# Relationships between NITROGEN USE EFFICIENCY and Potato Quality Traits: STARCH AND PROTEIN Responses

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ADELAIDE, SOUTH AUSTRALIA
WPC 2024
23-26 JUNE 2024

WORLD POTATO CONGRESS

# Nitrogen use efficiency

# NUE

**how effectively a plant utilizes the available nitrogen to produce yield**

ratio of crop yield to the amount of nitrogen supplied

improved NUE → sustainability and profitability

**Cleaner waters**: minimized nitrogen leaching and runoff

**Lower Greenhouse Gas Emissions**: Efficient nitrogen use decreases nitrous oxide emissions

**Sustainable Agriculture**:

Enhanced NUE promotes soil health and biodiversity, contributing to sustainable farming practices

**Cost savings.** Reduced need for nitrogen fertilizers

**Market competitiviness.**Lower production costs and higher yields

**Improved yield quality** (!?) .....

# Potatoes and NUE: key general associations (I)

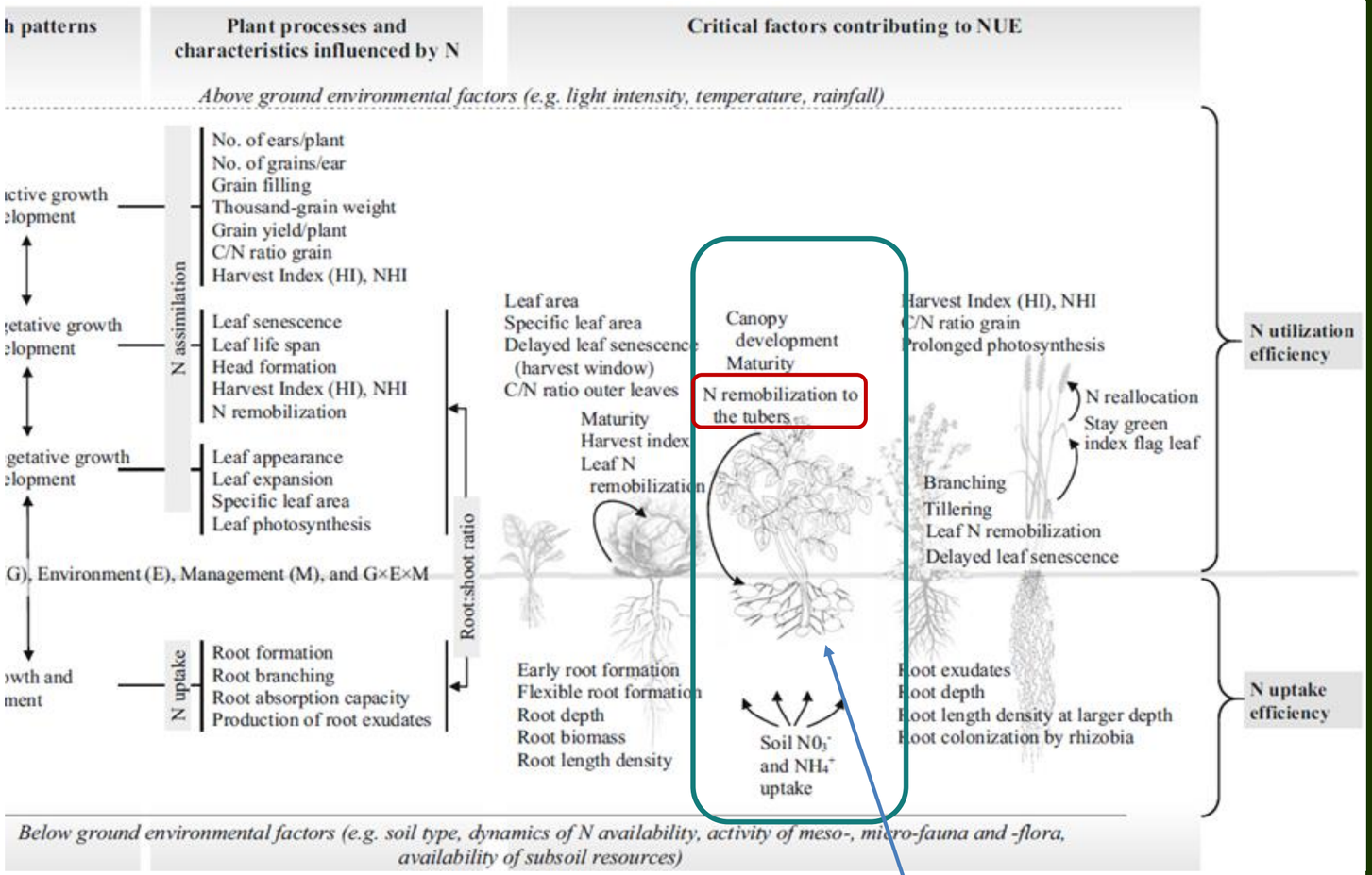


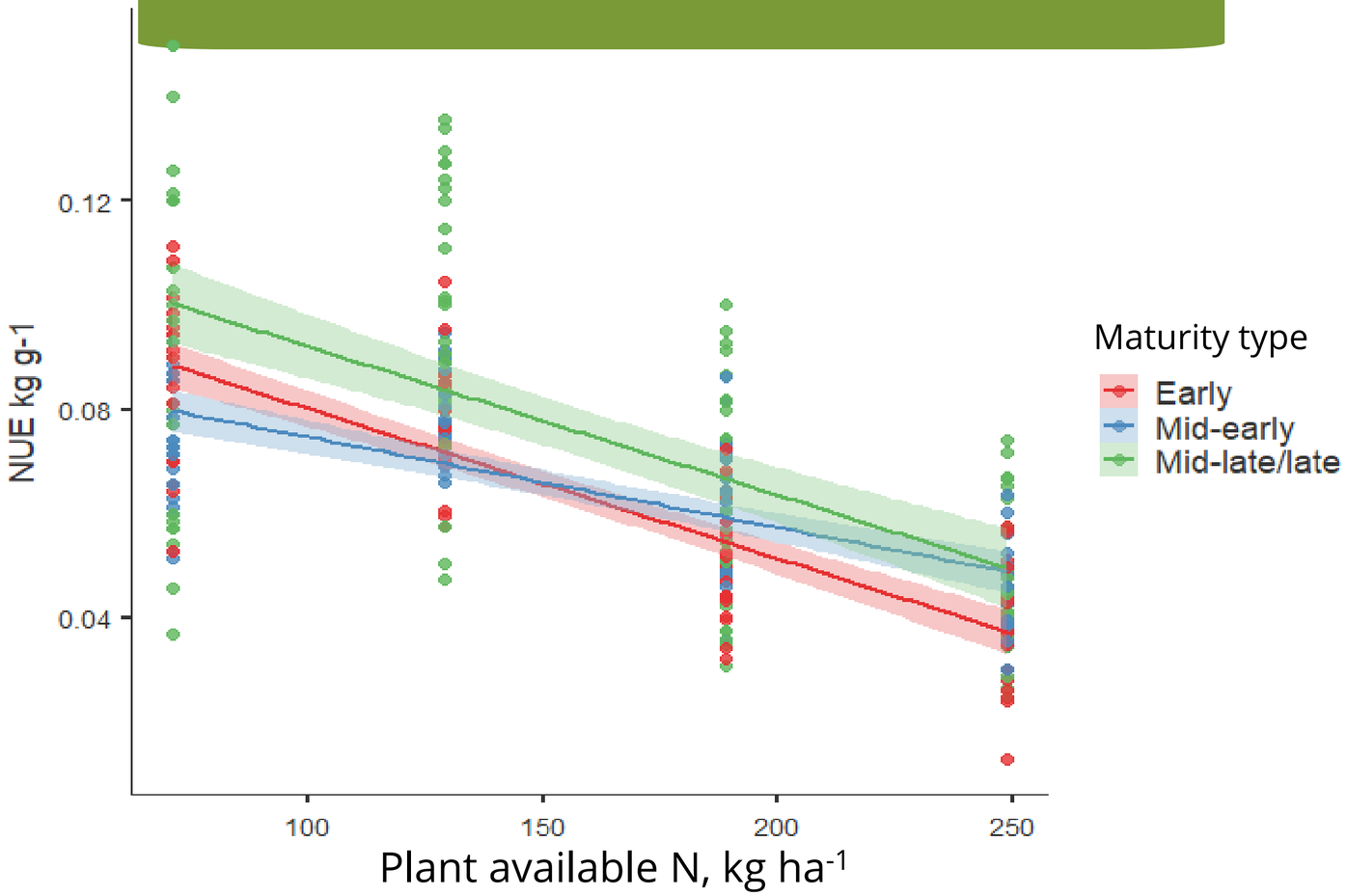

Image from Lammerts&Struik, 2017

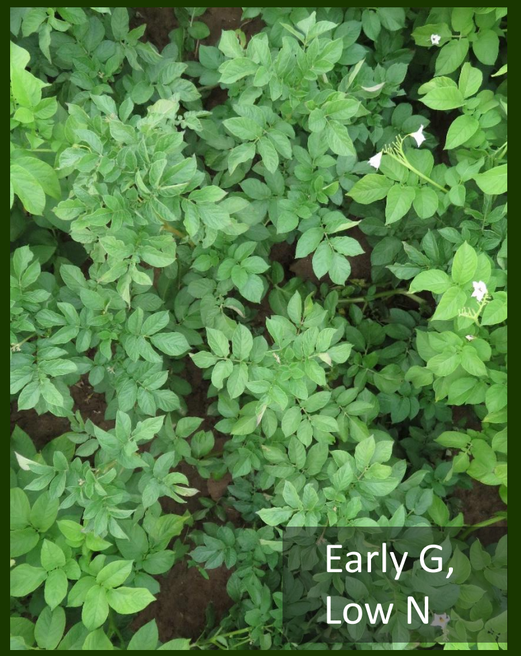
Shallow roots

## In general – low NUE


From: Sidhu, S. K., Zotarelli, L., & Sharma, L. K. (2024). A review of potassium significance and management approaches in potato production under sandy soils. Journal of Sustainable Agriculture and Environment, 3(2), e12106.

# Potatoes and NUE: key general associations (II)





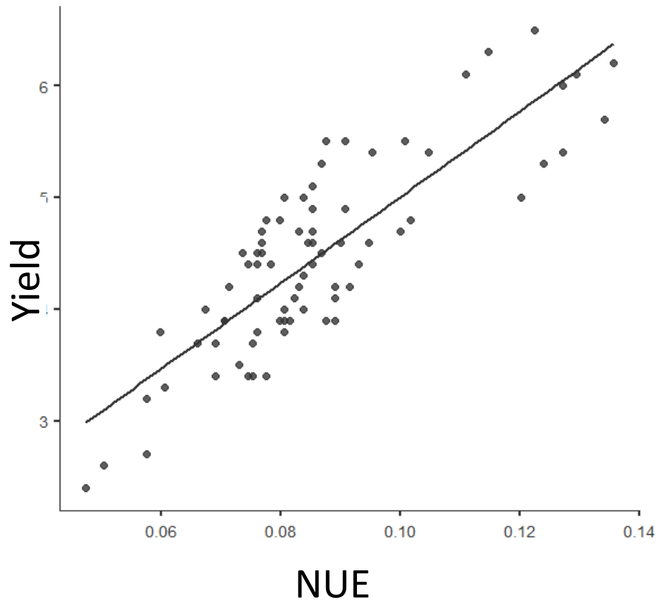
In regions with a short growing season, late genotypes cannot achieve their potentially high NUE

# Strategies to improve NUE

N management

**Variety selection**

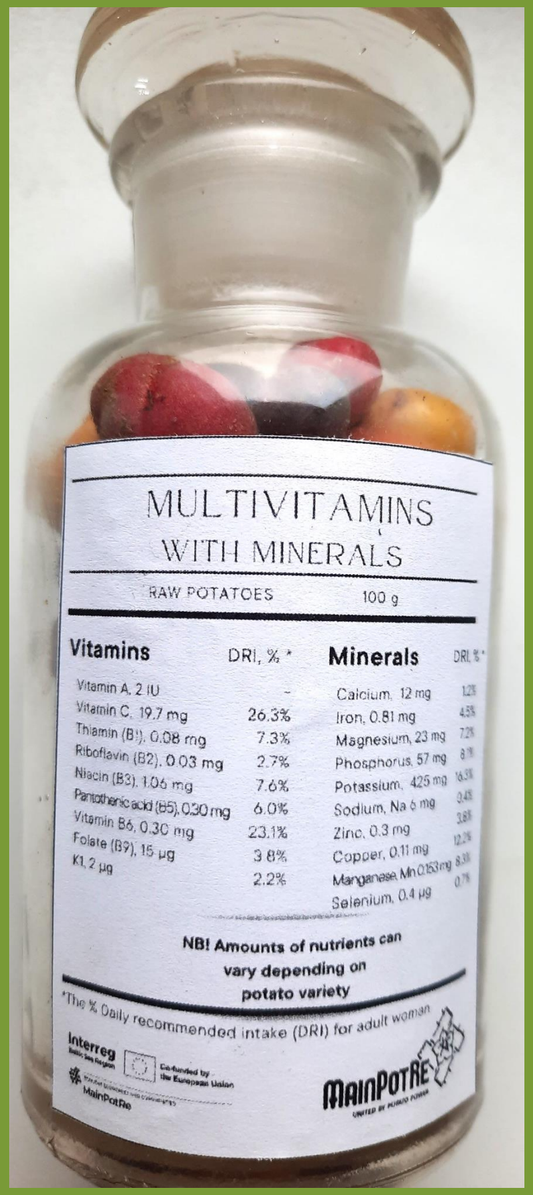
**Many crops (incl. potato) show significant genetic variation in their NUE**



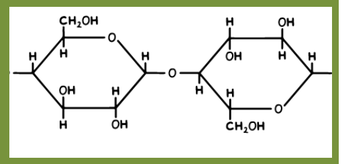

**NUE ↑**
**yield ↑**

Strategies to improve NUE

# YIELD QUALITY?




# Starch



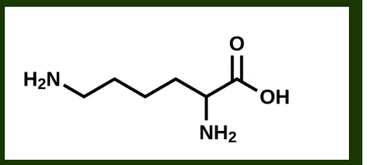

## content (%)

- Certain culinary applications
- Nutritional value (calories)
- Economic benefits
- ....

## yield, t ha$^{-1}$

- Economic gains
- Efficient resources utilization
- .....

# Protein




Low content (~2 % fresh weight)

Protein yield – one of the highest among crops

**High-quality** (close to egg protein): Contains all essential amino acids, with particularly high levels of lysine

Highly soluble and digestible

## Patatin – main group of potato protein

- health benefits
- Food industry – foaming, emulsifying, vine fining....

# The study

Priekuli location, Latvia

Planting – middle of May

Haulm killing – first days of September



# Experimental design

Two-year field trial

Loamy sand, high P, low to high K

Pre-crop – winter cereals

19 potato genotypes (3 maturity types)

4 nitrogen management treatments:

- ***Organic*** *(no added fertilizer)*
- ***Integrated*** *management with* ***three nitrogen application rates*** *(60, 120, 180 kg N/ha)*

4 replicates


**NUE=DM yield/plant available N**

# Quality traits determination

**Dry matter (DM) and starch content, % FW**– underwater weight method and relevant calculations

**Dry matter and starch yield, kg/ha** - calculated accordingly

**Crude protein , % DM** – Kjeldahl method for N for NIRs calibration. Then – NIRs express analysis (*Foss*)

**Crude protein yield, kg/DMY/ha** - calculated

**Pure protein** (for patatin determination) – BCA assay kit (*Novogen*)

**Patatin** relative abundance (**PRA**) in pure protein - microchip electrophoresis (*Agilent 2011 Bioanalyzer*)

# Major relatioships found

More data on genotype performance, differences between years etc.  can be found here



ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 110, No. 4 (2023), p. 329–338
DOI 10.13080/z-a.2023.110.037

## The effect of nitrogen use efficiency on significant traits of potato starch production

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### Abstract

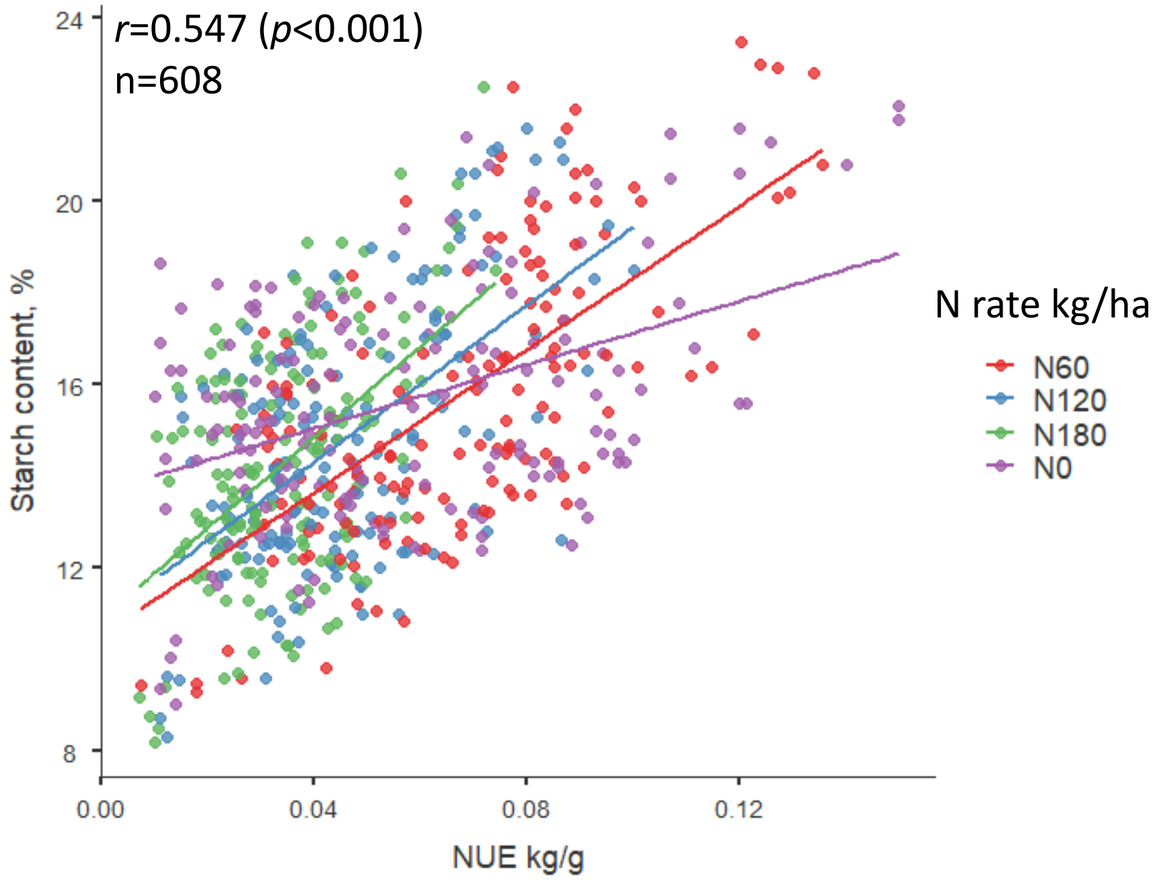
The improvement of nitrogen use efficiency (NUE) in potato (*Solanum tuberosum* L.) can reduce the required N input. As a result, economic benefits will increase, and environmental pollution will decrease due to N loss. The aim of the study was to determine the NUE of potato genotypes and to evaluate the relationship of NUE with the tuber yield, starch yield, and starch content at different N fertiliser rates. During a two-year experiment, the

Ilze Dimante*, Ilze Skrabule, Elina Sokolova, Inese Taskova, Dace Berga, Vita Sterna (2024) **Exploring the Relationship between Nitrogen Use Efficiency and Protein Concentrations in Potato Genotypes**. *In press*

# RELATIONSHIPS (starch)

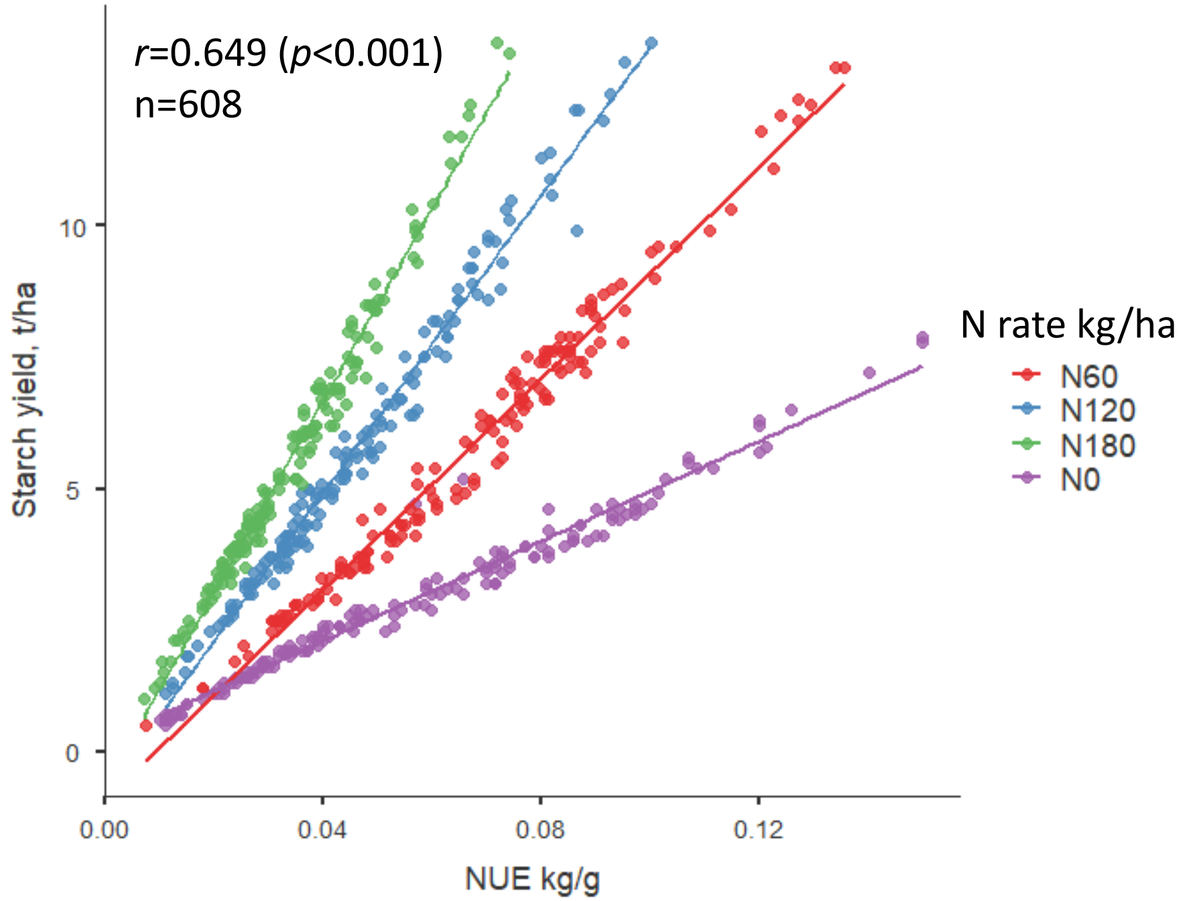
## NUE and starch content, %

Genotype p<0.001
N rate, p<0.001




## NUE and starch yield, t/ha

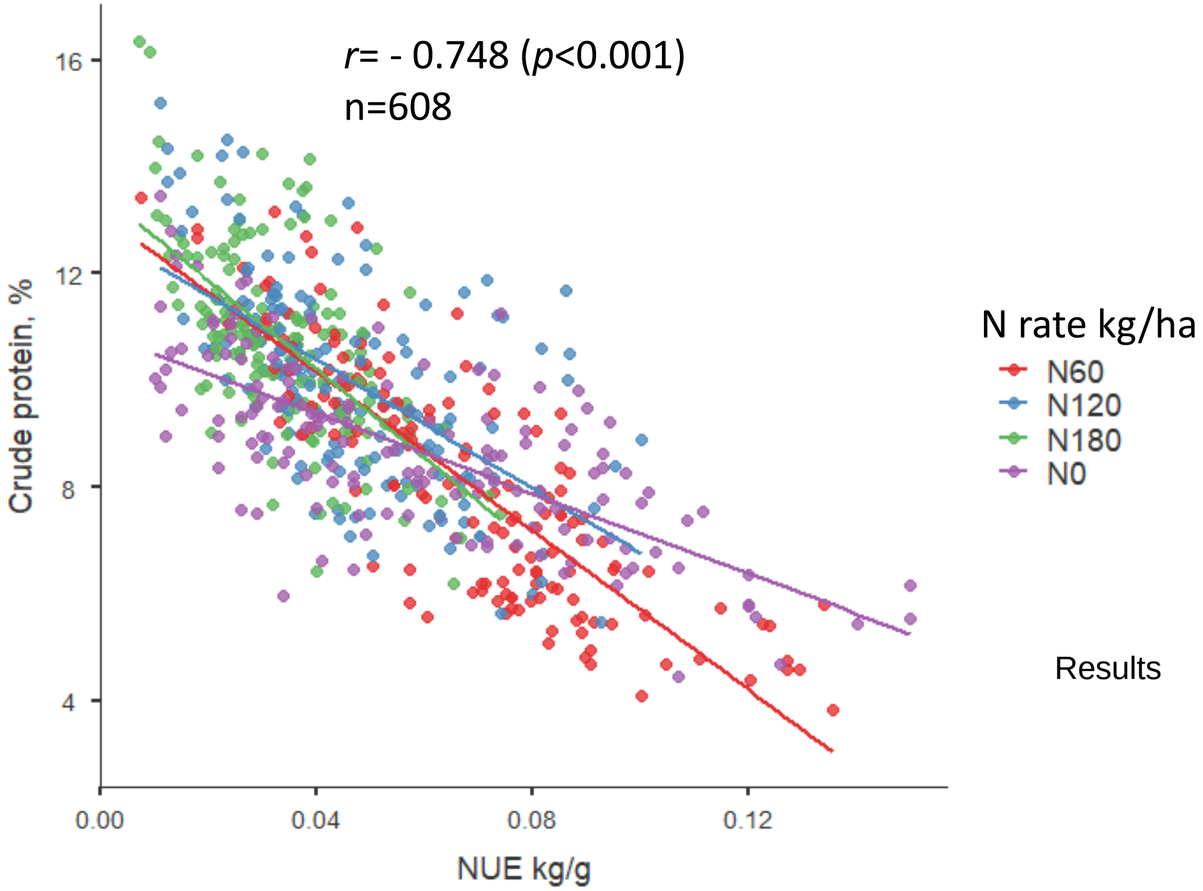
Genotype p<0.001
N rate, p<0.001



# RELATIONSHIPS (crude protein)

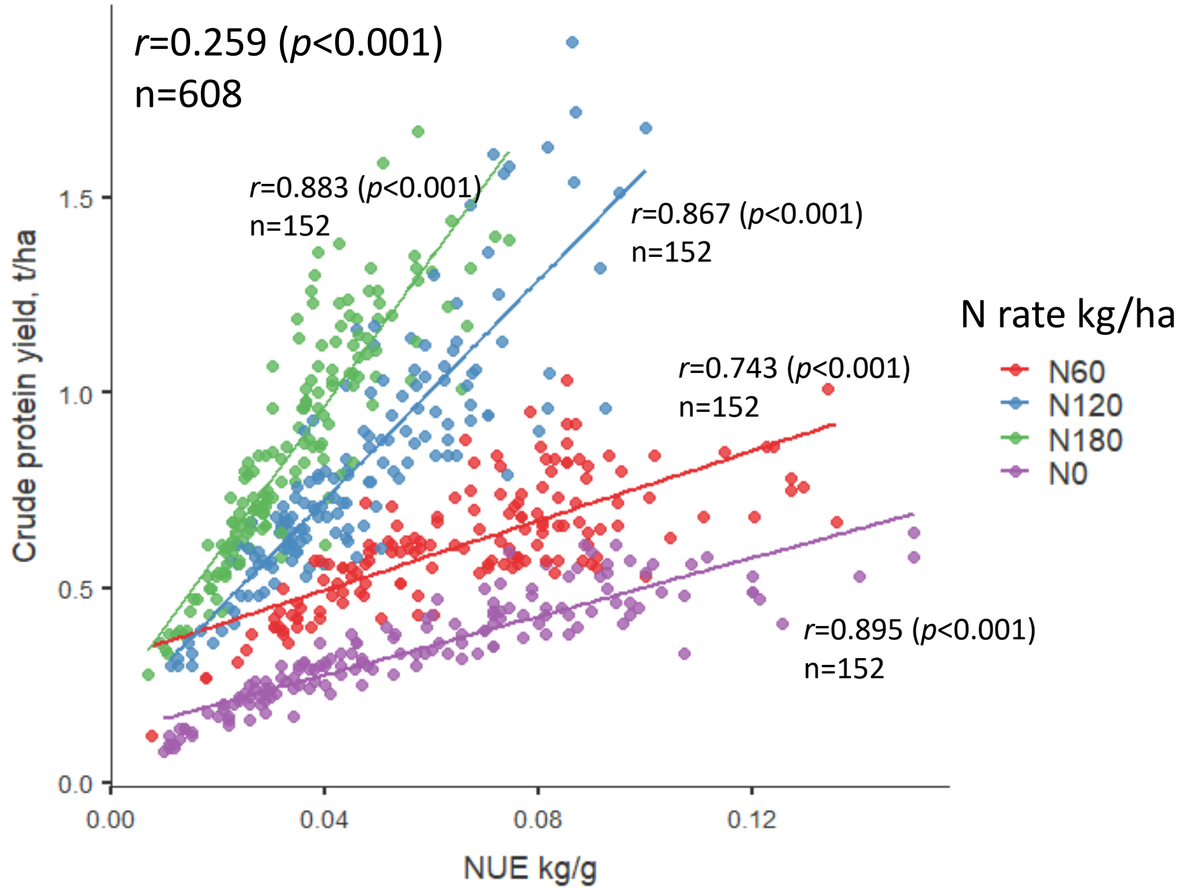
## NUE and crude protein, % DM

Genotype p<0.001
N rate, p<0.001




## NUE and crude protein yield, t/ha

Genotype p<0.001
N rate, p<0.001




Results

# PATATIN RELATIVE ABUNDANCE (PAR)

Genotype p<0.001

**N rate p=NS**

**NUE vs PRA**

**r= -0.213, p<0.01**

# Selection for NUE and starch and protein?

| Genotype | NUE kg/g | SC, % | CPC, % | SY, t/ha | CPY, t/ha |
|---|---|---|---|---|---|
| Agrie Dzeltenie | 0.0825 | 11.7 | 9.89 | 4.10 | 0.505 |
| Madara | 0.0754 | 14.7 | 8.56 | 4.86 | 0.559 |
| Monta | 0.0798 | 16.1 | 8.28 | 5.58 | 0.617 |
| Rigonda | 0.0783 | 15.5 | 7.02 | 5.46 | 0.511 |
| S 03067-33 | 0.0868 | 14.0 | 7.55 | 6.06 | 0.662 |
| Vineta | 0.0732 | 12.2 | 8.54 | 4.69 | 0.581 |
| Lenora | 0.0787 | 16.2 | 8.27 | 5.66 | 0.643 |
| Prelma | 0.0746 | 13.6 | 8.32 | 5.72 | 0.714 |
| S 01085-21 | 0.0775 | 15.5 | 7.64 | 5.54 | 0.585 |
| S 04065-2 | 0.0853 | 18.4 | 8.18 | 5.54 | 0.549 |
| S 11161-85 | 0.0791 | 14.1 | 10.90 | 4.97 | 0.751 |
| Verdi | 0.0824 | 18.7 | 8.44 | 5.50 | 0.560 |
| Brasla | 0.0893 | 17.2 | 8.32 | 5.80 | 0.623 |
| Imanta | 0.0858 | 17.9 | 8.26 | 5.53 | 0.578 |
| Jogla | 0.1260 | 19.9 | 6.59 | 9.32 | 0.774 |
| Magdalena | 0.1120 | 14.5 | 7.64 | 6.76 | 0.661 |
| Kuras | 0.1230 | 18.8 | 5.41 | 9.28 | 0.660 |
| Jelly | 0.0820 | 13.4 | 7.99 | 5.79 | 0.669 |
| S 11152-7 | 0.0570 | 17.0 | 9.15 | 3.94 | 0.475 |
| ***AVE*** | ***0.0857*** | ***15.7579*** | ***8.1553*** | ***5.7947*** | ***0.6146*** |
| ***STD*** | ***0.0166*** | ***2.2779*** | ***1.1290*** | ***1.3598*** | ***0.0795*** |

**N 60 kg/ha**

## Ranking

| |
|---|
| > AVE+1 SD |
| ≤AVE + 1 SD and ≥AVE - 1 SD |
| < AVE – 1 SD |

# Take home message

The lower N supply, the higher NUE (though genotypic differences)

## Significant relatioships

**+**

- Starch content and NUE
- Starch yield and NUE
- Protein yield and NUE

**-**

- Protein content and NUE
- Patatin relative abundance

Selection for high NUE, starch and protein yield possible

# Thank you!

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June 23, WPC 2024, Adelaide, Australia

# Speaker Disclosure

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