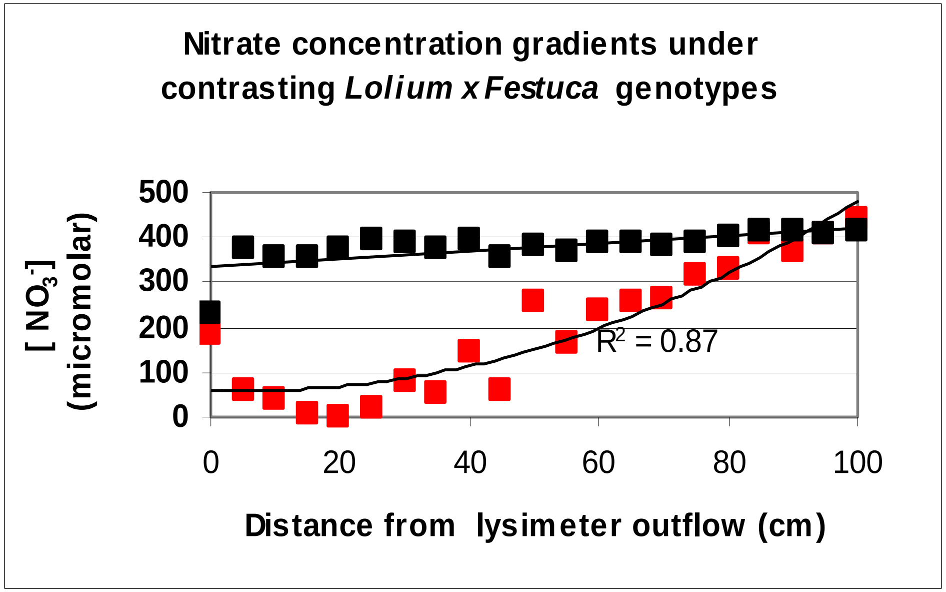
Variation in apparent fertiliser N recovery in herbage of 94 genotypes of the amenity x forage *Lolium perenne* mapping family (150 kgN/ha application).

Nitrate interception efficiencies in horizontal sand-bed lysimeters

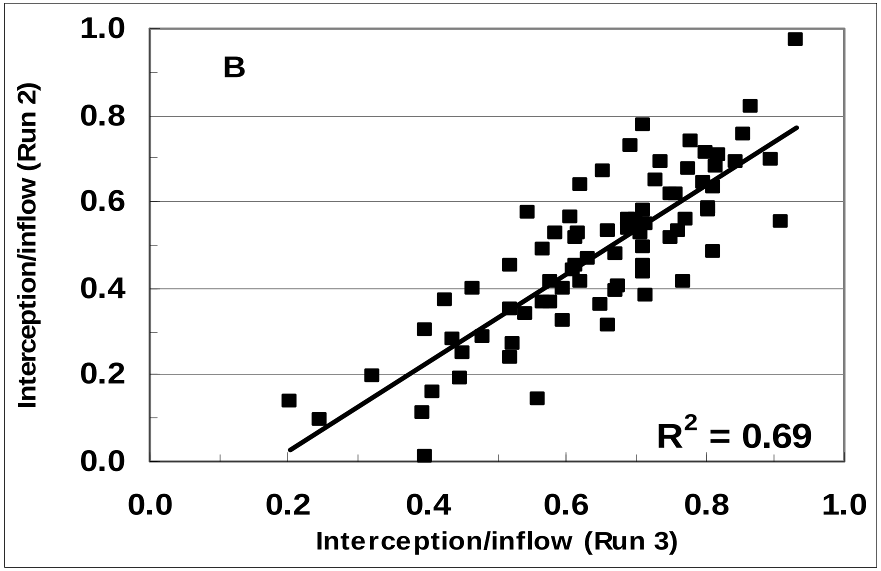


$$N_{uptake} = N_{inflow} - N_{outflow}$$

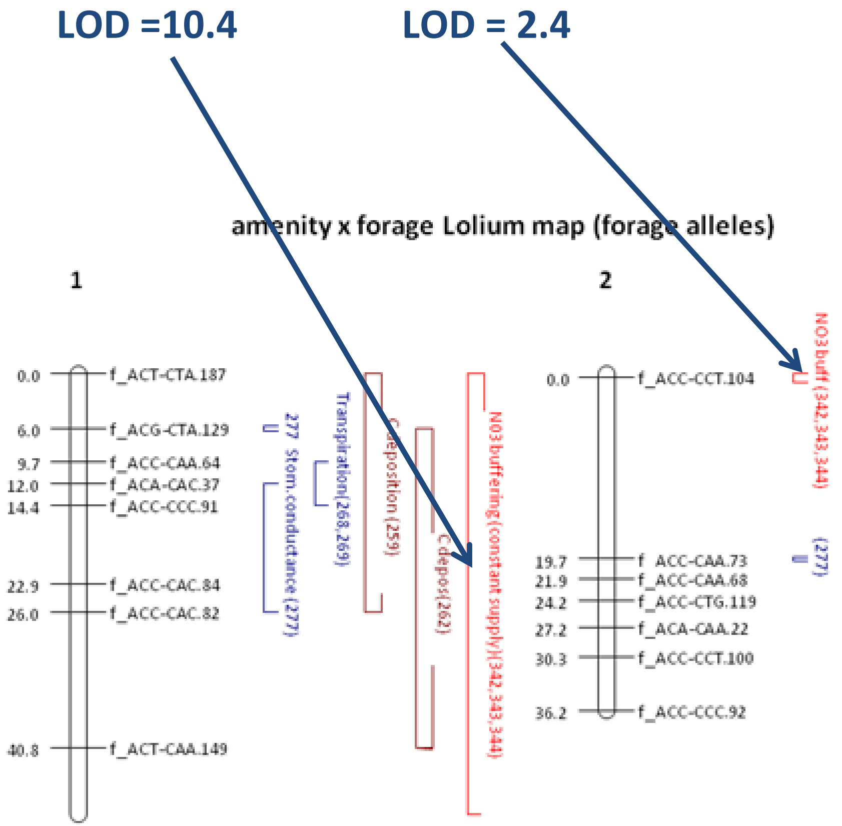
where $N_{outflow}$ is product of drainage rate from gutter and nitrate concentration in drainage

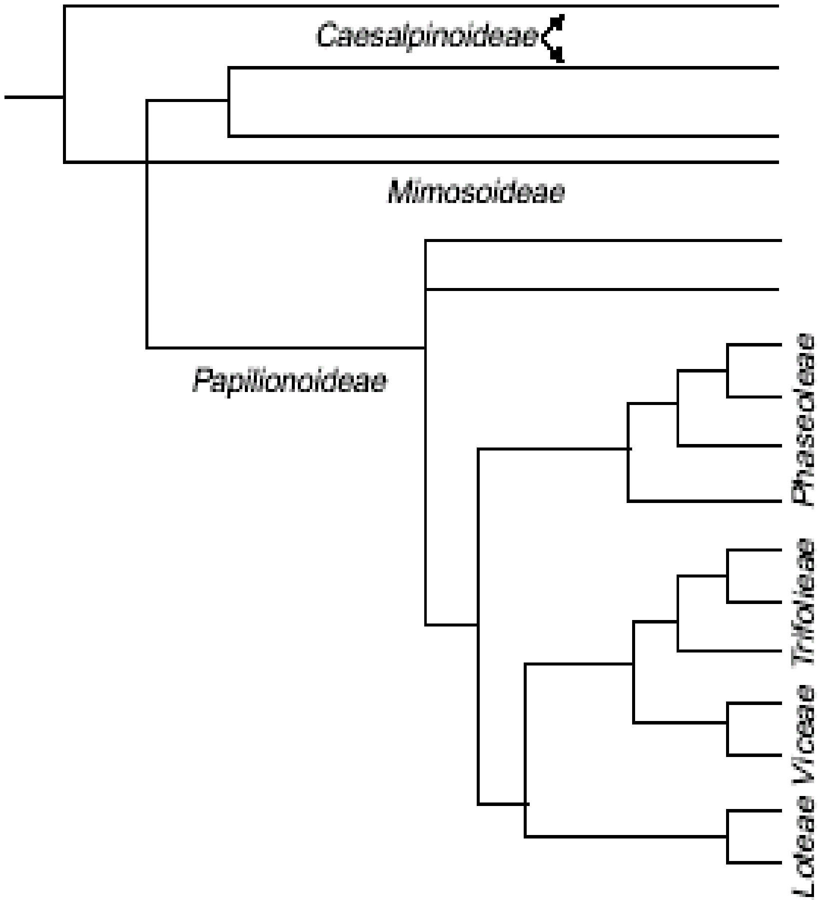


QTL for nitrate interception efficiencies in horizontal sand-bed lysimeters



Proportional interception of nitrate inflow by 80 ryegrass mapping family genotypes : run 2 was conducted under bright sunlight and run 3 under overcast conditions .





Genus	Representative	Chromosome number (1N)	Genome size (1C; pg)
Cassia	Senna	28 (7)	1.76
Acacia	Gum arabic	26 (13)	1.47
Lupinus	Lupins	26 (13)	0.90
Arachis	Ground nut	40 (10)	1.74
Phaseolus	Common bean	22 (11)	0.59
Vigna	Mungbean	22 (11)	0.52
Glycine	Soybean	40 (20)	1.10
Cajanus	Pigeon pea	22 (11)	0.86
Melilotus	Sweet clover	16 (8)	1.10
Trifolium	**Red clover**	**14 (7)**	**0.67**
Medicago	Barrel medic	16 (8)	0.47
Pisum	Garden pea	14 (7)	4.34
Vicia	Broad bean	12 (6)	13.06
Sesbania	Black locust	20 (10)	0.64
Lotus	***Lotus japonicus***	12 (6)	0.47

Current Opinion in Plant Biology

A phylogeny of legumes, featuring the three major subfamilies and details about selected crop species in the Papilionoideae. Estimates of chromosome number and genome size come from the Angiosperm C-value Database (http://www.rbgkew.org.uk/cval/homepage.html, Release 1.0).


TRANSLEG
Using translational genomics to underpin germplasm improvement for complex traits in crop legumes

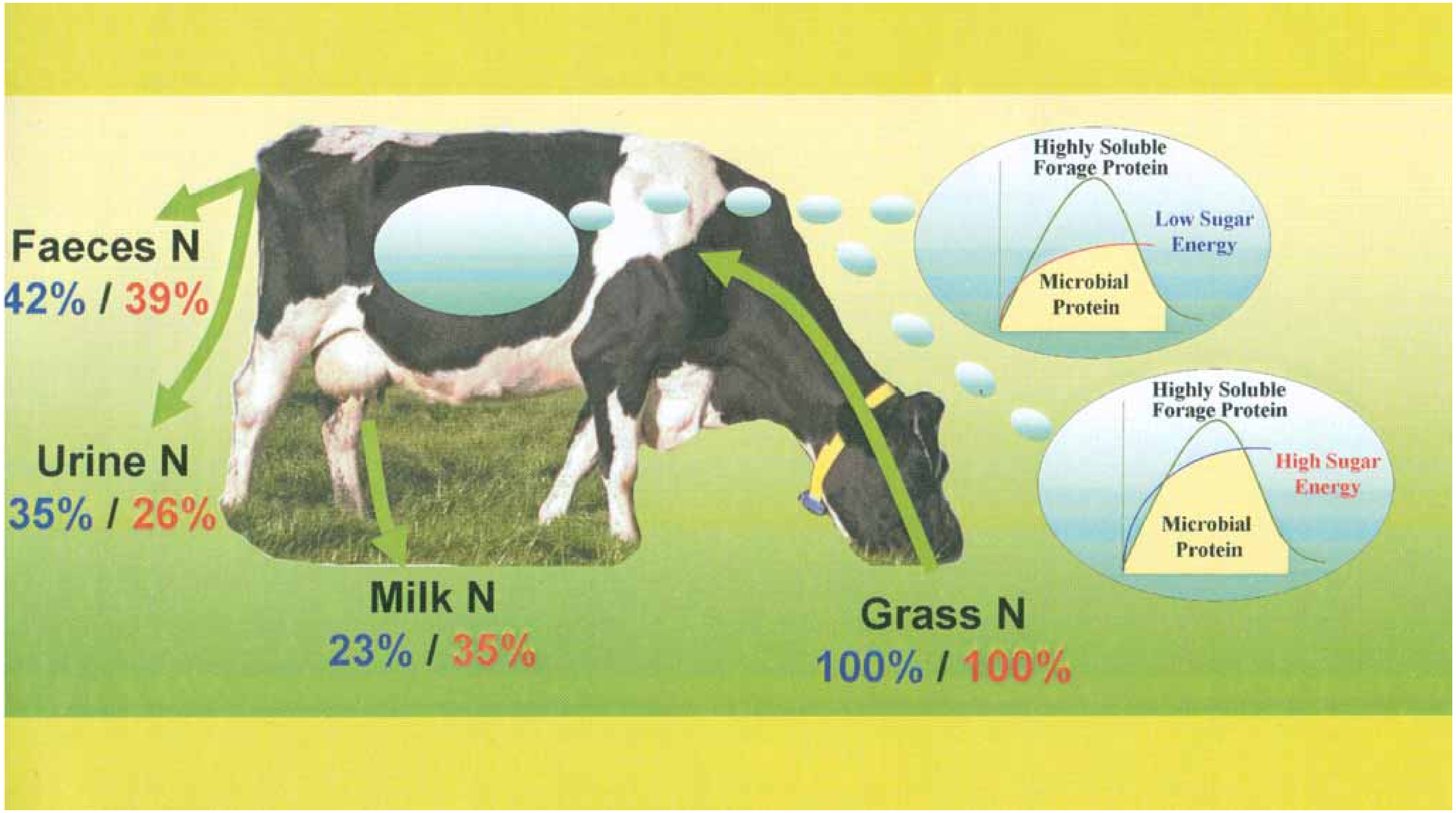
Utilisation of N in the rumen

- Efficiency of N use <20%
- Differences between production systems and diets and manures etc should be seen as a valuable resource.
- Mismatch between needs of plant production and needs of animal
- Mid 1990s: 30Mt N directly deposited under extensive grazing
- Emissions 0.002-0.0098kgN_2O-N/kg

Key Requirements

- More efficient use of N in the rumen
- Composition and management of excreta

Better use of herbage N with high sugar grass



Sugar content under simulated grazing
(1997, mean over 5 N levels)

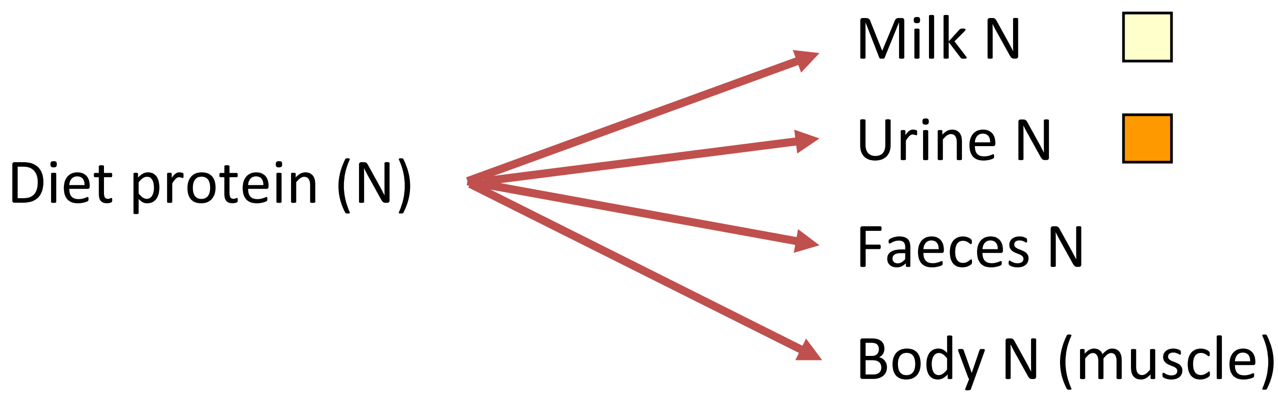
(Wilkins *et al*, unpublished data)

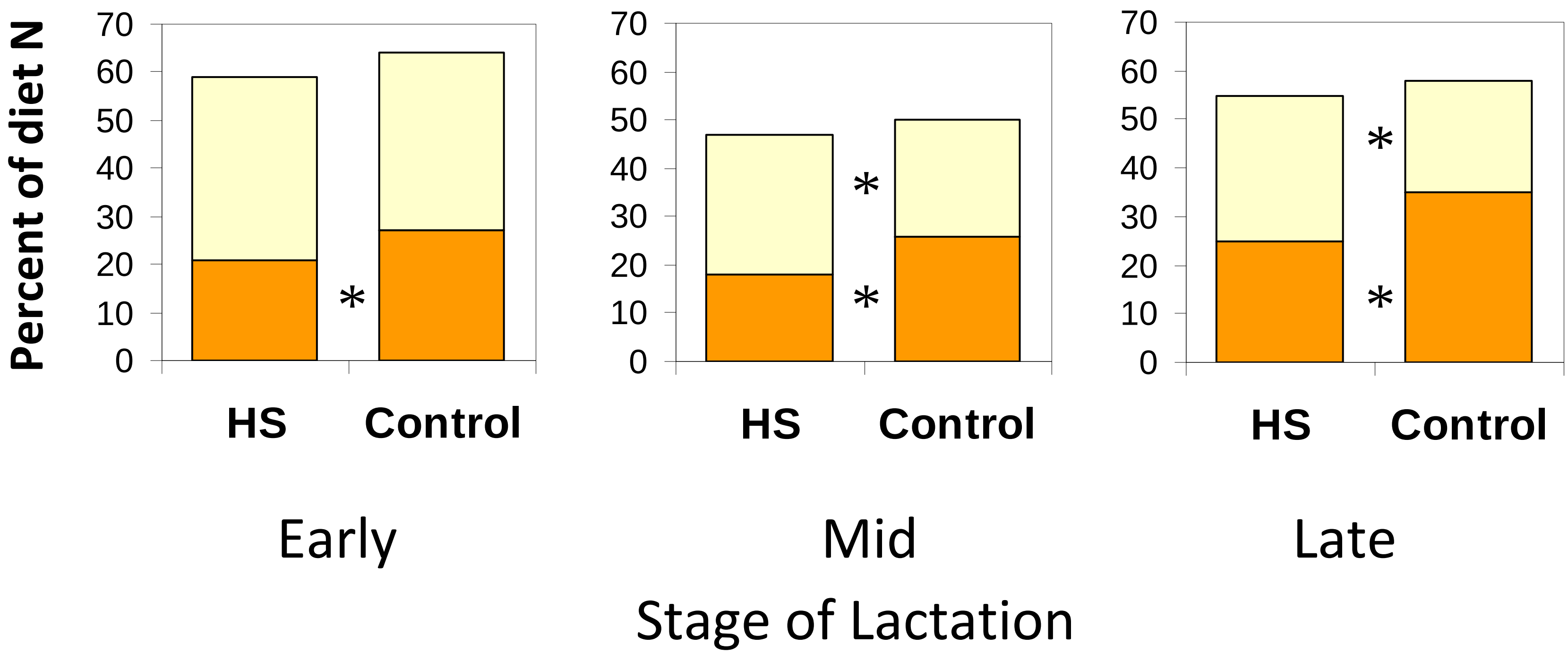
18% higher milk protein yield and 29% less N in urine from cows fed experimental high sugar grass

Performance	Normal variety	High sugar	Standard error
Milk yield (kg/day)	12.6	15.3	0.65
Milk protein yield (g/day)	434	528	22
N output in	100	71	5.0

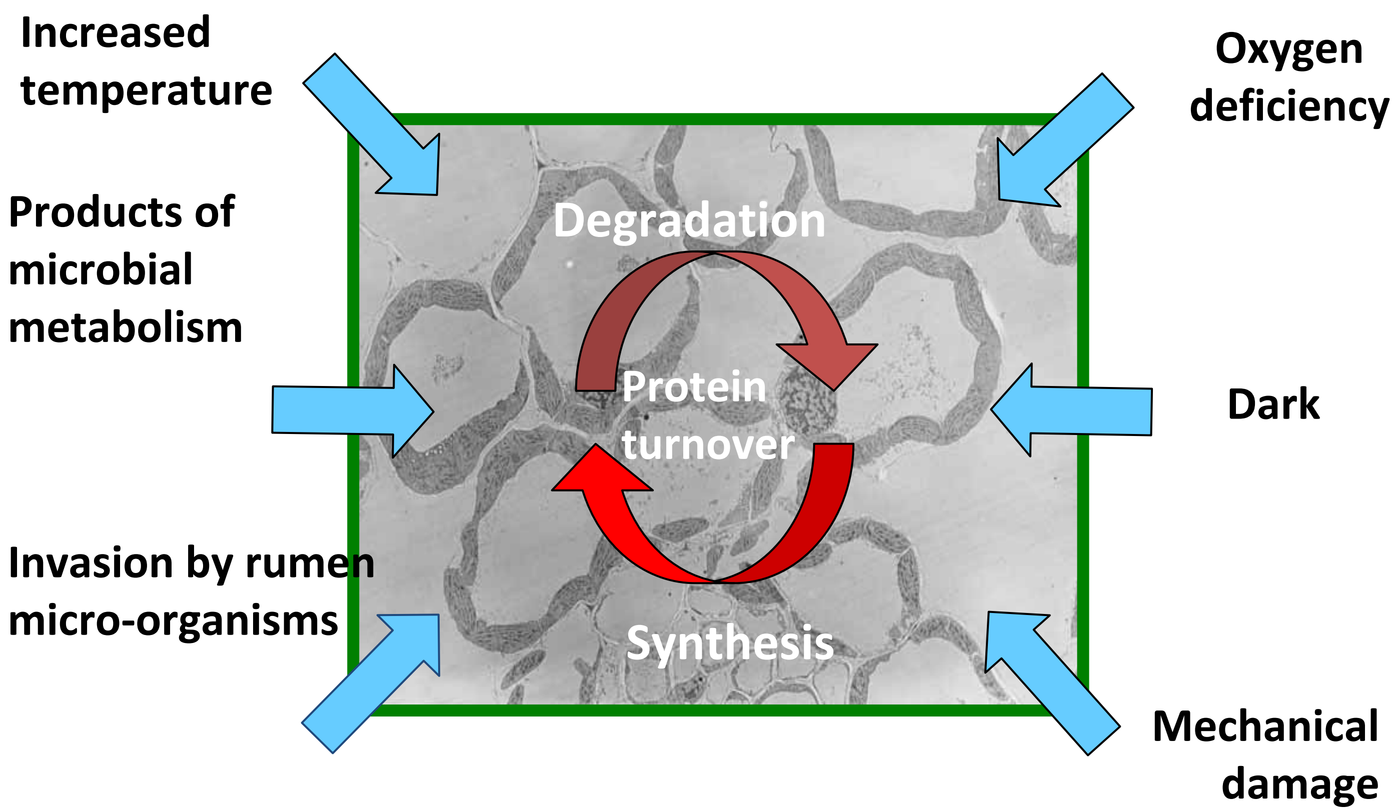
(from Miller et al, 1999. Grass and Forage Science 56, 383-394)

N partitioning

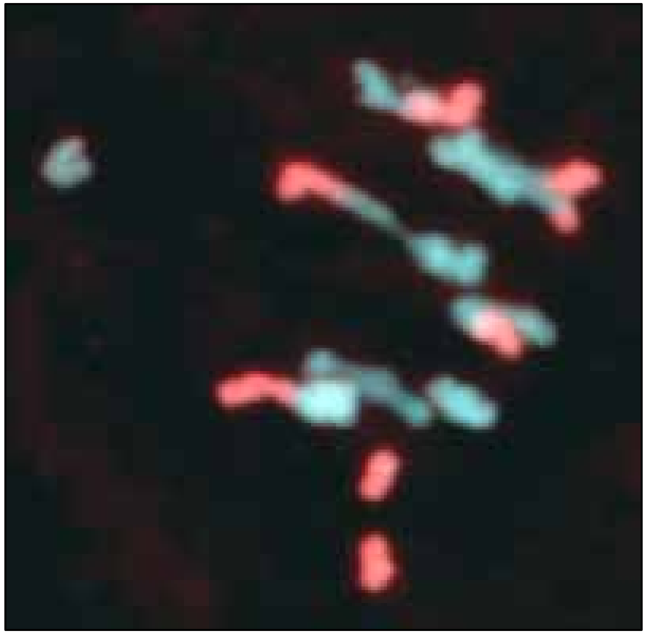


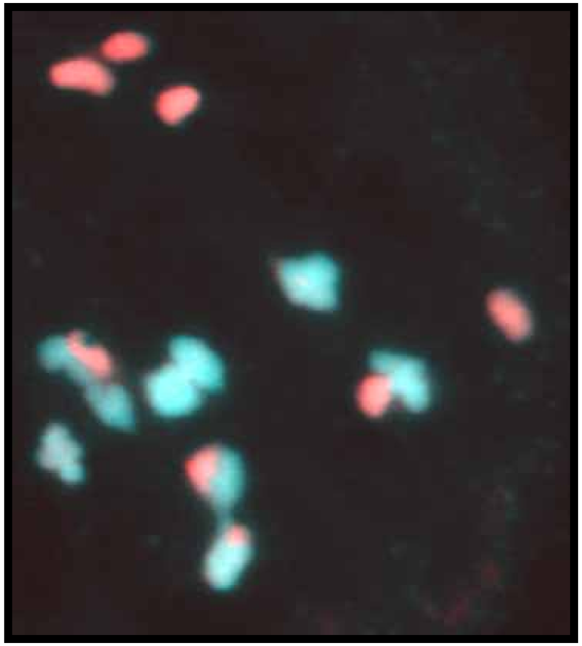


Plant cells respond to anaerobic & heat stress in the rumen – the result:- excessive proteolysis



Chromosome pairing and recombination in *L. multiflorum* x *F. glaucescens* BC_1 hybrids





Preferential chromosome pairing between *Lolium* chromosomes

2 homologous sets of *Lolium* chromosomes and 7 chromosomes of *Festuca*

Half-life values of leaf protein in rumen-like anaerobic conditions at 39°C

Species	Protein half life (h)
Vicia faba	0.88
Trifolium repens	0.96
Medicago sativa	1.71
Lolium multiflorum	3.67 ←
Lolium perenne	4.13 ←
Pisum sativum	4.24
Festuca pratensis	7.01
Lotus corniculatus	7.70
Festuca mairei	9.40
Trifolium pratense	10.08
Festuca glaucescens	18.24 ←
Onobrychis viciifolia	19.15
Brassica oleracea	22.39

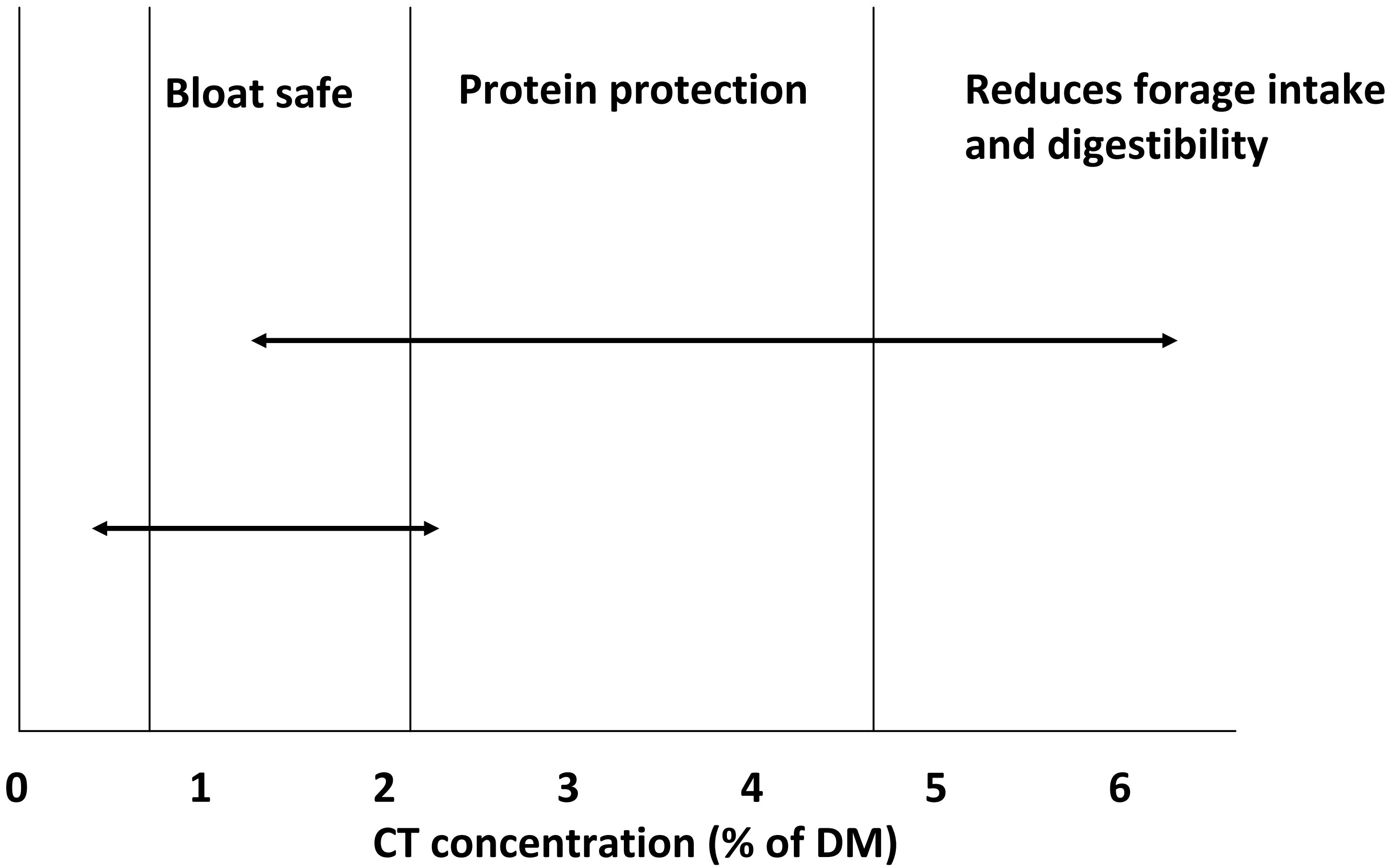
Dietary approaches to reducing methane emissions from enteric fermentation

- Grazing/concentrate
- Digestibility, carbohydrate supply, lipids
- Tannins

Condensed tannins

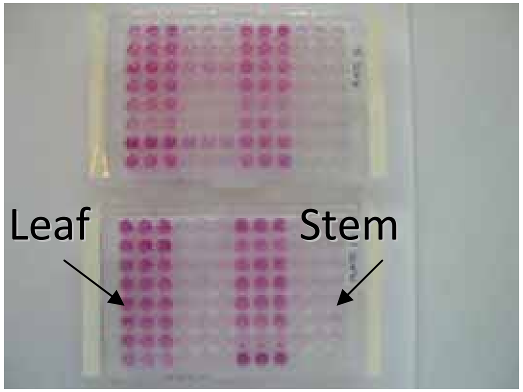
- Secondary compounds
- Protein protection
- Reduce bloat
- Possible reduction in methane emissions

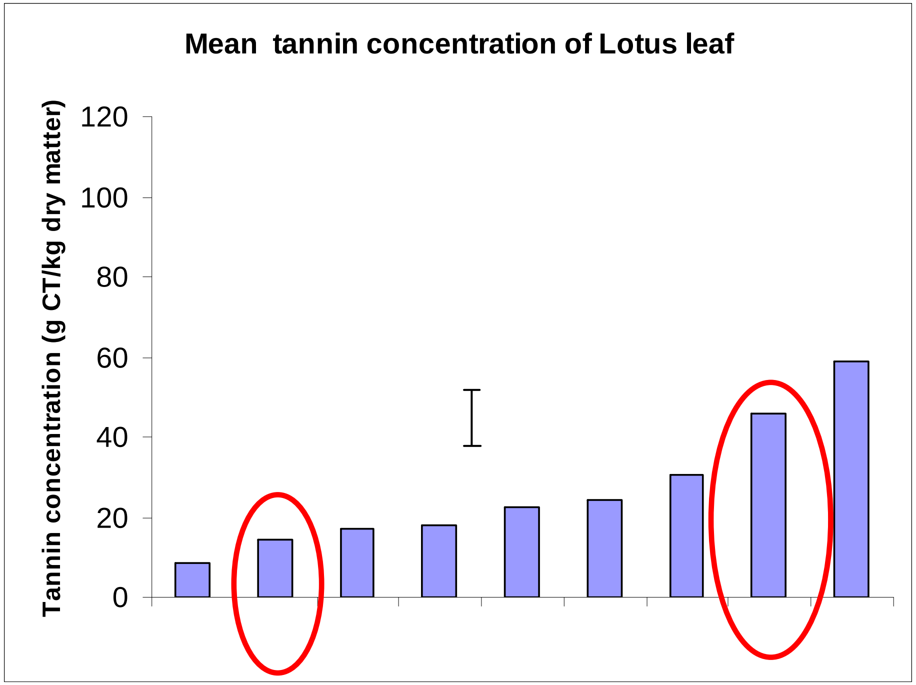
Variation in tannin content in spaced plants



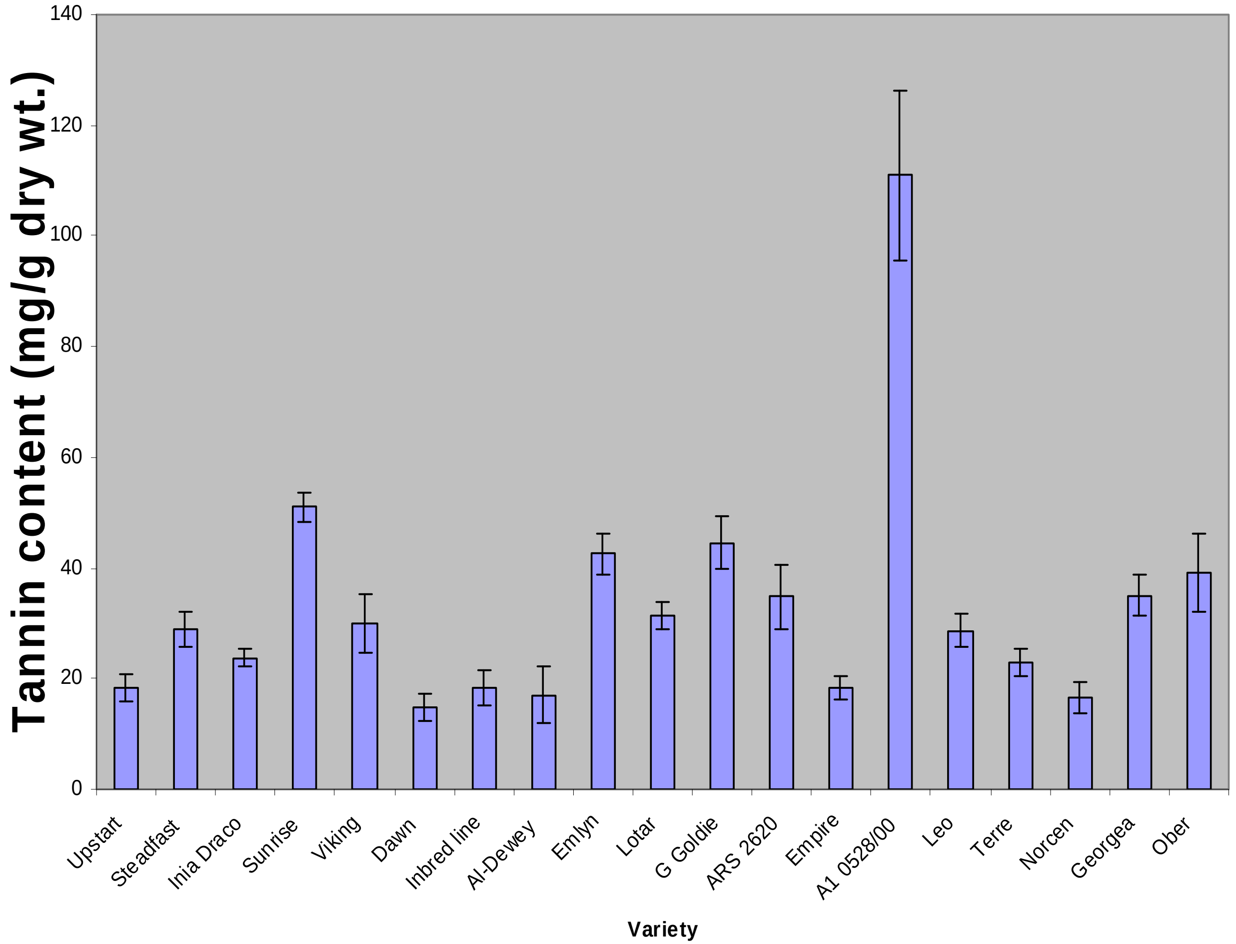
Quantifying tannin content

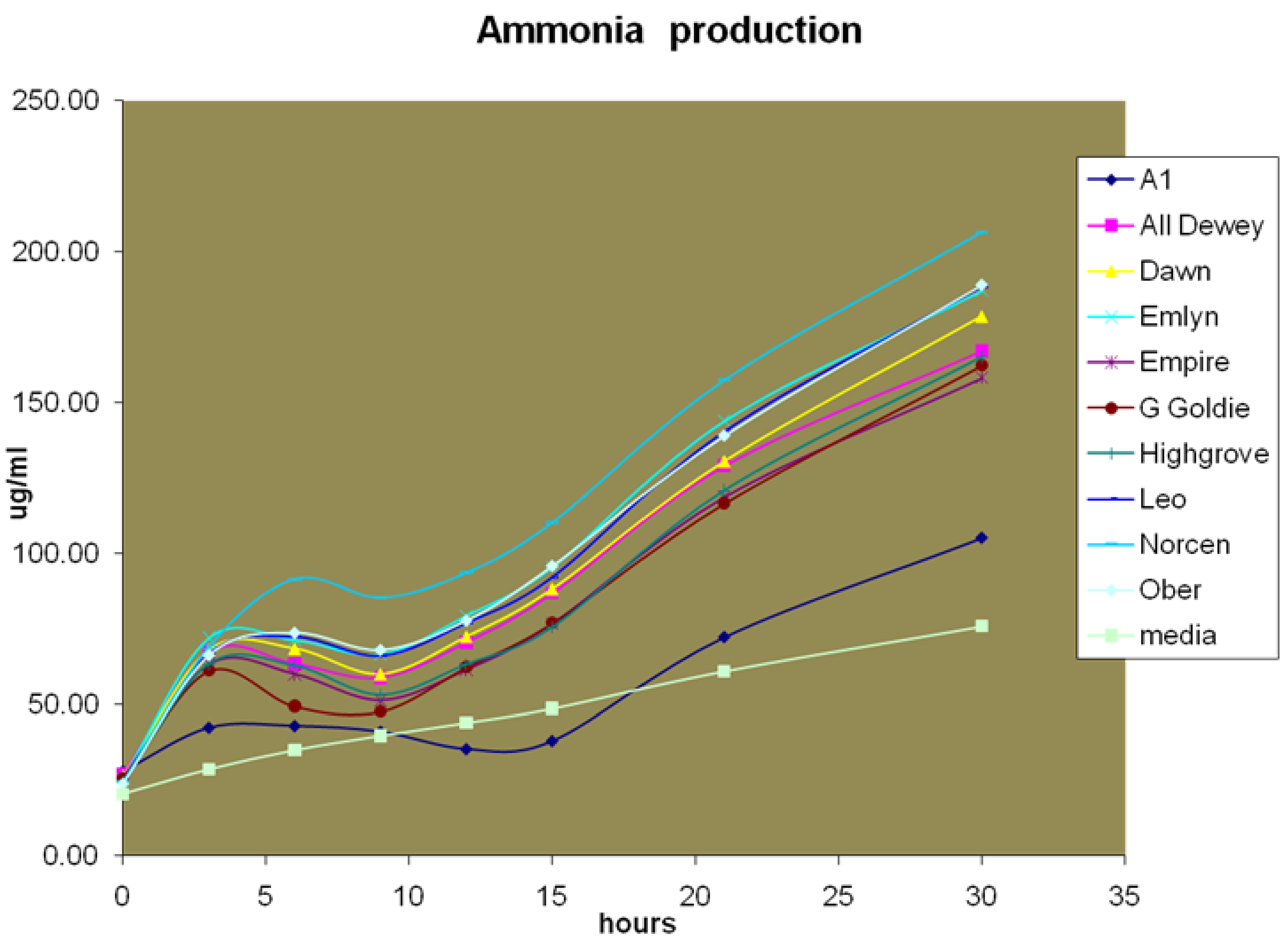
High throughput assay developed





Variation in leaf tannin content




Ammonia production
250.00
200.00
150.00
100.00
50.00
0.00
ug/ml
0
5
10
15
20
25
30
35
hours
A1
All Dewey
Dawn
Emlyn
Empire
G Goldie
Highgrove
Leo
Norcen
Ober
media

Research Challenges

- Harnessing the power of genomics for precision breeding in forages(and feeds)
- Understanding multifunctionality: delivering meat and milk with ecosystem services
- Improving our knowledge of soil-plant-rumen-soil interfaces
- Optimising efficient use of fixed Nitrogen