

Perennial cereal rye: Experience and research results from Denmark

Virginia (Gina) Nichols, tenure-track assistant professor

Emma Randahl-Beltran, Anders Nielsen, Cecilie Anker Johnstad-Møller, Claus Krough Madsen

Jordbruksverket FoU-dagarna
11-12 November 2026, online

Novo Nordisk Foundation













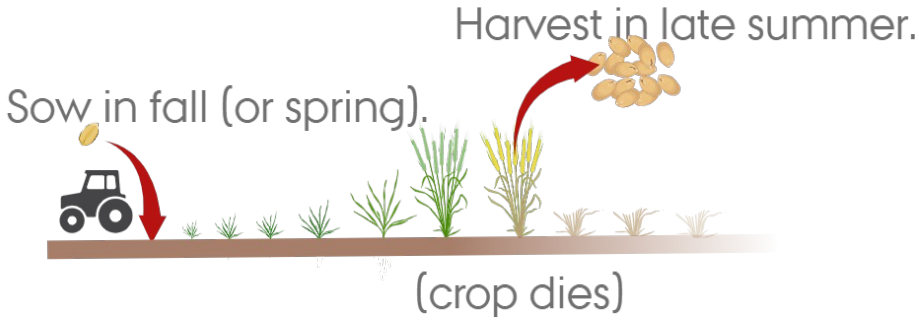
- Motivation
- The experiment
- Results



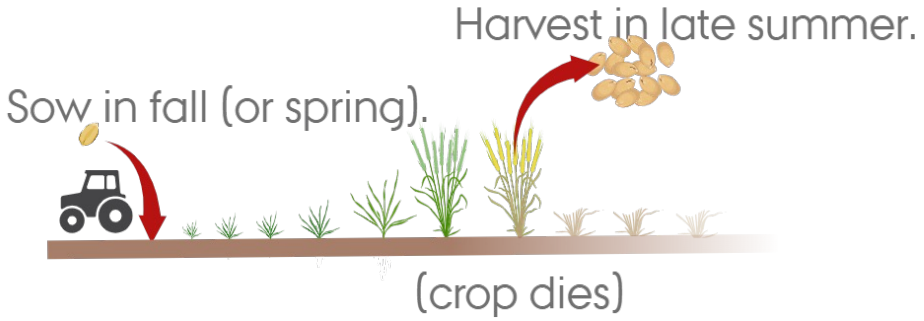
- **Motivation**
- The experiment
- Results



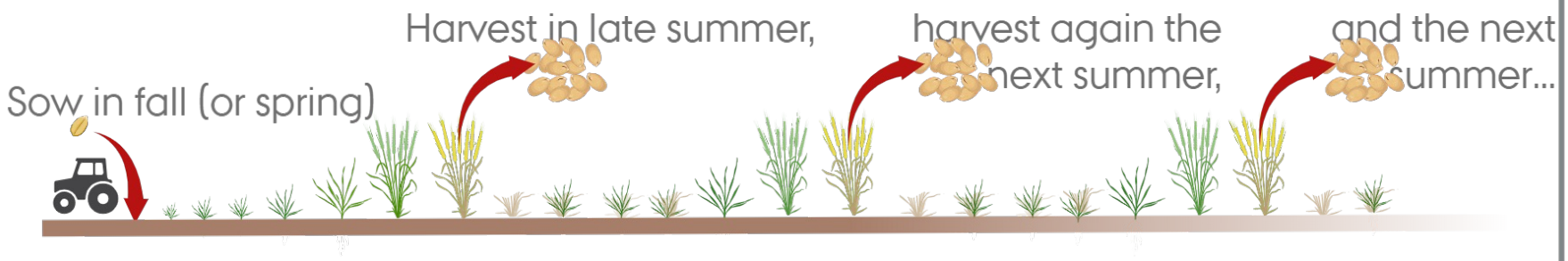
Annual grain crop



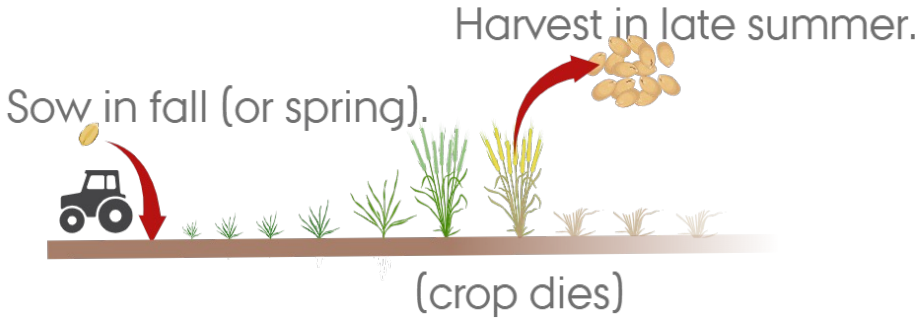
Annual grain crop



Perennial grain crop

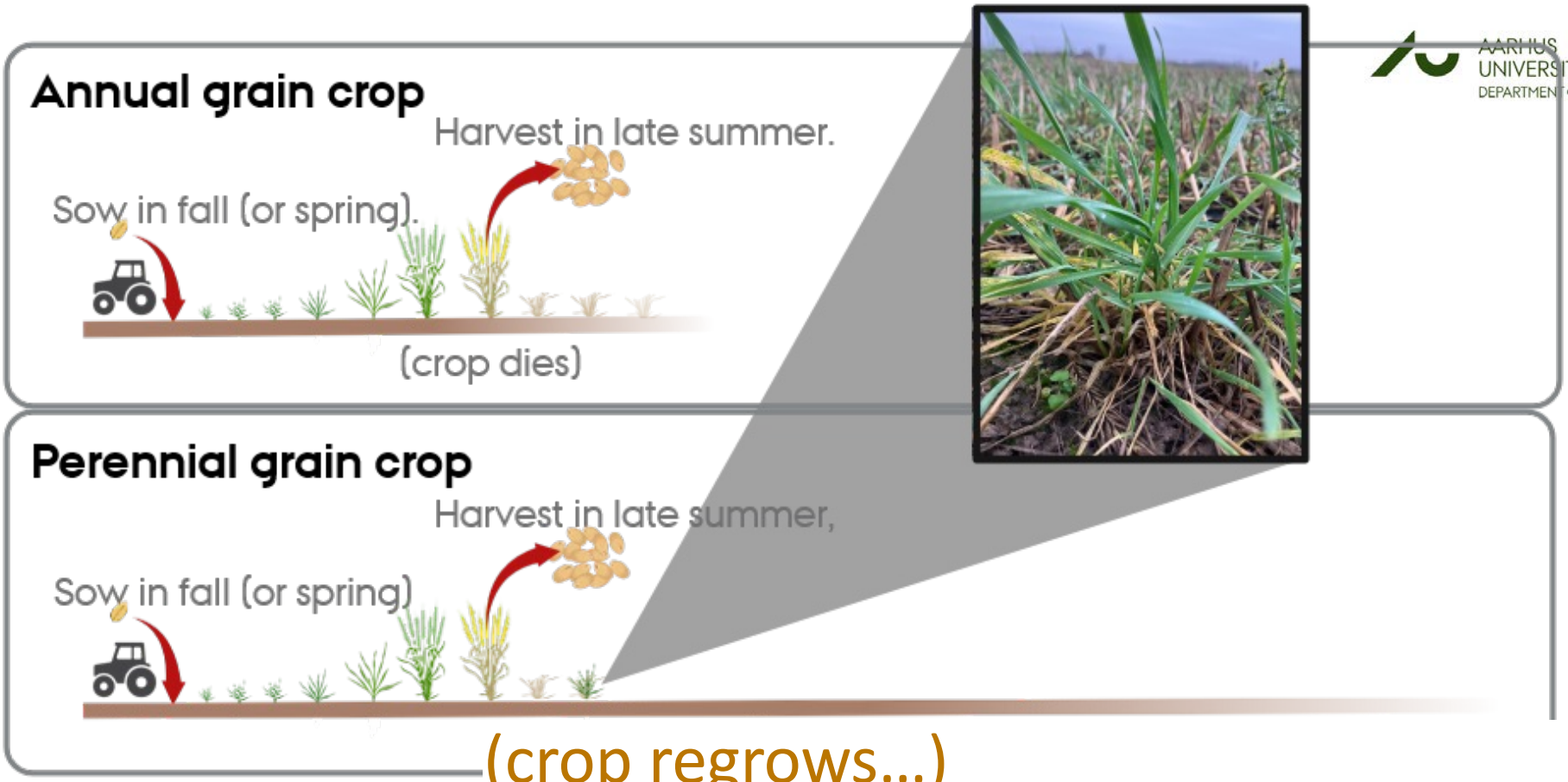


Annual grain crop



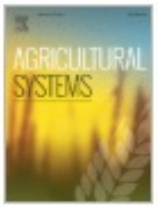
Perennial grain crop





(crop regrows…)

Agricultural Systems
Volume 234, April 2026, 104657



Self-cover cropping systems and the *plusquam*-annual: New tools for cropping system sustainability

Virginia Nichols [a], Prabin Bajgain [b], Laura Dixon [c], Kim Henrik Hebelstrup [a], Claus Krogh Madsen [a], Robin Morgan [d], Valentin Picasso [e]

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Funded by the European Union

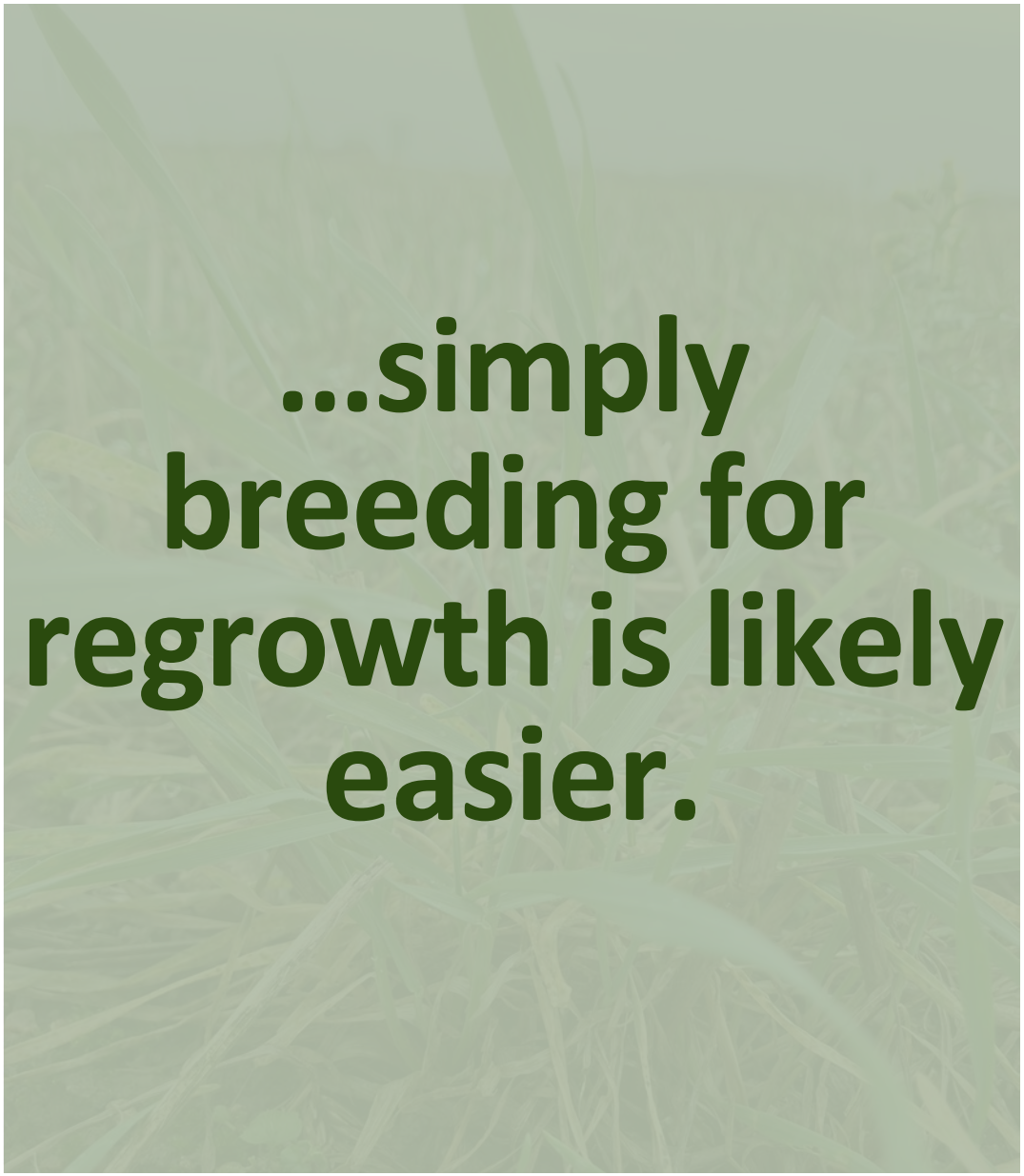
- **Motivation**
- The experiment
- Results



- Motivation
- The experiment
- Housekeeping

Getting multiple grain yields is challenging…

- Motivation
- The experiment
- Results

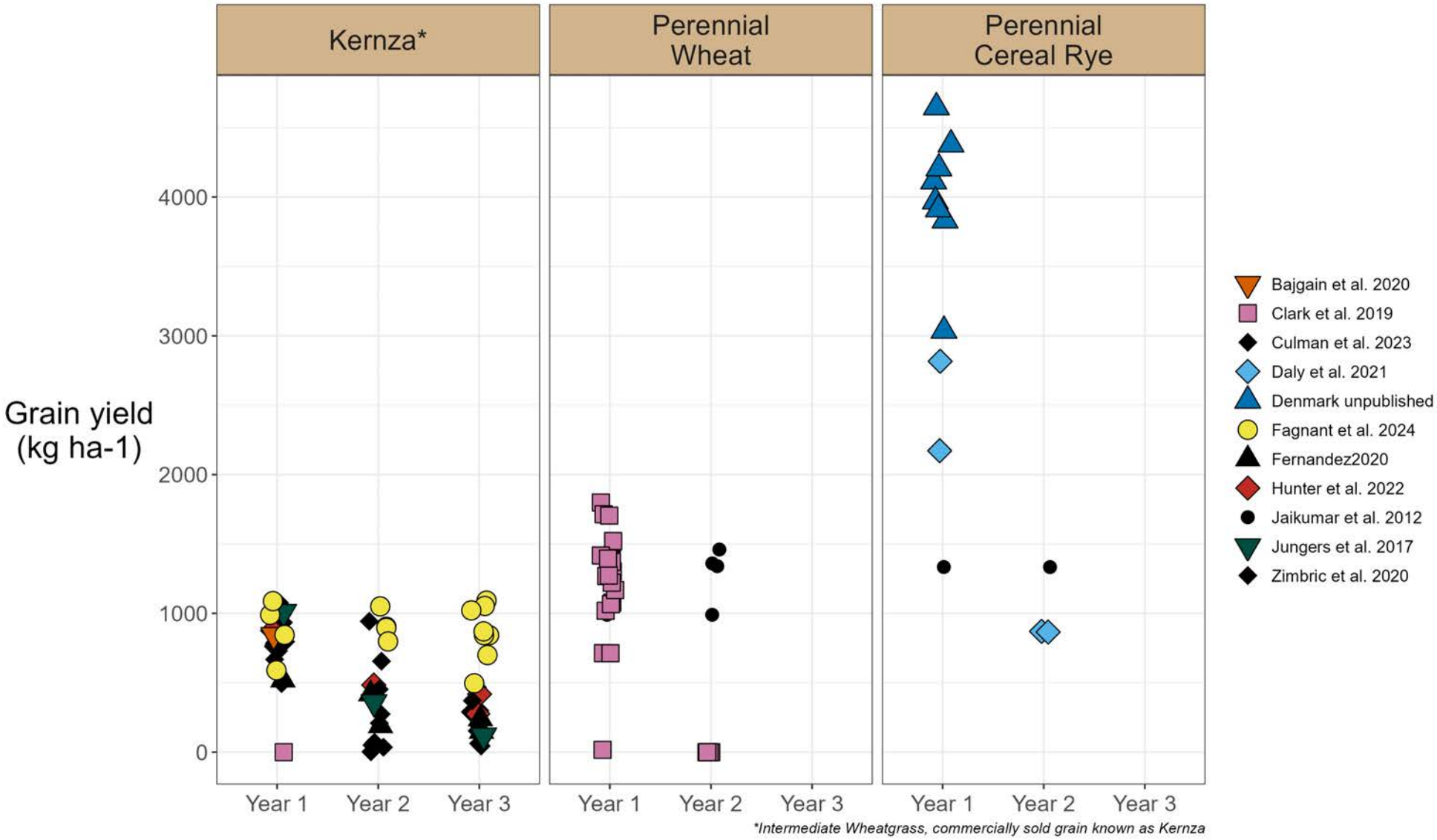


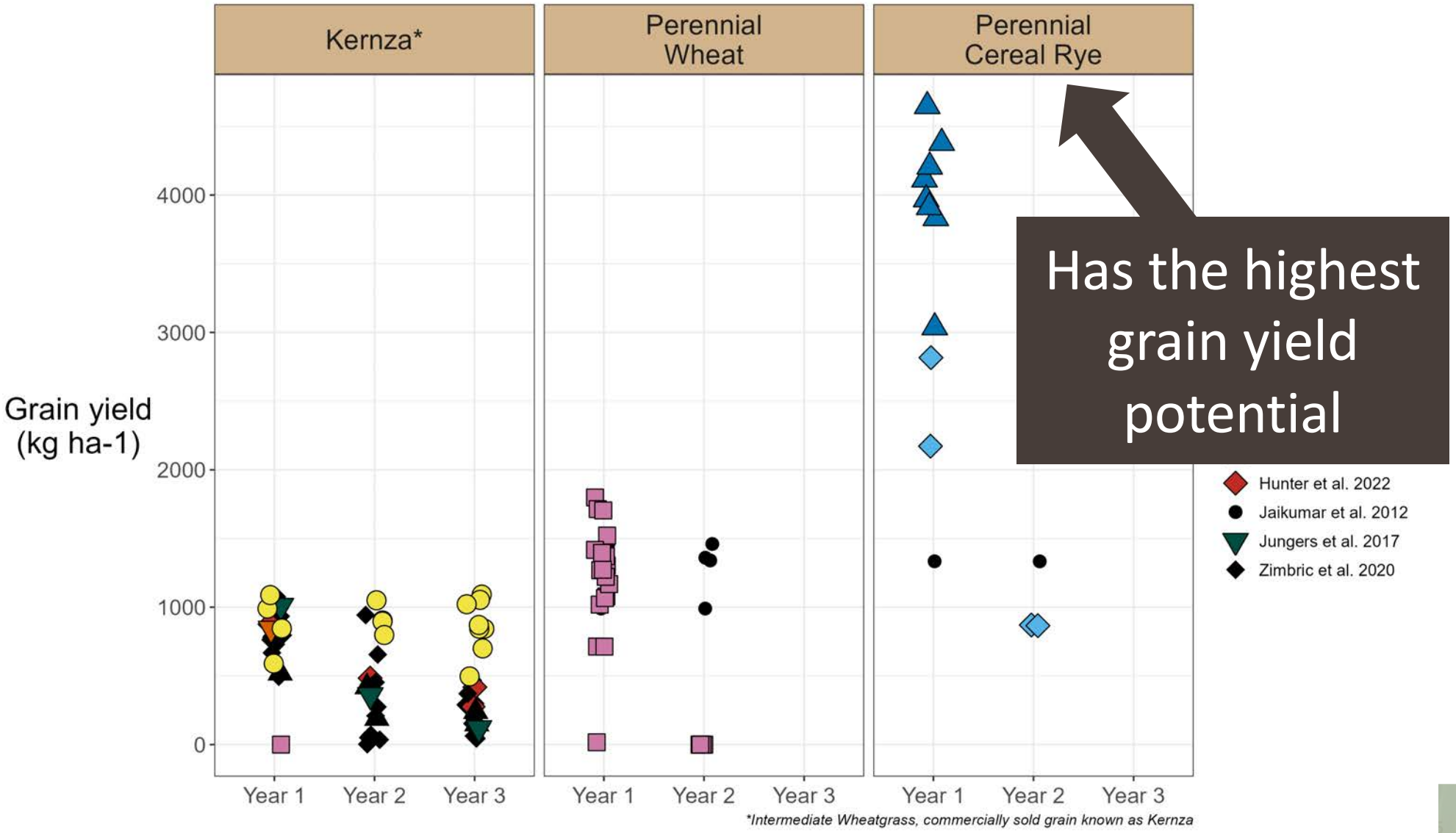
Motivation

The experiment

Results




Kernza*
Perennial Wheat
Perennial Cereal Rye
Grain yield (kg ha-1)
4000
3000
2000
1000
0
Year 1
Year 2
Year 3
Bajgain et al. 2020
Clark et al. 2019
Culman et al. 2023
Daly et al. 2021
Denmark unpublished
Fagnant et al. 2024
Fernandez2020
Hunter et al. 2022
Jaikumar et al. 2012
Jungers et al. 2017
Zimbric et al. 2020
*Intermediate Wheatgrass, commercially sold grain known as Kernza

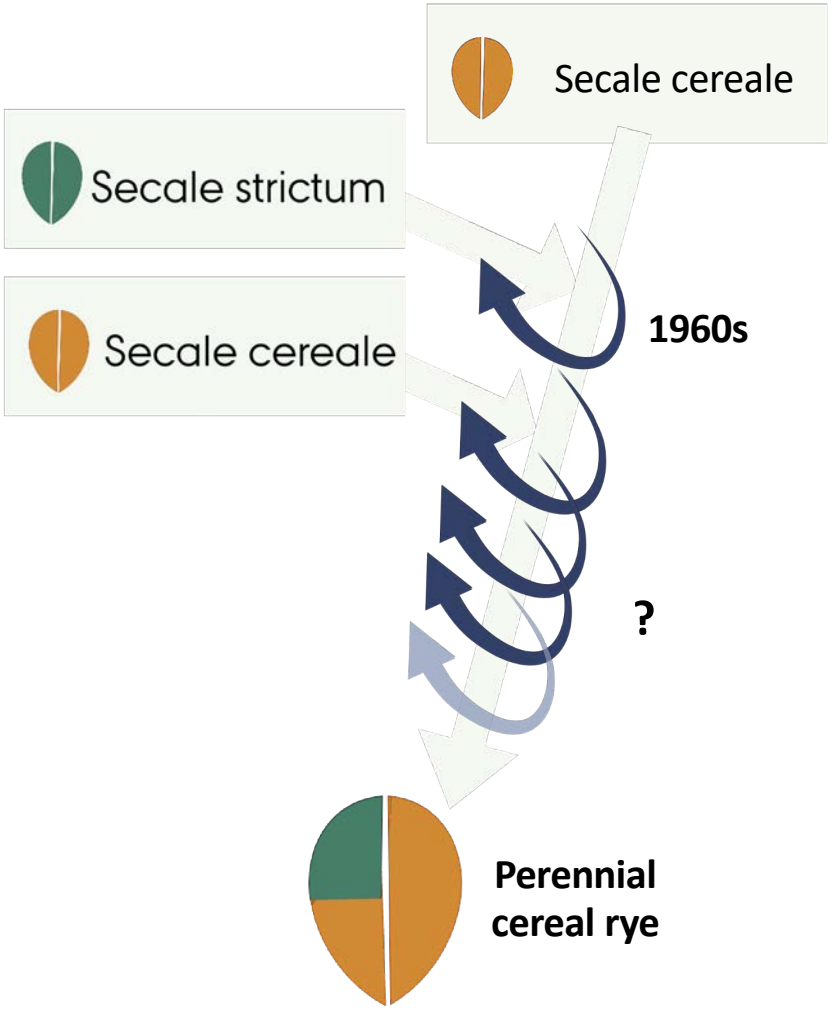

Kernza*
Perennial Wheat
Perennial Cereal Rye
Grain yield (kg ha-1)
4000
3000
2000
1000
0
Year 1
Year 2
Year 3
Has the highest grain yield potential
Hunter et al. 2022
Jaikumar et al. 2012
Jungers et al. 2017
Zimbric et al. 2020
*Intermediate Wheatgrass, commercially sold grain known as Kernza

Perennial rye

Secale strictum x

S. cereale



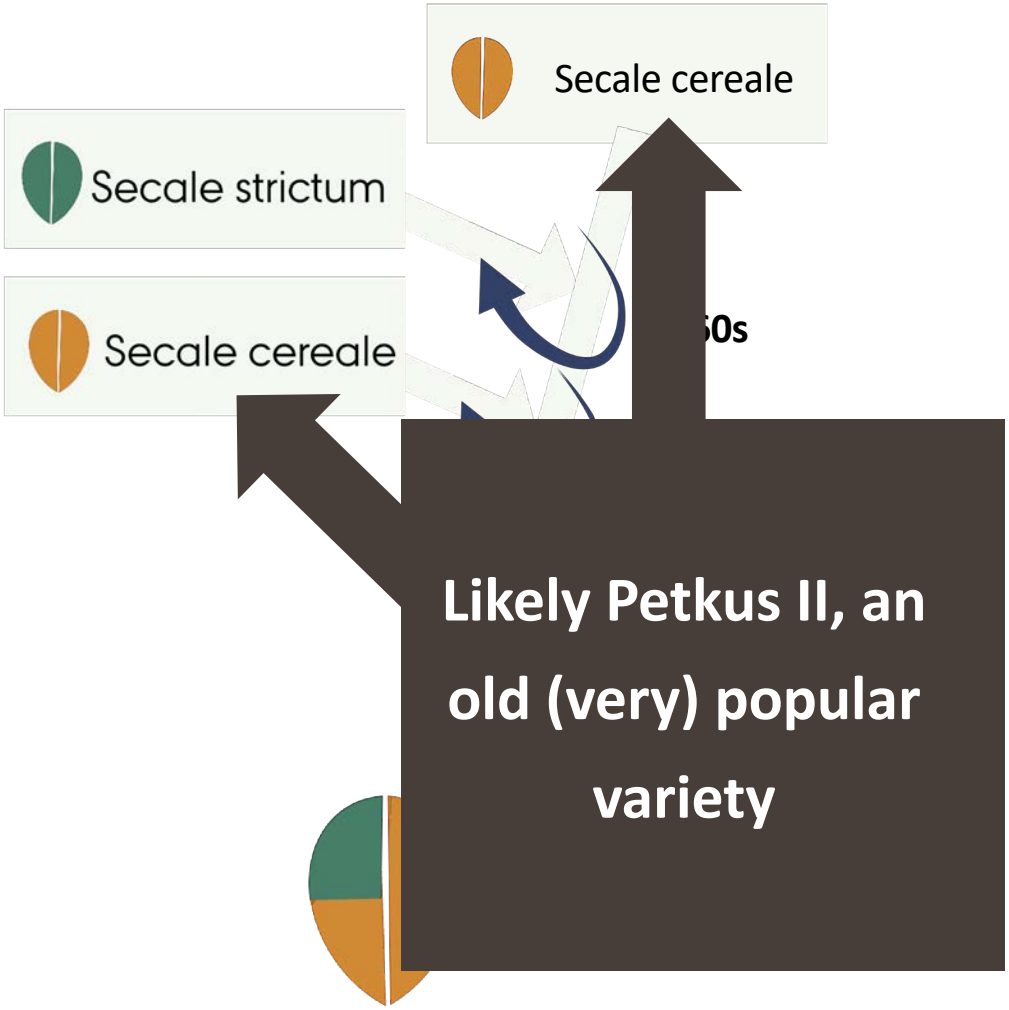


Perennial rye

Secale strictum x

S. cereale





Research questions

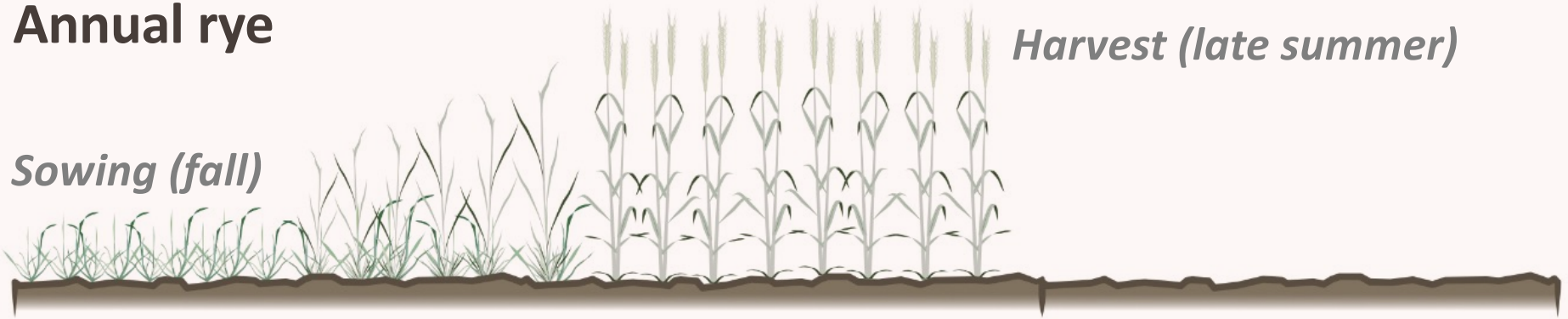
AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- What is the **yield potential** of perennial rye as compared to modern annual rye in Denmark?

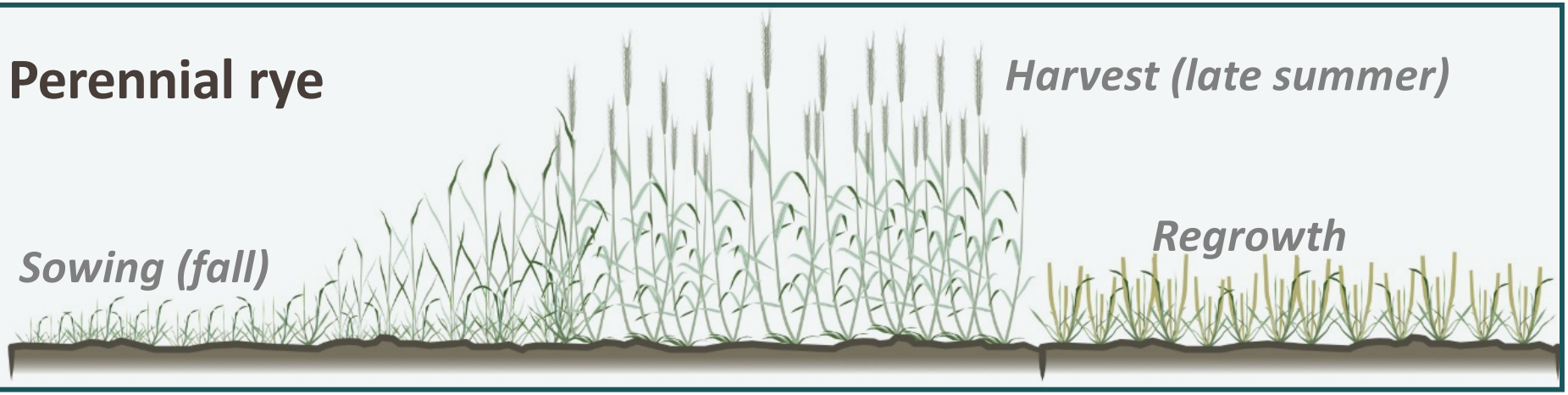
- Is **weed suppression** compromised in the perennial rye crop compared to annual rye?

- Can the perennial rye fall **regrowth** offer additional environmental or agronomic value?

Annual rye

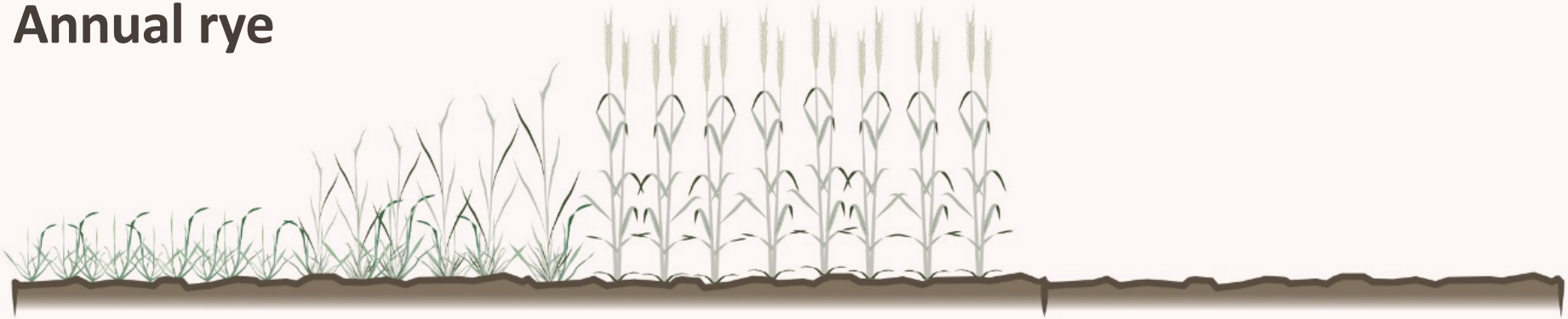


Perennial rye

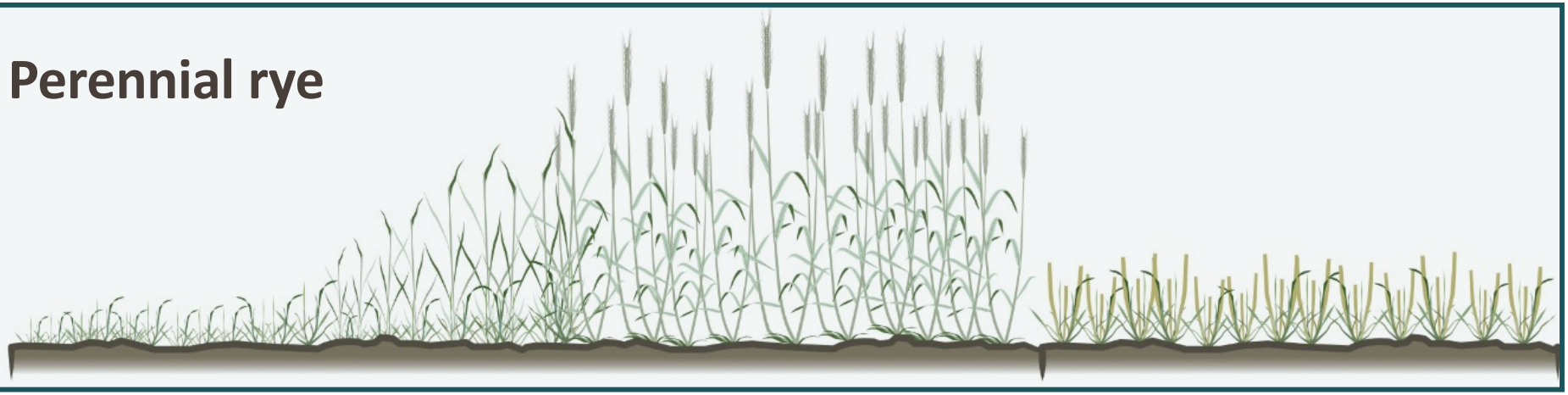




Annual rye



Perennial rye

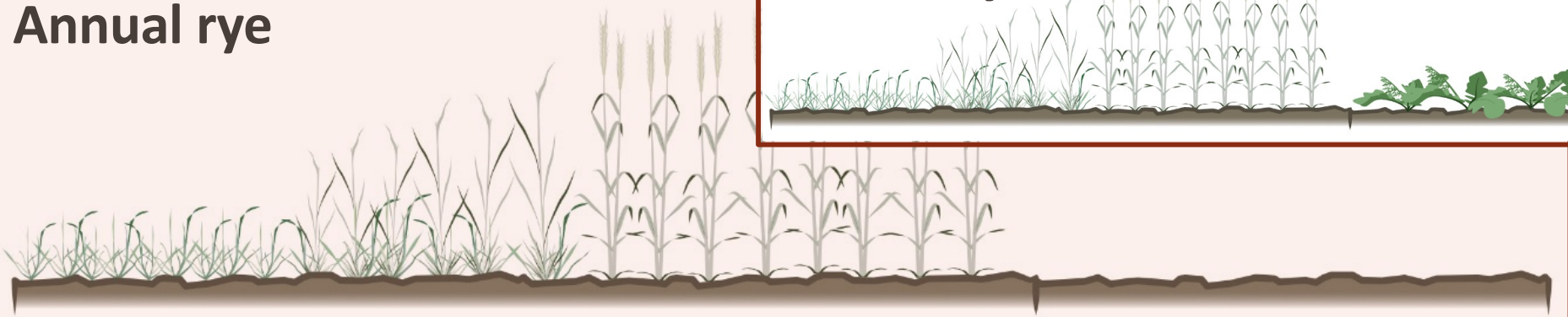




Emma Randahl-Beltran

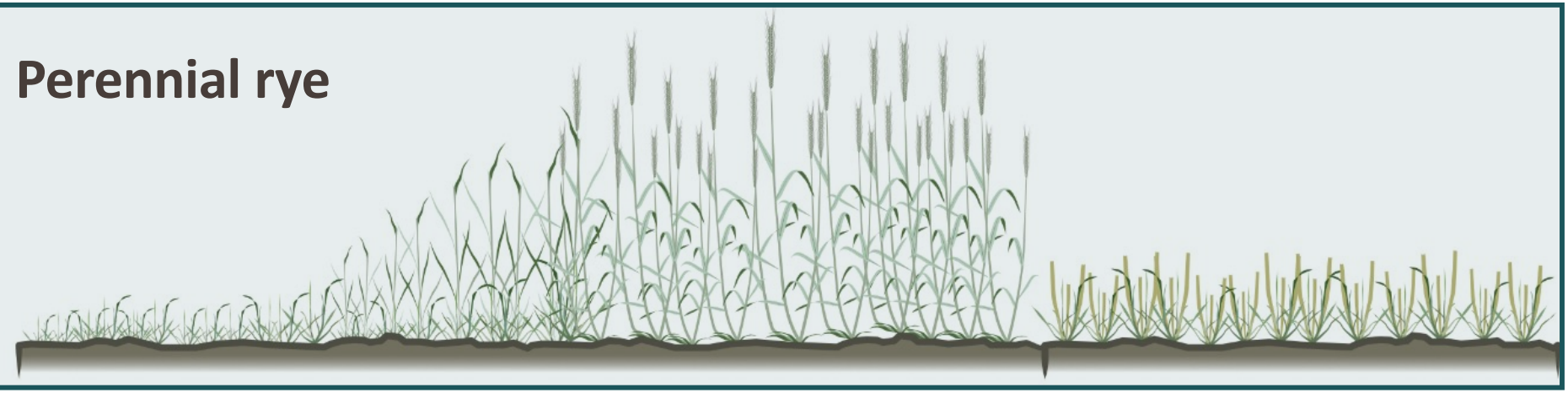
Funded by the European Union

Annual rye



Annual rye + CC

Perennial rye

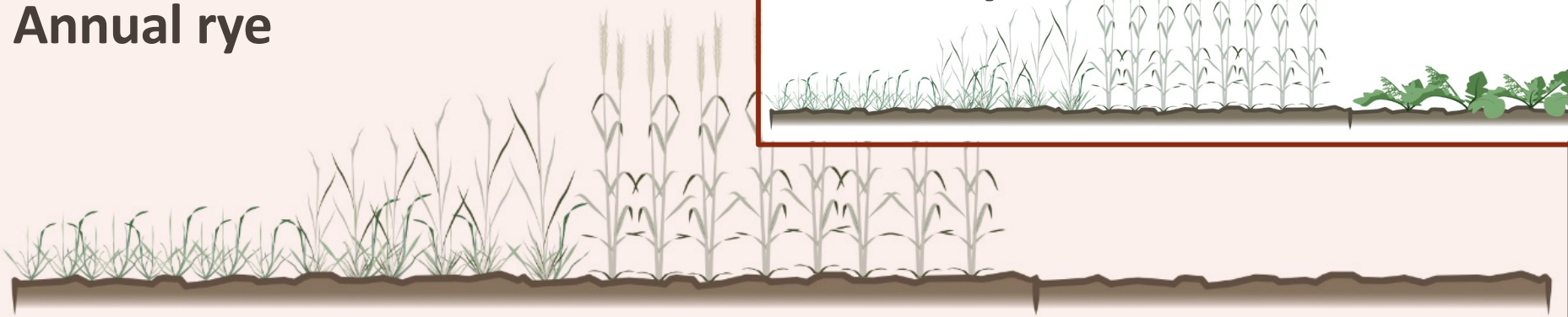




Emma Randahl-Beltran

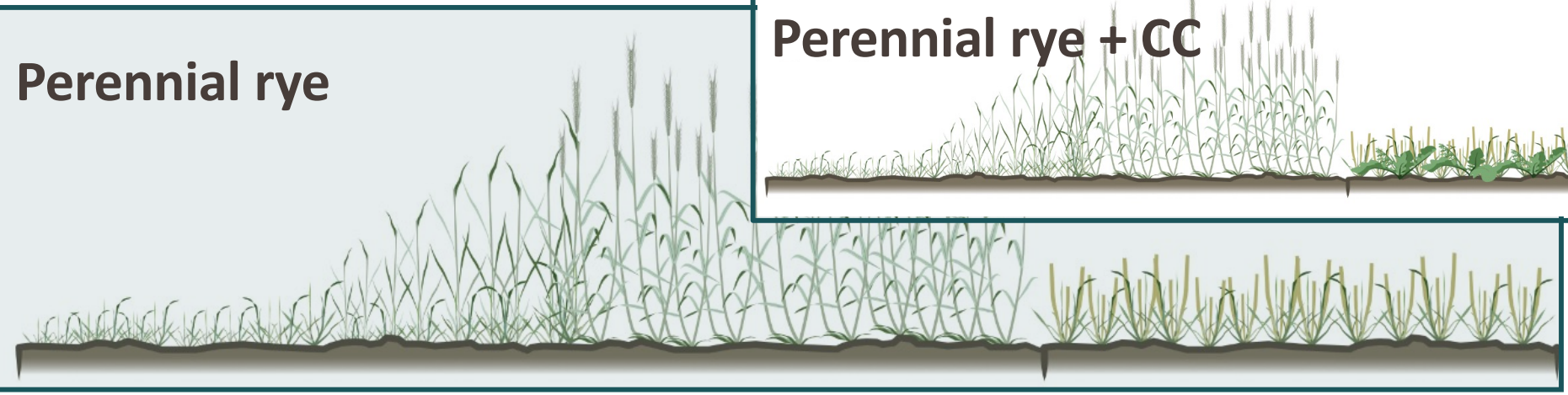
Funded by the European Union

Annual rye



Annual rye + CC

Perennial rye

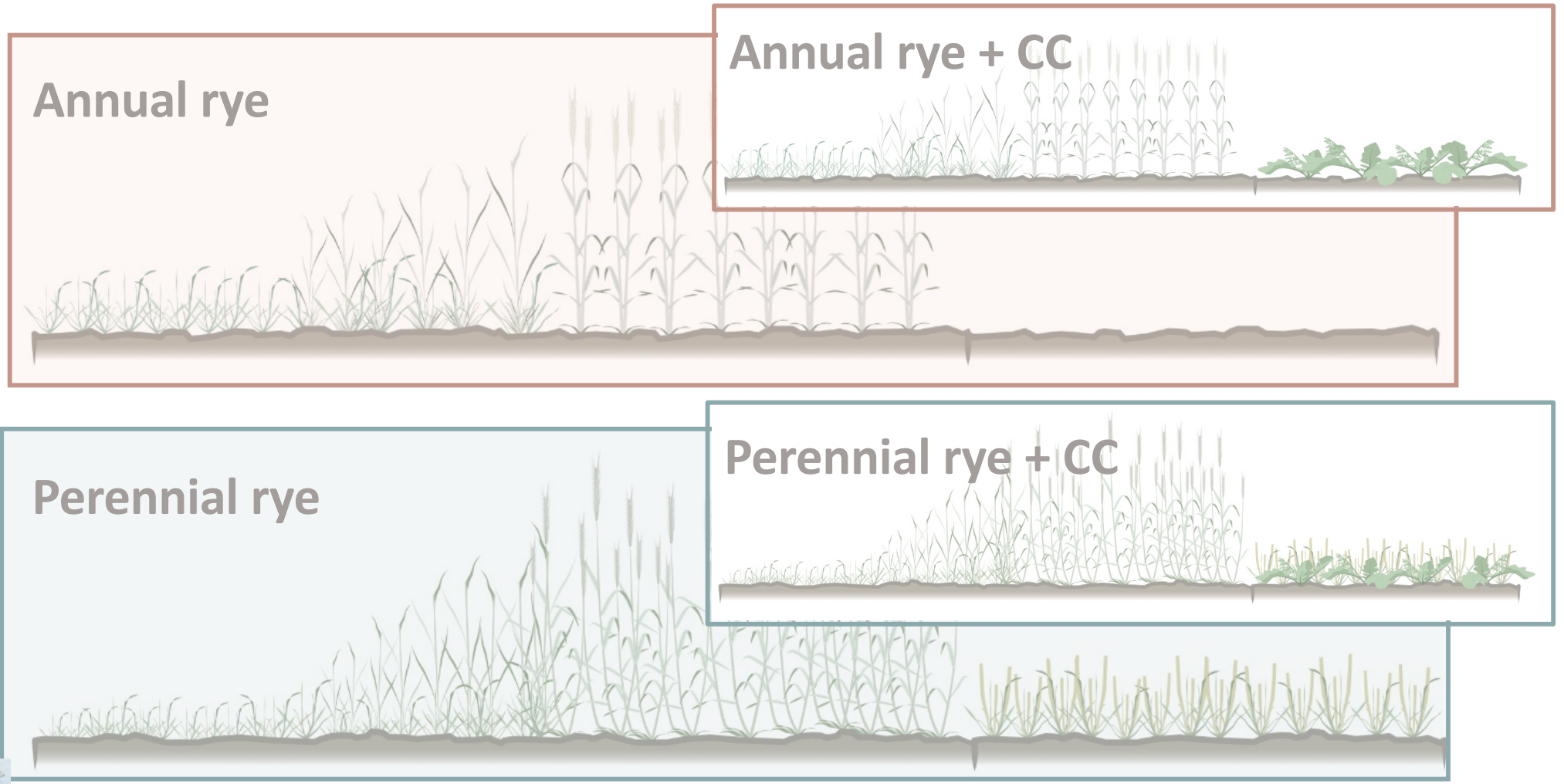


Perennial rye + CC



Emma Randahl-Beltran

Funded by the European Union





Emma Randahl-Beltran

Grown (1) conventionally and (2) without herbicides



2024/2025 season





2024/2025 season



2025/2026 season





General management

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- Inversion tillage used for plot preparation
- 160 kg N ha-1*
  - Split application, 70 kg N ha-1 in March, 90 kg N ha-1 in late April
- Planting target of 300 plants m-2
- Used growth regulators
- Had treatments both with and without the use of herbicides

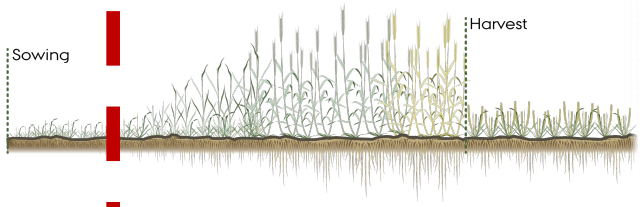
**This is likely not necessary for the perennial rye*

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

2024 2025 2026 2027









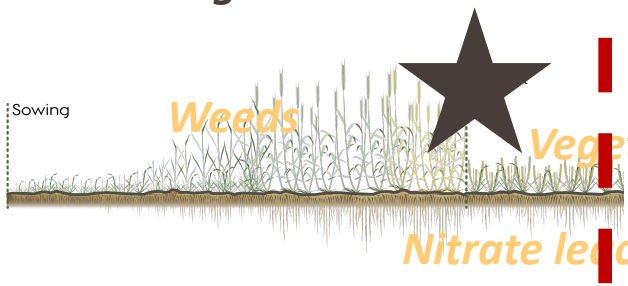
Funded by the European Union

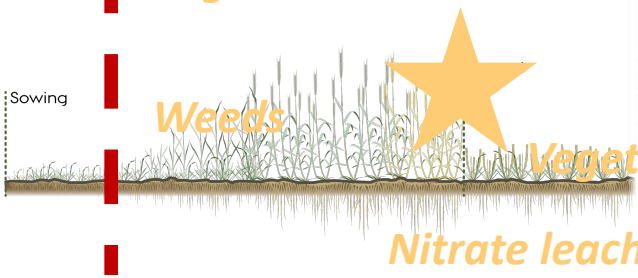
Emma Randahl-Beltran

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

2024 2025 2026 2027









Motivation

The experiment

Results



- Motivation
- **The experiment**
- Results

Two years of yield data, one season of weed/nitrate leaching data

Motivation

The experiment

Results



Grain yields

Weeds



Fall biomass

Nitrate leaching

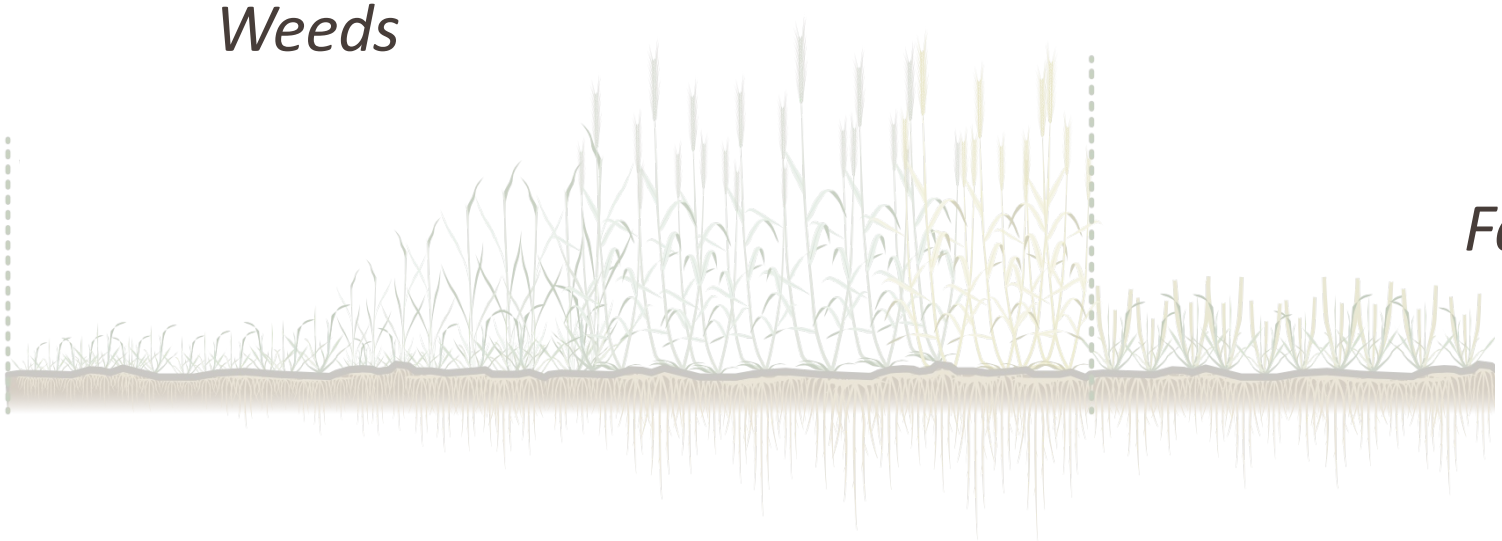


Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Weeds



Fall biomass

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

Yields

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

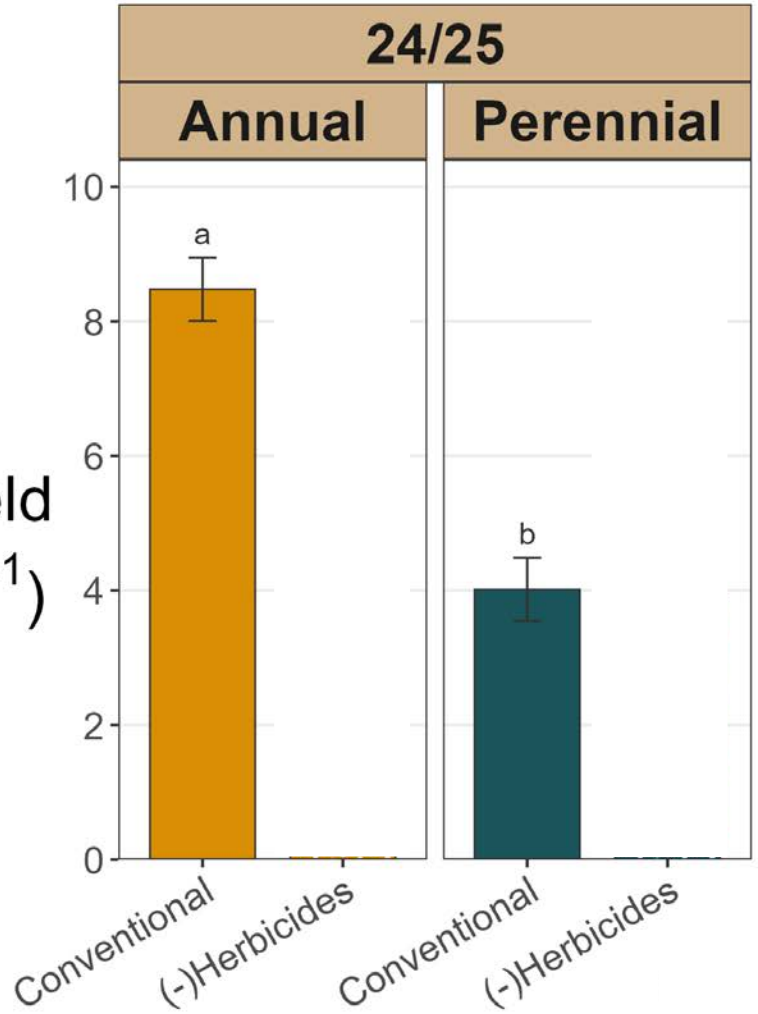


Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Yields



First grain yield (Mg ha^{-1})



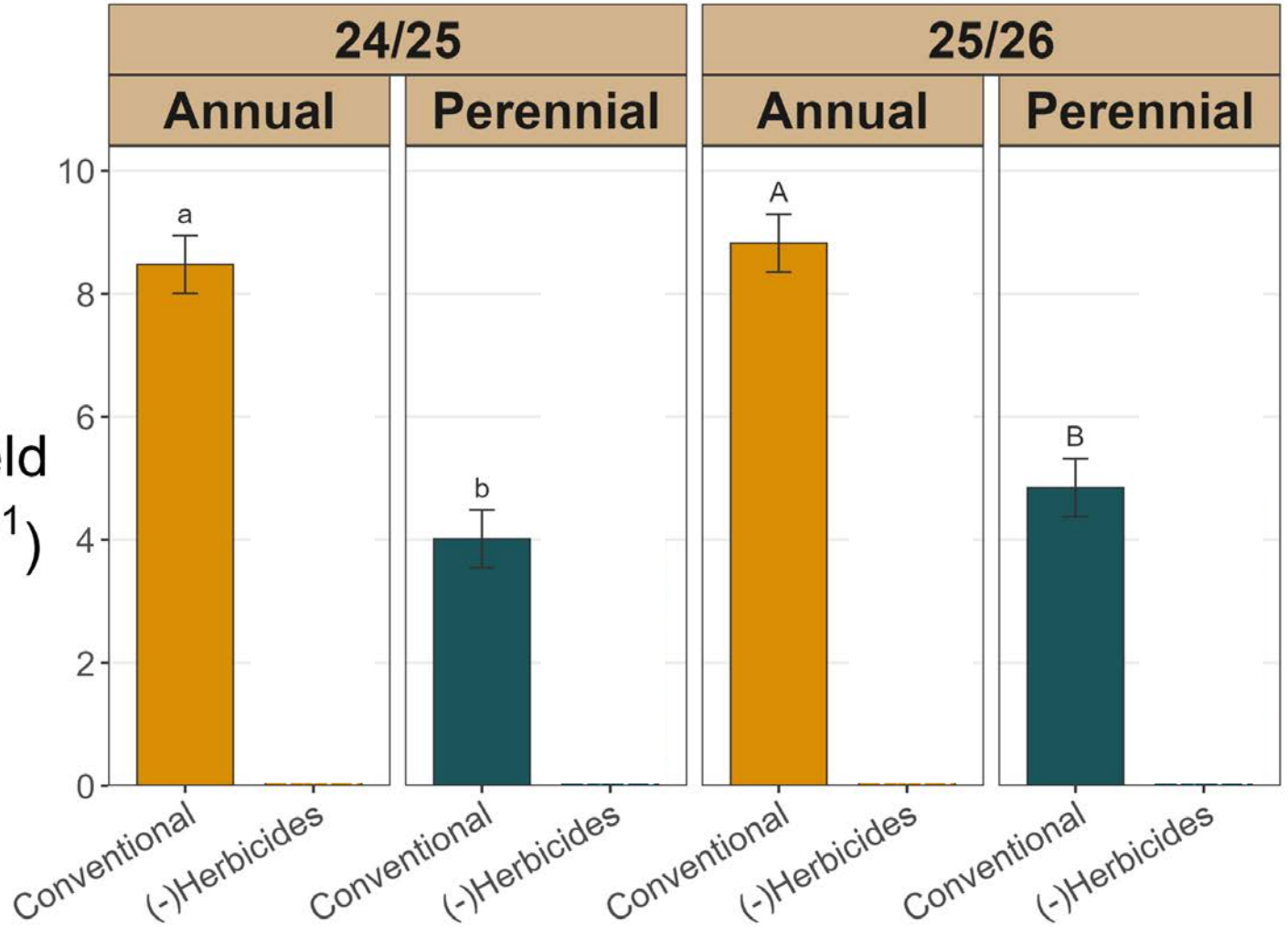


Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Yields



First grain yield (Mg ha^{-1})



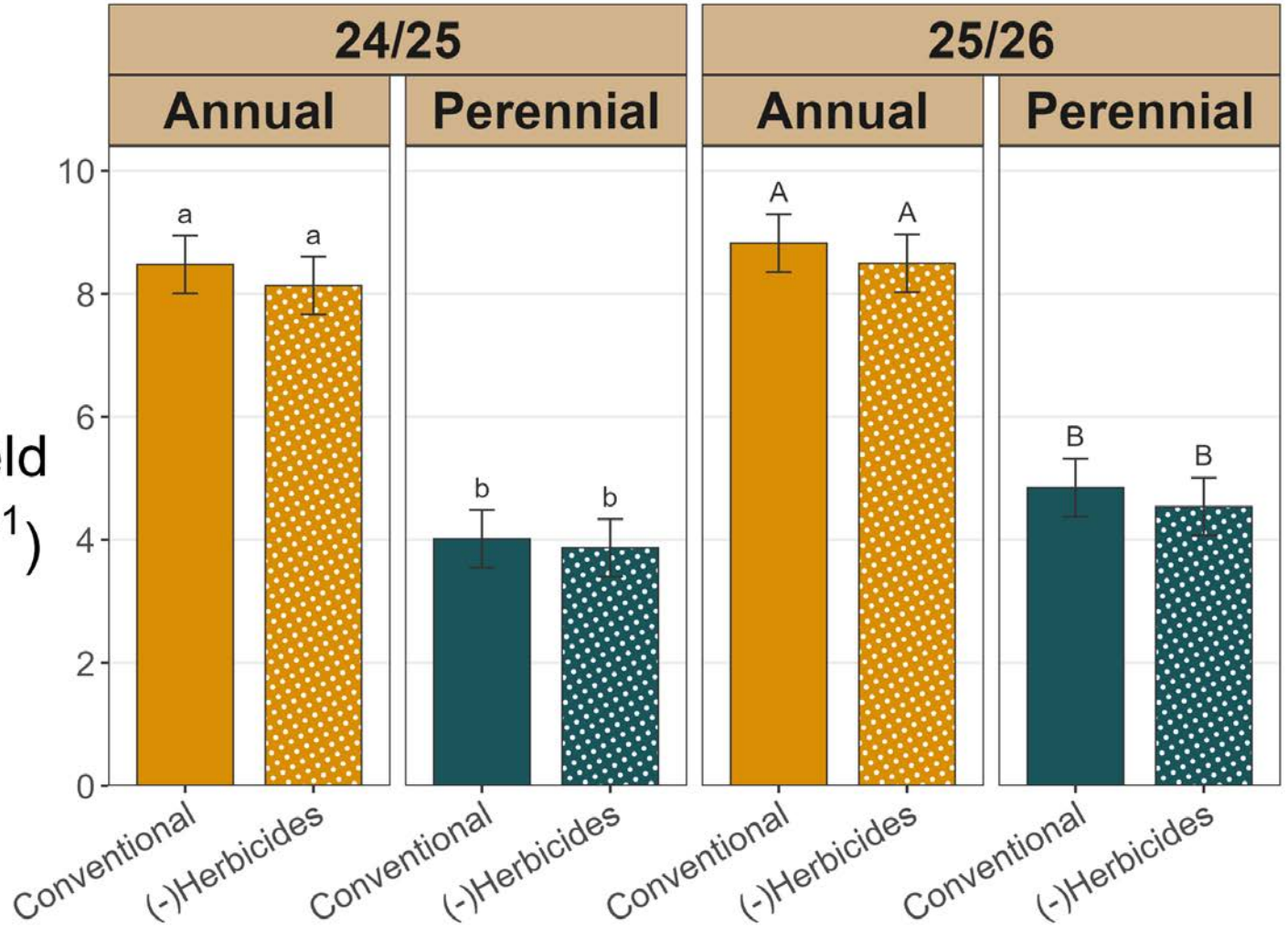


Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Yields



First grain yield ($Mg\ ha^{-1}$)





Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Grai



ARHUS
NIVERSITY
PARTMENT OF AGROECOLOGY

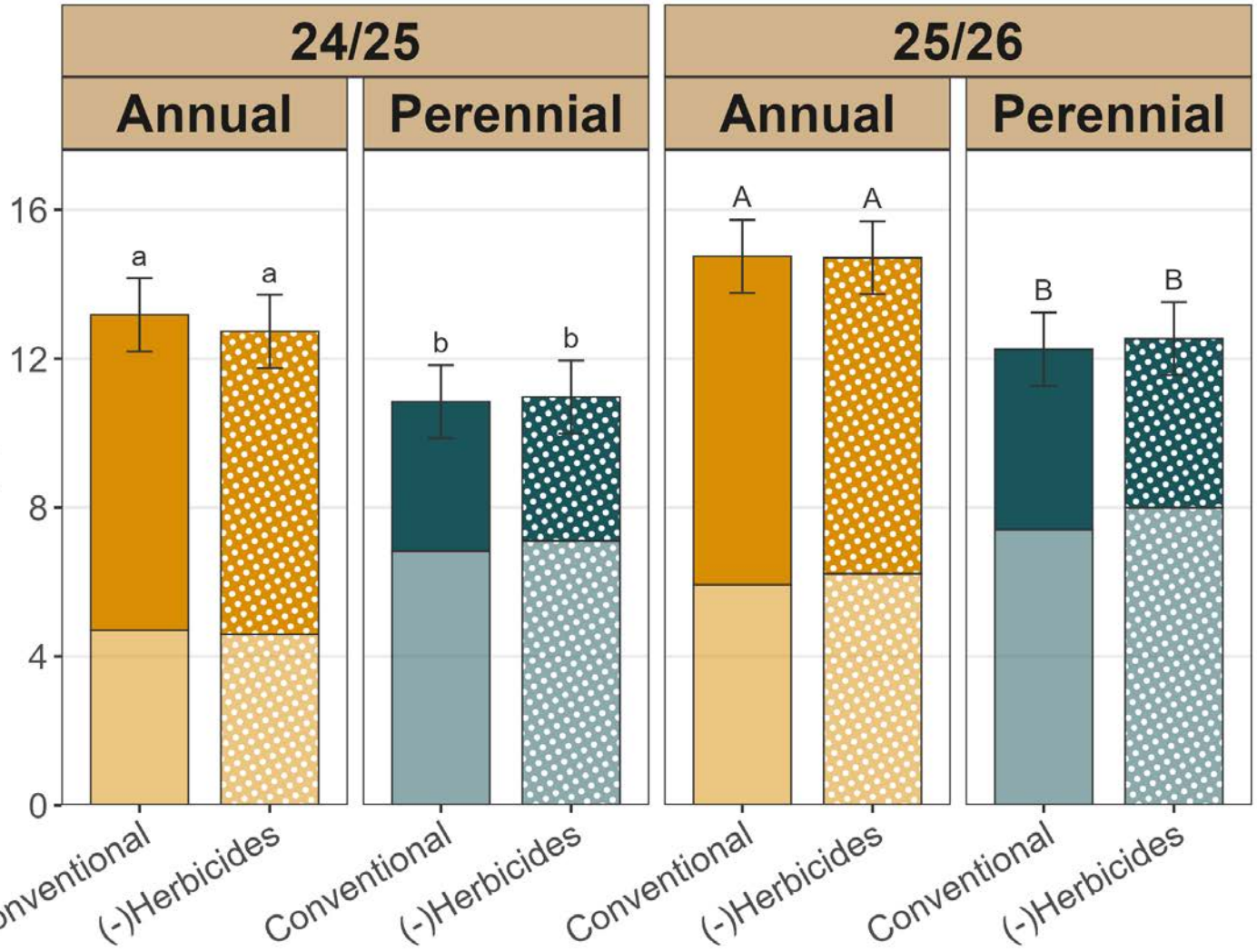
Funded by
the Europe

Yields





Grain + straw yield ($Mg\ ha^{-1}$)





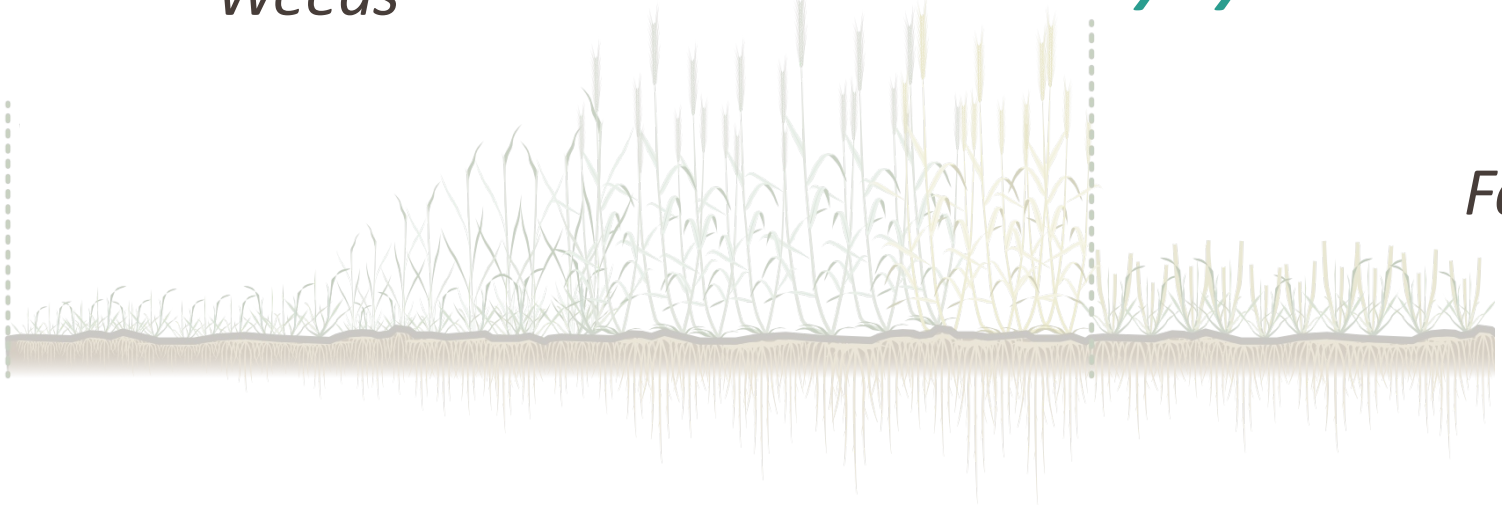
Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds



Fall biomass

Nitrate leaching



Emma Randahl-Beltran

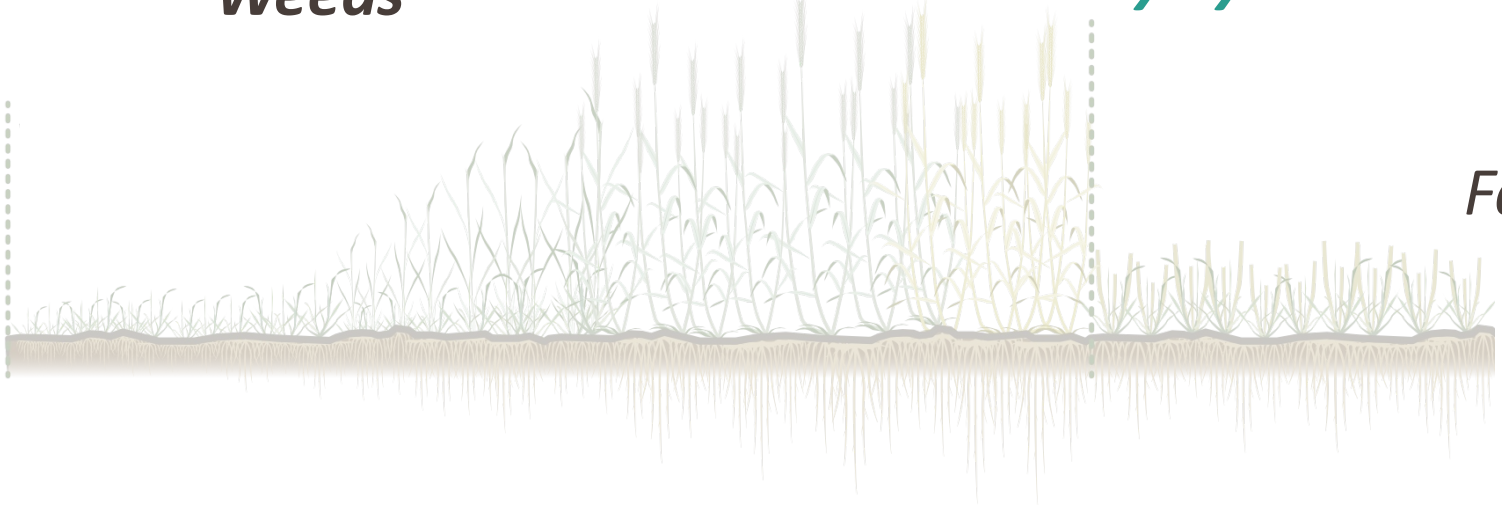
Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds



Fall biomass

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

Weeds -

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY



Emma Randahl-Beltran

Funded by the European Union

Weeds – *WITH* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY



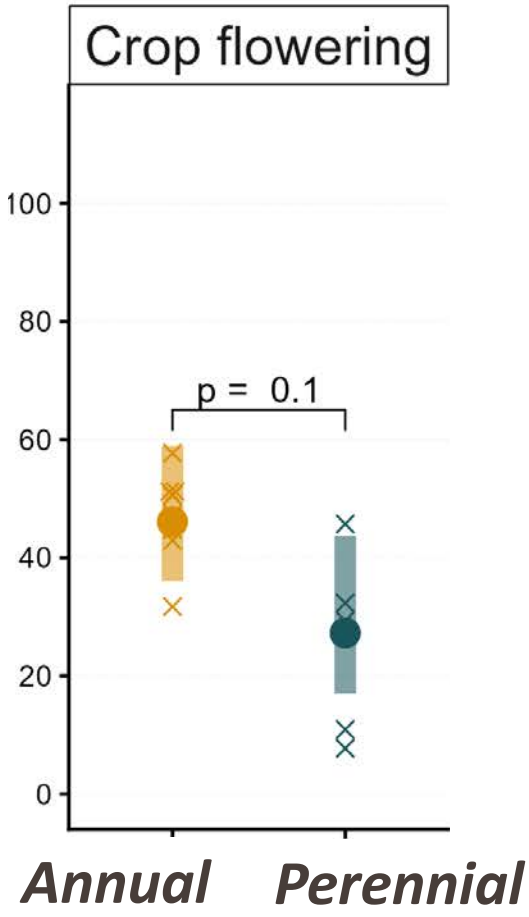
Emma Randahl-Beltran

Funded by the European Union

Weeds – *WITH* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





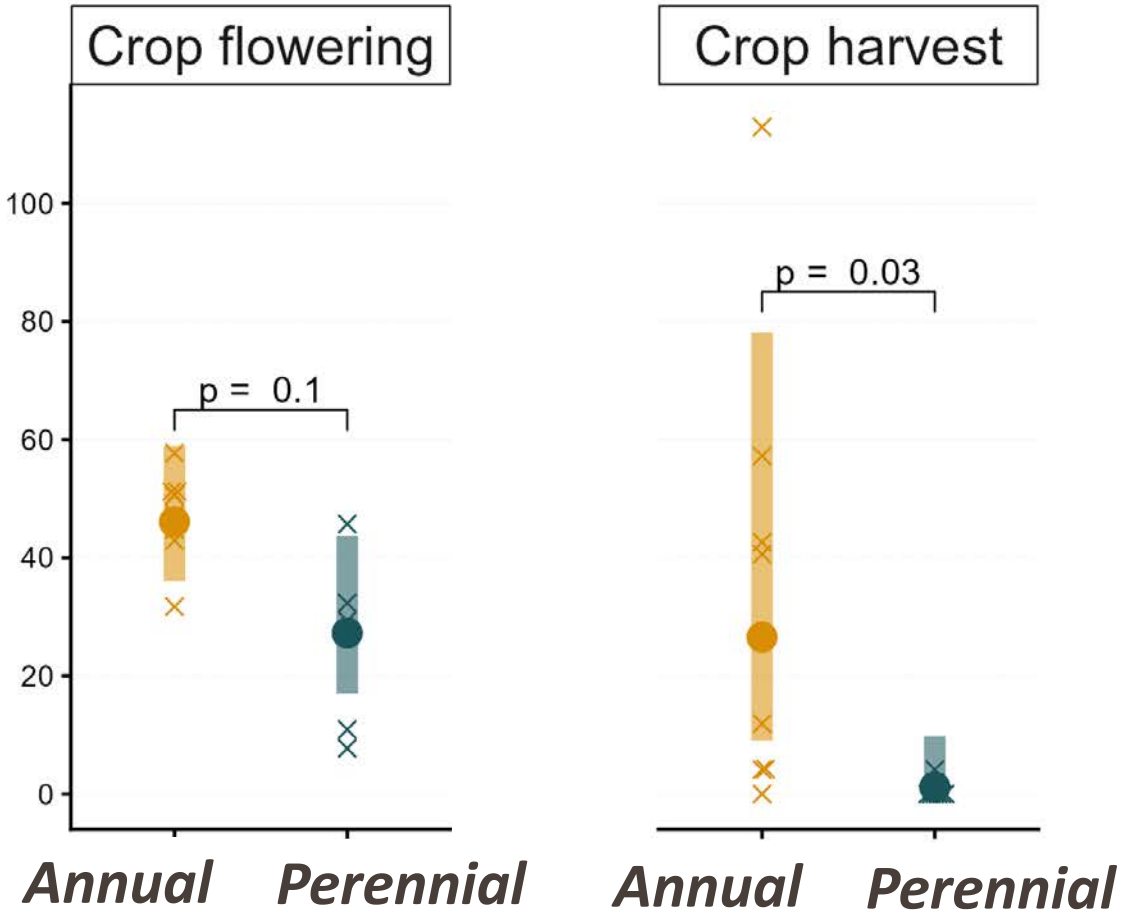
Funded by the European Union

Emma Randahl-Beltran

Weeds – *WITH* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





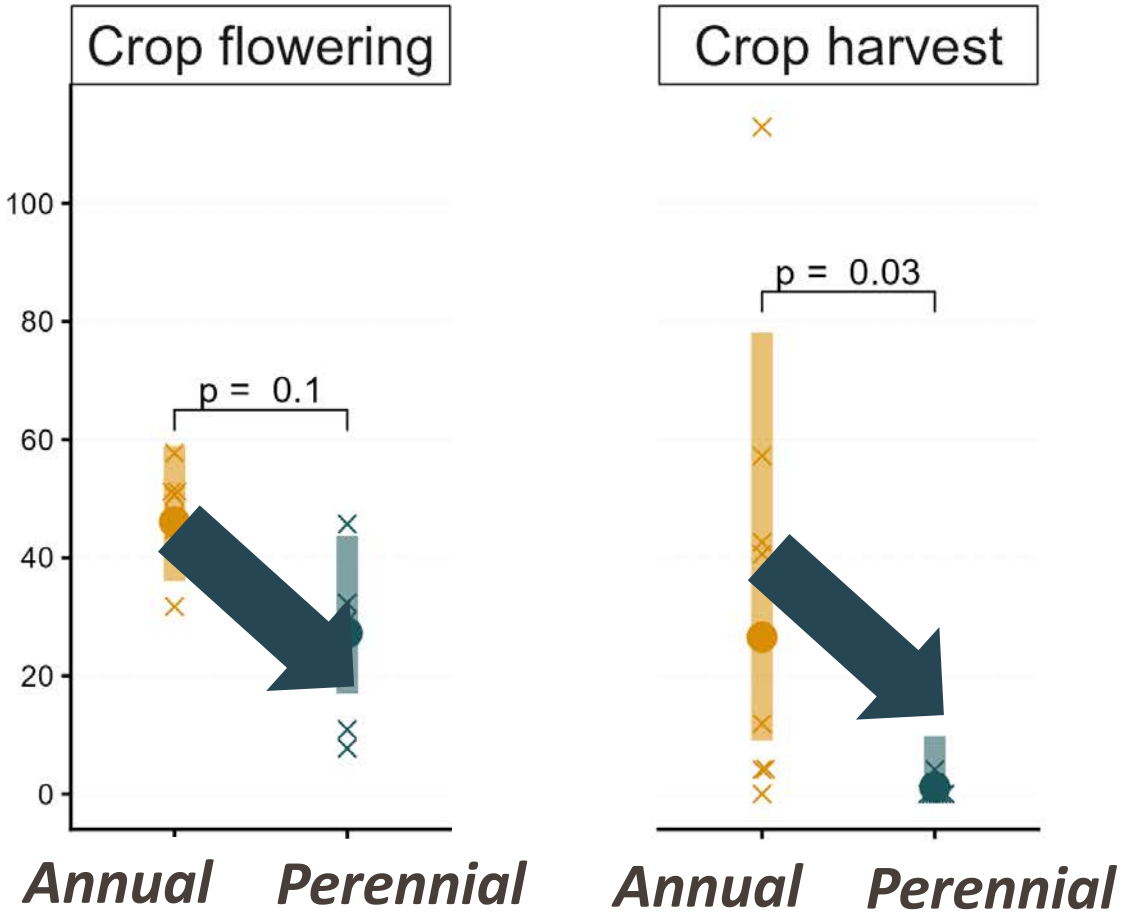
Funded by the European Union

Emma Randahl-Beltran

Weeds – *WITH* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





Funded by the European Union

Emma Randahl-Beltran

Weeds - *WITHOUT* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY



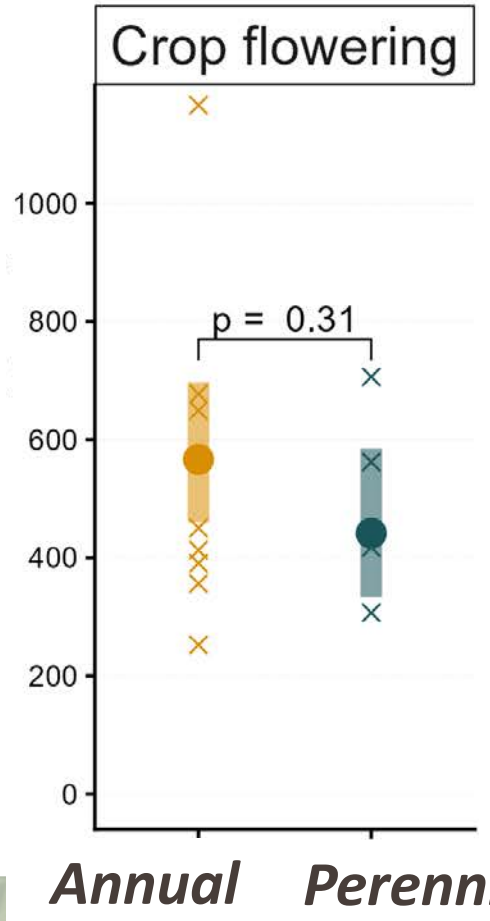
Emma Randahl-Beltran

Funded by the European Union

Weeds - *WITHOUT* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





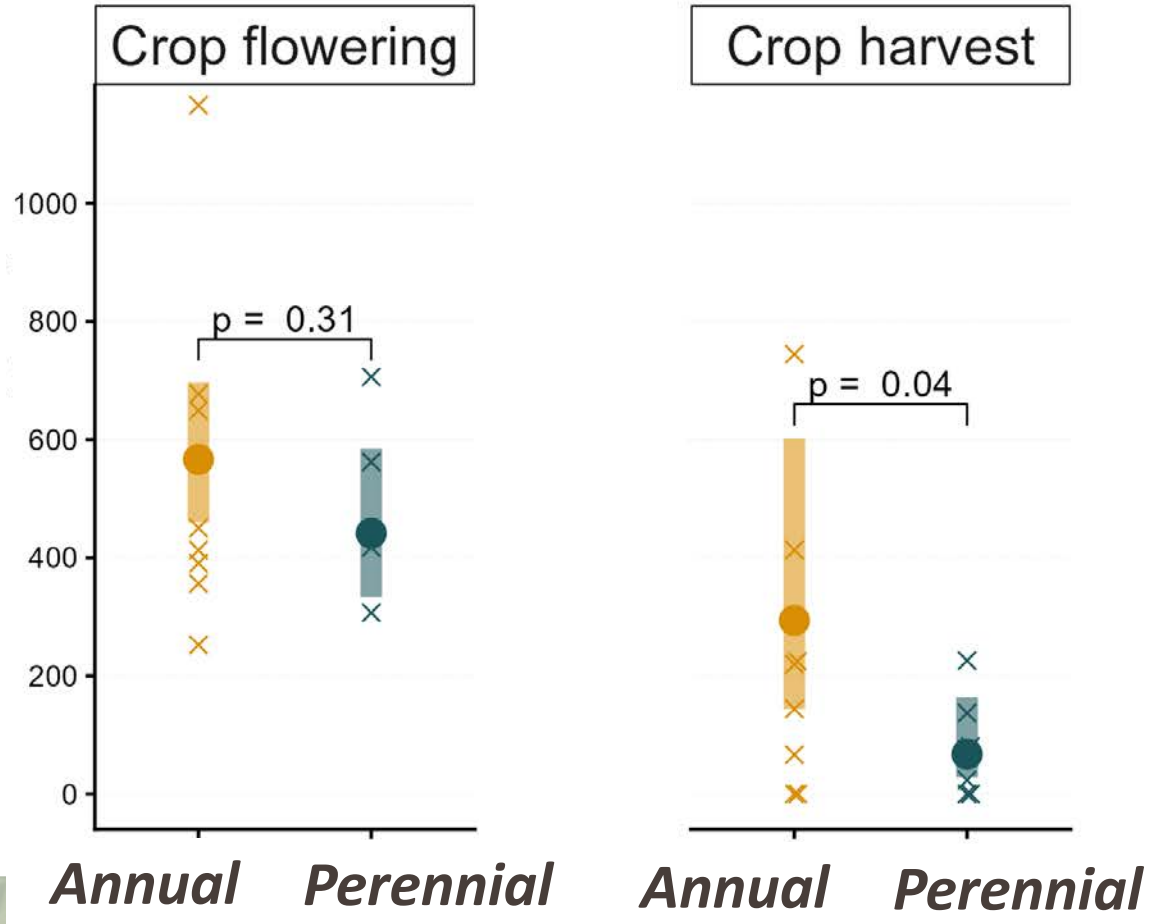
Funded by the European Union

Emma Randahl-Beltran

Weeds - *WITHOUT* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





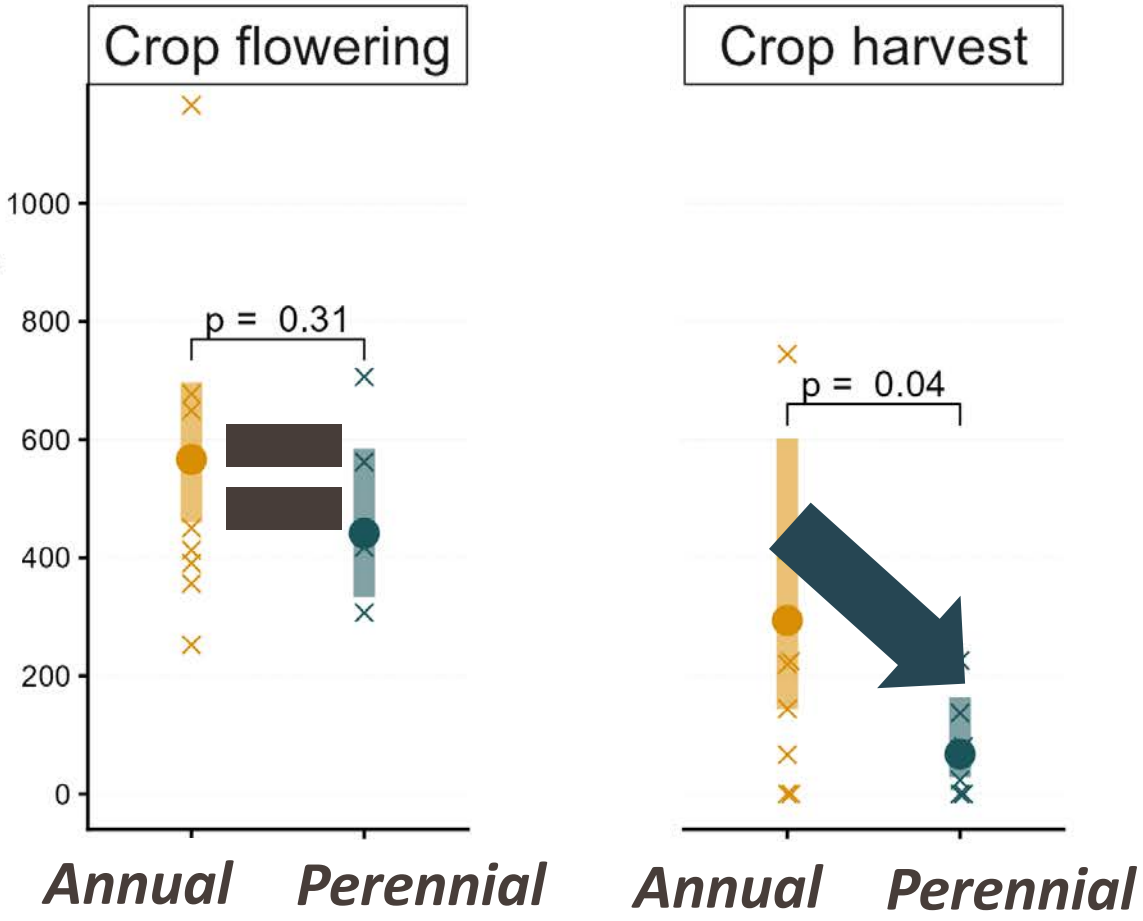
Funded by the European Union

Emma Randahl-Beltran

Weeds - *WITHOUT* herbicides

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Weed biomass (kg ha-1)





Funded by the European Union

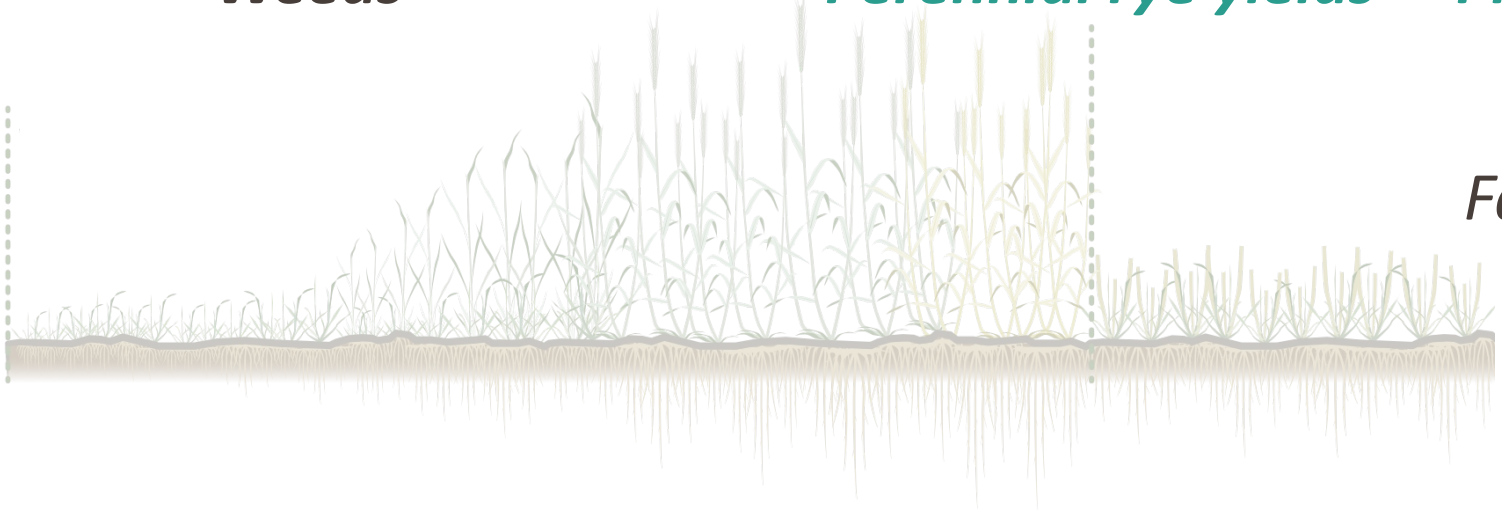
Emma Randahl-Beltran

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Weeds

Perennial rye yields ~ 4 Mg/ha



Fall biomass

Nitrate leaching



Emma Randahl-Beltran

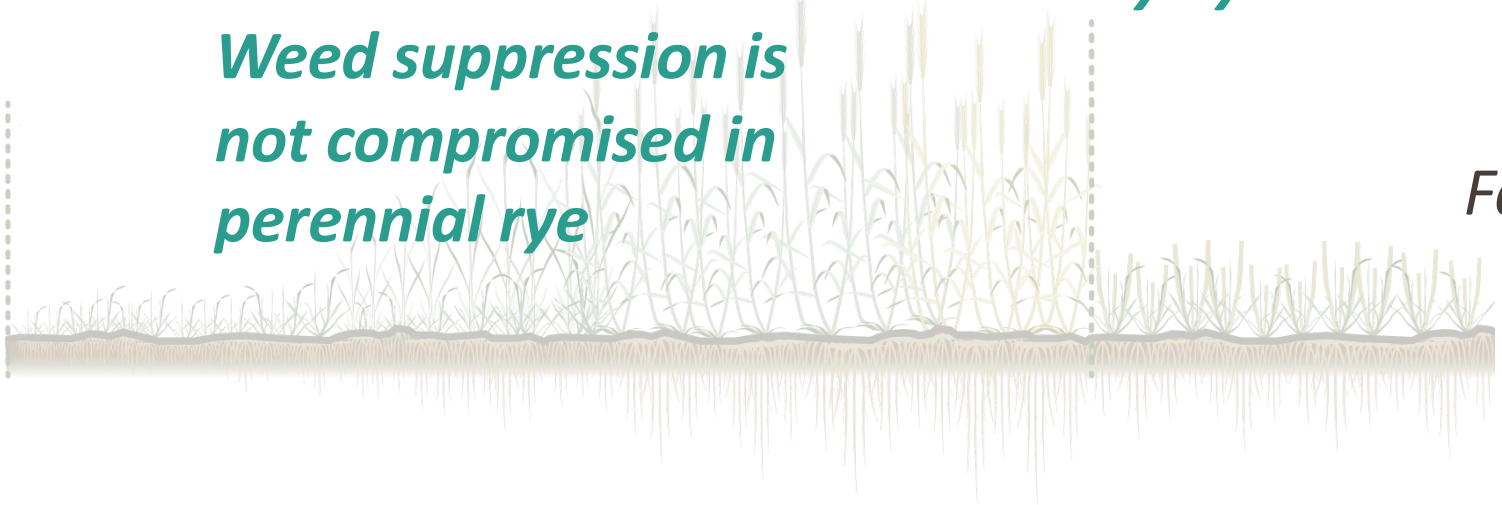
Funded by the European Union

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye



Fall biomass

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Nitrate leaching



Emma Randahl-Beltran

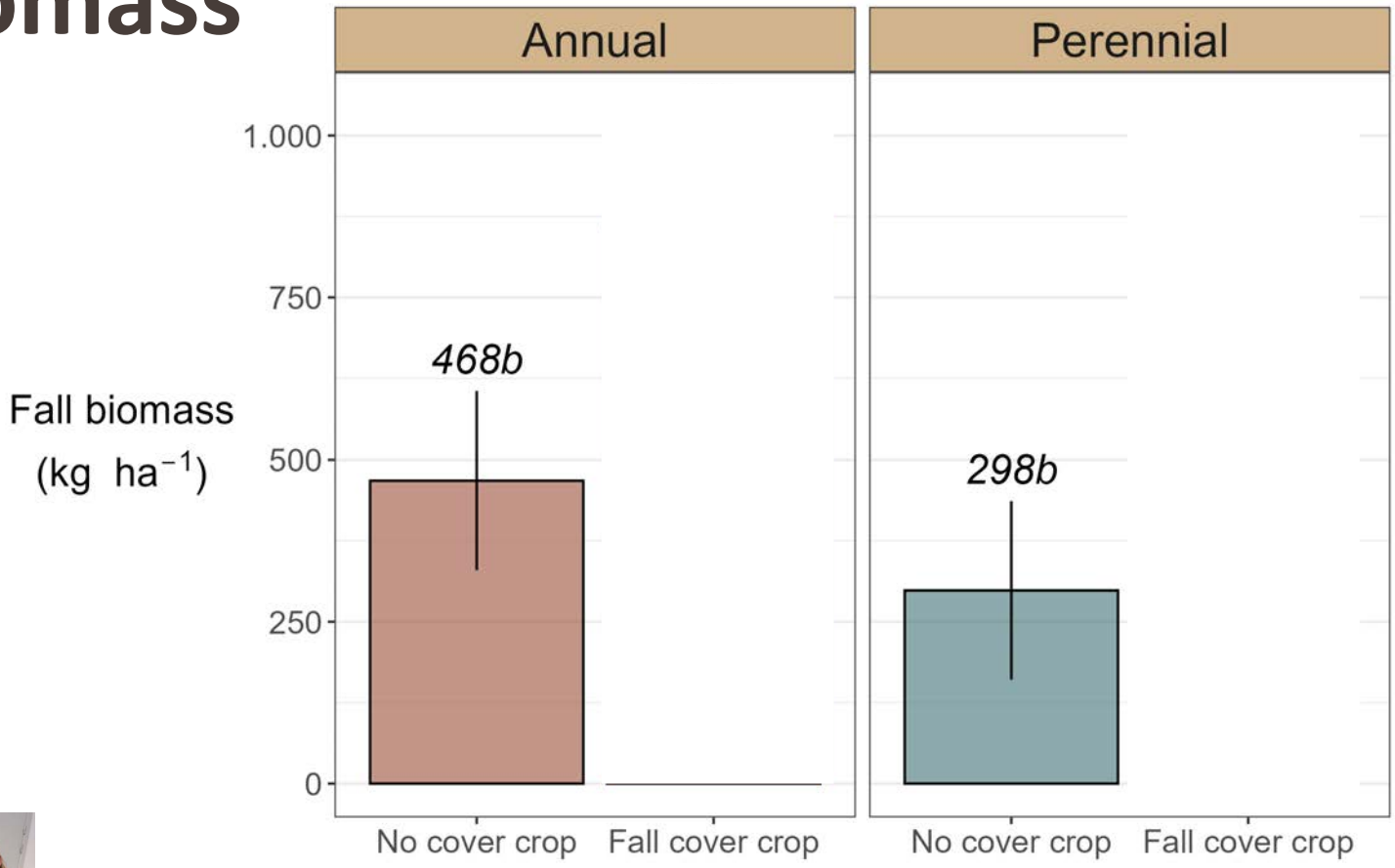
Funded by the European Union

Fall biomass

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

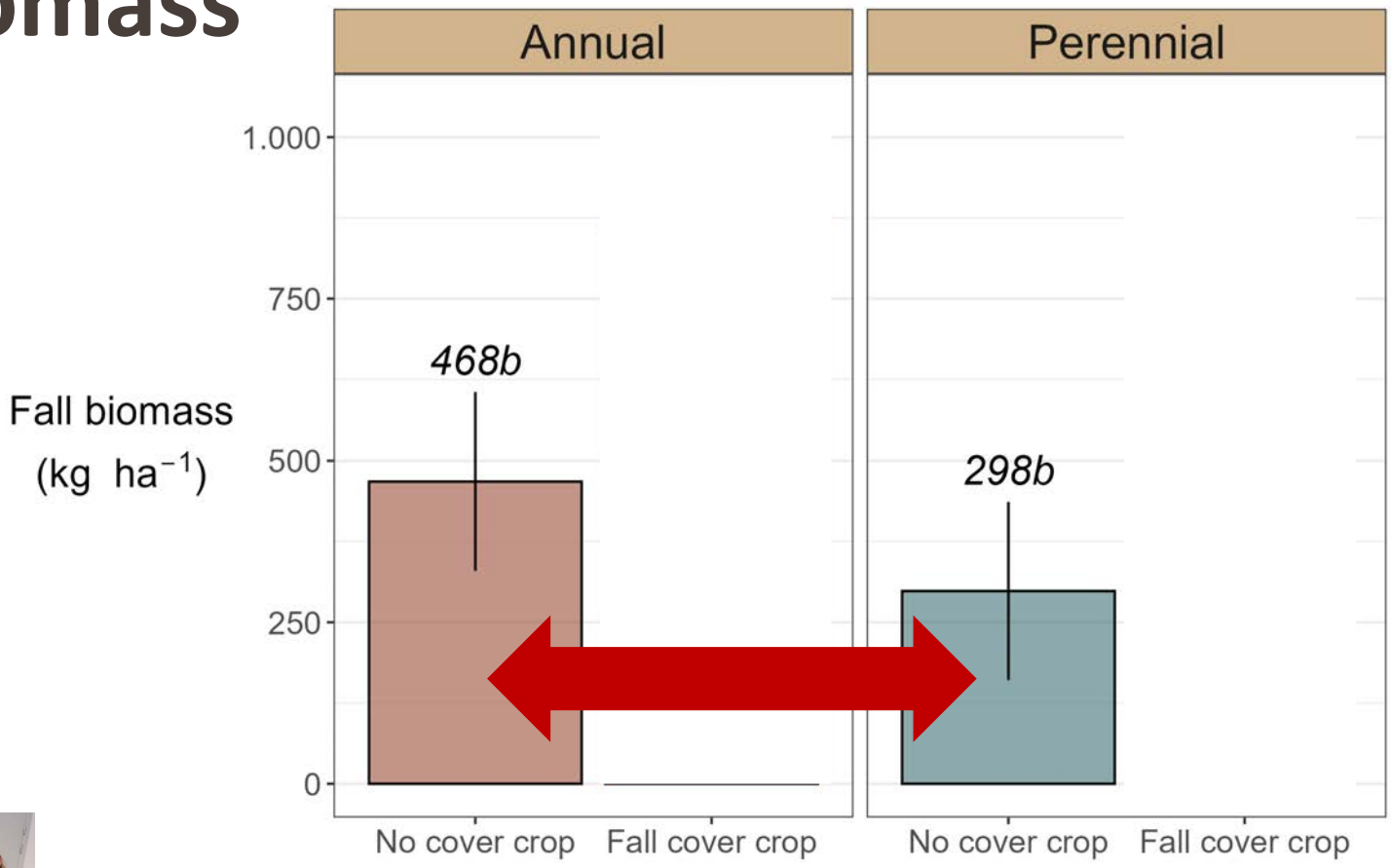


Fall biomass





Fall biomass





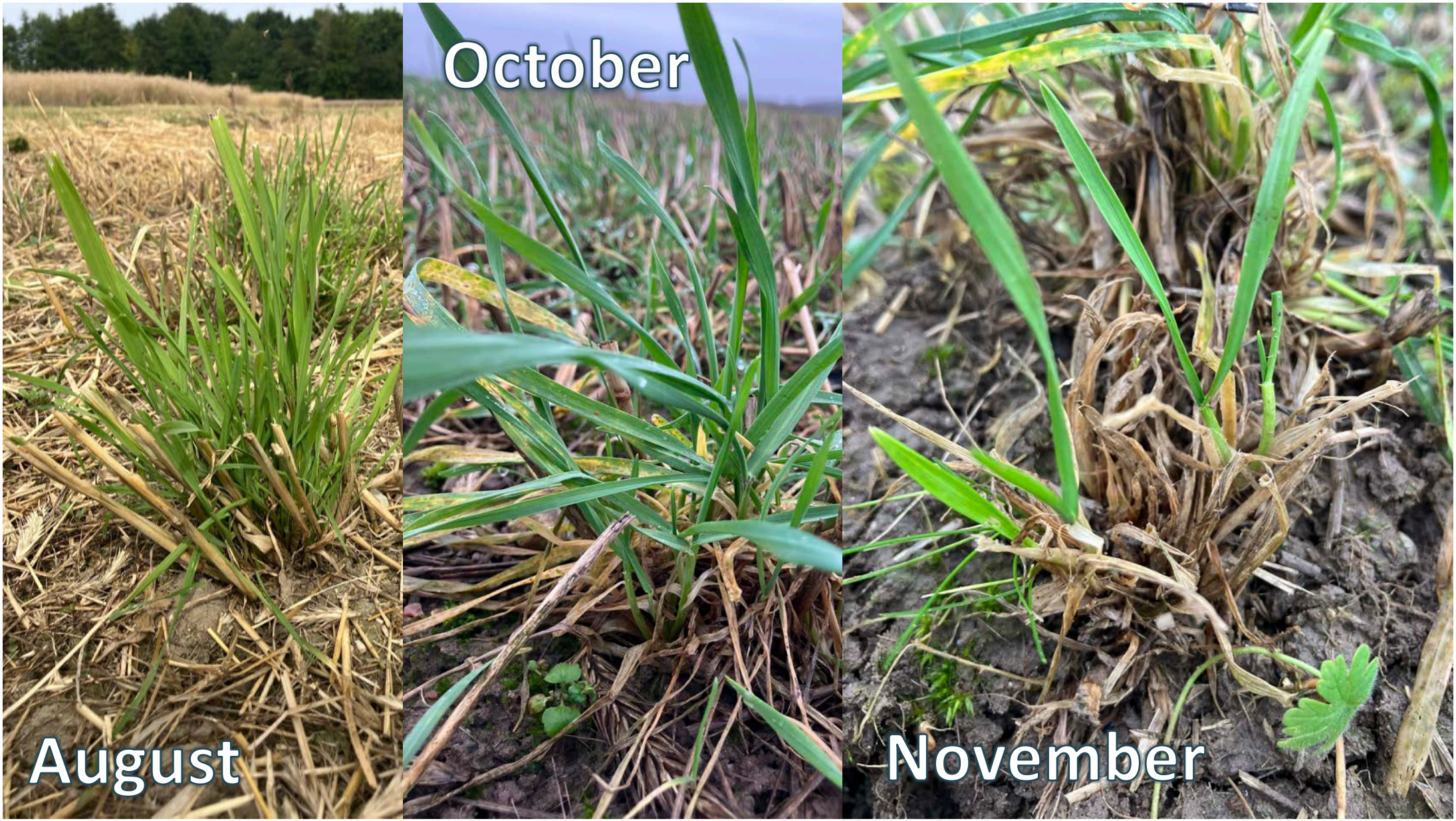


AARHUS
UNIVERSITY
DEPARTMENT OF AGROECOLOGY

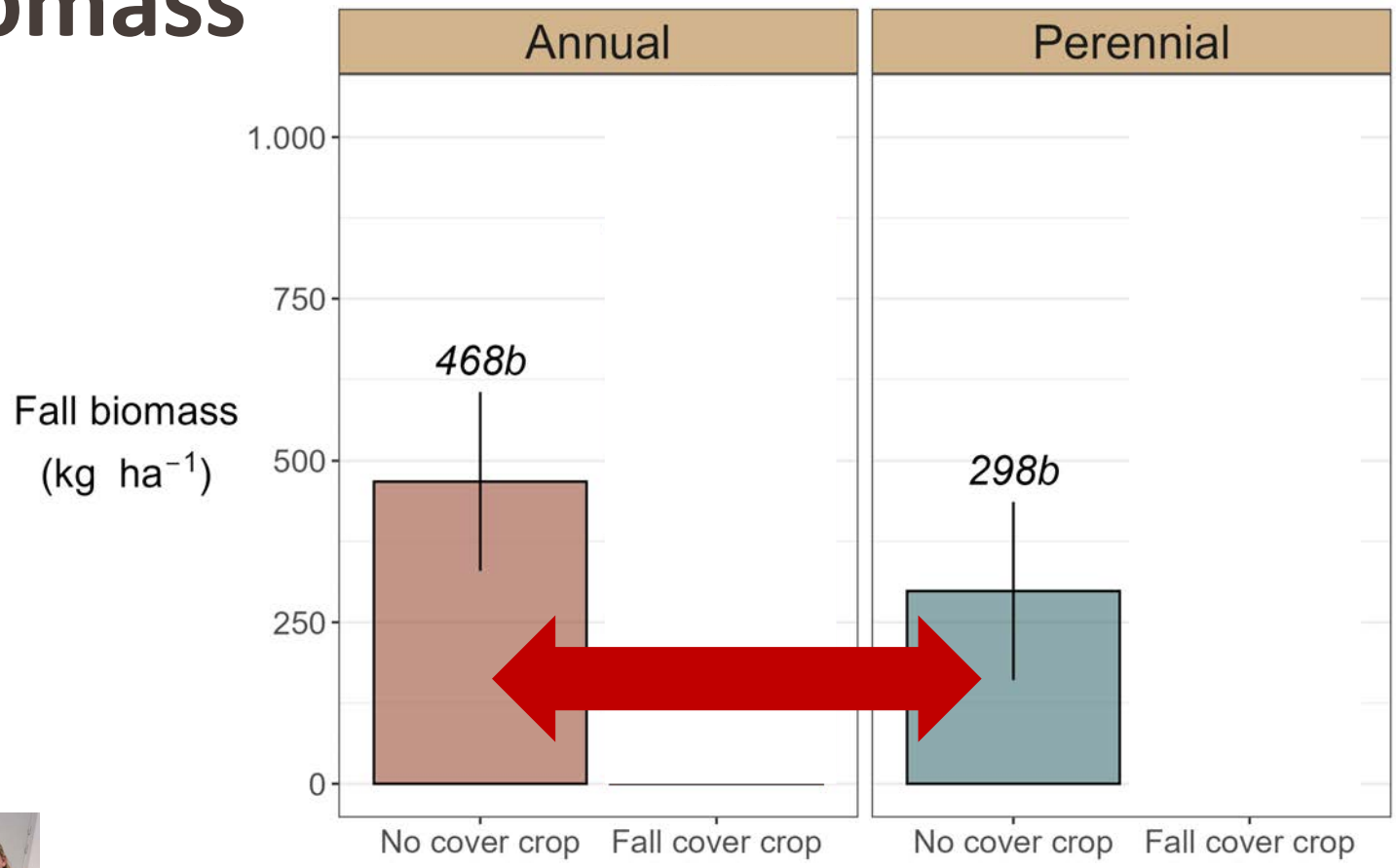




AARHUS
UNIVERSITY
DEPARTMENT OF AGROECOLOGY

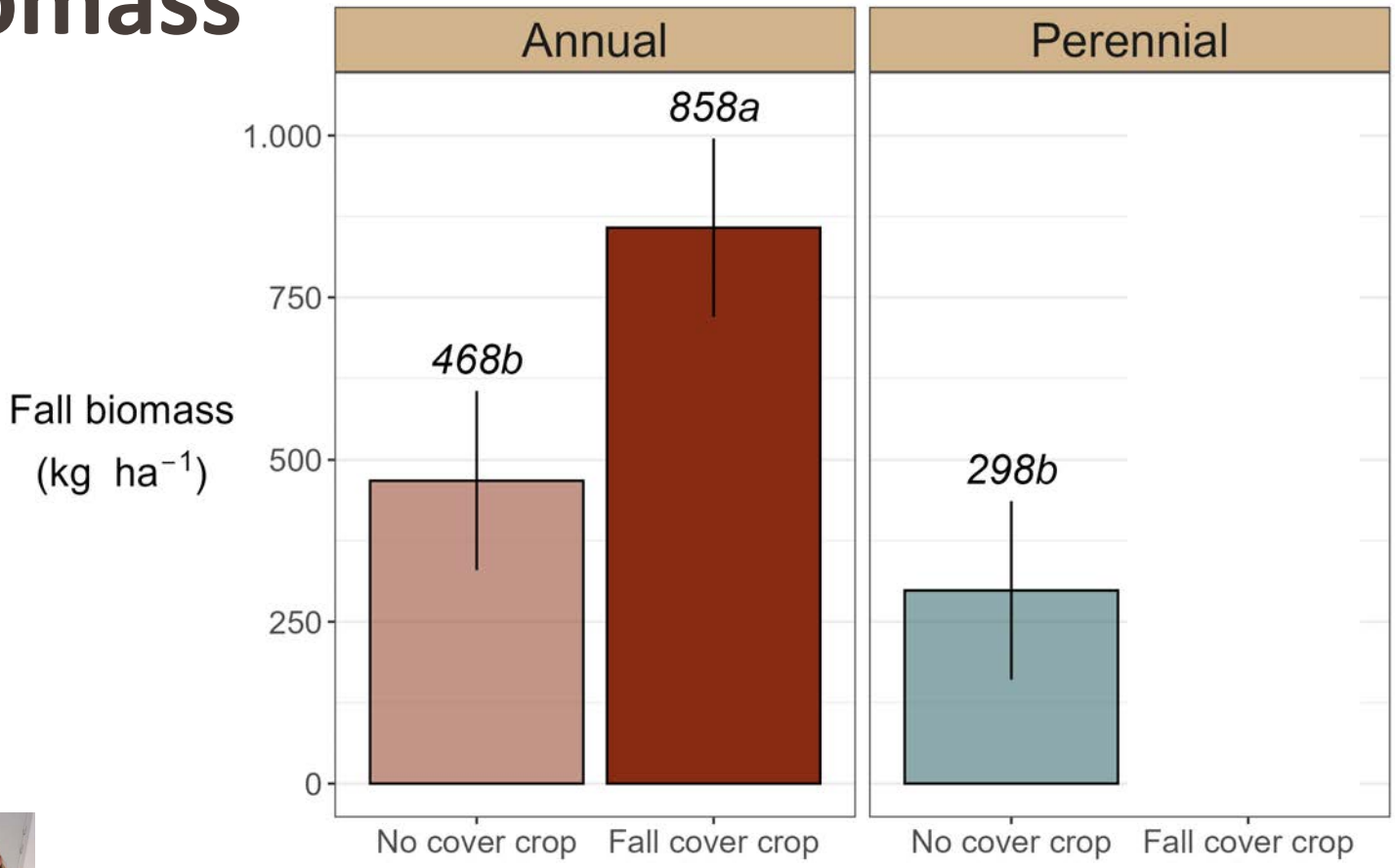

August
October
November

Fall biomass



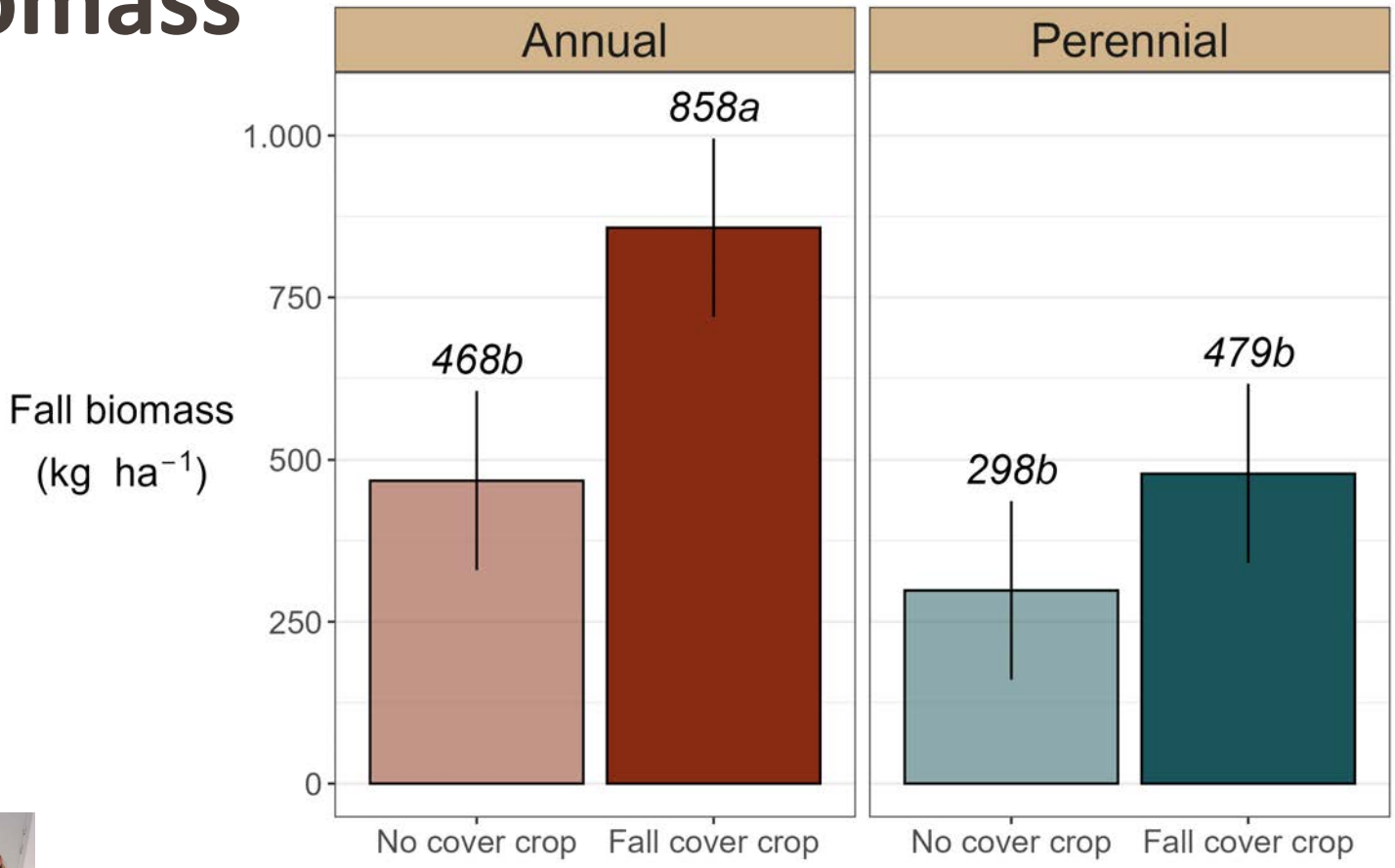


Fall biomass



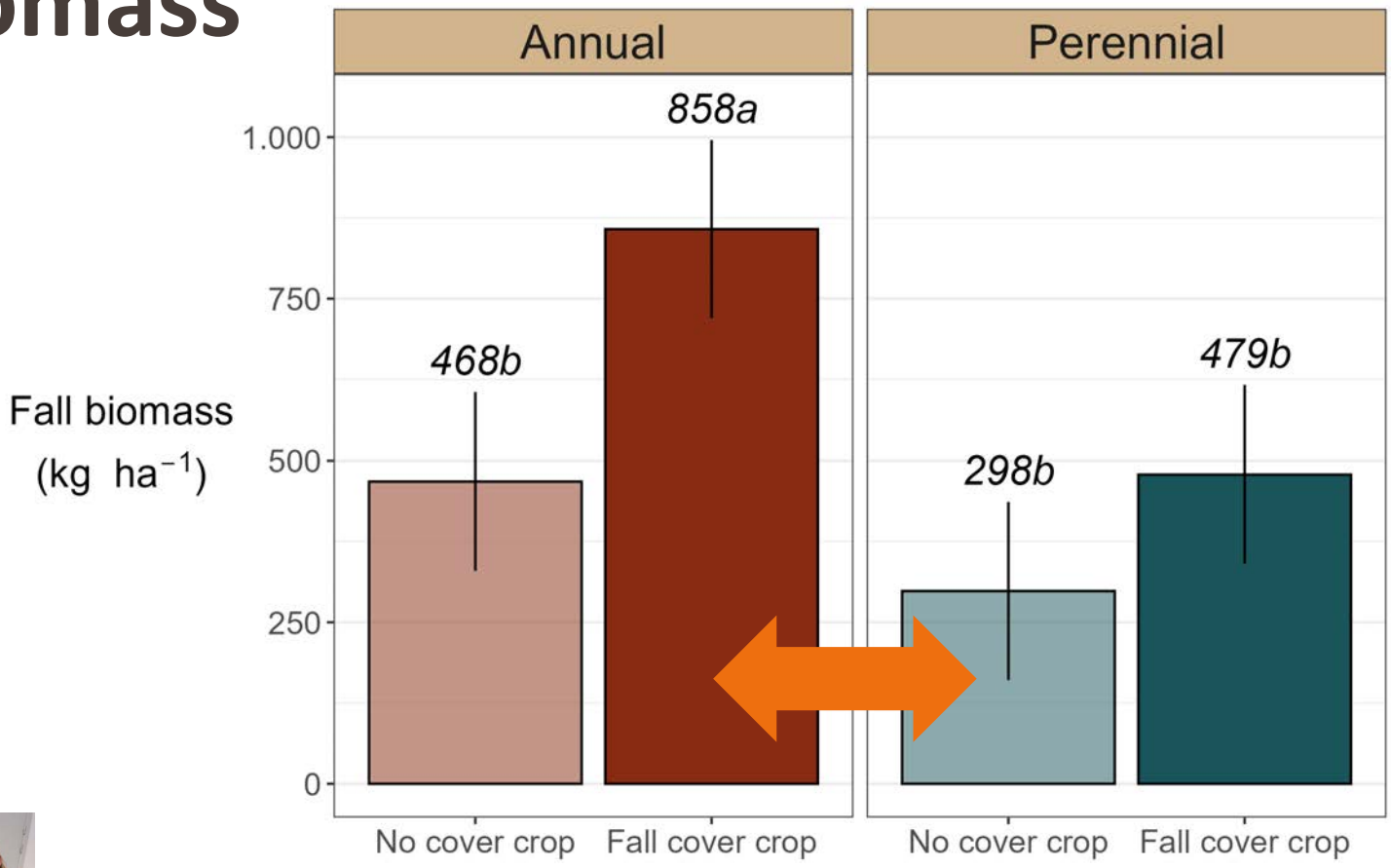


Fall biomass

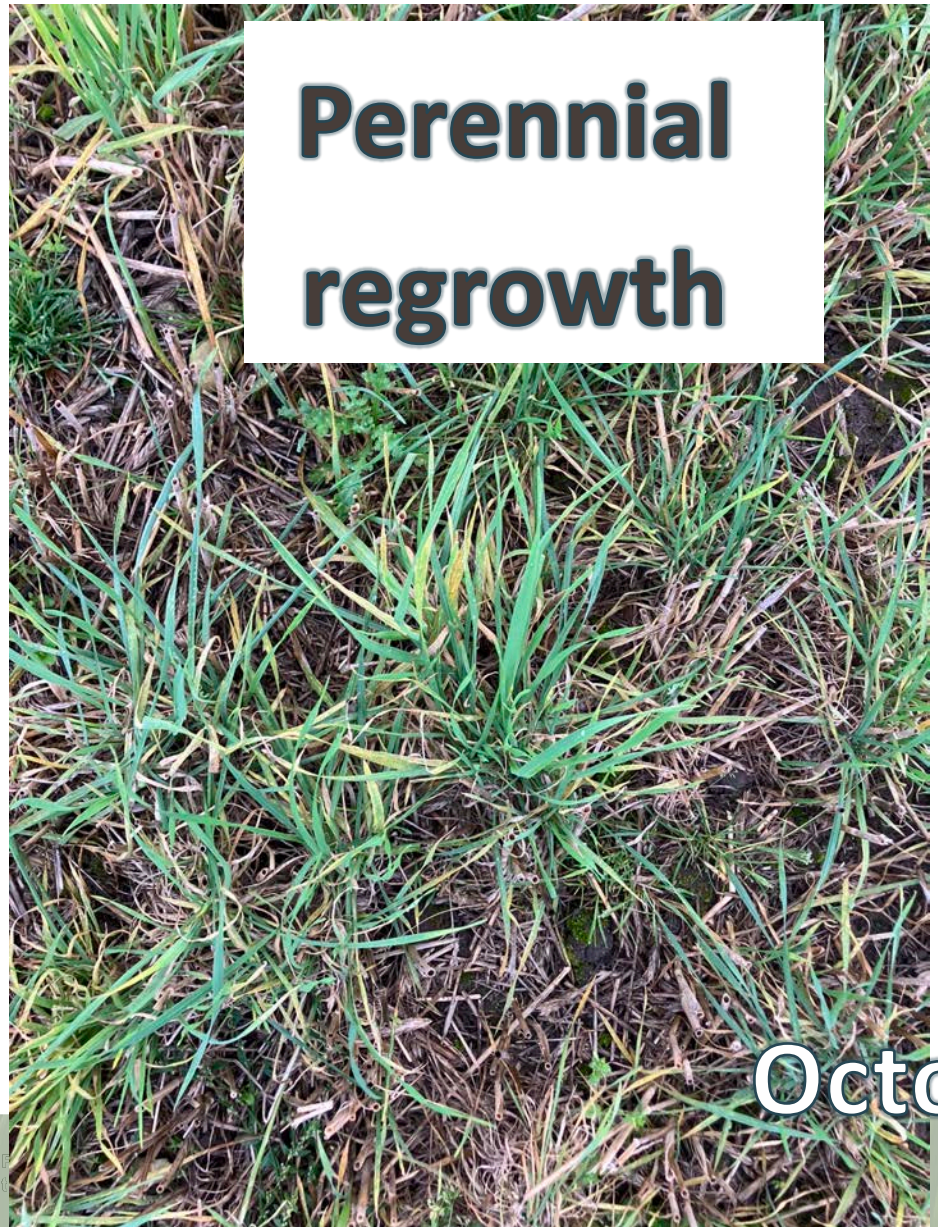


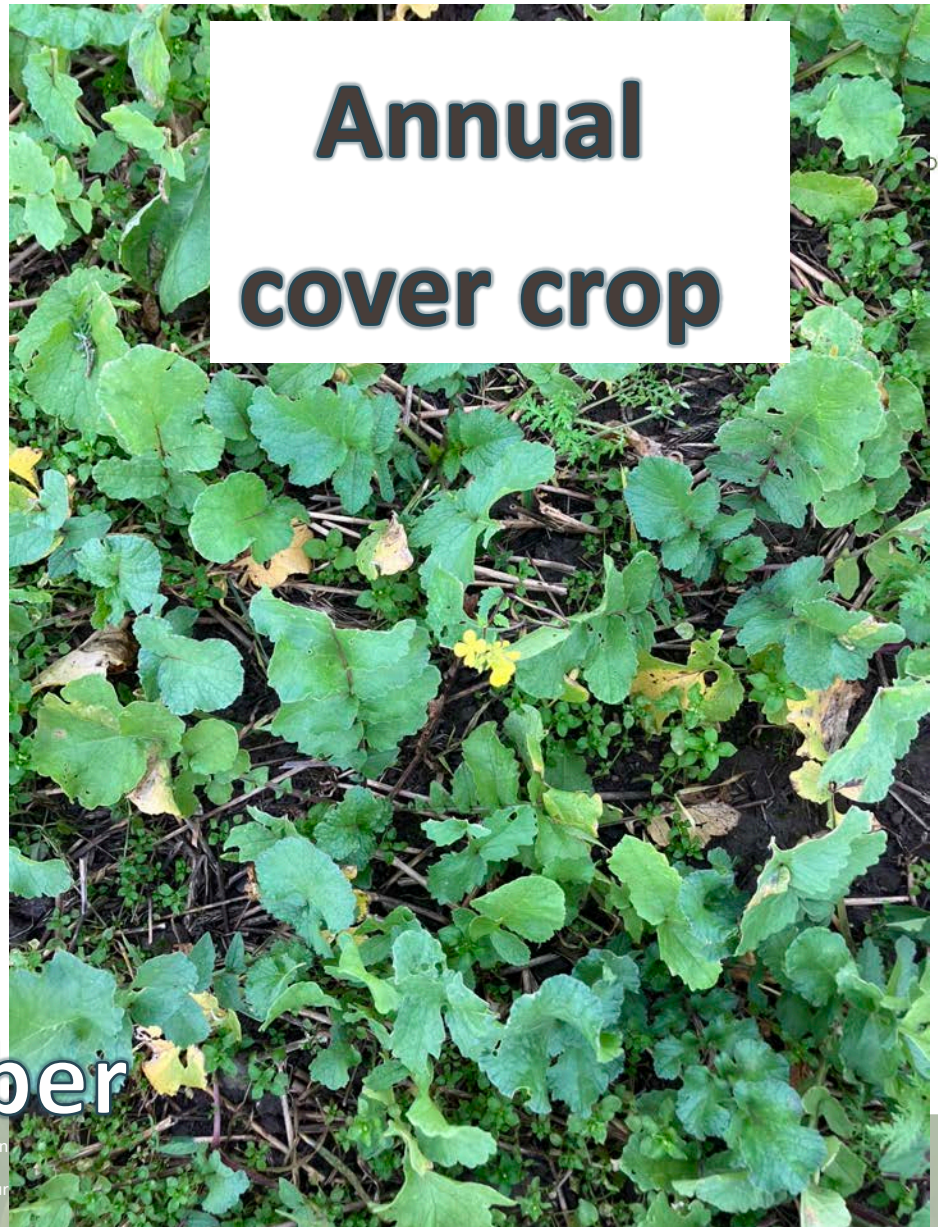


Fall biomass



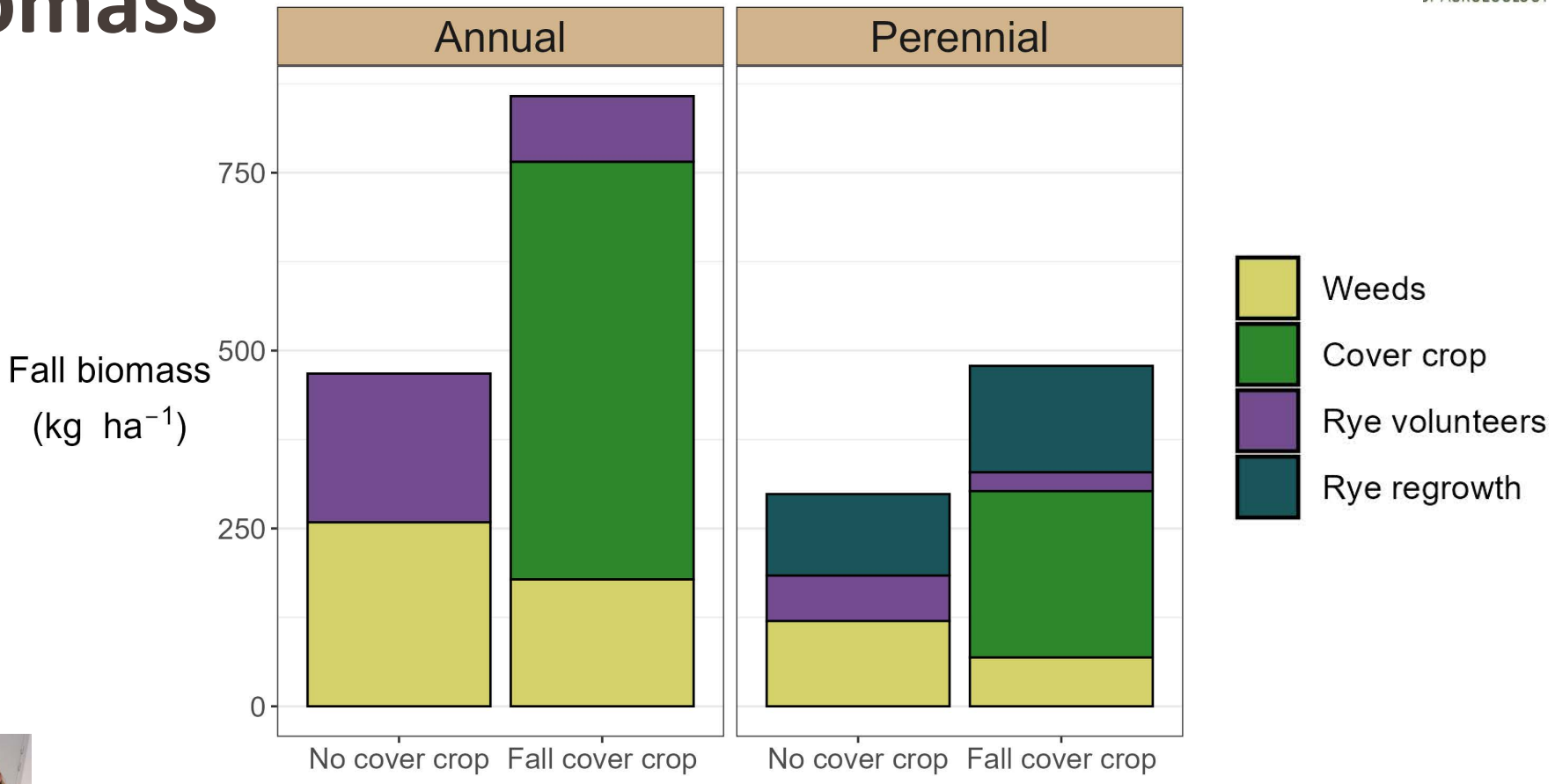






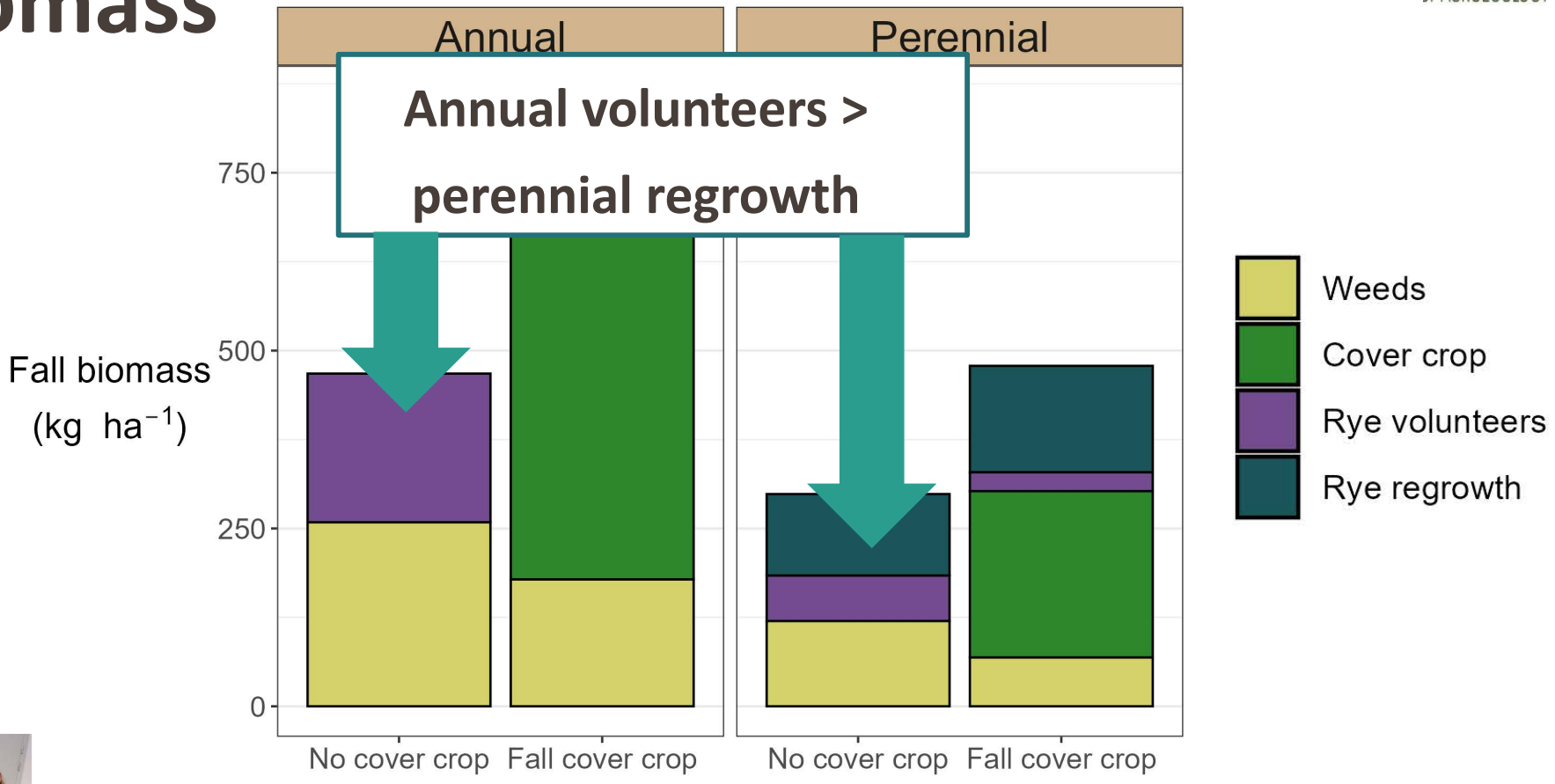
October

Fall biomass



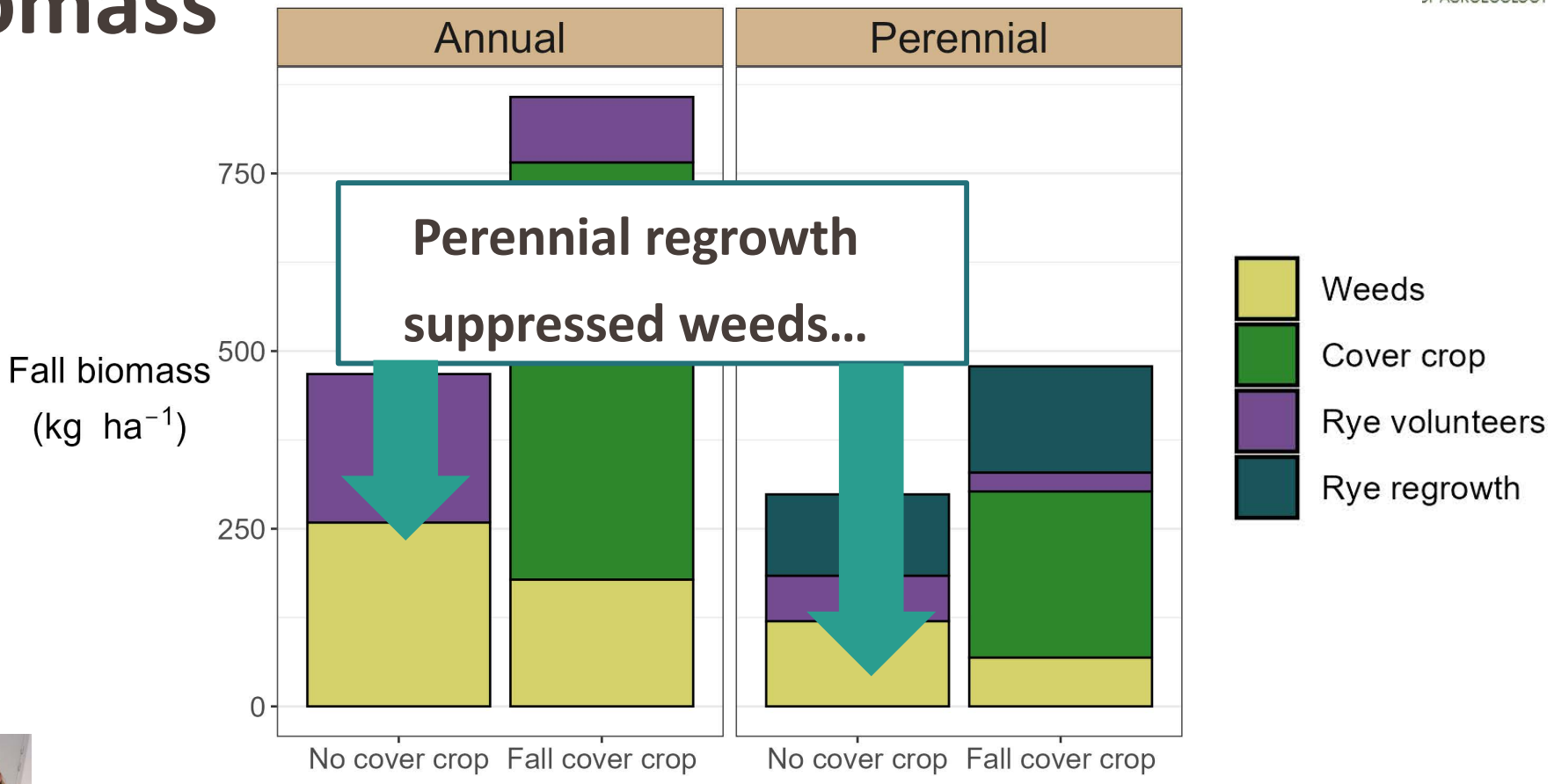


Fall biomass



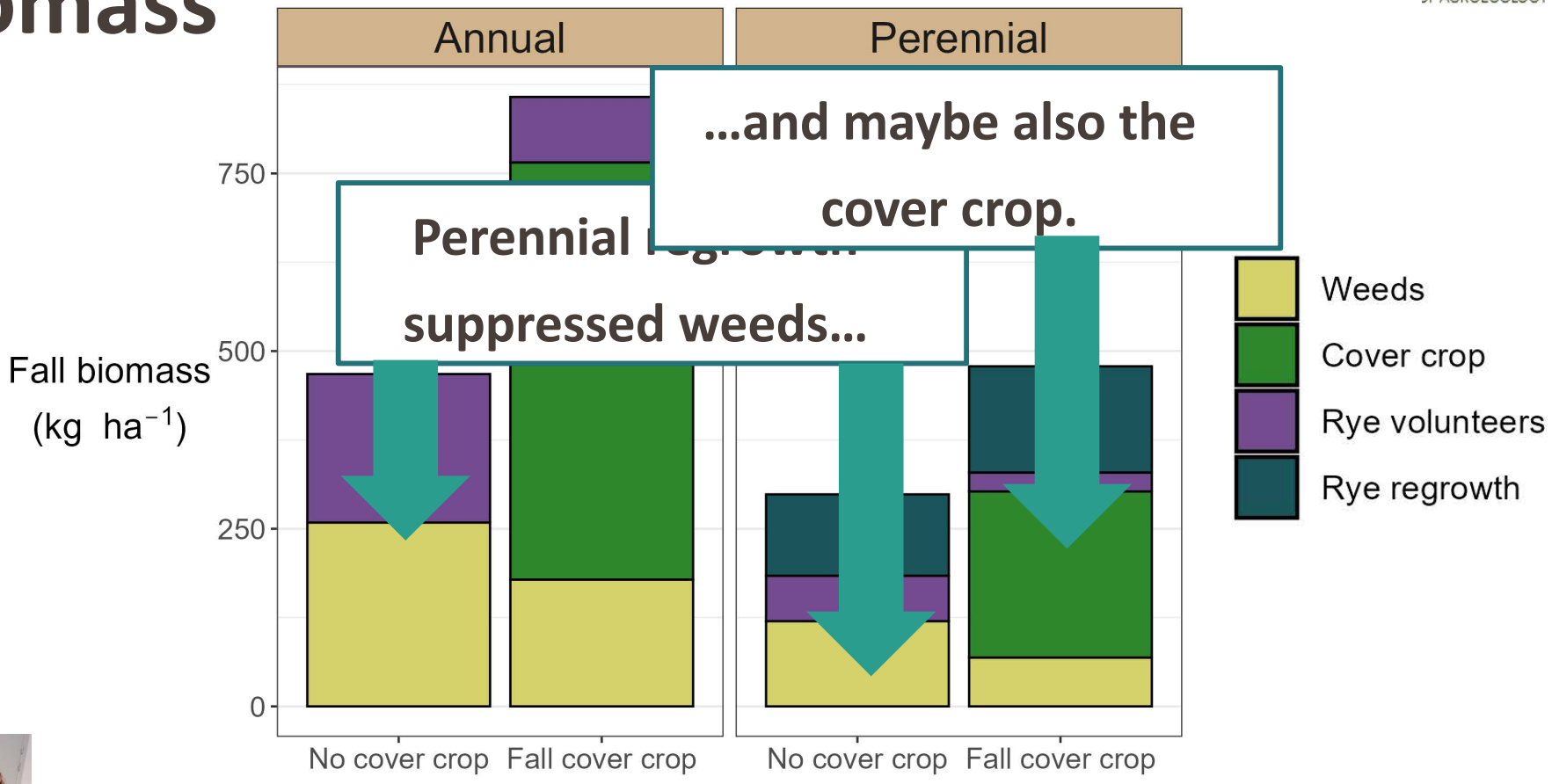


Fall biomass





Fall biomass





AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Regrowth is not as good as a cover crop

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Regrowth is not as good as a cover crop

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

Nitrate leaching

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY



Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Fall biomass rankings

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Annual + CC

Annual

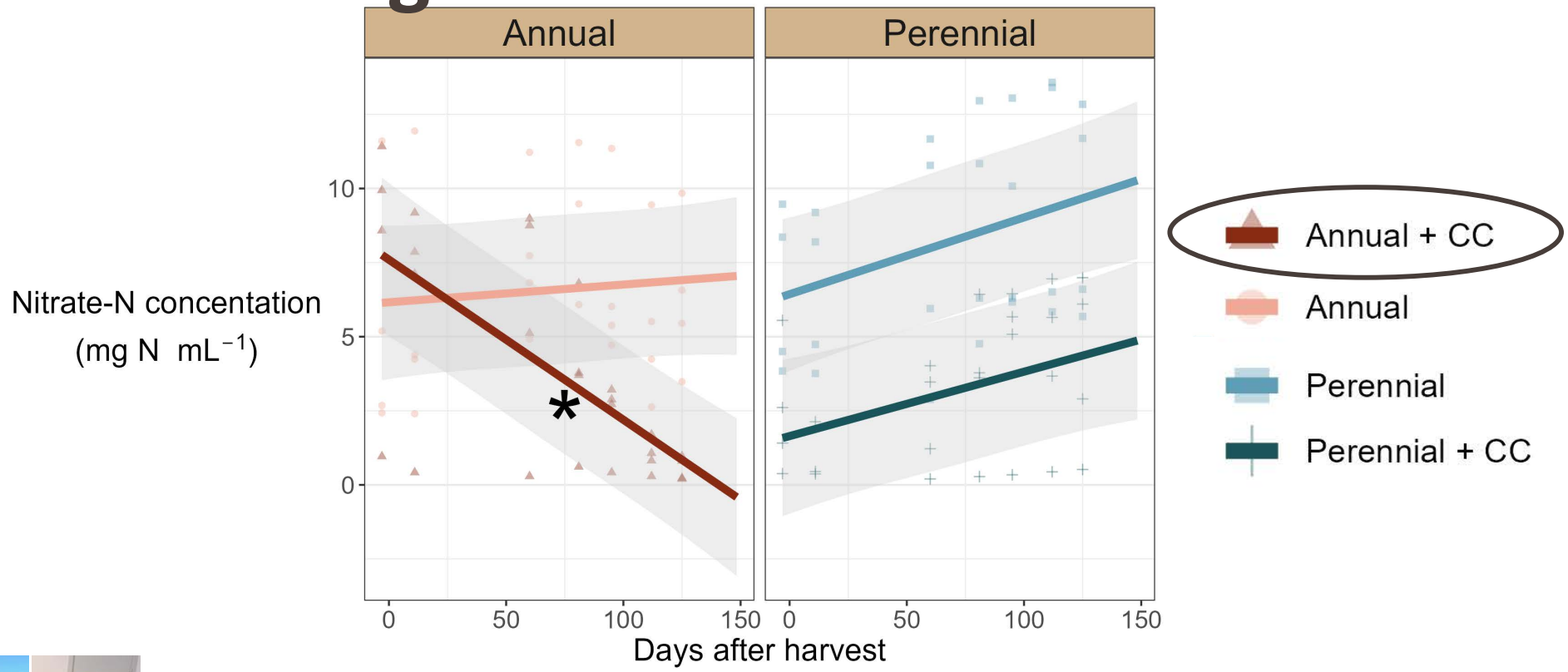
Perennial

Perennial + CC



Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

Nitrate leaching





Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Regrowth is not as good as a cover crop

Nitrate leaching



Emma Randahl-Beltran

Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Grain yields

Perennial rye yields ~ 4 Mg/ha

Weeds

Weed suppression is not compromised in perennial rye

Fall biomass

Regrowth is not as good as a cover crop

Nitrate leaching

Regrowth is not as good as a cover crop



Funded by the European Union

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

One season's worth of data…



Emma Randahl-Beltran,

Motivation

The experiment

Results



Research questions

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- What is the **yield potential** of perennial rye as compared to modern annual rye in Denmark?

- Is **weed suppression** compromised in the perennial rye crop compared to annual rye?

- Can the perennial rye fall **regrowth** offer additional environmental or agronomic value?

Research questions

AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- What is the **yield potential** of perennial rye as compared to modern annual rye in Denmark? **Half the grain yields, 1.5x straw yields**

- Is **weed suppression** compromised in the perennial rye crop compared to annual rye? **Equal to or better weed suppression**

- Can the perennial rye fall **regrowth** offer additional environmental or agronomic value? **There is no evidence for that.**



AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- One perennial *spring* wheat line tested in 2026
- Yielded around 1 Mg ha-1 in grain
- Had very good regrowth
- Harvested ~1 Mg ha-1 of forage in October
- Just planted a perennial *winter* wheat

My take-aways

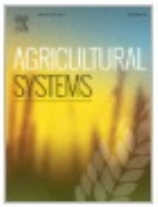
AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

- Perennial cereal rye may not be a good candidate for implementation in an annual rotation as a self-cover cropping system.

- Perennial rye may offer more value when grown for two or more years

- Perennial wheat lines may be better ‘self-cover croppers’

Agricultural Systems
Volume 234, April 2026, 104657



Self-cover cropping systems and the *plusquam*-annual: New tools for cropping system sustainability

Virginia Nichols [a], Prabin Bajgain [b], Laura Dixon [c], Kim Henrik Hebelstrup [a], Claus Krogh Madsen [a], Robin Morgan [d], Valentin Picasso [e]

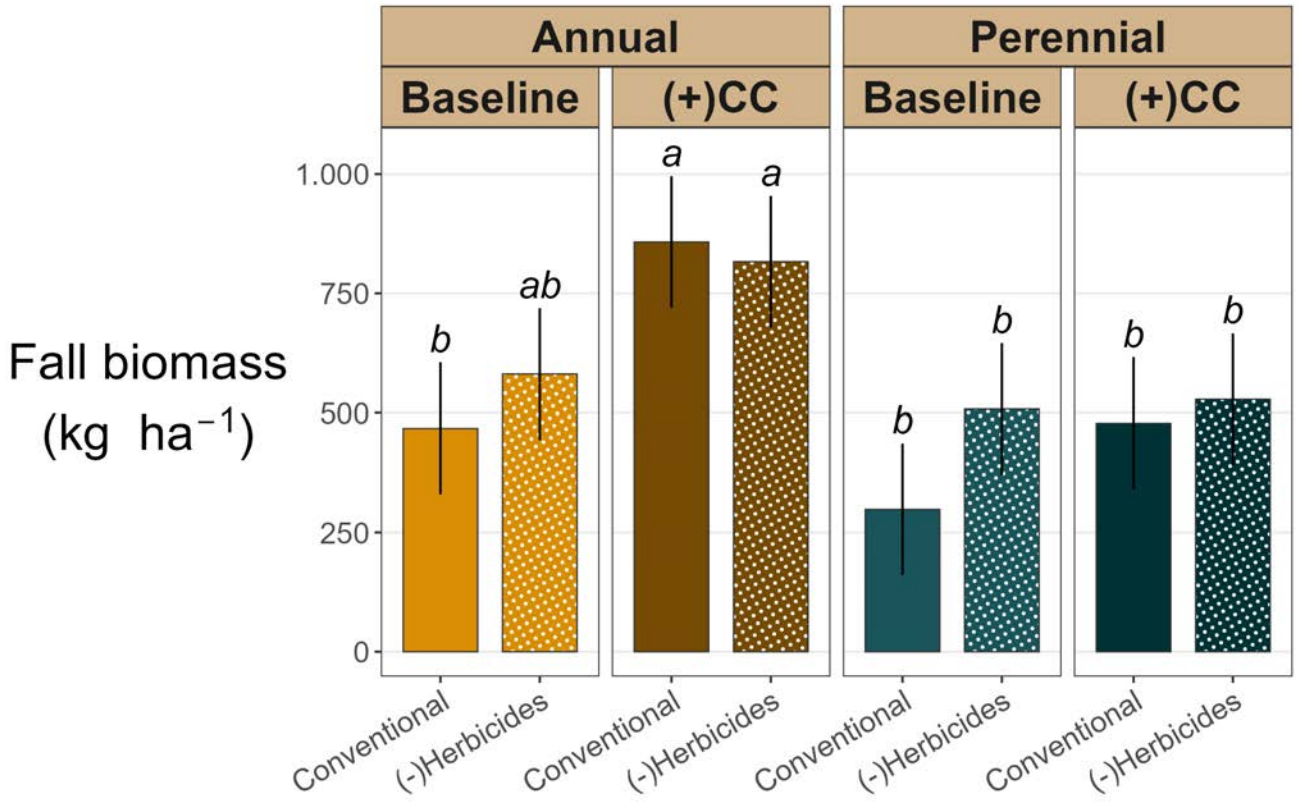
AARHUS UNIVERSITY
DEPARTMENT OF AGROECOLOGY

Thank you for listening!

gina.nichols@agro.au.dk

Funded by the European Union

Fall biomass





Emma Randahl-Beltran, Anders Nielsen, Cecilie Johnstad-Møller