QUANTIFYING HOW WINTER WHEAT CROPS ACCUMULATE AND USE NITROGEN RESERVES DURING GROWTH

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Overview

- Background and rationale of research
- Quantifying canopy N pools
- Crop N allocation at flowering
- Crop N remobilisation and uptake from flowering to harvest
- Breeding for improved NUE

Benefits of improved N-use efficiency

- *In high input systems*: reduced excessive fertiliser N inputs whilst maintaining high yield potential
- *In low input systems*: improved yield response to N inputs in low resource environments
- Overall reduced environmental impacts due to use of and pollution from N inputs

Understanding N-use efficiency

- N-Use Efficiency (NUE) is the grain yield per unit of N available in the soil.

- NUE is the multiple of two components:

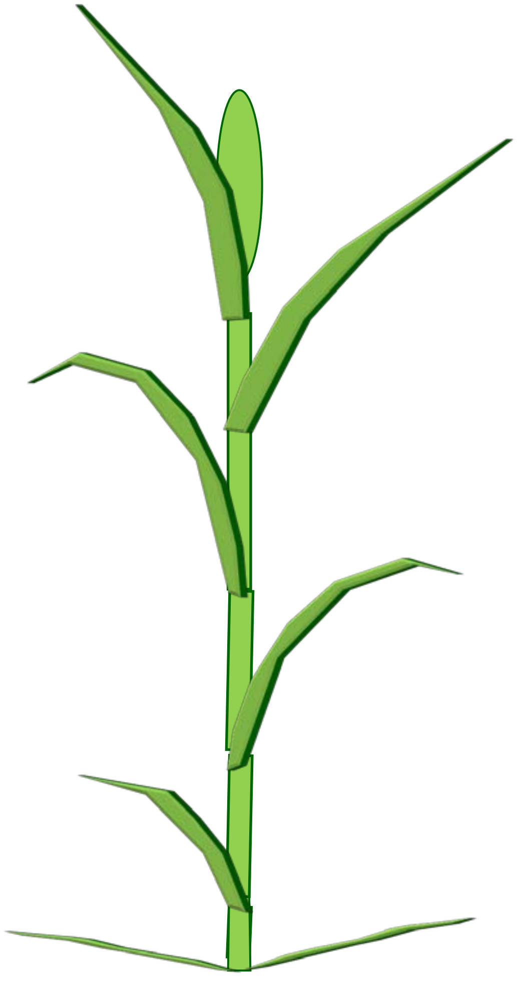
NUE = N Uptake E * N Utilisation E

N uptake / N supply *Grain yield / N uptake*

- NUE can be improved by both uptake and utilisation of N

N utilisation E can be improved by reducing inessential crop N

Defining canopy N pools



1. **Photosynthetic N** (PN):
   - photosynthetic proteins in green tissues

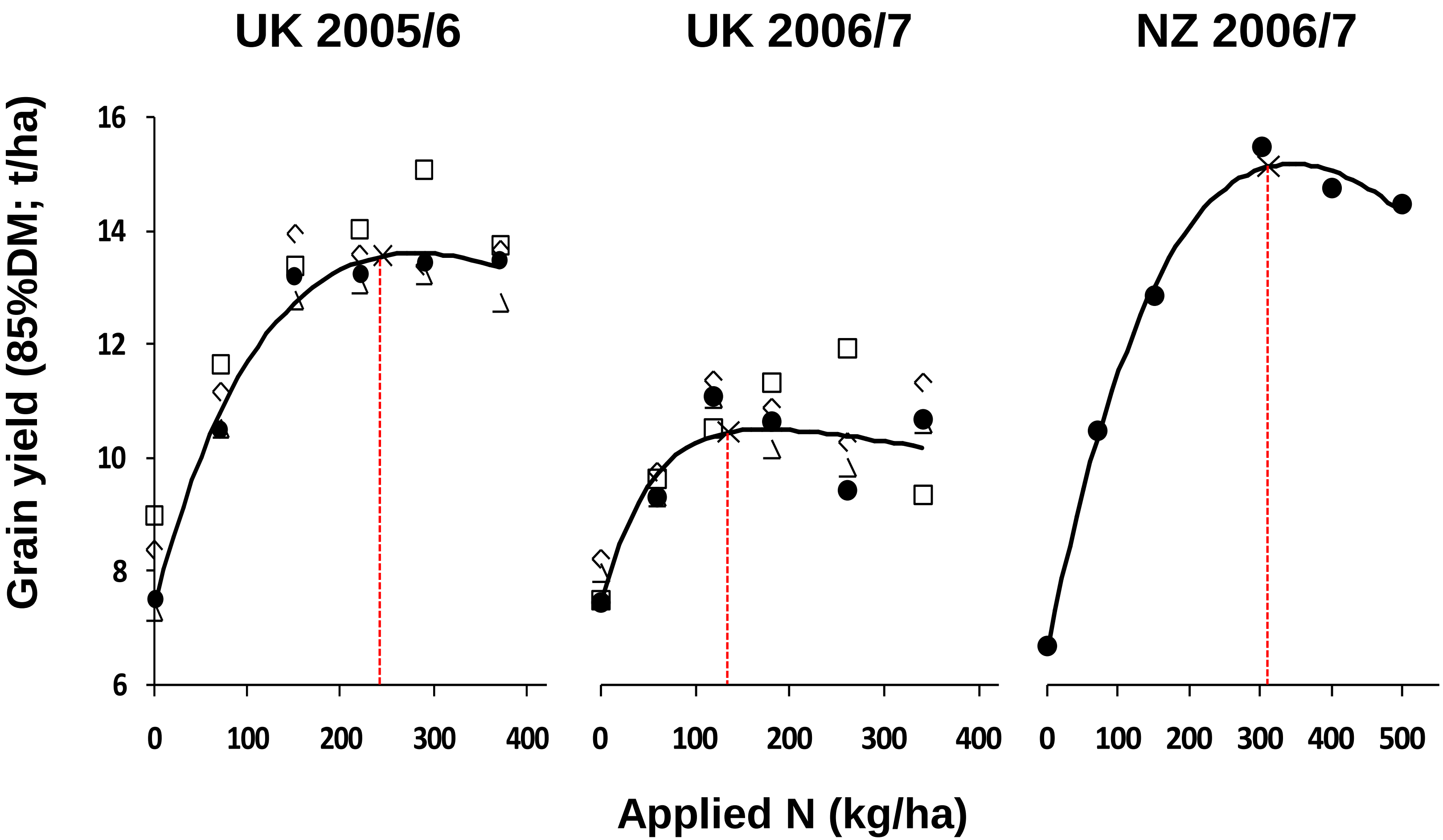
2. **Structural N** (SN):
   - structural supporting tissues and vascular connections

3. **Reserve N** (RN):
   - canopy N not allocated to PN or SN pools

Experiments

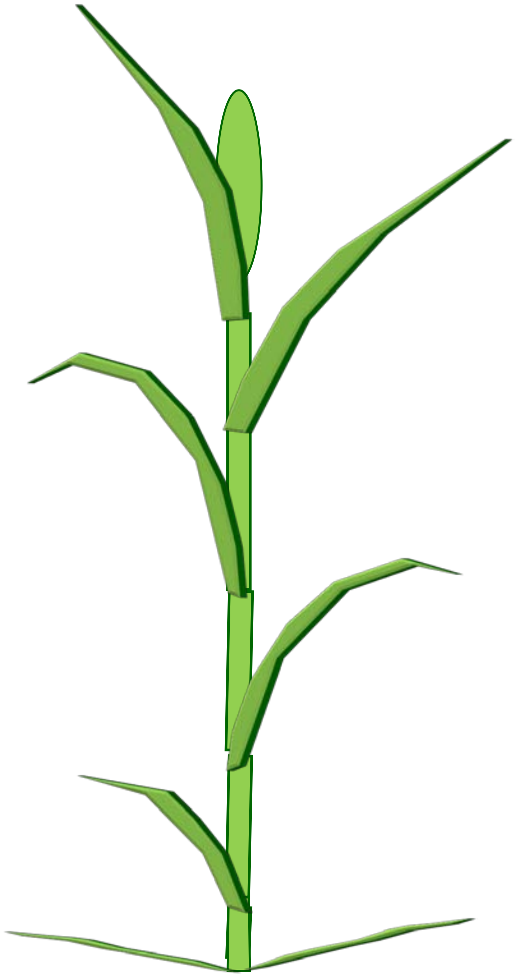
- Two sites (UK & New Zealand) and 3 field experiments
- Range of N treatments (nil N to supra-optimal N) applied to four winter wheat (feed) cultivars
- Sequential sampling for dry matter and N%, with canopy partitioned into four components

Grain yields



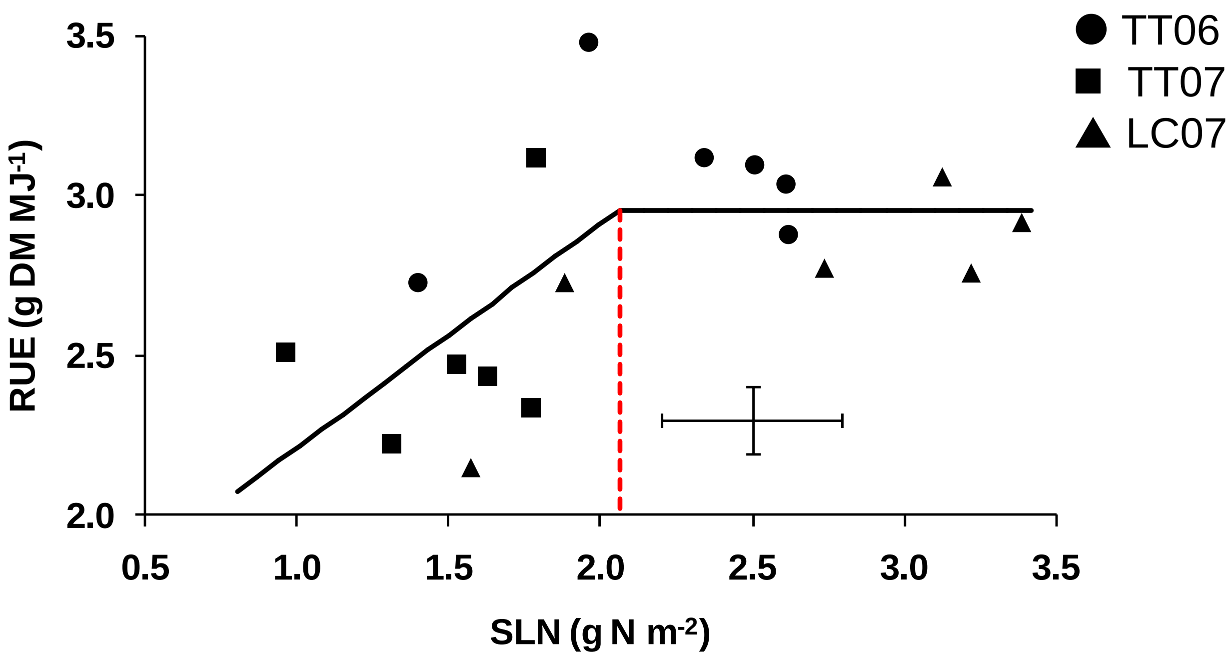
Main variety: ● Istabraq; with fitted curve and economic optimum yield (X) with SE
Other varieties: □ Atlanta; △ Claire; ◇ Savannah

Canopy N allocation model at flowering

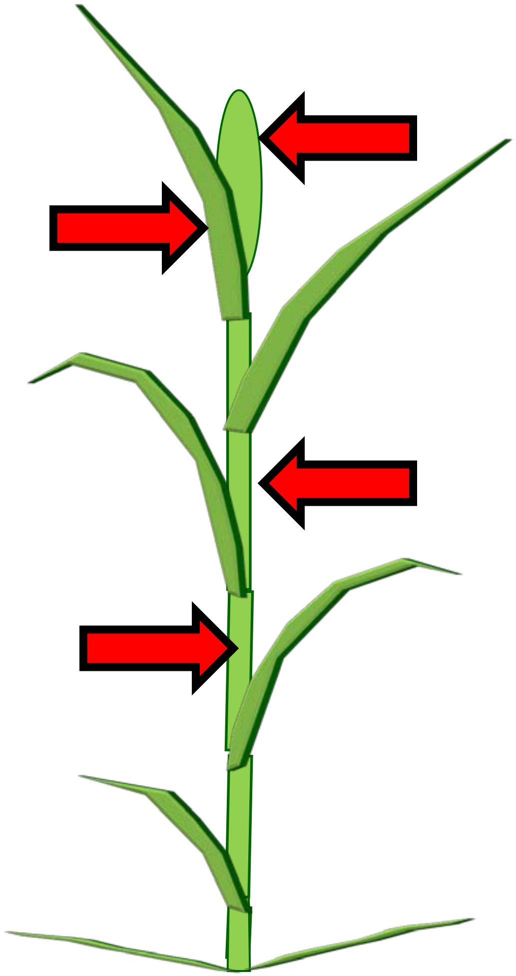


For individual crop components (leaf lamina, leaf sheath, true stem and ear):

SN+PN per unit area of the green tissues was set at the breakpoint of the relationship between Specific Leaf N and RUE:



Canopy N allocation model at flowering



For individual crop components (leaf lamina, leaf sheath, true stem and ear):

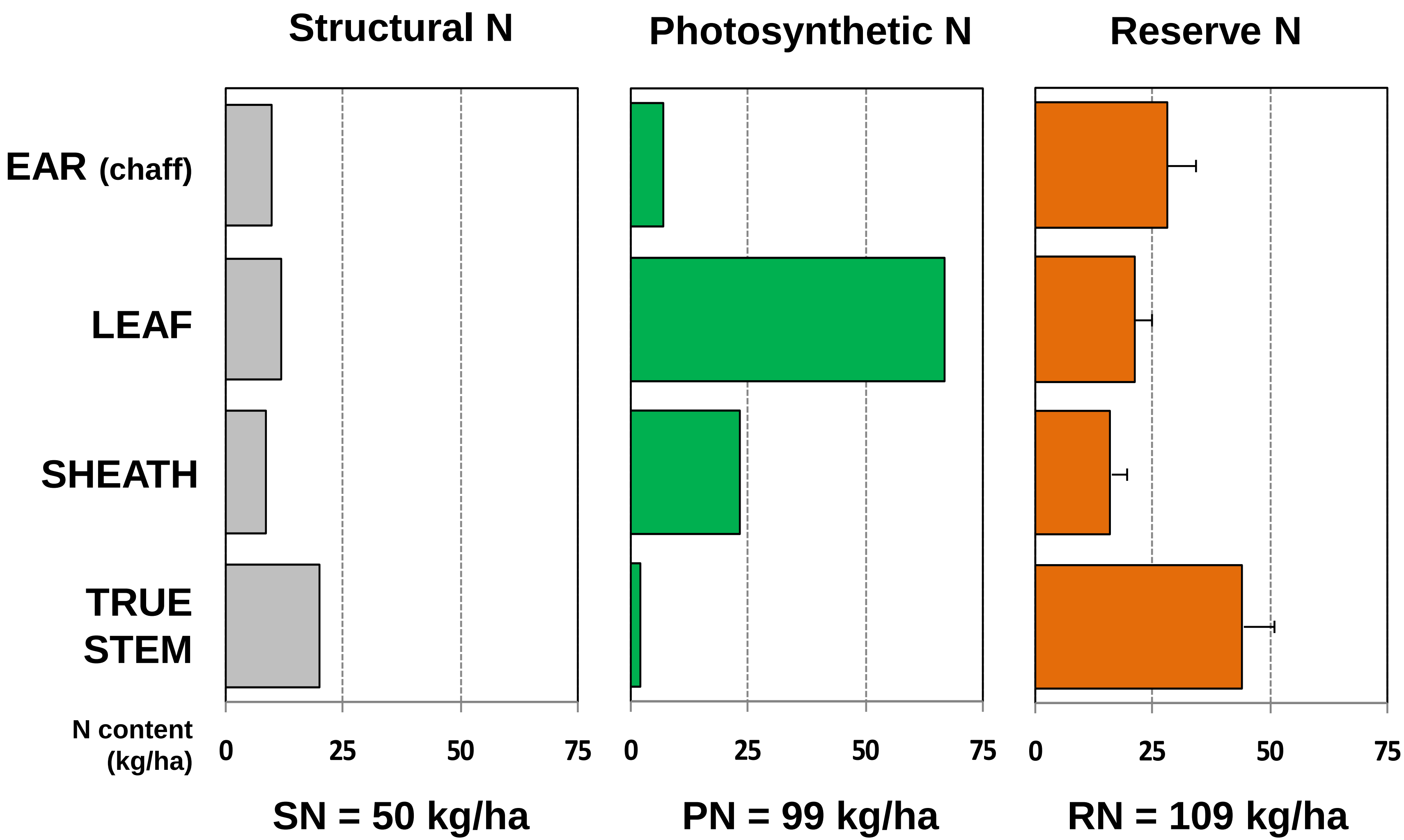
SN+PN = Green Area x 2.061 g N m^{-2}

SN = AGDM at harvest x minimum N% at harvest

PN = (SN+PN) - SN

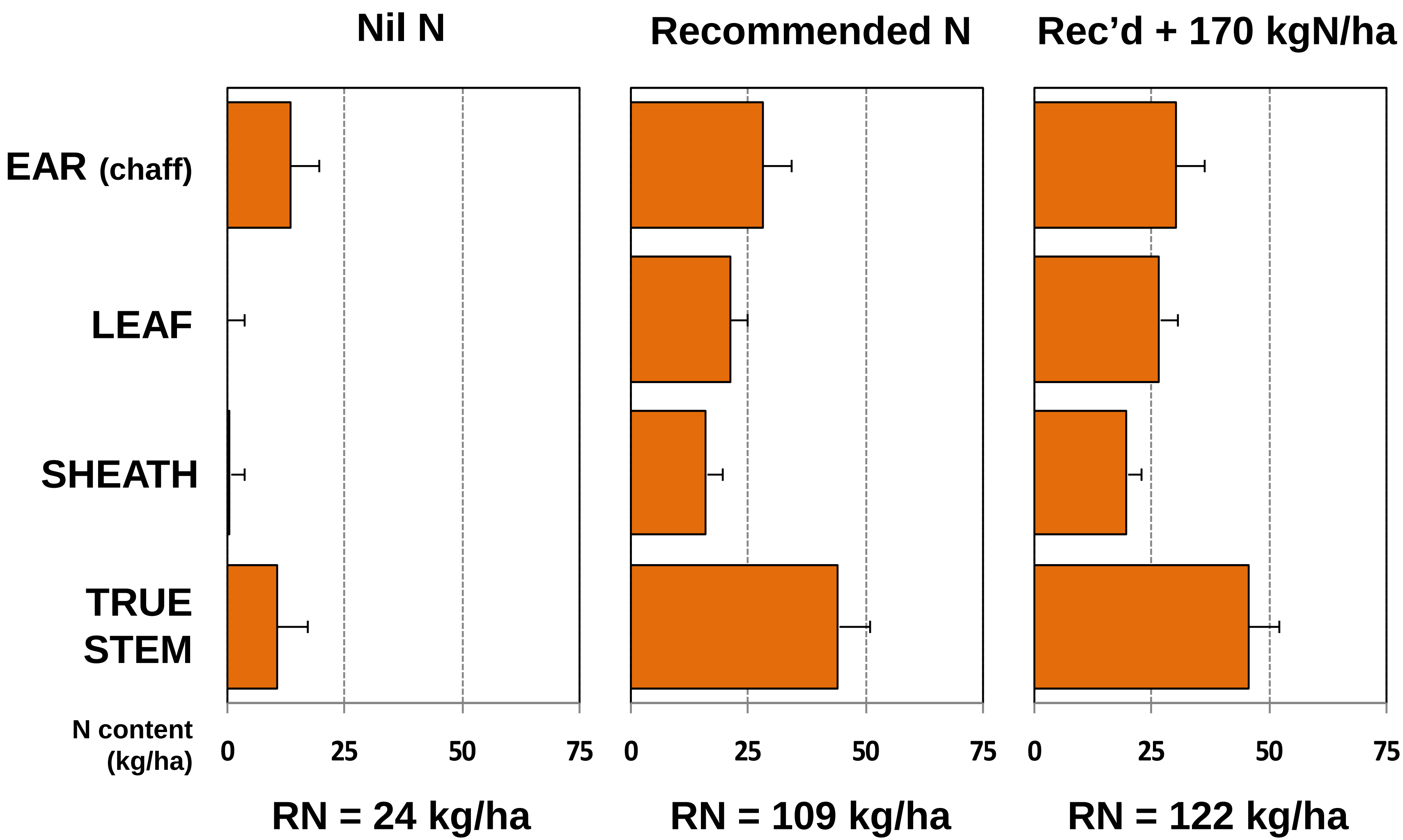
RN = AGN – (SN+PN)

N allocation at flowering



Istabraq at recommended N treatment, mean for 3 experiments

Reserve N at flowering



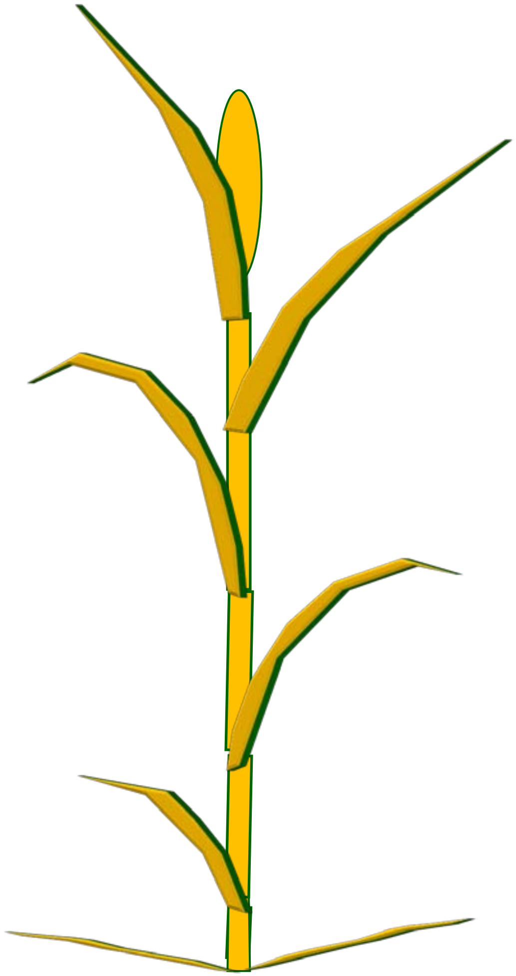
Istabraq at 3 N treatments, mean for 3 experiments

Genetic effects at flowering

	Above-ground N	Reserve N	True stem RN
Genetic range at rec'd N treatment	252-277 kg/ha	90-109 kg/ha	47-54 kg/ha
Probability (G) Probability (G*N)	ns ns	<0.01 ns	ns ns

- Varieties selected to contrast for N partitioning
- Only small varietal differences in allocation to N pools
- Atlanta allocated more Reserve N to the ear, but associated with earlier flowering

Post-flowering N remobilisation and uptake



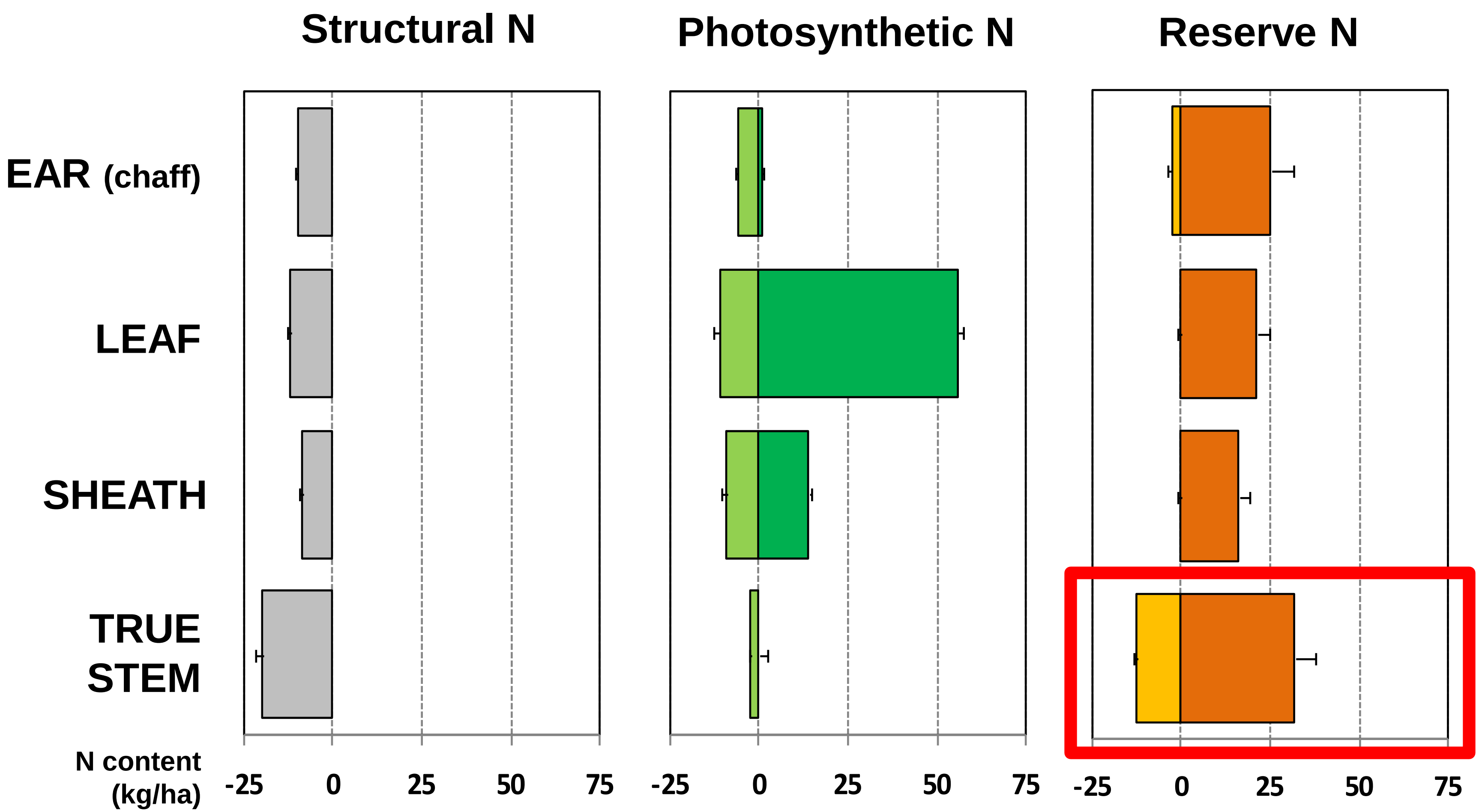
For individual crop components (leaf lamina, leaf sheath, true stem and ear):

Structural N was assumed to remain in straw at harvest

Reserve N appeared to be remobilised to grain before photosynthetic N

N in the crop at harvest which was not present in the crop at flowering was termed '**post-anthesis N uptake**' (PANU)

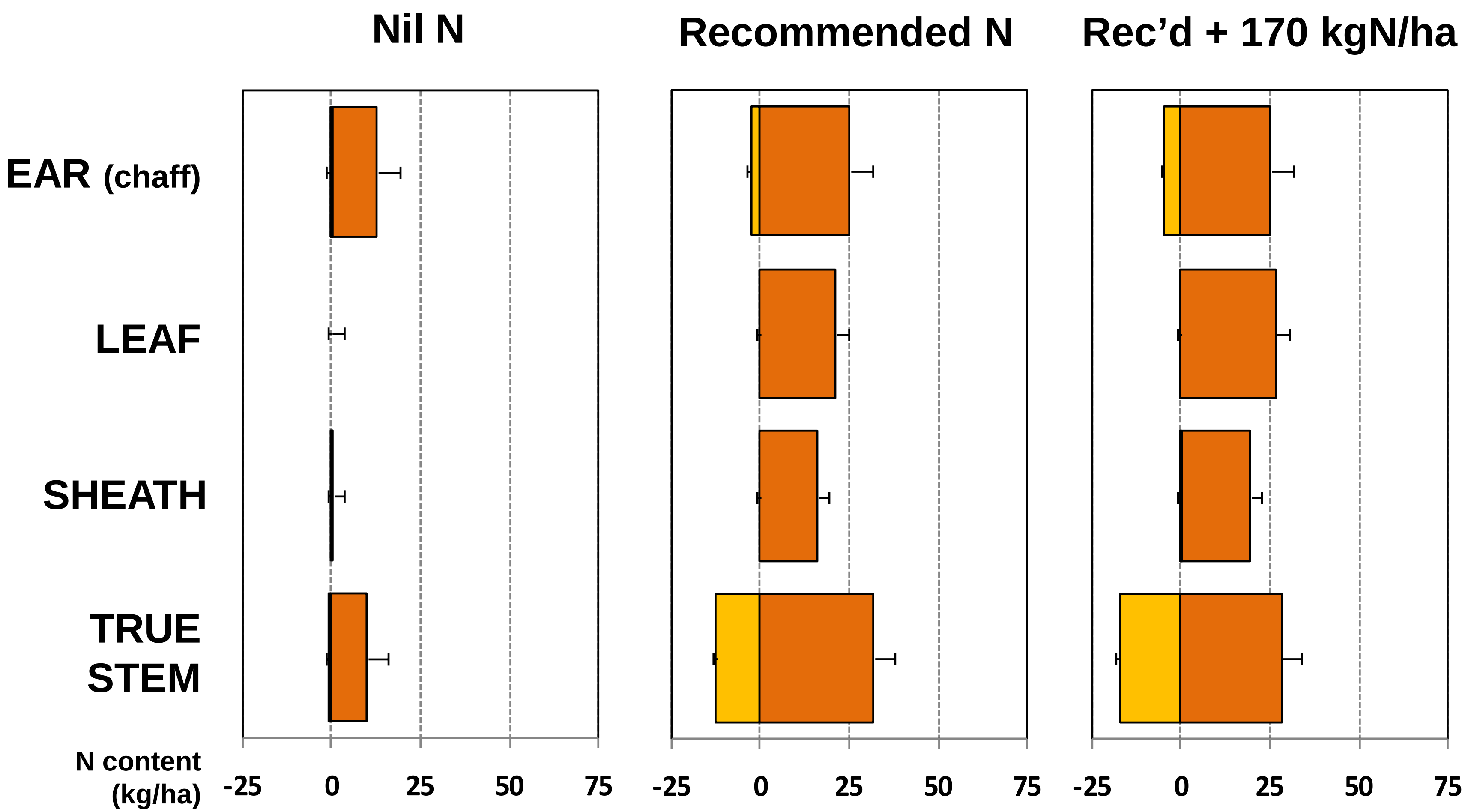
N unloading at harvest



Negative values N in straw : Positive values N to grain

Istabraq at recommended N treatment, mean for 3 experiments

Reserve N unloading at harvest



Negative values N in straw : Positive values N to grain

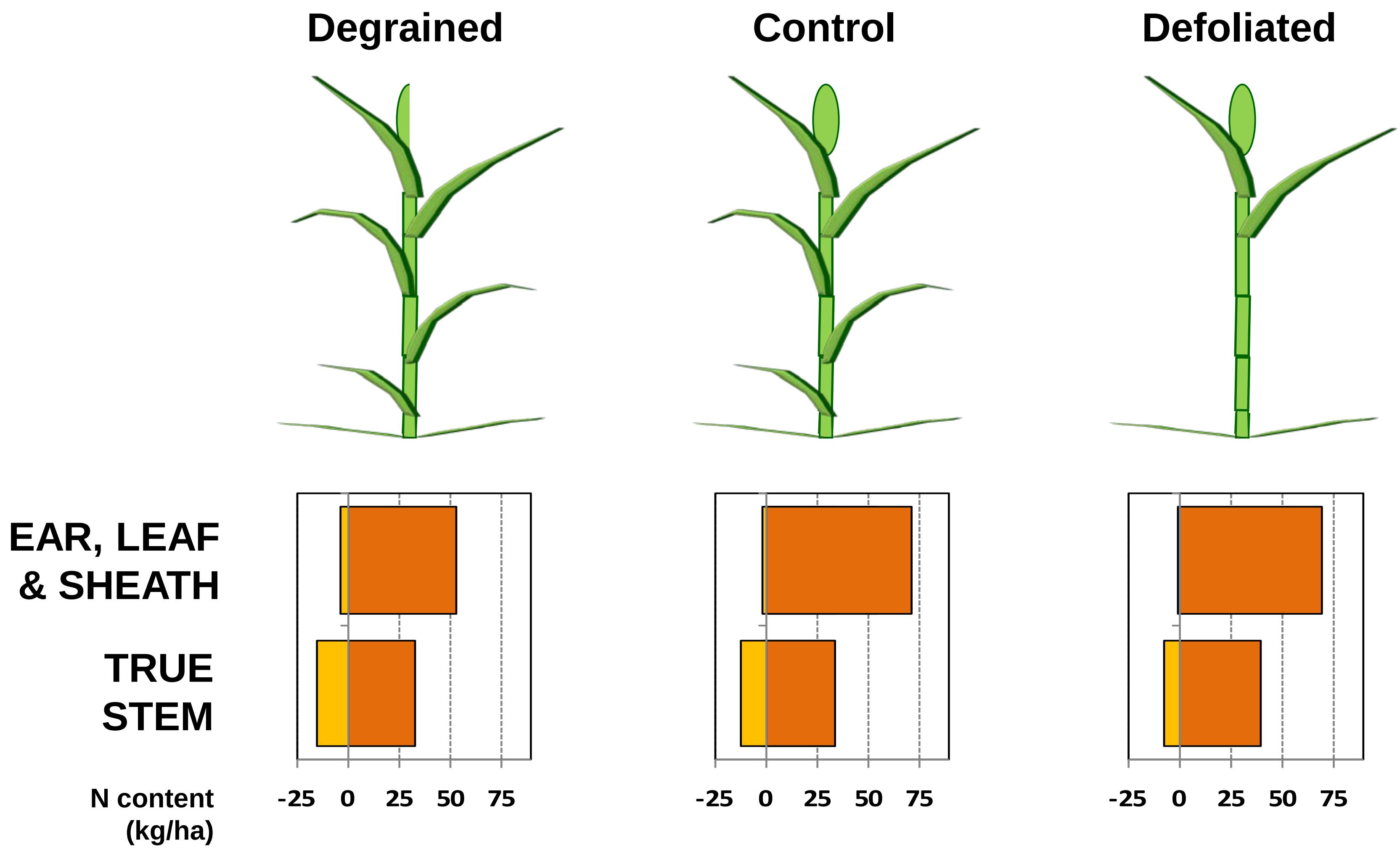
Istabraq at 3 N treatments, mean for 3 experiments

Genetic effects at harvest

	Above-ground N	Remobilsed true stem RN	Non-remobilsed true stem RN
Genetic range at rec'd N treatment	313-325 kg/ha	32-40 kg/ha	11-16 kg/ha
Probability (G) **Probability (G*N)**	ns ns	ns ns	<0.01 ns

- Only small varietal differences in RN remobilisation
- Varietal effect of non-remobilised true stem RN – although both effect and range small
- Atlanta remobilised more ear RN to the grain, but associated with earlier flowering increasing ear RN

Reserve N unloading in post-flowering N source/sink manipulations



Negative values N in straw : Positive values N to grain

Istabraq at recommended N treatment, mean for 2 experiments

Conclusions

- **New model shows significant role of RN:**
  - *Up to flowering:* 109 kg/ha RN at recommended N of which 27% in leaf lamina and 41% in true stem
  - *During grain-filling:* 94 kg/ha RN remobilised; 100% of leaf lamina RN, but 72% of true stem RN
- **True stem has important RN function:**
  - Large physical size and central location
  - But contained 12 kg/ha RN in straw at harvest
  - Small varietal difference in non-remobilised RN
  - N source/sink manipulations indicate potential for increased remobilisation of RN

Breeding for improved NUE

- **Optimisation of RN :**
  - *Feed wheats*: Lower grain N to reduce requirement for true stem RN accumulation
  - *Bread wheats*: Increased true stem RN mobilisation efficiency during grain-filling
- **Screening for target traits:**
  - True stem traits such as wall thickness, height and N content
- **Search for genetic variation:**
  - In wider wheat germplasm, relatives of wheat and synthetically derived wheats
  - Potential for gene introgression

Acknowledgements

The University of Nottingham

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