Multi-criteria optimisation of *Thinopyrum intermedium*

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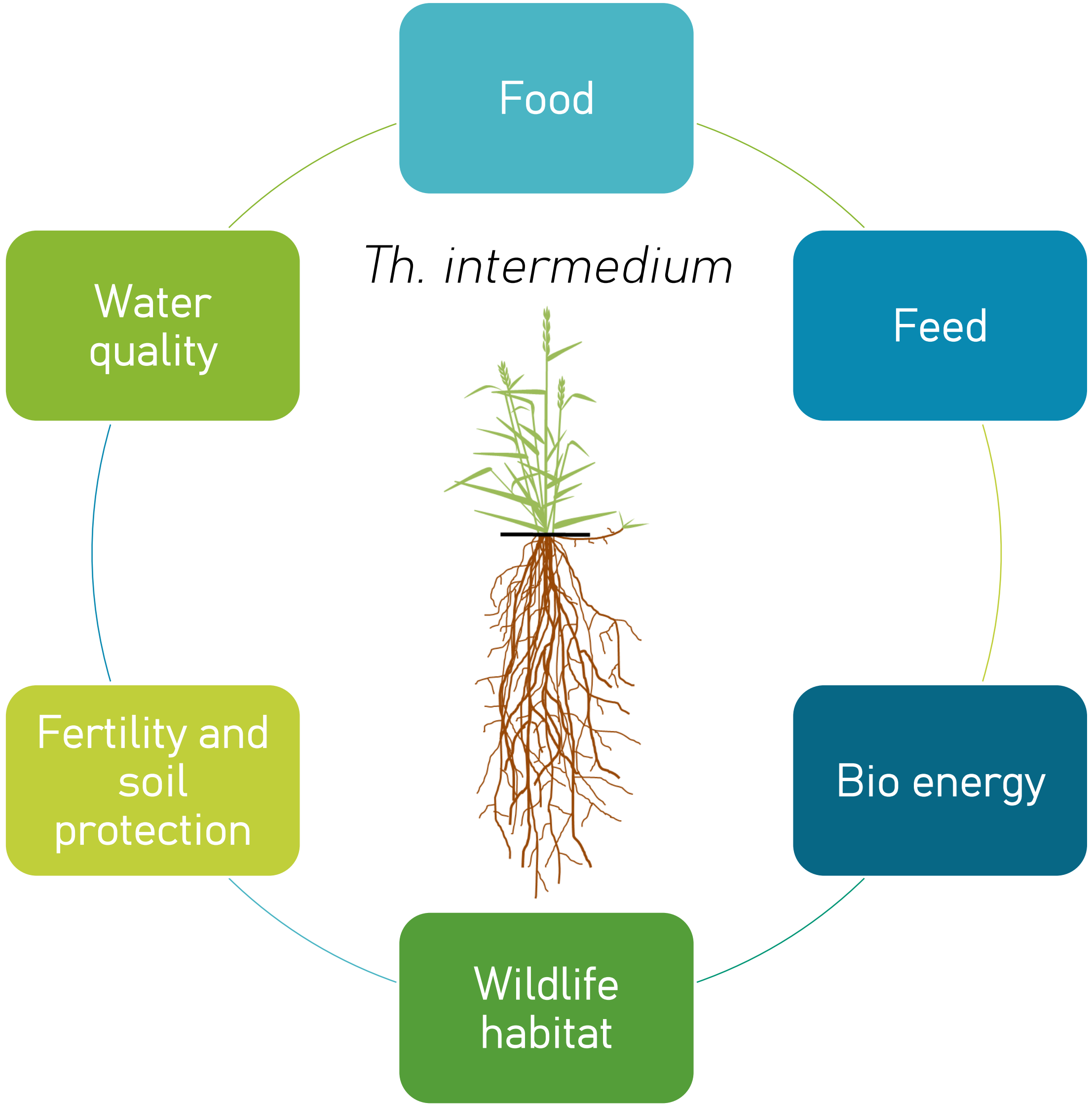
Introduction

- Lack of knowledge regarding :
  - Growing habits ?
  - Field management ?
- How to optimize its production ?
  - Food & Feed



Introduction

Differentiated agronomic management

Forage management :

Mowing strategies :

- Autumn mowing
- Multiple spring mowing

Legumes association :

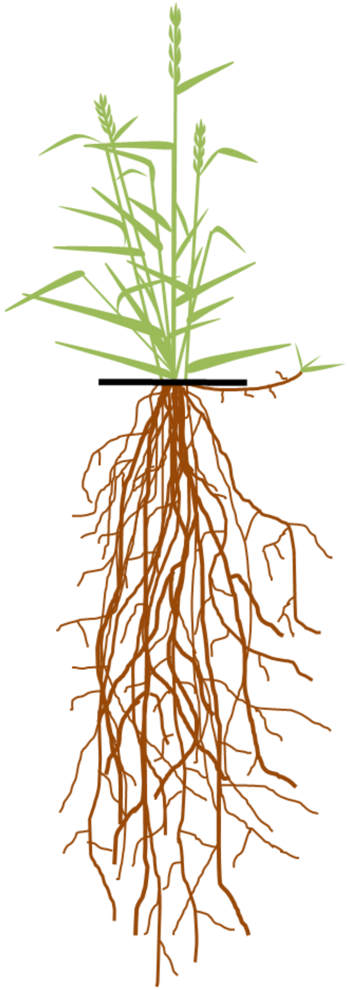
- WC
- RC
- Alfalfa

Implantation :

- Sowing date
- Interrow spacing

N treatments:

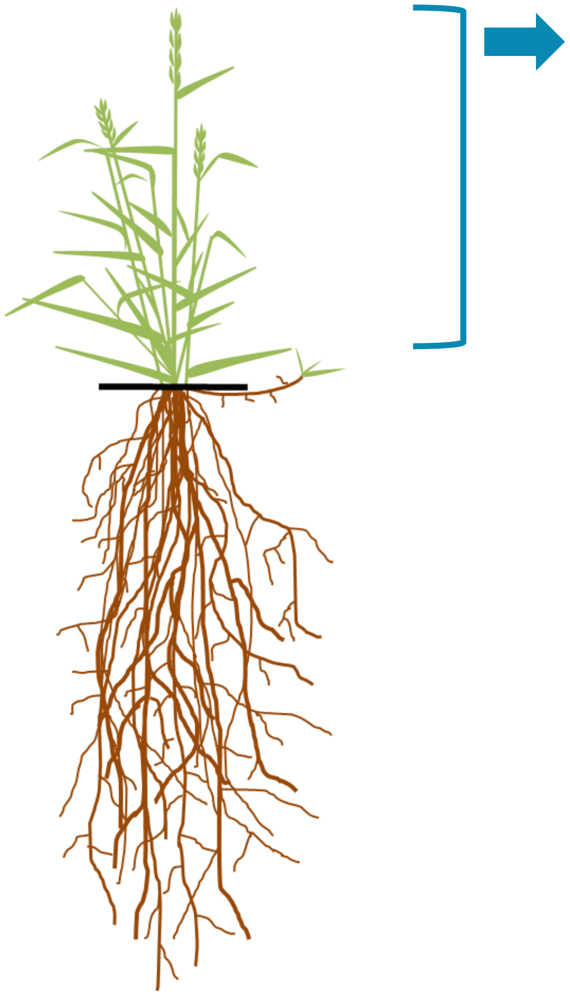
- Amount
- Time of application



- Allocation towards grains
- Nitrogen needs
- Forage production

- Allocations towards ground-level and belowground organs

Grain production



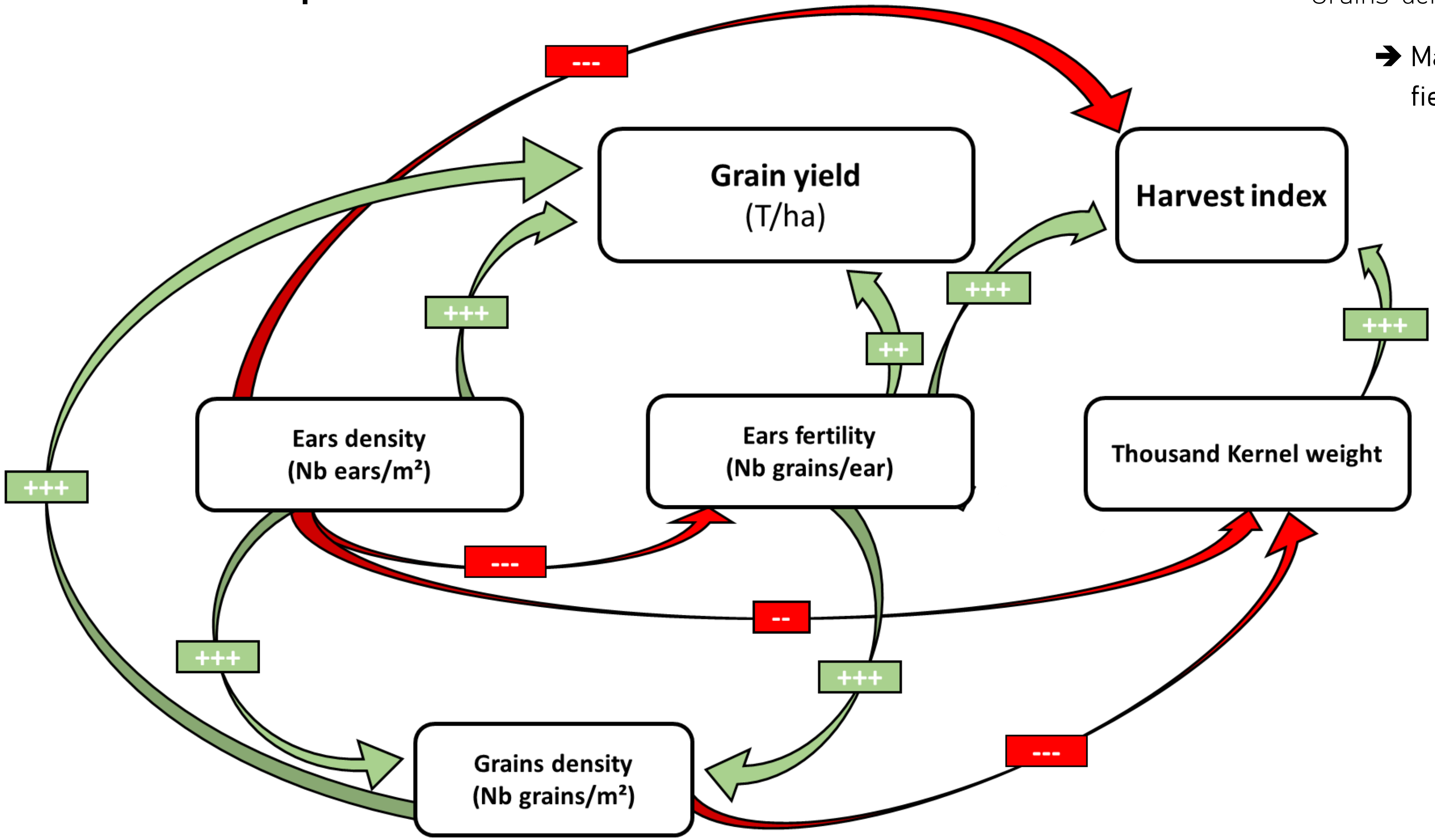
Allocation towards grains

Grain production

- Low Harvest index ~ 10% (Grain yield ~1T/ha)
  - Small grains + Low ears'fertility
  - No influence of N fertilization or mowing

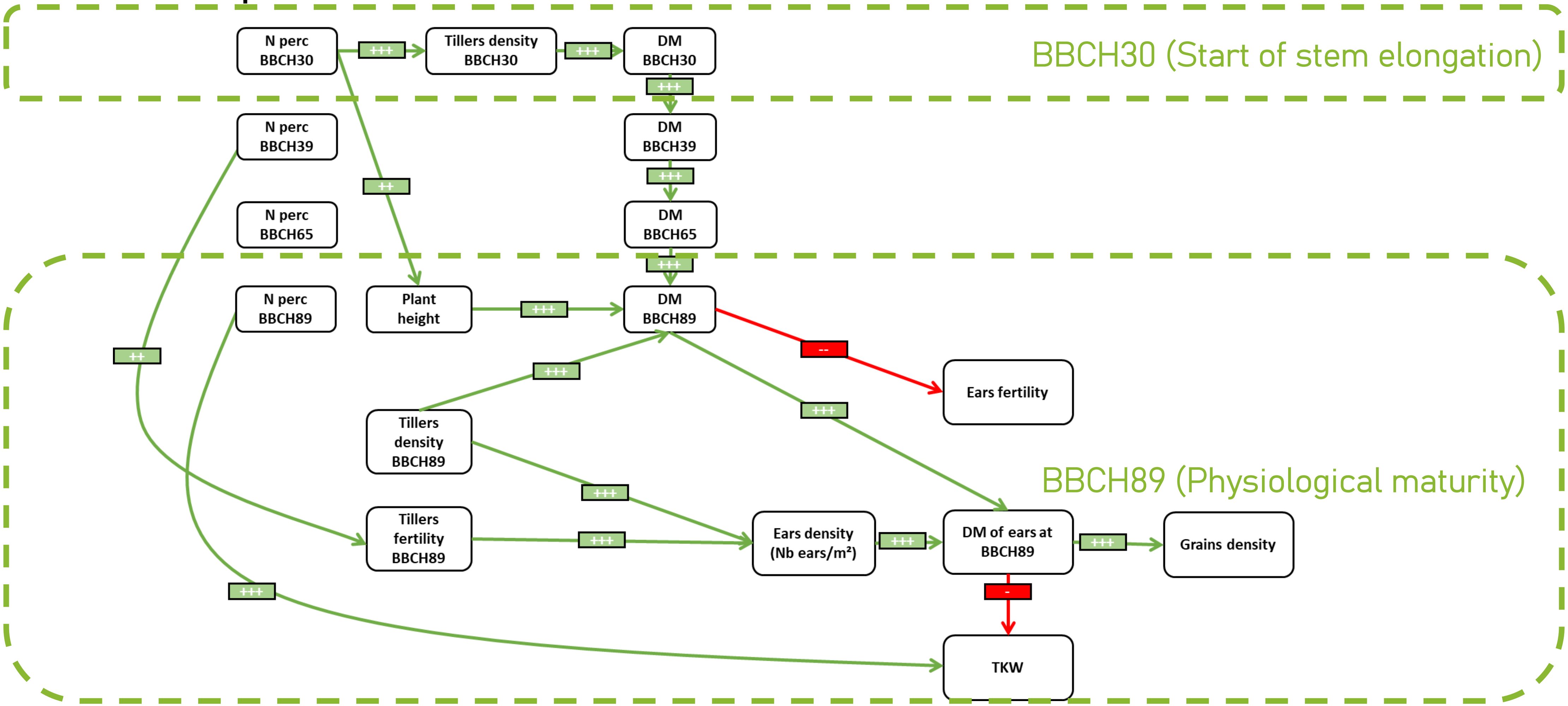
    → Genetic limitations
- Strong relationship of grain yield with :
  - Ears' density
  - Grains' density

➔ Maximize ears' density to maximize grains' density in field



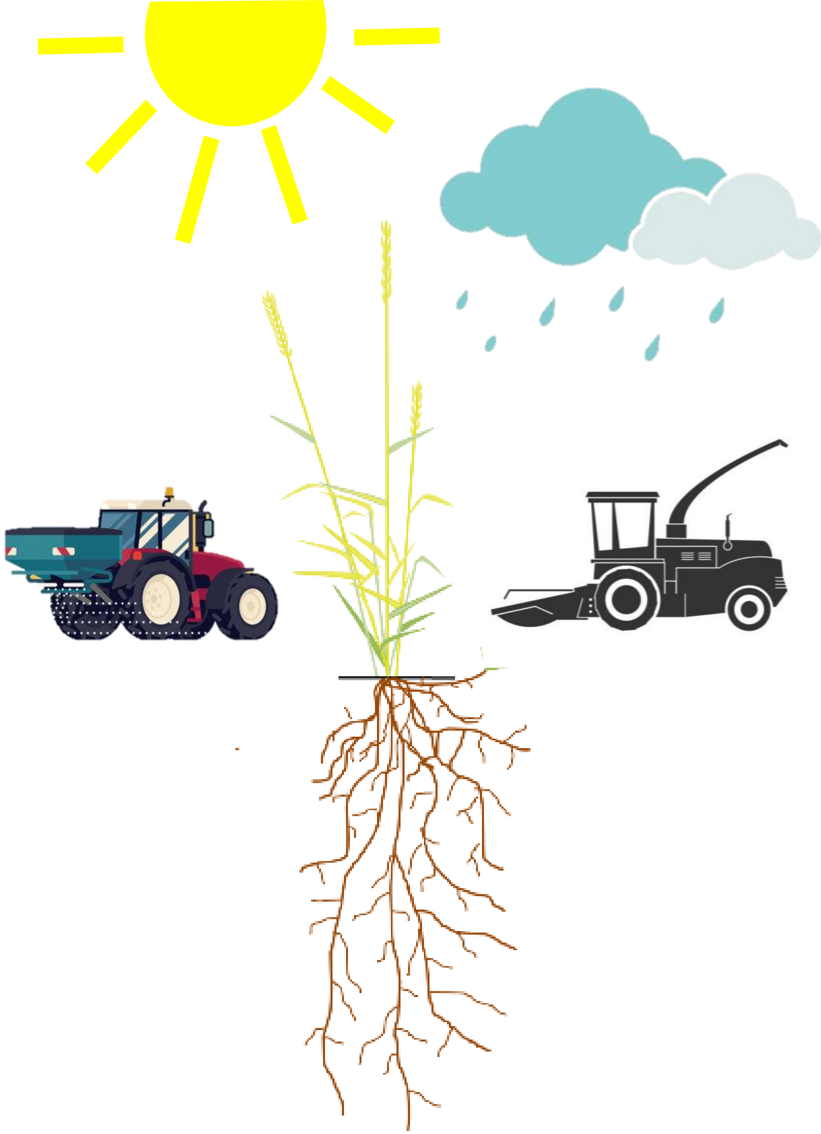
Grain production

- Positive relationship between aboveground DM production and grain yield (Grains' density, ears' density)
- Negative relationship between aboveground DM production and harvest index (TKW, Ears' fertility)

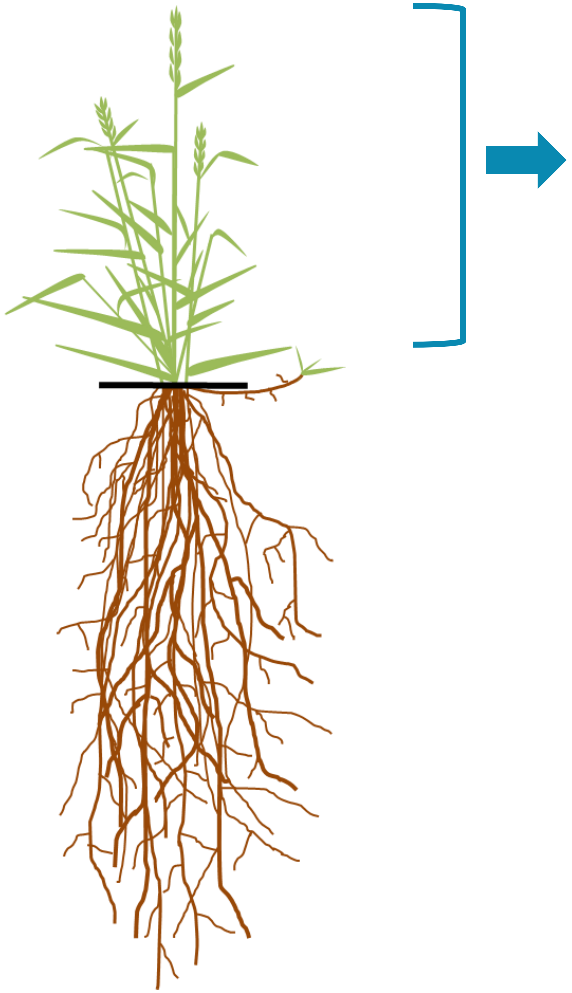


Grain production

- Study on the agro-climatic impact on the grain production
  - Weather indicators
    - Scalding t° during grain filling
    - Vernalizing t° before entering reproductive stage
    - Radiation
    - Water balance
    - ….
  - N treatments
  - Fall mowing



Nitrogen nutrition index



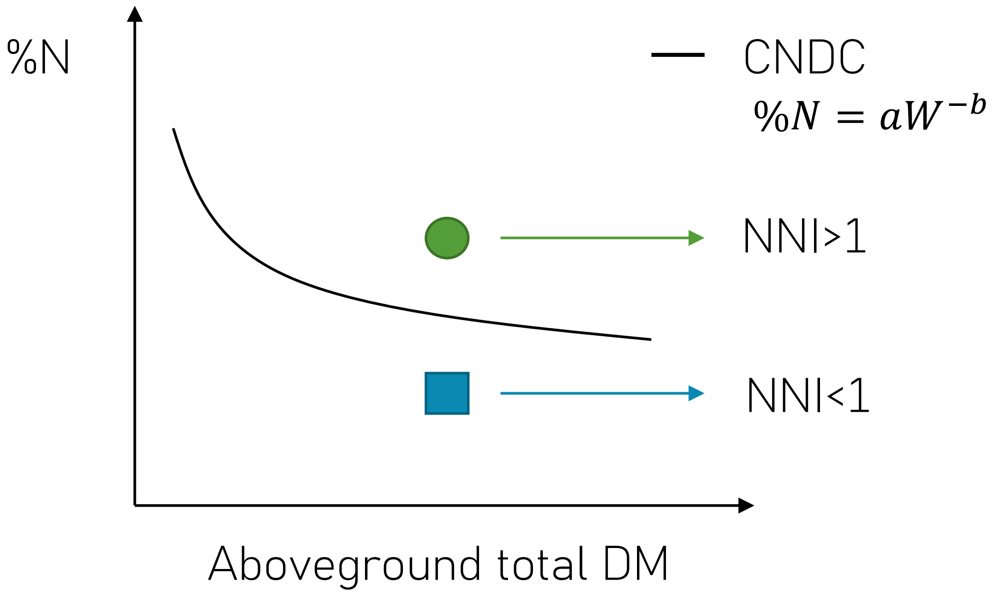
Nitrogen needs

Nitrogen nutrition index

- N mangement remains crucial !
    - Impact on crop ecophysiology & crop productivity
    - Environnemental issues
    - Economic costs

« What are the N requirements of the crop ? »

Nitrogen nutrition index



- Critical N dilution curve (CNDC) : a powerful tool !

- N nutrition index (NNI) = actual %N / critical %N
  - NNI>1 : N luxury consumption situations
  - NNI<1 : N defficiency situations

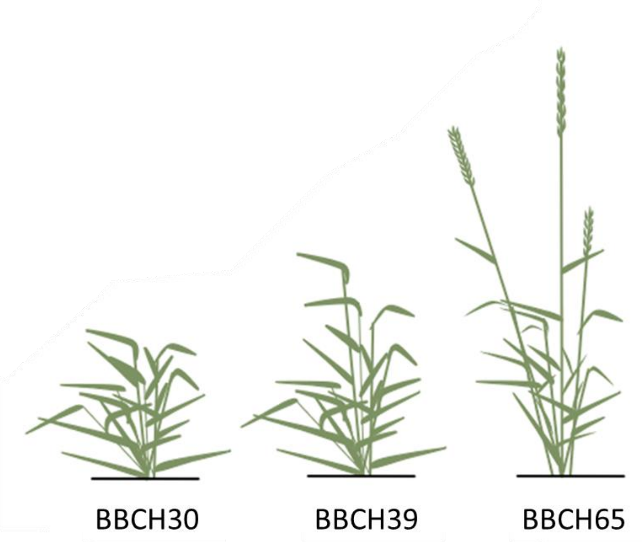
- Different approaches : Greenwood *et al*. (1990), Justes *et al*. (1994), Makowski *et al.* (2020)

Nitrogen nutrition index

- CNDC set-up :
    - One experimental field (Be)
    - 3 years
    - 8 N treatments : 0 to 150 kgN/ha (Jungers *et al.*, 2017).
    - 3 phenological stages

- CNDC validation :
    - Five experimental fields (Fr)
    - Variable N management
    - 3 phenological stages

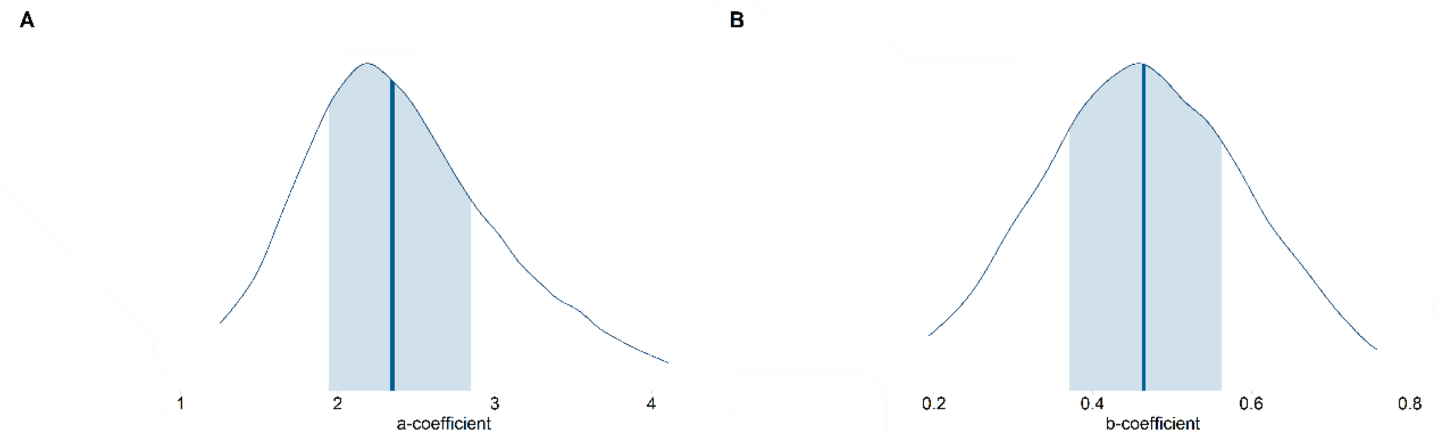
Splitting			**Total N dose**	**Code**
BBCH29	**BBCH39**	**Vegetative stage**		
0	0	0	0kg N/ha	0+0+0N
50	0	0	50kg N/ha	50+0+0N
50	0	50	100kg N/ha	50+0+50N
100	0	0	100kg N/ha	100+0+0N
100	0	50	150kg N/ha	100+0+50N
100	50	0	150kg N/ha	100+50+0N
0	100	0	100kg N/ha	0+100+0N
50	50	50	150kg N/ha	50+50+50N



Nitrogen nutrition index

- Use of the Bayesian hierarchical model
  - Response of DM to N content follow a linear-plus-plateau function
  - Variability of this function's parameters accross sampling dates described by a posteriori probability function

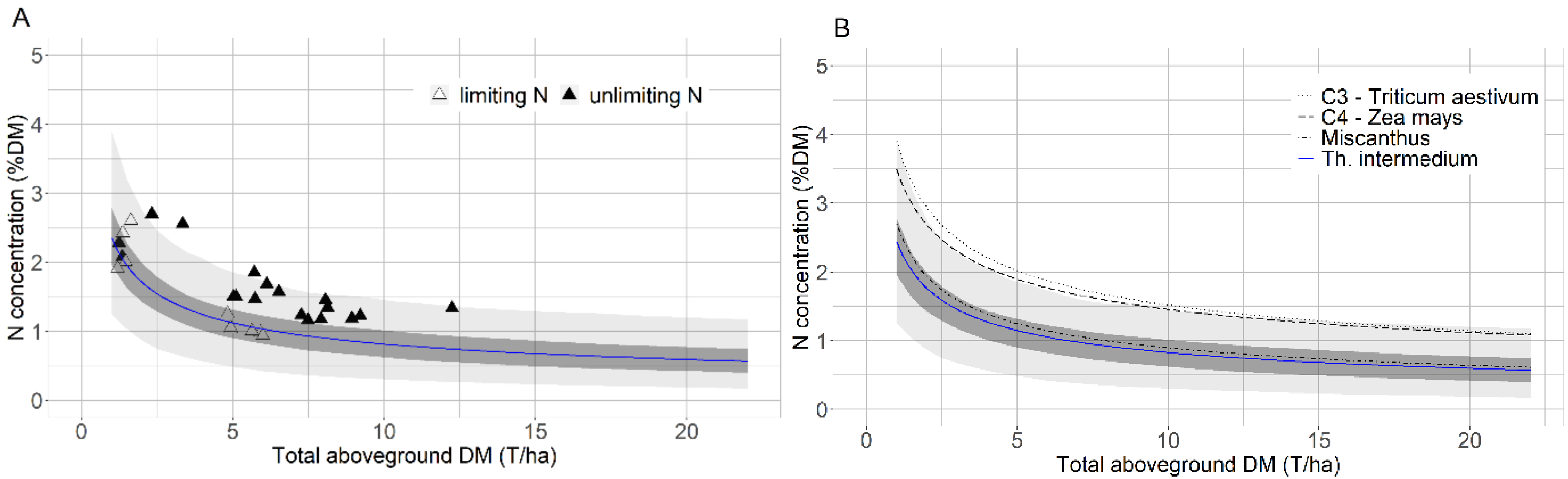
    -> derived parameter values of CNDC and their confidence intervals
  - Priors definition (expertise and empirical observations)



Fagnant et al., in prep.

Nitrogen nutrition index

Coefficients	*a*	*b*	*%N = a.MS⁻ᵇ*
Critical curve	2,35	-0,46	$\%N = 2.35DM^{-0.46}$
95% CI	[1,25; 4,10]	[0,19; 0,76]	

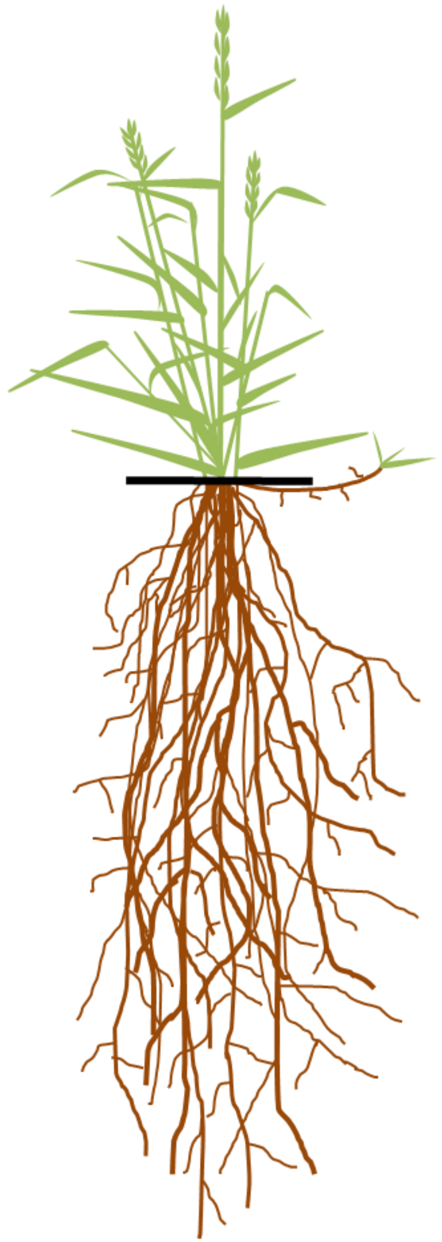


→ Reduced level of N nutrition of *Th. intermedium* compared to C3 or C4 species

→ Similar behavior as the one reported for perennial crop (e.g. : Miscanthus, vineyard)

Fagnant et al., in prep.

Nitrogen nutrition index



This behavior might be linked to following growing patterns :

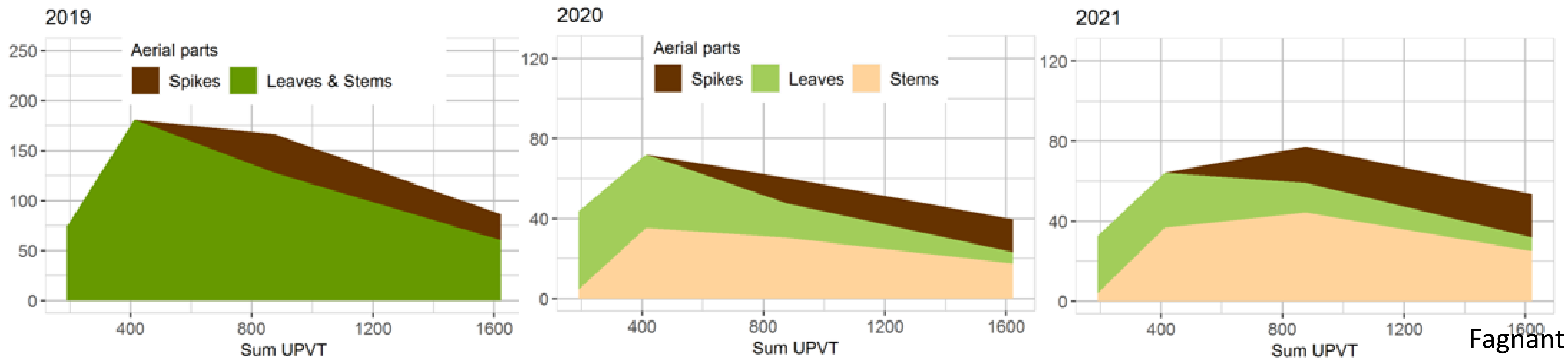
- High absorption efficiency (Jungers *et al*, 2019)
    - Deep and dense root system
    - Extended growing season

- High N use efficiency (Sprunger *et al.*, 2018)
    - Important above- and belowground DM production per N aplied

- Possible resource conservation strategy – Hypothesised by Duchêne *et al.*, 2020 reported in other perennial grasses Maire *et al.*, 2009

Nitrogen nutrition index

- Aboveground N uptake tend to decrease during the 2nd phase of the growing cycle
- Possible N cycling through translocation to perennial organs
  - Translocation of nutrients towards belowground organs – Reported by Sakiroglu *et al.*, 2020
  - Potential storage within stem bases ? – Reported in other perennial grasses by White (1973).



Fagnant et al., in prep.

Nitrogen nutrition index

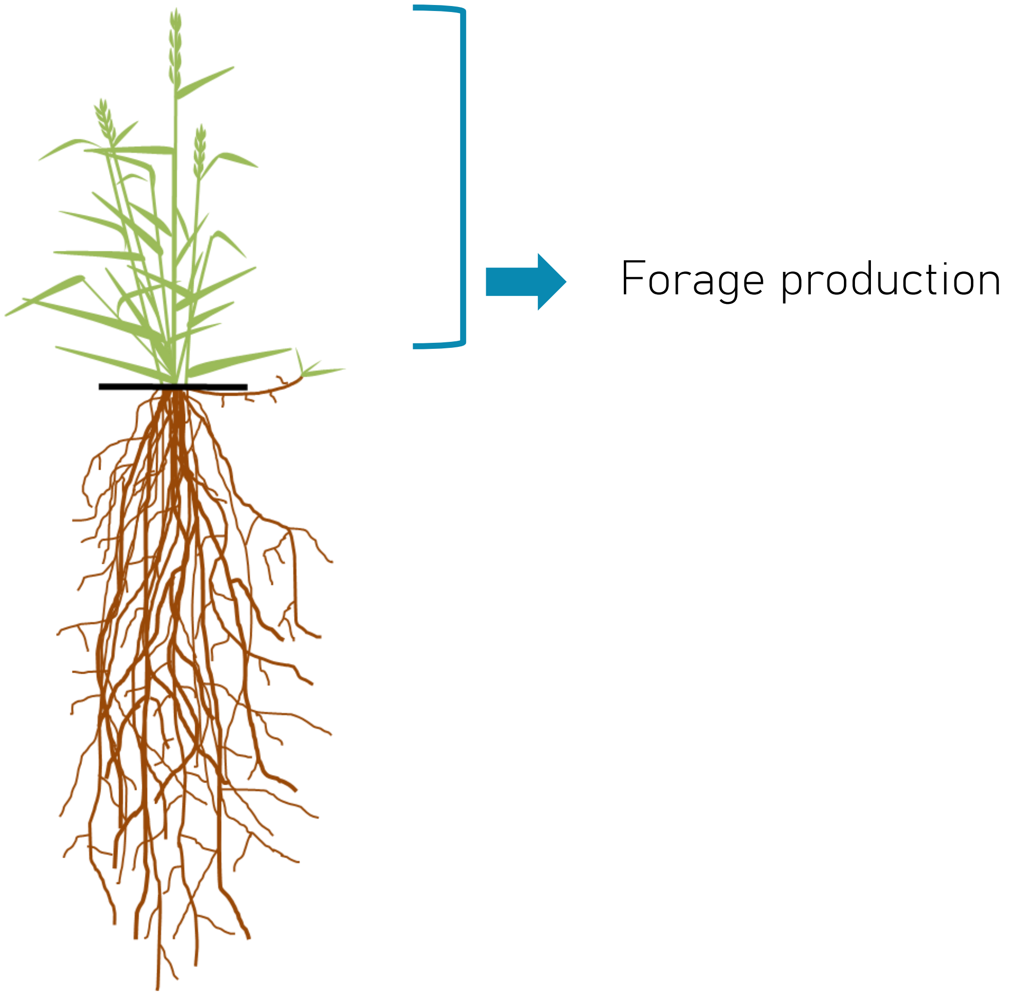
- *Th. intermedium* is able to reach high aboveground DM with low N needs

- Long-term survival strategy relies on
  - Weaker resource allocation to reproductive seeds
  - Important investment in perennial basal and belowground organs

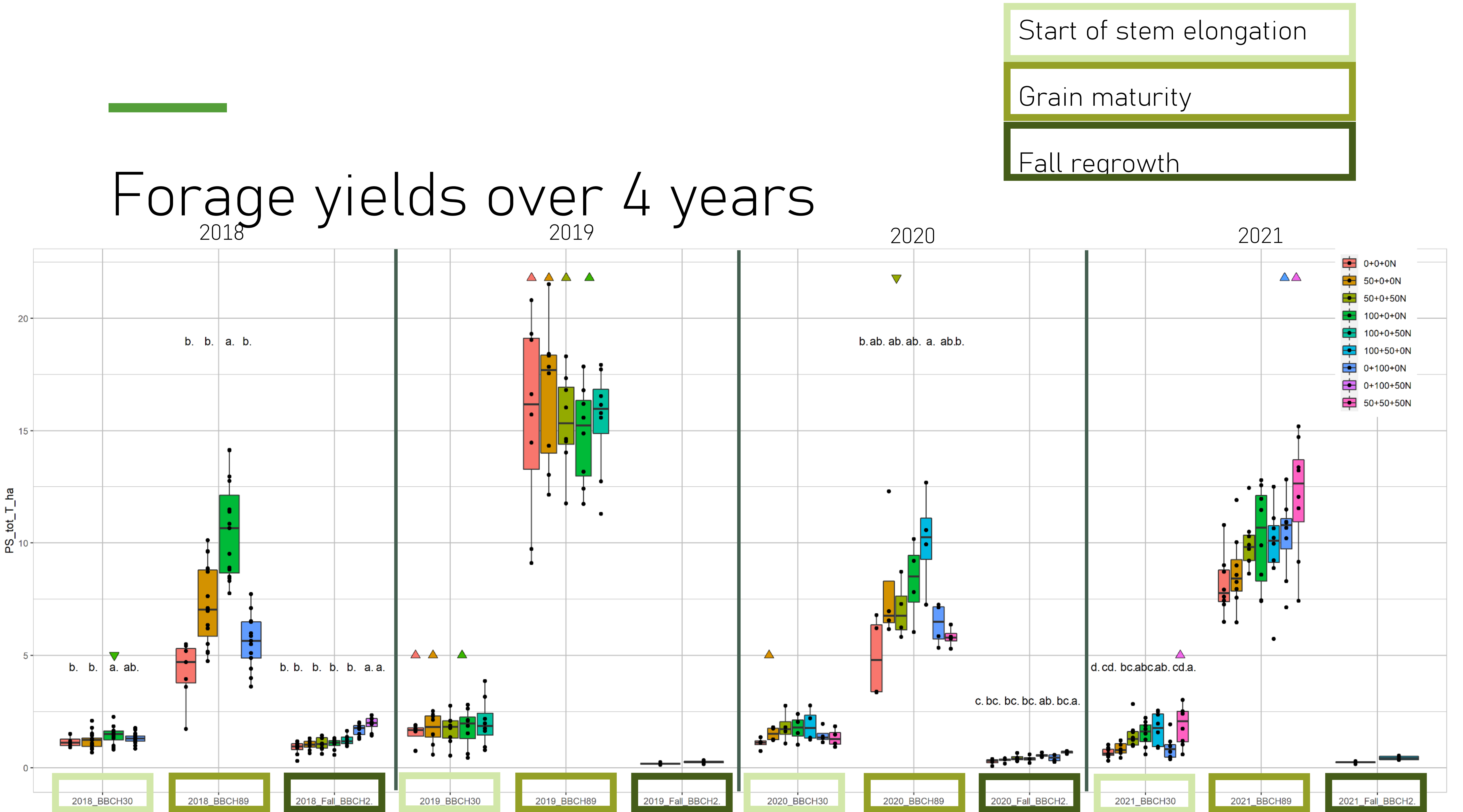
- CNDC = helpful tool to define N requirements in various pedo-climatic environments

  → Adjust accordingly the soil-crop management

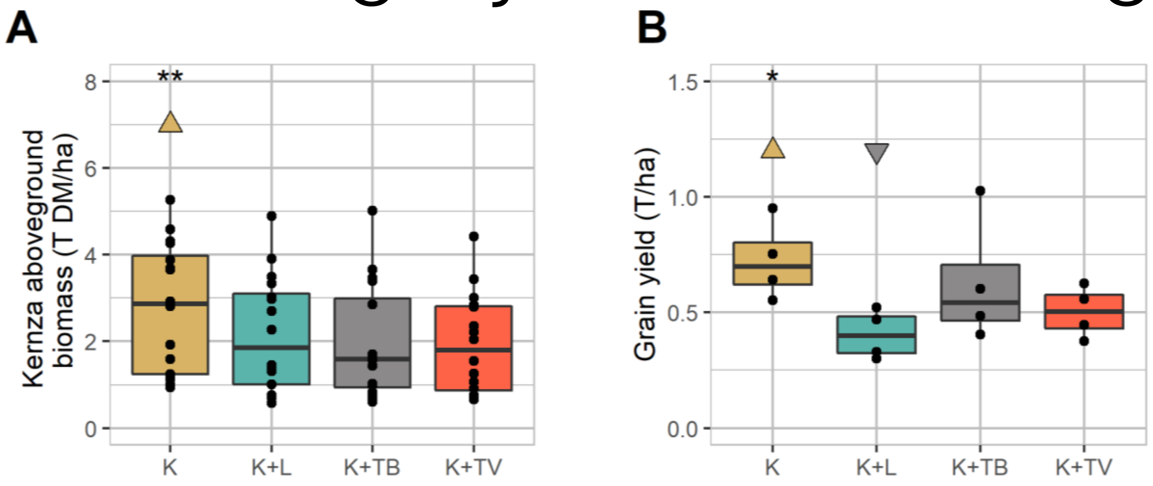
Forage production

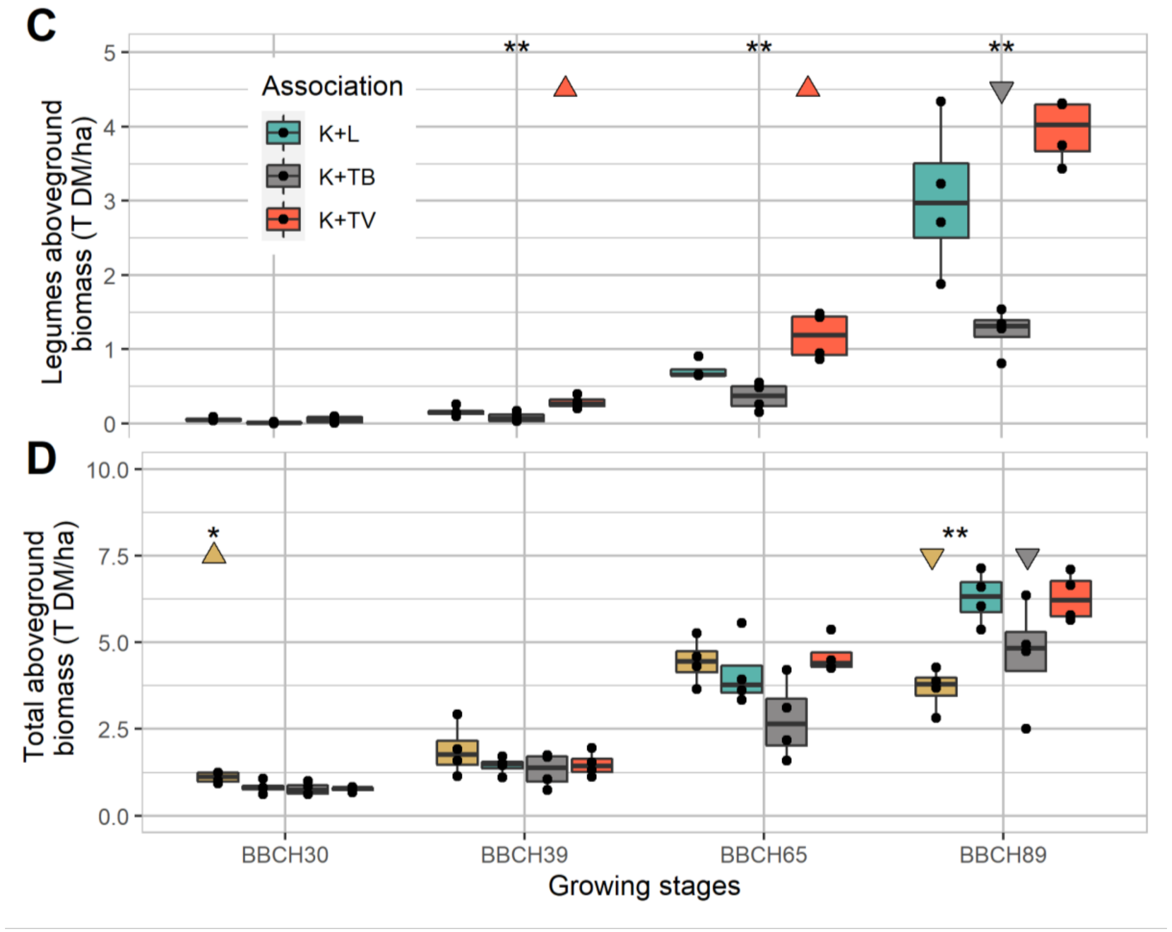


Forage yields over 4 years



Forage yields over legumes association





<u>Establishment year :</u>

- ! High weed competition
  - Insufficient coverage of legumes to compete
- Competition of legumes on the crop
- White clover : ground level development <30cm
- Alfalfa & red clover : highest development
  - Later phenology of alfalfa

Assesement of forage quality

- Infrared spectrometry and chemometrics

  Chemical analysis on the whole plant

  - Analytical DM
  - Total ash content
  - Total nitrogen matter (MAT) (Kjeldahl)
  - NDF (Van Soest *et al*. (1991))
  - ADF (Van Soest *et al*. (1991))
  - ADL (Van Soest (1963))
  - Crude cellulose (CB) (Weende)
  - Digestibility of OM (DMO) (De Boever *et al*. (1986))

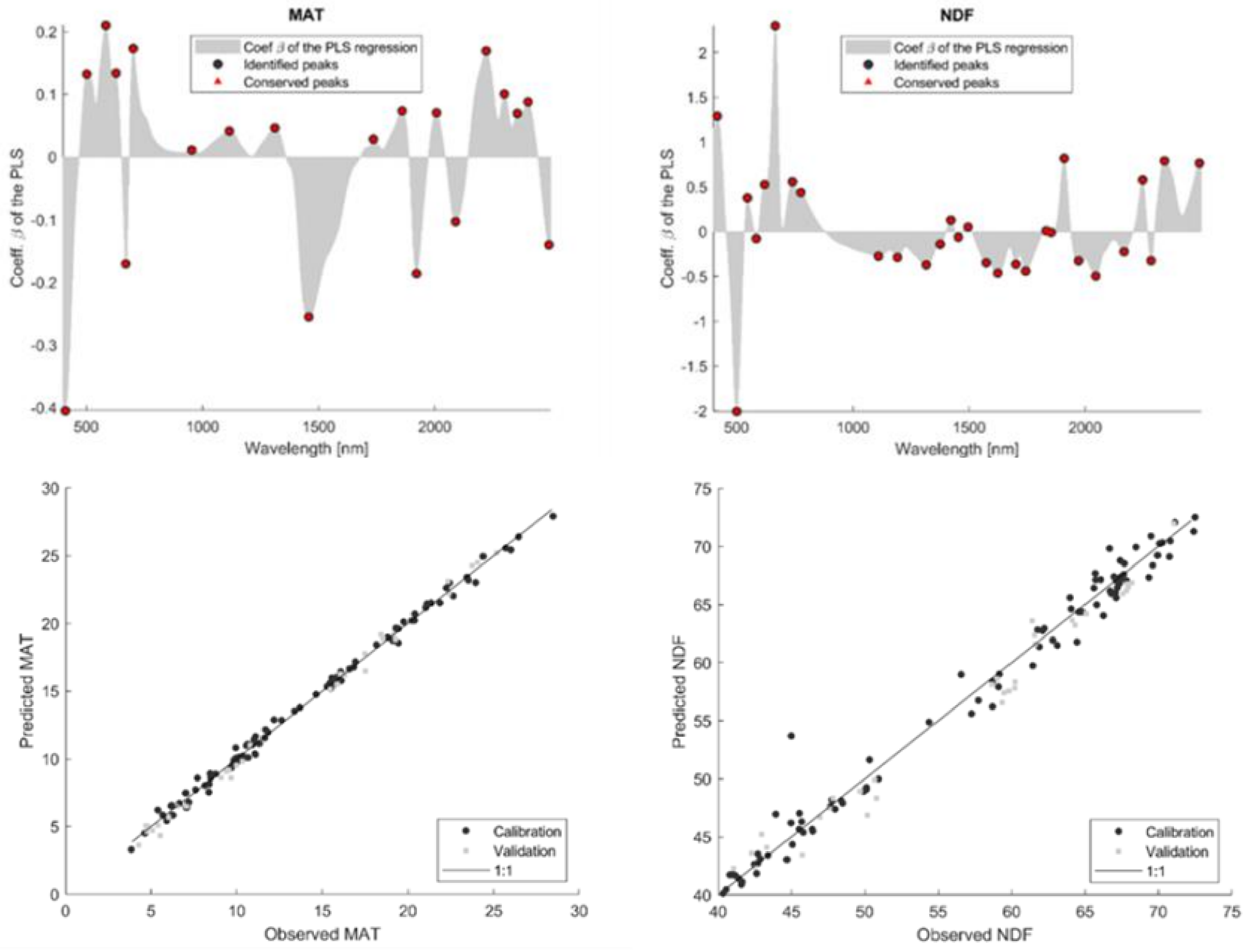
  Infrared spectra (XDS Monochromator Type XM-1000-FOSS), 400-2500nm

Assesment of forage quality

- Preprocessing of spectra
  - SNV method
  - Detrend
  - Savitzky-Golay algorithm
- PLS regression

  Identify the wavelengths of interest (explaining the variability of chemical values)
- Multiple linear regression

  Predict forage values
- Calibration and validation on Belgian and French data



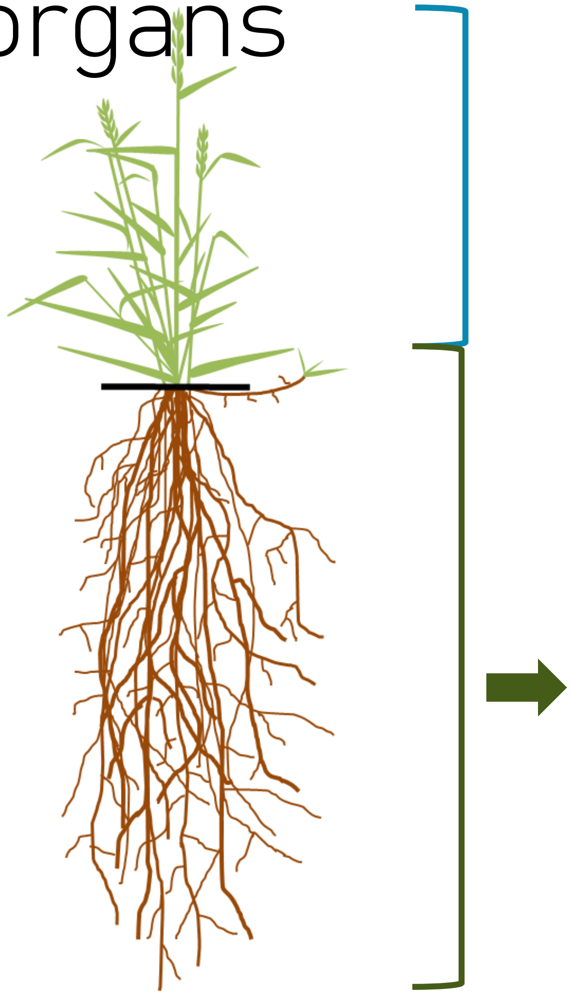
Assesment of forage quality

	Vegetative stage					Flowering stage				
	Tot N (% DM)	Cellulose (% DM)	Energy (g/kg DM)	Protein (g/kg DM)	Energy-protein ratio (g/kg DM)	Tot N (% DM)	Cellulose (% DM)	Energy (g/kg DM)	Protein (g/kg DM)	Energy-protein ratio (g/kg DM)
Orchardgrass (INRA, 2018)	24,5	17,7				9,8	33,9			
Meadow fescue(INRA, 2018)	23,5	18,6				11,3				
English ryegrass (INRA, 2018)	22,3	19,7				9,6	31,5			
Timothy grass (INRA, 2018)	20,2	22,4				7,2	36,1			
« Good quality grass » **(Limbourg (1997) cited by Crémer, 2015)**			1000	95	60					
Wheat straw (INRA, sd)								482	23	-21
Kernza BBCH30	17,7	19,7	1023	100	16					
Kernza fall vegetative stage	23,9	23,3	940	97	82					
Kernza BBCH39	10,6	35,3	743	56	-16					
Kernza BBCH65						7,7	40,0	482	23	-21
Kernza BBCH89						5,3	33,8	490	18	-37

Needs of a lactating dairy cow : >850 VEM, >80 DVE (Cuvelier et al., 2015)

Needs of a of a BBB suckling cow : >700-900 VEM, >40-70 DVE (Beckers, 2018)

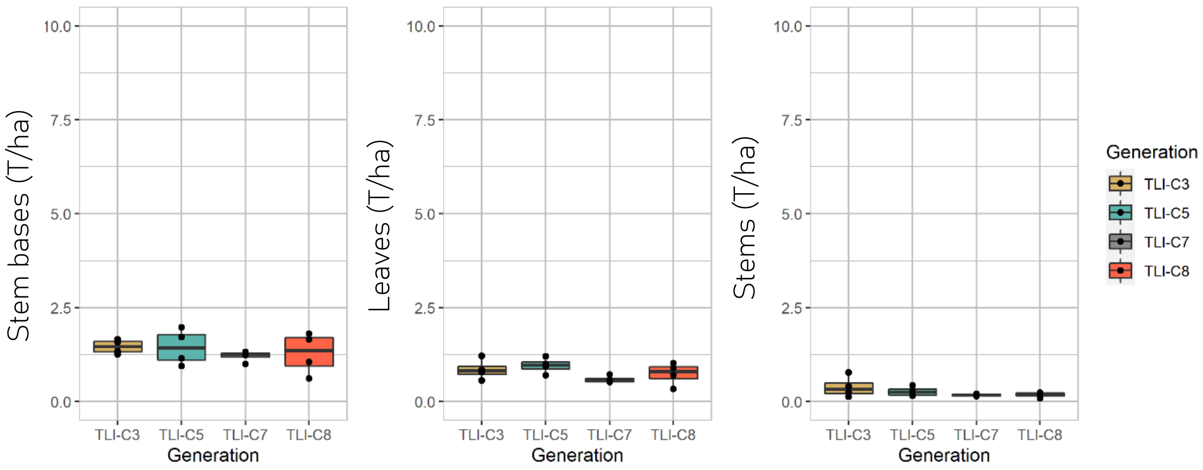
Allocation to perennial organs



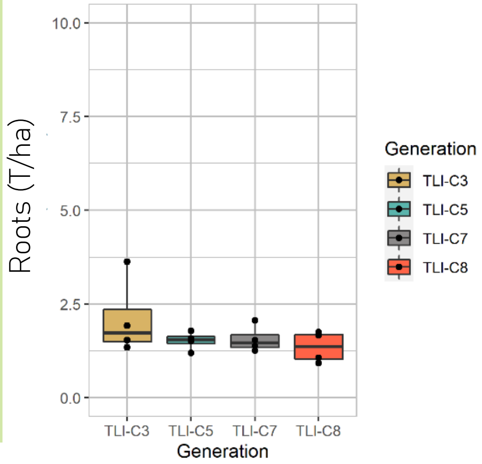
Agronomic performances: Generations

BBCH30 | BBCH39 | BBCH65 | BBCH89

Aboveground



Belowground



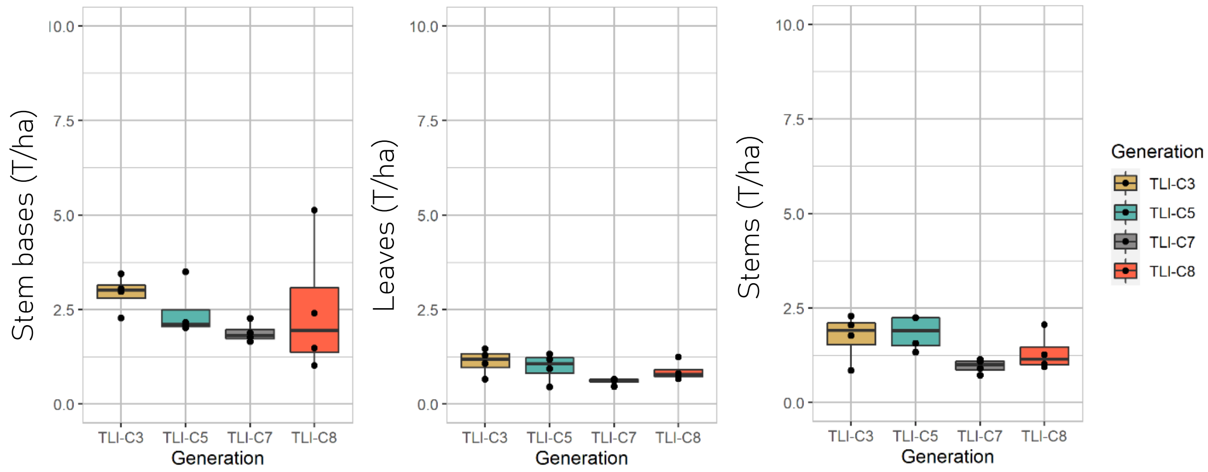
Establishment year :

- ~ 1,4 t/ha Stem bases' DM
- ~ 0,8 t/ha Leaves' DM
- ~ 0,3 t/ha Stems' DM
- ~ 1,6 t/ha Roots' DM
- No rhizomes

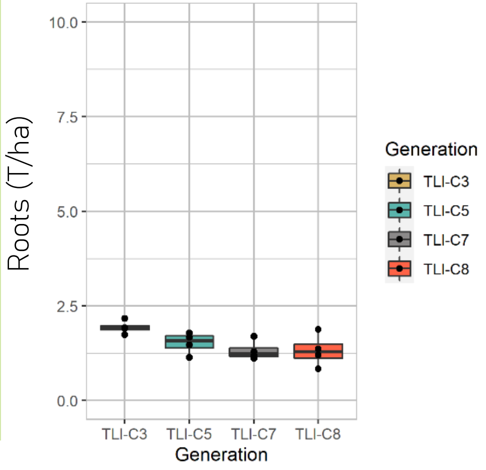
Agronomic performances: Generations

BBCH30 | BBCH39 | BBCH65 | BBCH89

Aboveground



Belowground



Establishment year :

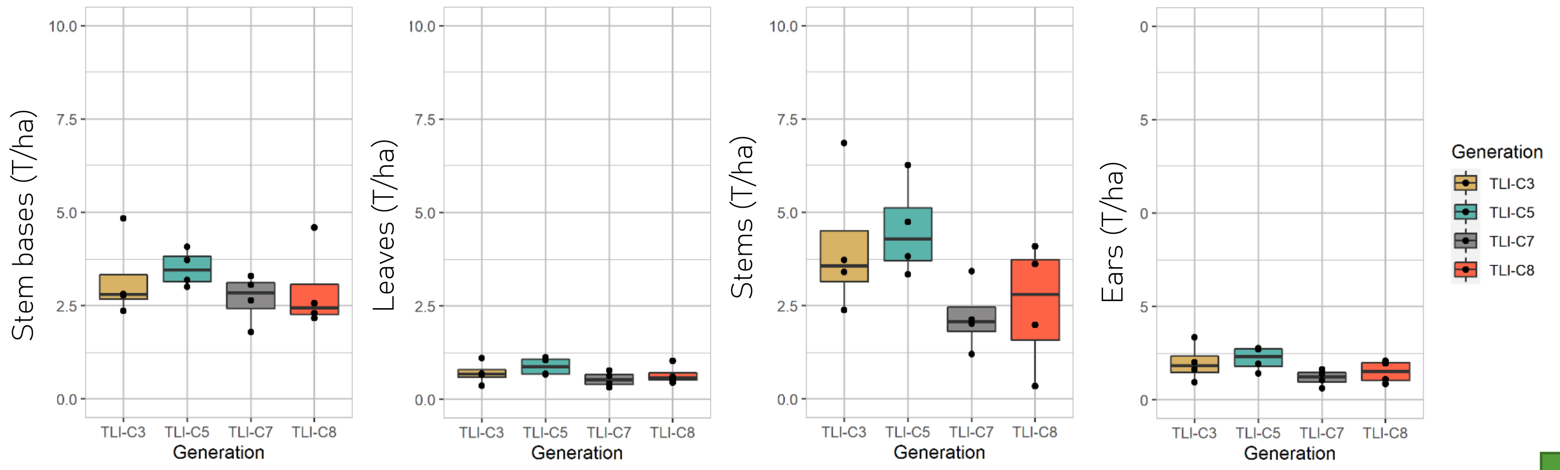
- ↗ Stem bases' DM
- ~ Leaves' DM
- ↗ Stems' DM
- ~ Roots' DM
- No rhizomes

compared to previous stage

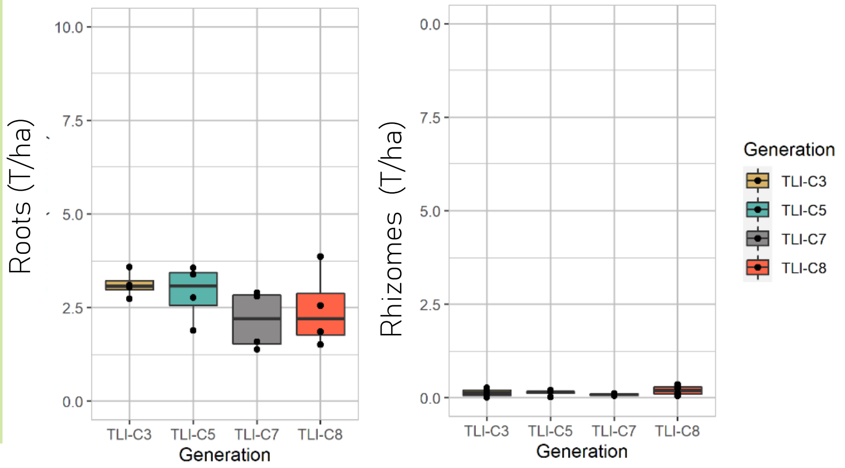
Agronomic performances: Generations

BBCH30 | BBCH39 | BBCH65 | BBCH89

Aboveground



Belowground



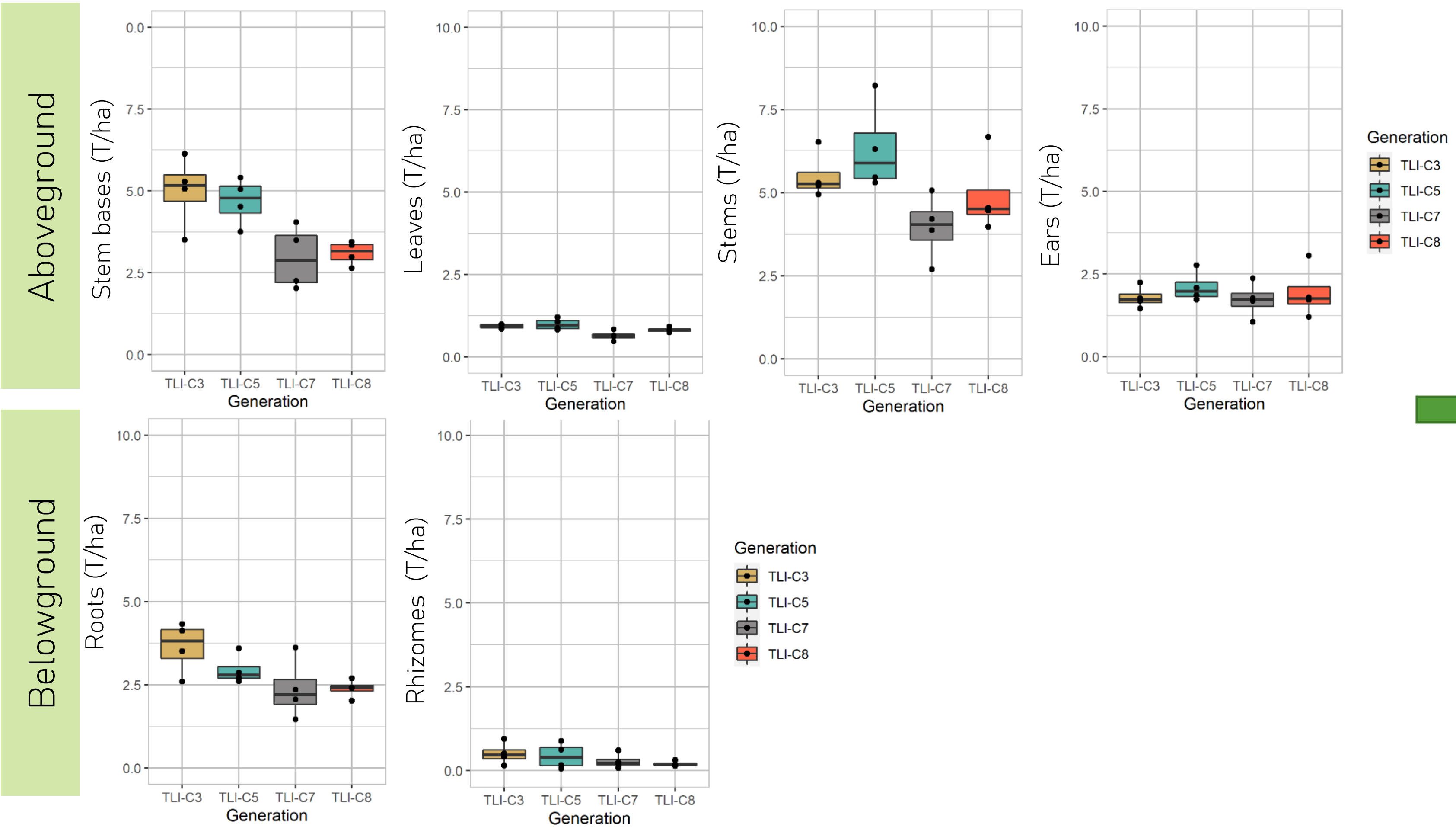
Establishment year :

- ↗ Stem bases' DM
- ~ Leaves' DM
- ↗ Stems' DM
- Ears' set up
- ↗ Roots' DM
- Rhizomes' set up

compared to previous stage

Agronomic performances: Generations

BBCH30 | BBCH39 | BBCH65 | BBCH89



Establishment year :

- ↗ Stem bases' DM
- ~ Leaves' DM
- ↗ Stems' DM
- ↗ Ears' DM
- ~ Roots' DM
- ↗ Rhizomes' DM ~ 0,4T/ha

compared to previous stage

THANKS FOR YOUR ATTENTION

QUESTIONS ?

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