Maintaining Constant Tiller and Spike Fertility to Achieve Stable Grain Yield of *Thinopyrum intermedium*.

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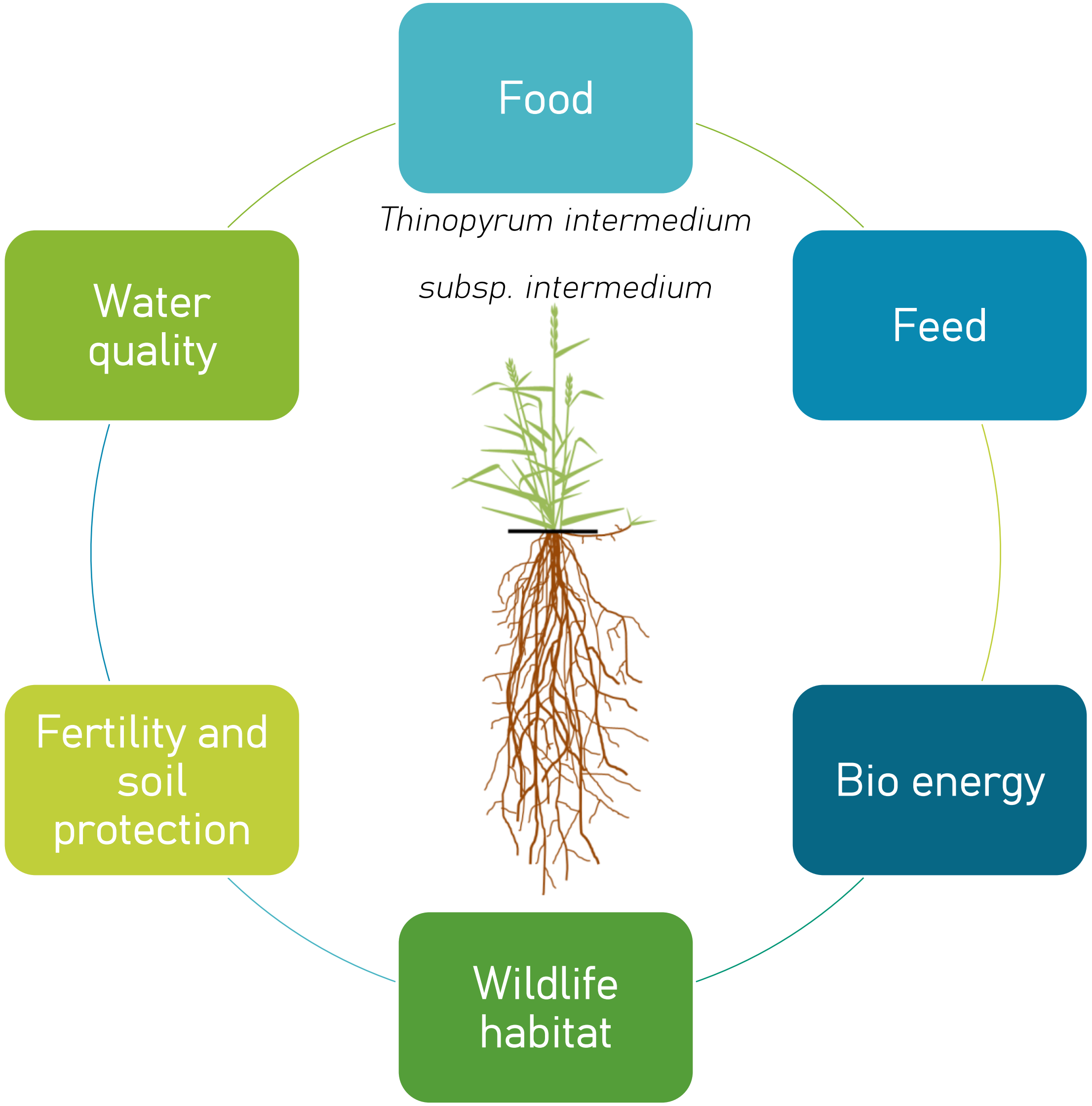
Introduction

- Newly developed **perennial grain crop (Kernza®)**
  (DeHaan *et al.*, 2018)
  - Perenniality → Ecosystem services
  - Dual production → Grain and forage



Introduction

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  - Perenniality → Ecosystem services
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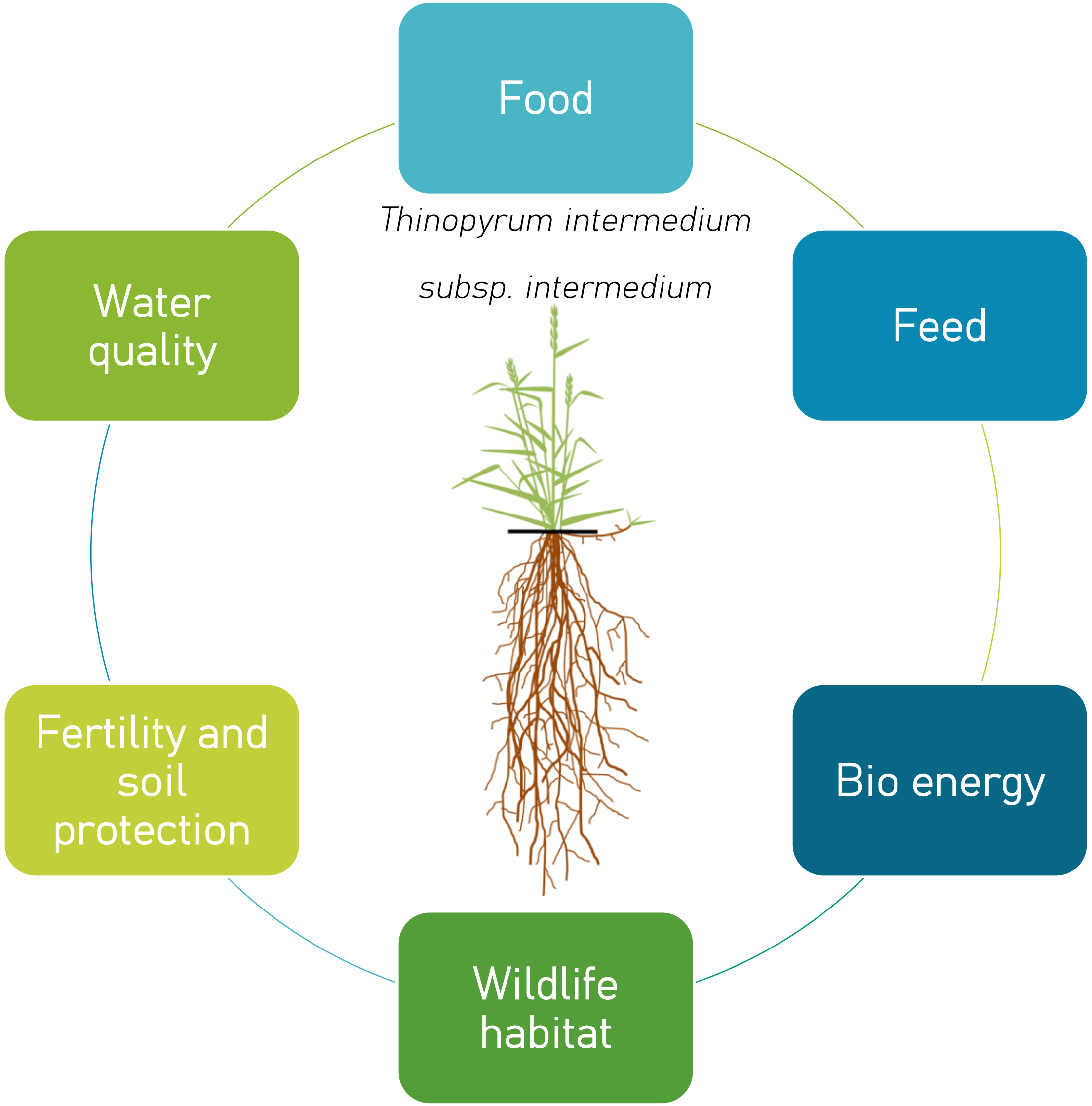
- Nascent stage of domestication:
  - Promising progress
  - **Low and variable resource allocation to grains**

    (Culman et al., 2013; Newell & Hayes, 2017; Zhang et al., 2015)



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  - Variable and low proportion of **fertile tillers** as crop ages: ↘ grain yield

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  - **Variability** in floret site utilization

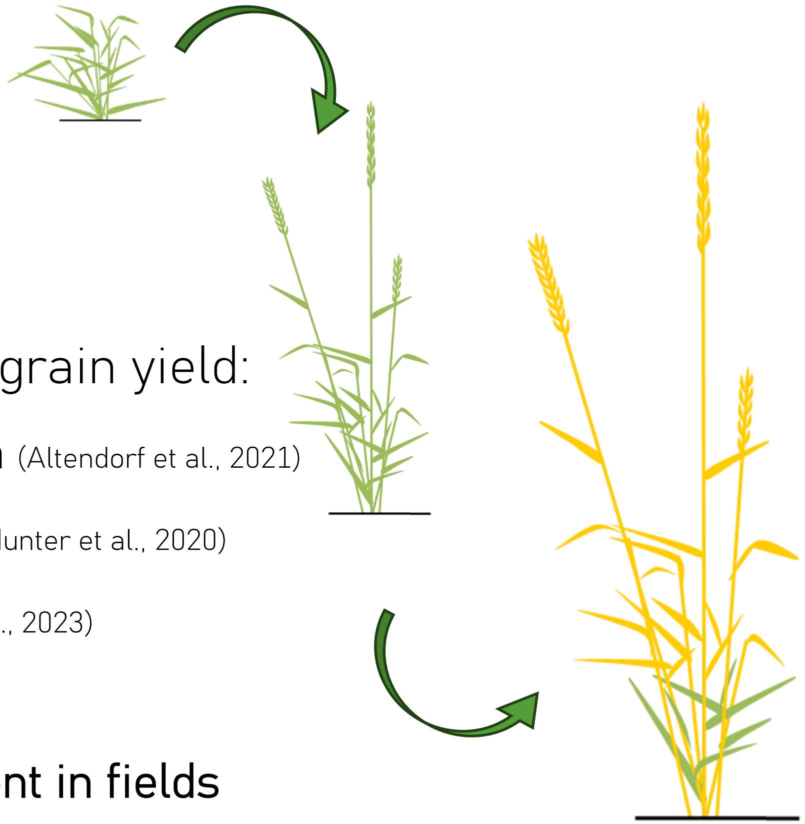
    (Elgersma, 1985; Altendorf et al., 2021)
  - Potential competition between **several sink organs** at the end of the growing season (i.e., grains, rhizomes, deep root system or dormant buds)

    (Hay & Porter, 2006; Lafarge & Durand, 2011)

Introduction

- Lack of understanding of crop development and the resulting grain yield:
  - Importance of **reproductive tiller density** and **floret site utilization** (Altendorf et al., 2021)
  - Strong **trade-off** between **tiller density** and **fertility** (Jungers et al., 2017; Hunter et al., 2020)
  - **Yield decline** as stand ages: ↘ HI up to 50% (Culman et al., 2023; Duchene et al., 2023)

➔ 31% of global yield increase would be linked to **better management in fields**
(Bajgain et al.; 2022)



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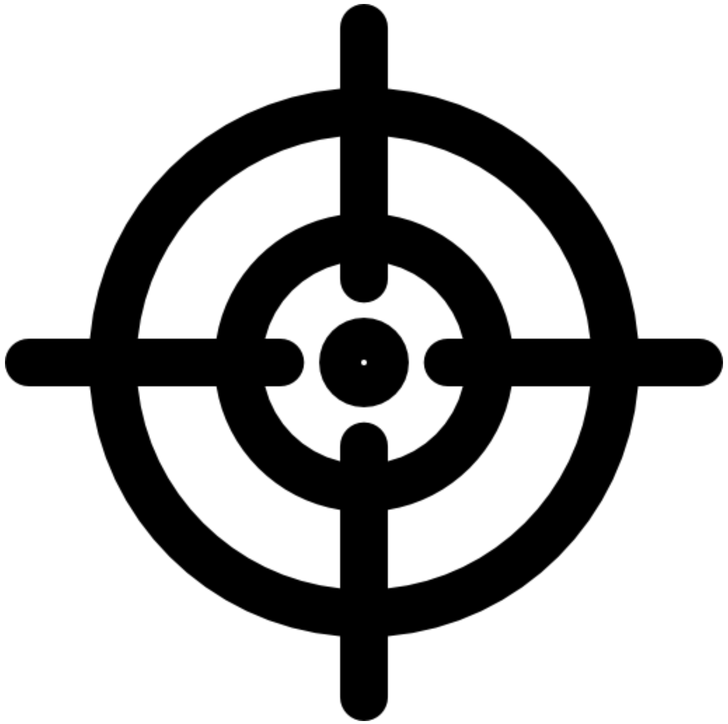


- **Objectives**:
  - Understand:
    - The **developmental traits influencing grain yield** and elucidate their interrelations
    - The influence of **autumn defoliation, N fertilization and stand age** on crop growth and yield

➔ Provide additional support for the **design of adapted crop management** strategy for *Th. intermedium.*

Material & Method

Management treatments

(A) N fertilization		
Total N dose (kg N ha^{-1})	Splitting (kg N ha^{-1})	
	Early-spring (tillering)	Autumn Vegetative stage
0	0	0
50	50	0
100	50	50
100	100	0

(A) Forage harvest

- Summer straw harvest + Autumn defoliation
- Summer straw harvest

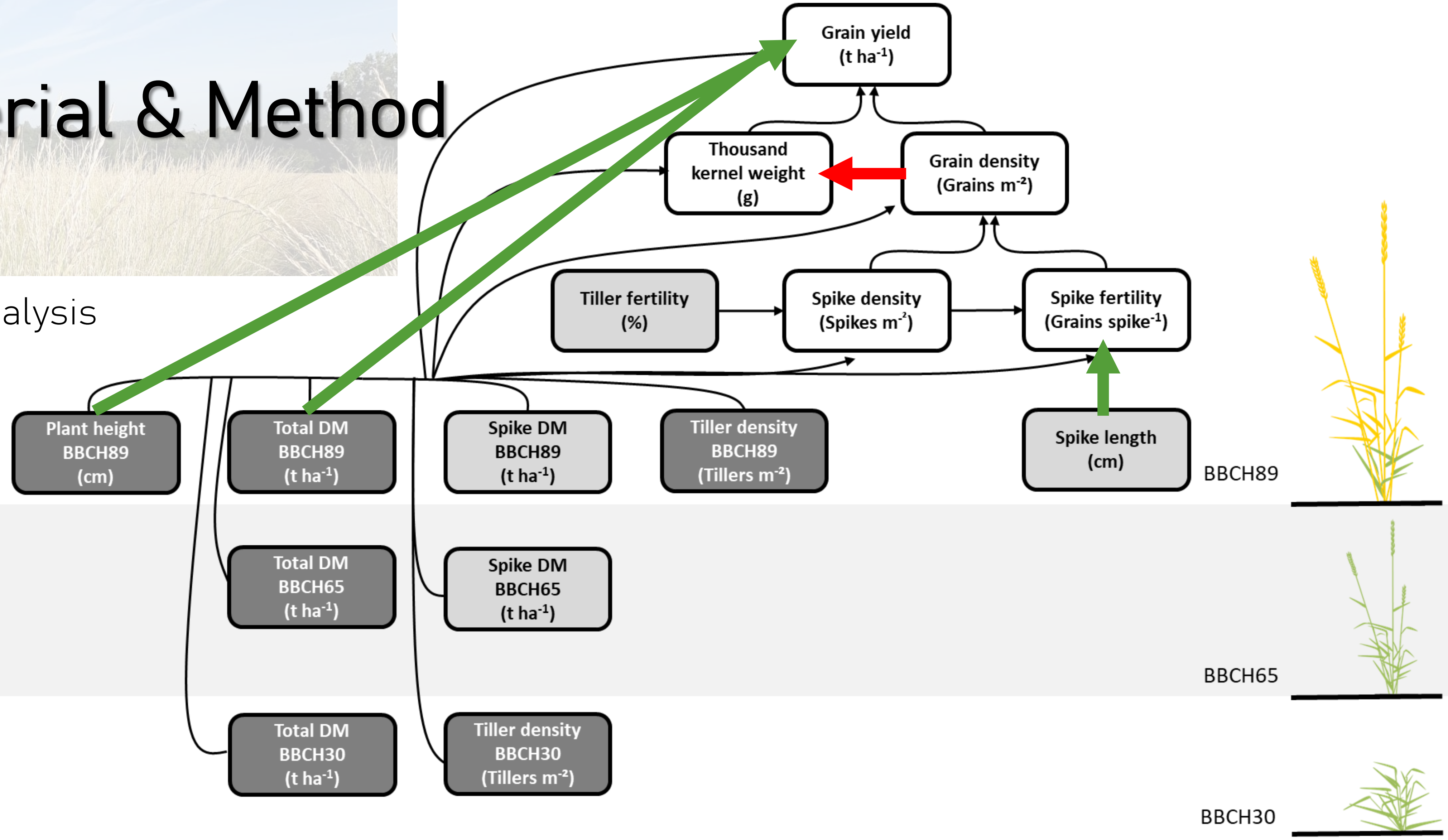
- **Belgian field** experiment
  - **Deep and fertile soil** conditions
  - Four grain production years (i.e., establishment year + three regrowing years)
  - Various **N treatments**
  - **Autumn defoliation** compared to the only summer defoliation

- Various measurments
  - **During the growing season**: tiller density, aboveground biomass
  - **At grain harvest**: grain yield, TKW, spike density, grain density, spike fertility, plant height, harvest index, nitrogen harvest index, …

Fagnant et al., major revision – European J. of Agronomy.

Material & Method

- Path analysis



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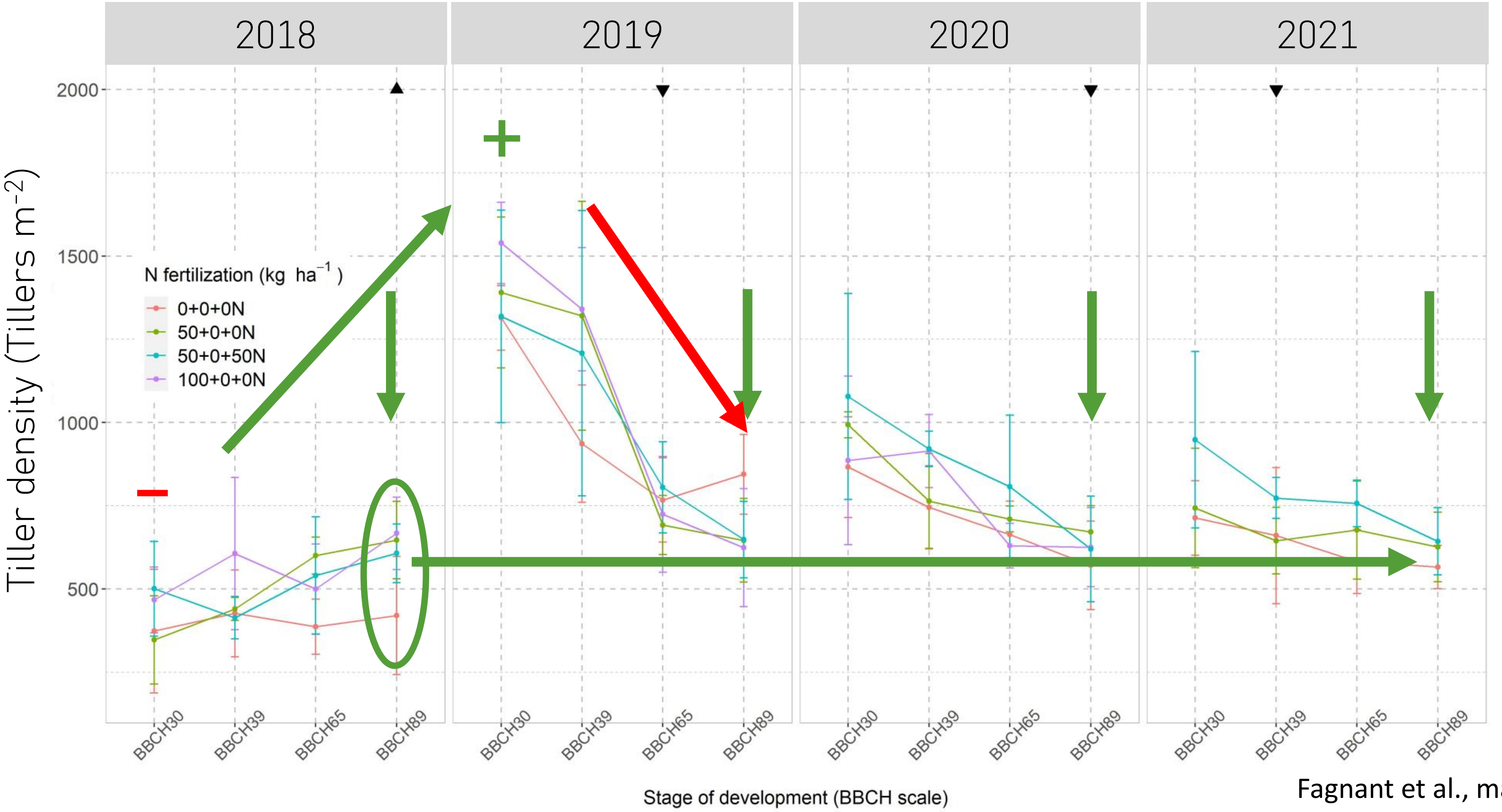
Results



- ↗ **Tiller density** during the **establishment** year
- **Overproduction** of tillers in 2019 => **strong mortility**
- Unique **positive influence of N** in the **establishment year**

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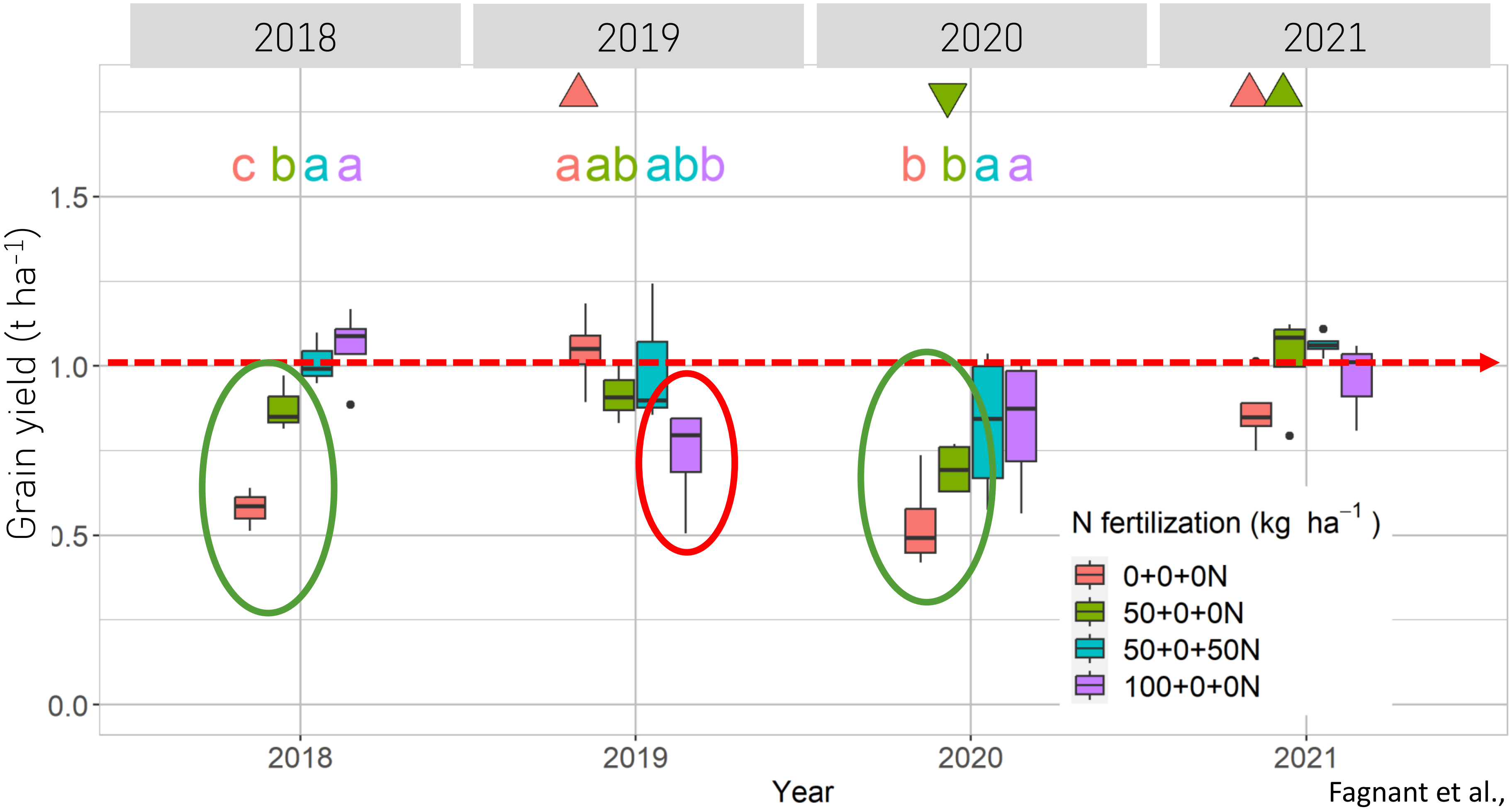
Results



- No grain yield decrease with stand age
- Positive influence of N fertilization except in 2019

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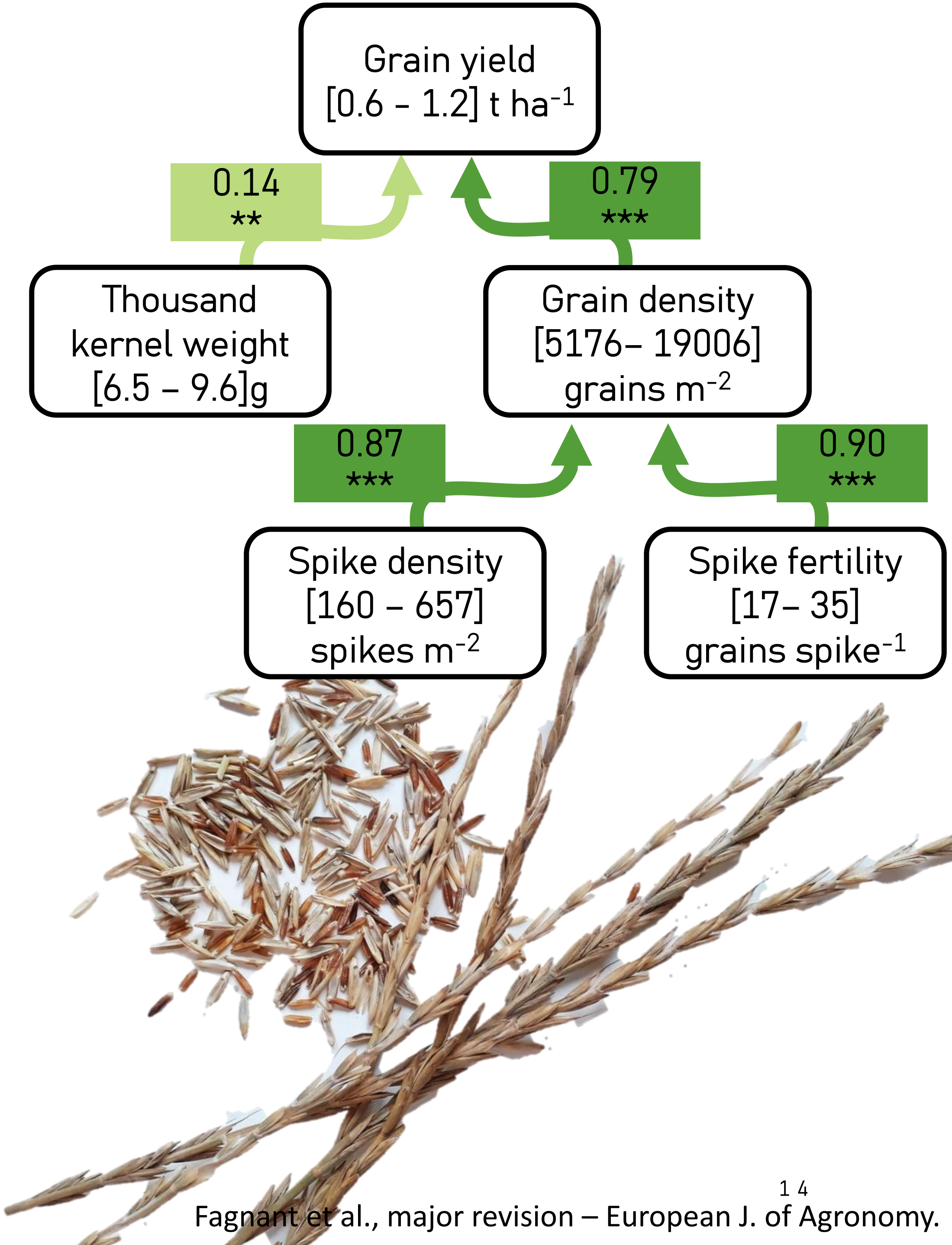
Results & Discussion

- **Grain yield** explained by:
  - **Spike density** x **spike fertility**

- **Optimal spike density**: ~= 400spikes m^{-2}

- **Low spike fertility BUT constant** as the crop ages:
  - Floret fertility <49% (larson et al, 2019)

    → Limitation for seed production



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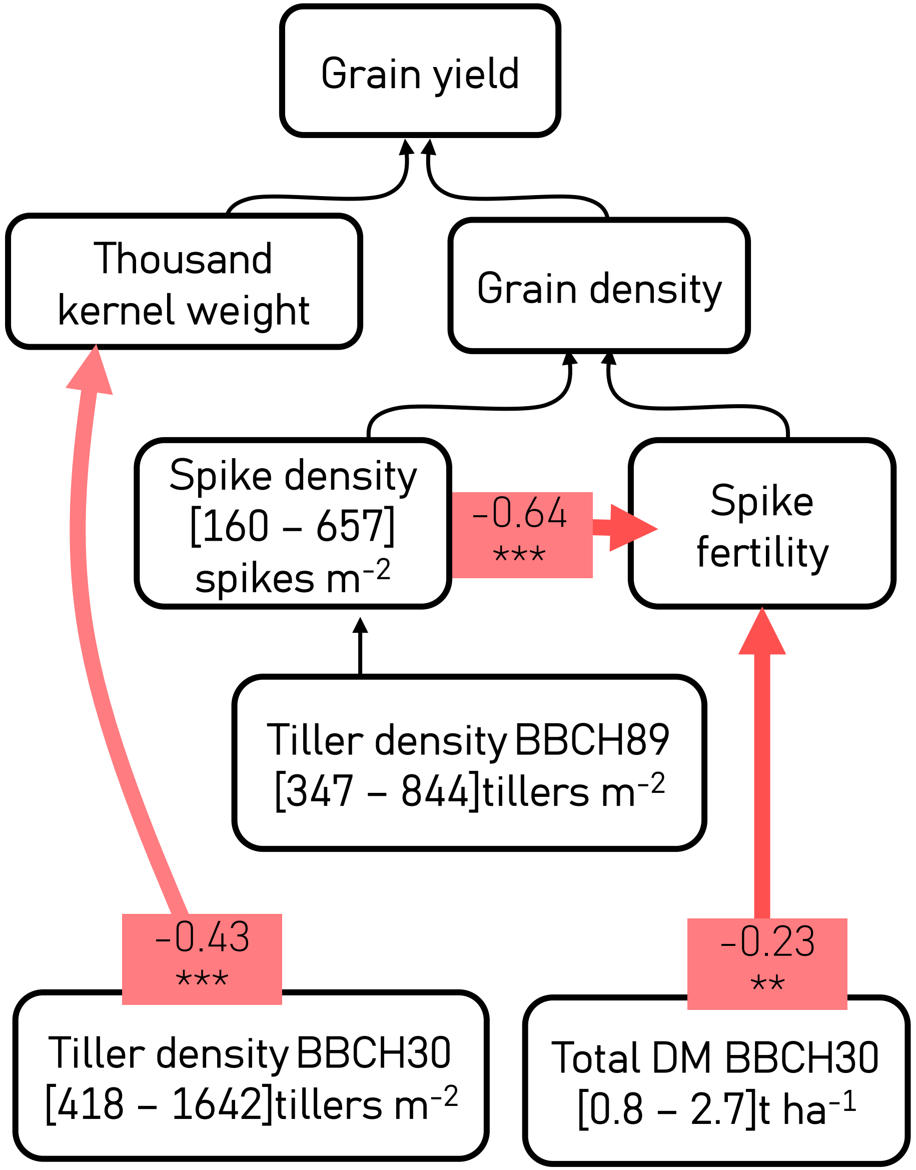
Results & Discussion

- **Compensation** mechanisms:
  - Between **yield per spike** and yield per **plant**

- **When early biomass is peaking:**
  - Inhibition of reproductive growth of tillers: ↘ **Yield per spike**
  - Tillers mortality (~=50%)

- Probable **optimal tiller and spike density**:

Hunter et al., (2022) : [620 – 2730]tillers m^{-2} & [370 – 960] spikes m^{-2}



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Results & Discussion

- Impact of agronomic management:

1) **N fertilization**:
   - Positive effect on spike density and spike DM
   - Negative effect on grain yield when excessive aboveground biomass

2) **Autumn defoliation**:
   - ↘ Biomass in the next growing season
   - ↗ Yield per spike through TKW

3) **Exportation and shredding** of post-harvet residues
   - Light perception of early *Th. intermedium* tillers (present since early autumn) maybe the future reproductive tillers (Langer, 1979)

Conclusions

- How agronomic management can help maintain constant grain ?

1) **Avoid early excessive biomass and tiller density:**
   - Reduce N fertilization at tillering (>1000tillers m^{-2} at BBCH30)
   - Autumn defoliation

2) **Maintain reproductive potential of tillers:**
   - Early autumn tillers maybe the future reproductive tillers (Langer, 1979)
     → Favor light perception through exportation and shredding of post-harvet residues
     → Potential positive effect of autumn N fertilization
   - Support of spike density and spike DM with an early spring N fertilization

➔ **100kg N ha^{-1} splitted between autumn and early spring** seemed optimal

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THANKS FOR YOUR ATTENTION !

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QUESTIONS ?

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$$spike\ fertility = \frac{grain\ yield}{spike\ density.\ \frac{TKW_{un}}{1000}}$$

$$grain\ density = spike\ fertility\ .spike\ density$$