Improvements in nitrogen use efficiency of barley to meet the climate change induced challenges - means provided by plant breeding

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Nitrogen use efficiency

- Need to improve NUE
  - Costly input
  - Environmental effects

- Climate change induced changes in production environment

- Breeding and utilization of all potential gene pools

- Nitrogen use efficiency experiment
  - Genotype differences & breeding effect
  - Connection with other traits
  - Association of gene markers with NUE
Materials and methods

• 195 barley genotypes
  • 72 NordGen genotypes + 123 cultivars (from 1910’s till 2010)
  • Field trials 2011-2012
• 2 nitrogen rates: 35 and 70 kg N/ha
  • 9 unfertilized genotypes
  • 3 replicates
• Nitrogen use efficiency indices
• SNP genotyping
  • 1536 SNP-markers (UCLA)
  • Associate mapping: N use indices, disease resistance
Definitions

NUE: nitrogen use efficiency
    kg grain/kg available N (fertilizer N + soil N)

Subcomponents of NUE:
NUPE: nitrogen uptake efficiency
    kg plant N/kg available N (fertilizer N + soil N)
NUTE: nitrogen utilization efficiency
    kg grain/kg plant N (straw + grain N)

NHI: nitrogen harvest index (%)
    percentage of plant N in grain
Grain yield (kg/ha)

Yield (kg/ha)

\[ y = 10.75x - 17387 \]
\[ R^2 = 0.51642 \]

\[ y = 12.638x - 20710 \]
\[ R^2 = 0.59731 \]

Year of release

N35
N70

SGW +
Grain number +
Harvest index (HI) +
Stem length –
Lodging –
Nitrogen use efficiency: NUE (kg grain/kg available N)

NGB-material

\[ R^2 = 0.5863 \]

\[ R^2 = 0.5021 \]

Year of release

NUE

N35

N70

NUE + 30-35%
Nitrogen uptake efficiency: NUPE (kg plant N/kg available N)

NUPE + 20-25%

R² = 0.4433

R² = 0.2981

NGB-material

Year of release

NUPE

N35

N70
Nitrogen utilization efficiency: NUTE (kg grain/kg plant N)

- NUTE + 10%
- \( R^2 = 0.1845 \)
- \( R^2 = 0.2672 \)

Year of release

NGB-material

N35
N70
Nitrogen harvest index: NHI (%)
Conclusions

- Breeding has greatly improved agronomic traits and yielding capacity
- Modern cultivars outperformed the land races in N use efficiency
- However, some of the landraces had high N utilization or uptake efficiency → potential crossing material for breeding programmes
- Some DNA-markers (SNP) associated with N use efficiency indices. These markers may fasten the backcrossing process in plant breeding and enable efficient screening of N traits

- Breeding will be an important mean to
  - cope with the climate change induced changes in production environment (prolonging growing season in northern areas)
  - further improve N use efficiency in crop species
Nitrogen use efficiency

Cultivar:
- Yield
- Yield stability

Cultivation:
- Seed
- Field
- Crop protection
- Precision agriculture
- Water

Are needed to secure the realization of the available potential of a genotype as fully/efficiently as possible.
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