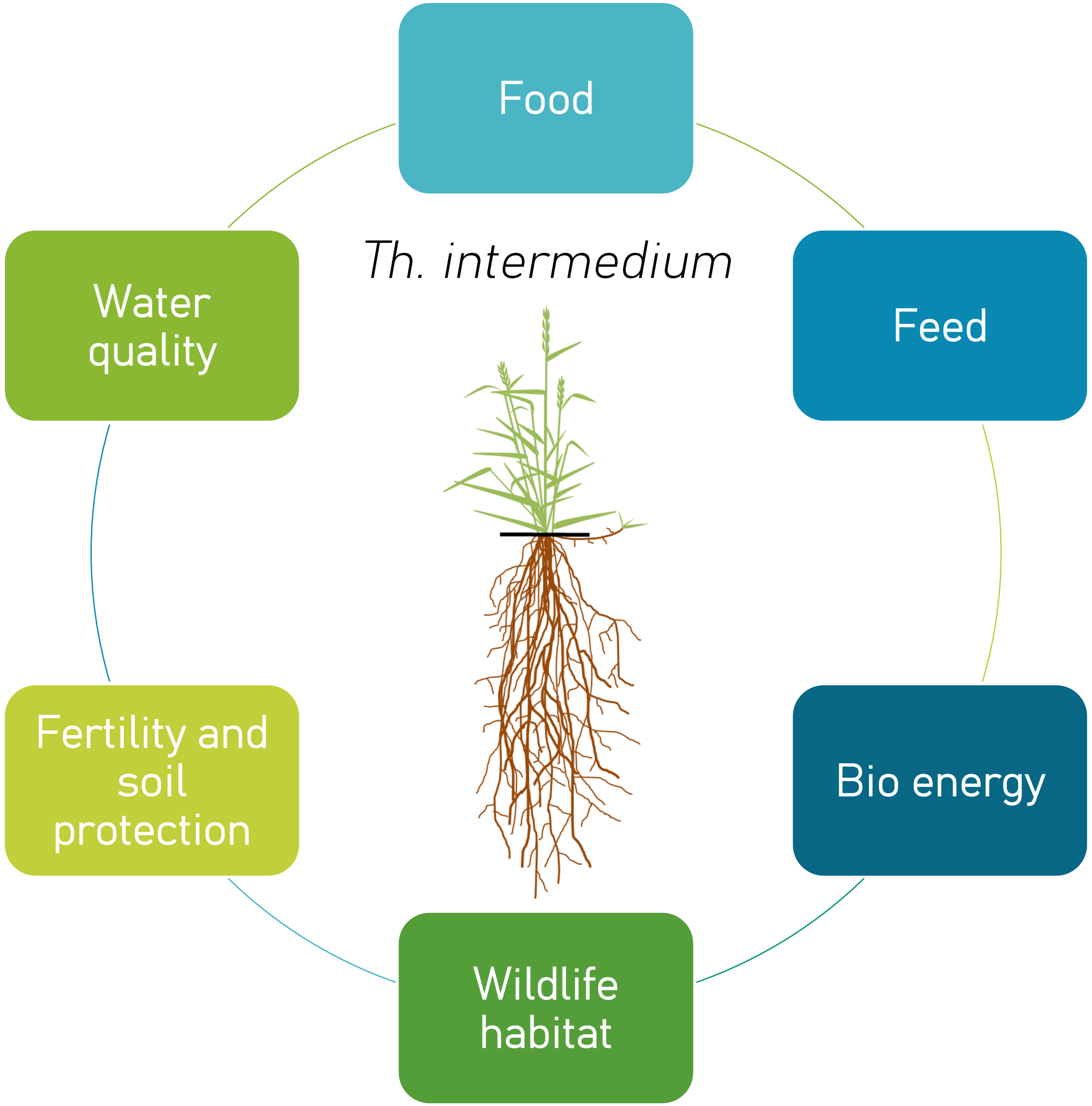
Describing N dilution curve and physiological behavior of *Thinopyrum intermedium*

FAGNANT L., DUCHÊNE O., CELETTE F., DAVID C., BINDELLE J., DUMONT B.

Introduction

- Newly developed **perennial cereal crop known under the trade name Kernza ®** (DeHaan *et al.*, 2018)
  - Perenniality → Ecosystem services
  - Dual production → Grain and forage

- Lack of knowledge regarding :
  - Growing habits ?
  - Field management ?



Introduction

- Perenniality induces …
  - Low and variable ressource allocation to grains

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

  - Large ressource allocation to belowground organs (short rhizomes, deep root system)

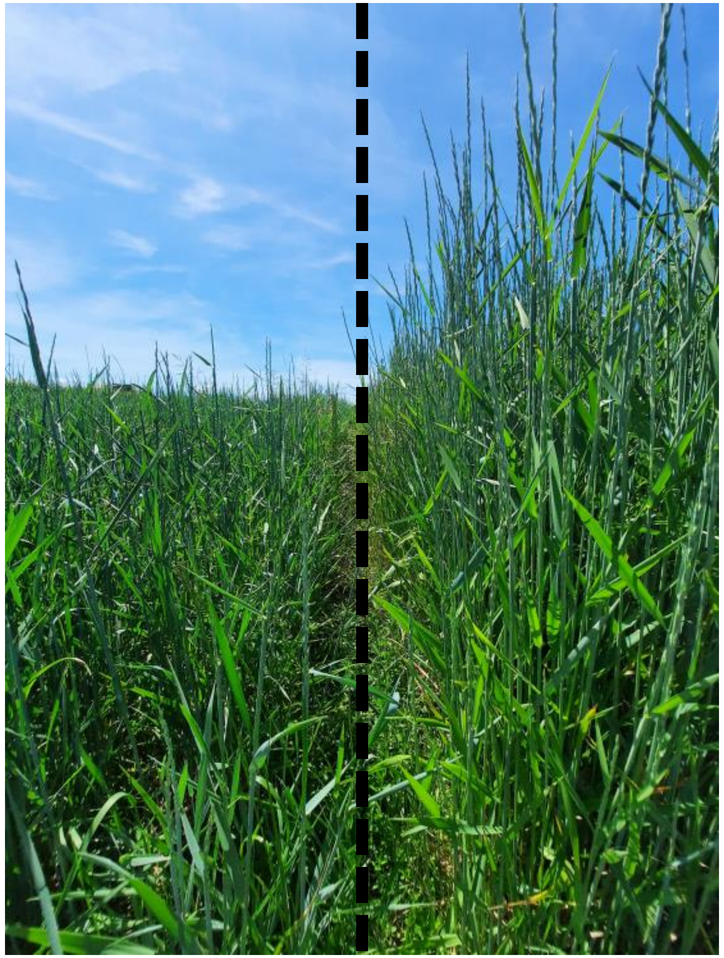
    (Ogle *et al.*, 2011; Sainju *et al.*, 2017; Sakiroglu *et al.*, 2020; Sprunger *et al.*, 2018).

  - Better soil exploration and resource use (Culman *et al.*, 2013; Duchene *et al.*, 2020; Jungers *et al.*, 2019).
    - Deep and extensive root system
    - Extended growing period

Introduction

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

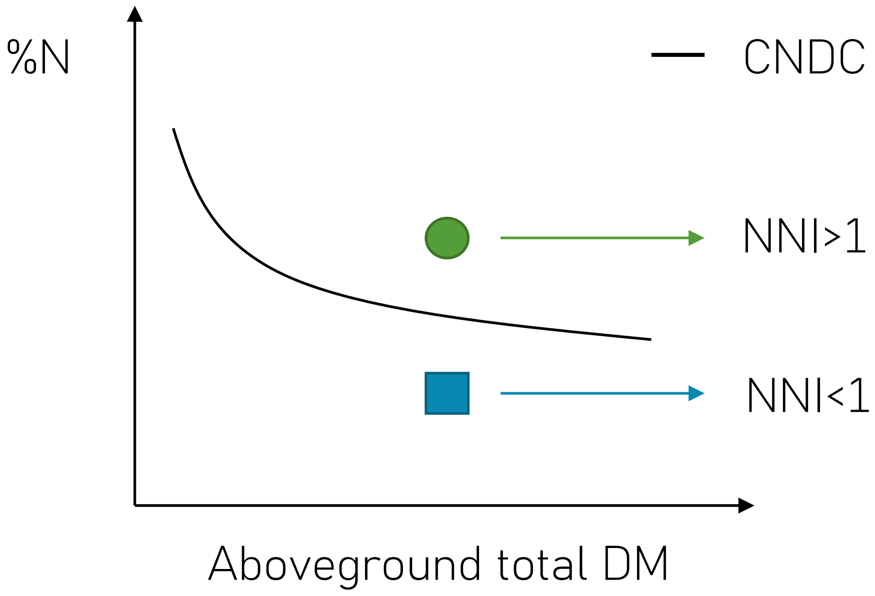
« What are the N requirements of the crop ? »



Low N inputs

High N inputs

Introduction



- 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

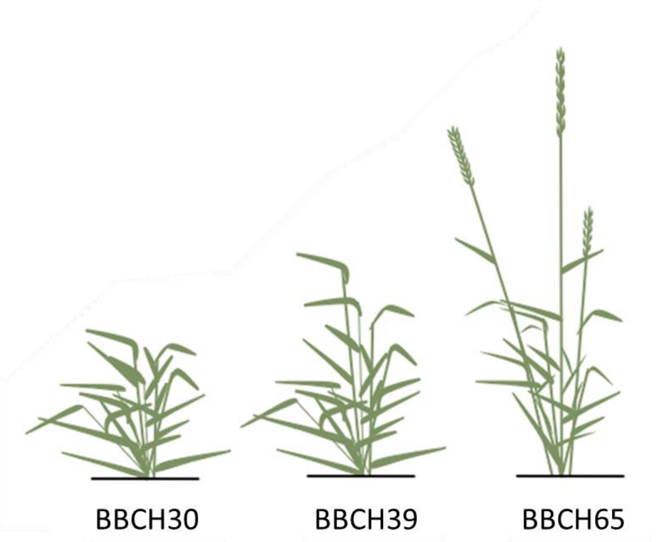
- Different approaches : Greenwood *et al*. (1990), Justes *et al*. (1994), Makowski *et al.* (2020)

Material & Method

- 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

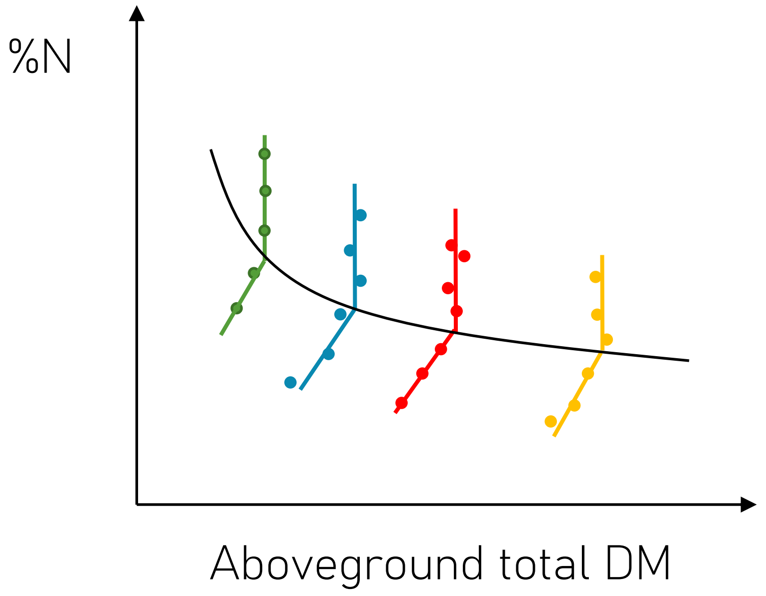


Material & Method

- Approach developped by Justes *et al*. (1994) and Makowski *et al.* (2020)
    - Not applicable with the consolidated dataset

- Approach developped by Greenwood *et al*. (1990)
    - ANOVA on DM and its corresponding %N
    - DM max with the %N min = critical %N
    - Non-linear regression on critical %N points

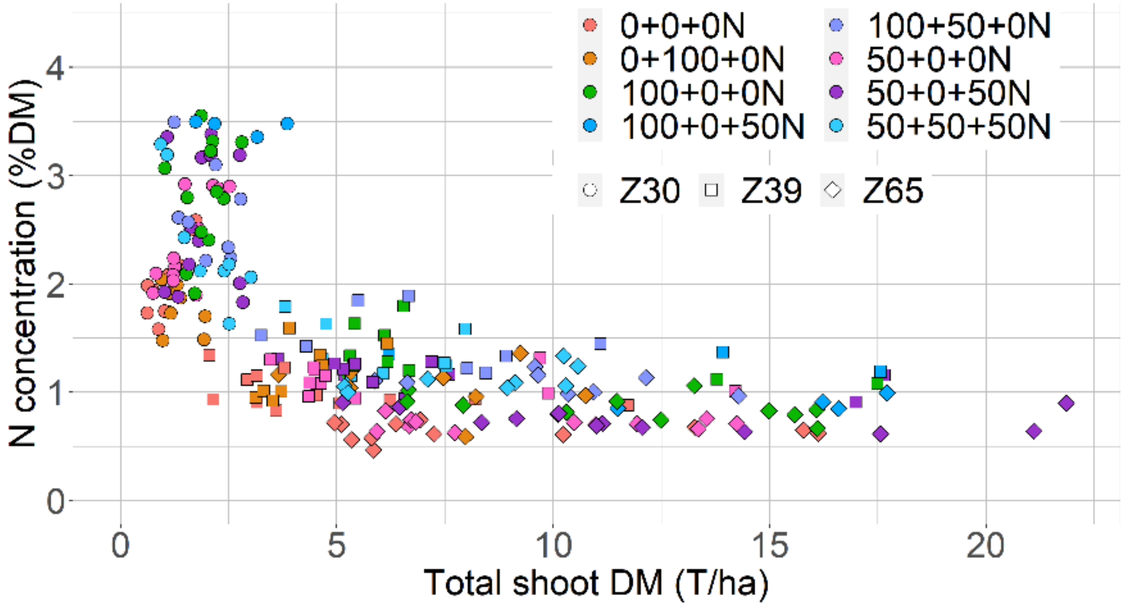
      $\%N = a.DM^{-b}$



Adapted from Justes *et al*. (1994)

Results

Overview of Be dataset

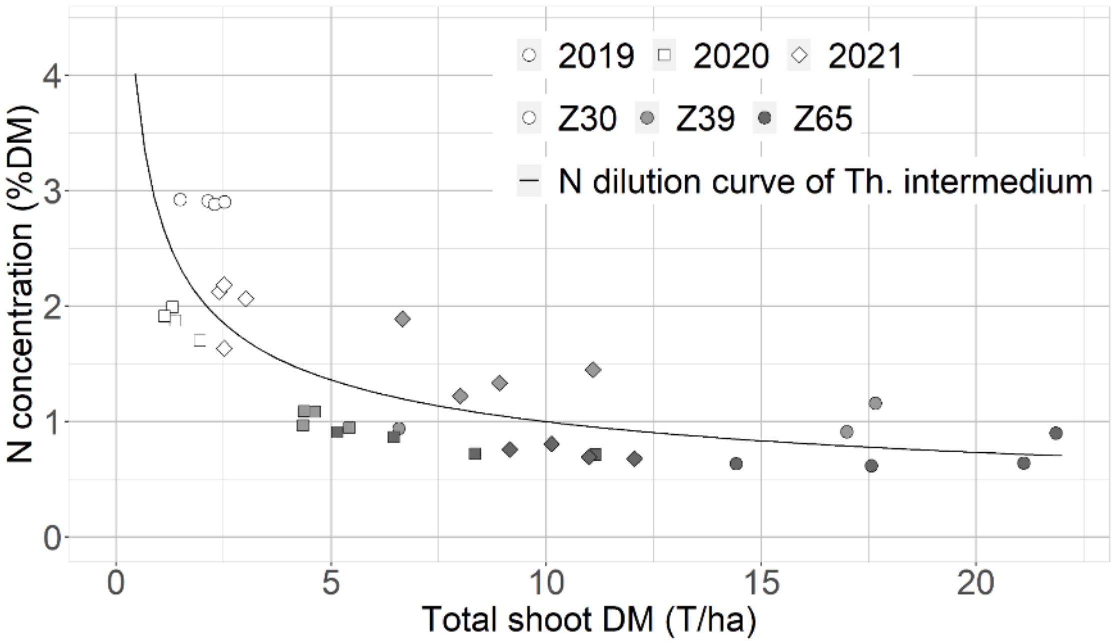


Fagnant et al., in prep.

Results

Coefficients	*a*	*b*	*%N = a.MS^-b^*
Critical curve	2.78	-0.45	%N = $2.78M^{-0.45}$
90% CI	[2.31; 3.30]	[-0.59;-0.32]	r^2=0.60

CNDC set-up on Nc points



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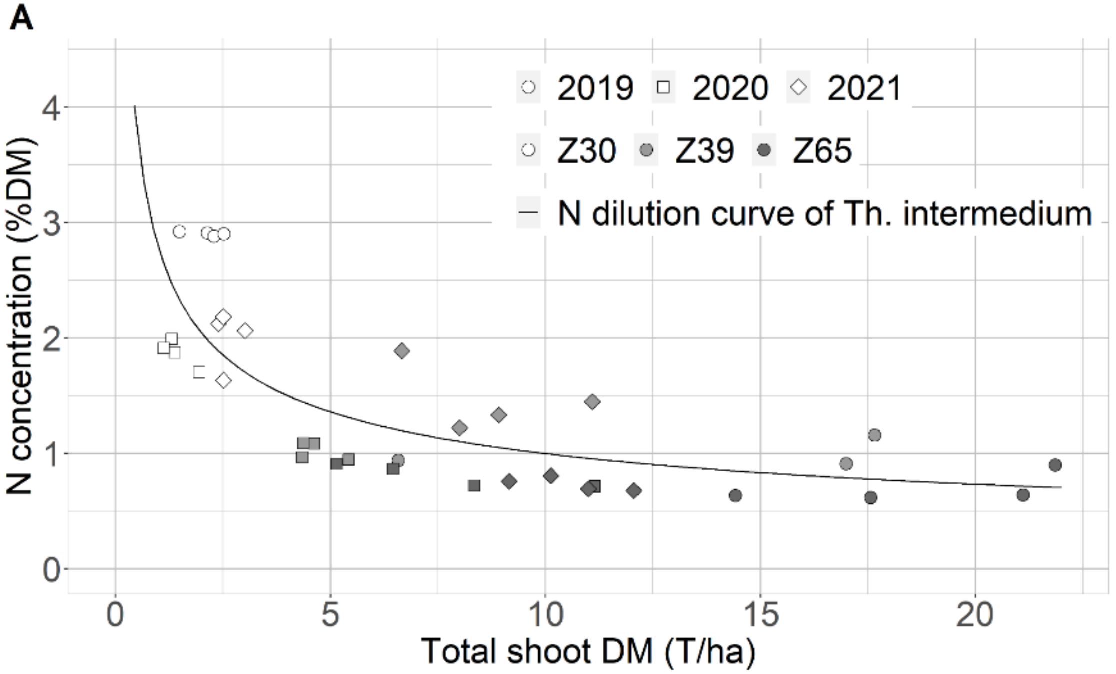
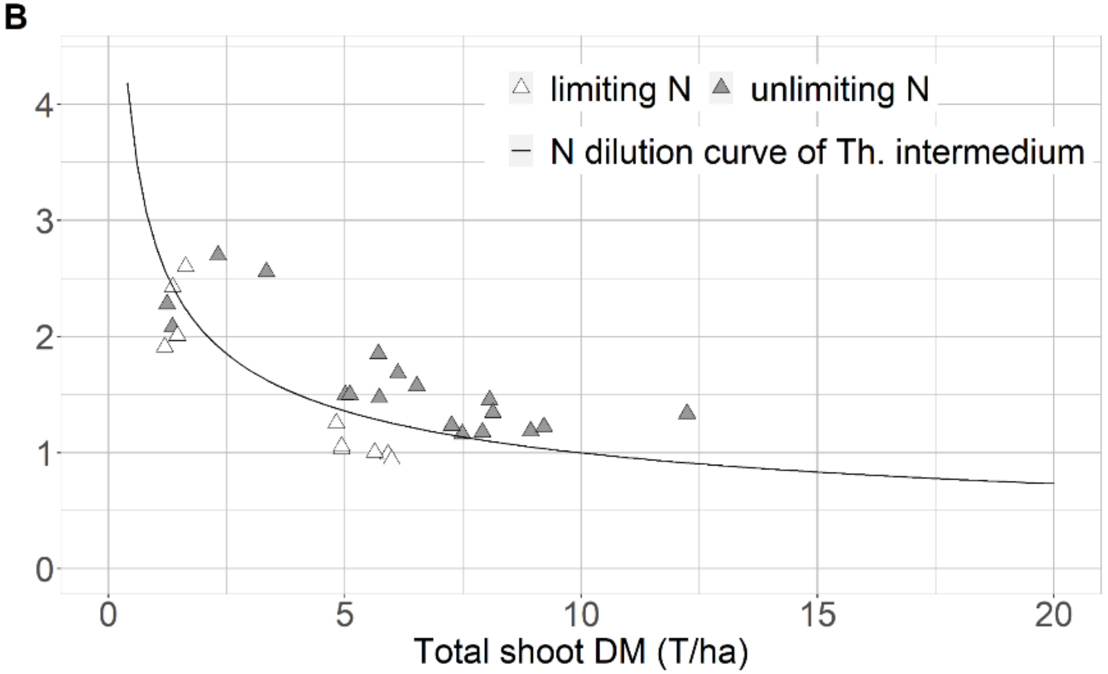
CNDC set-up



CNDC validation (Fr dataset)



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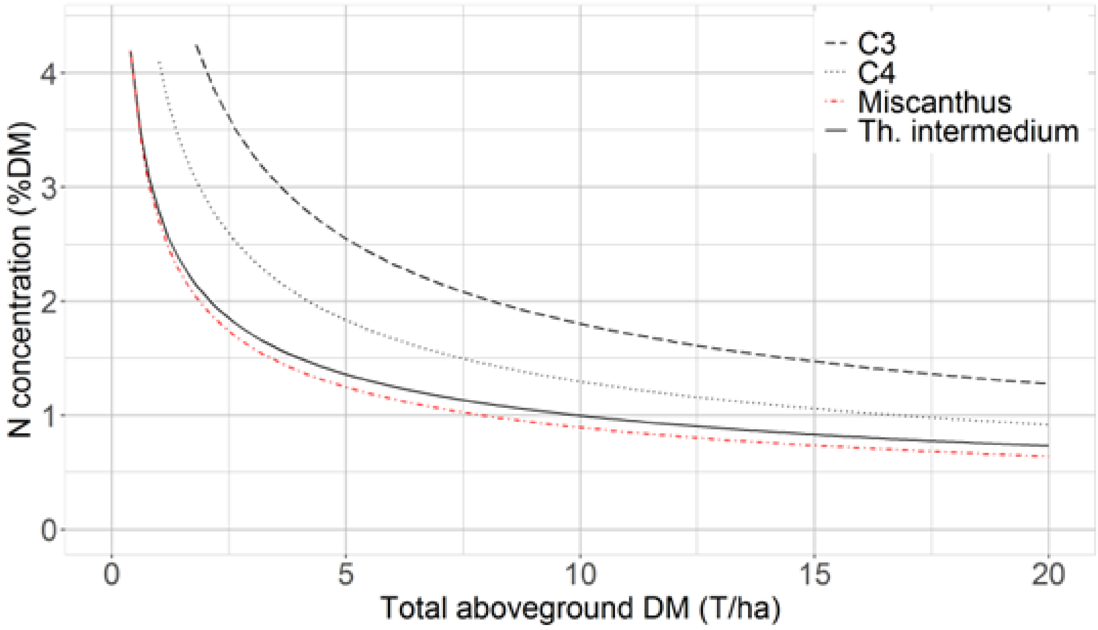
Results

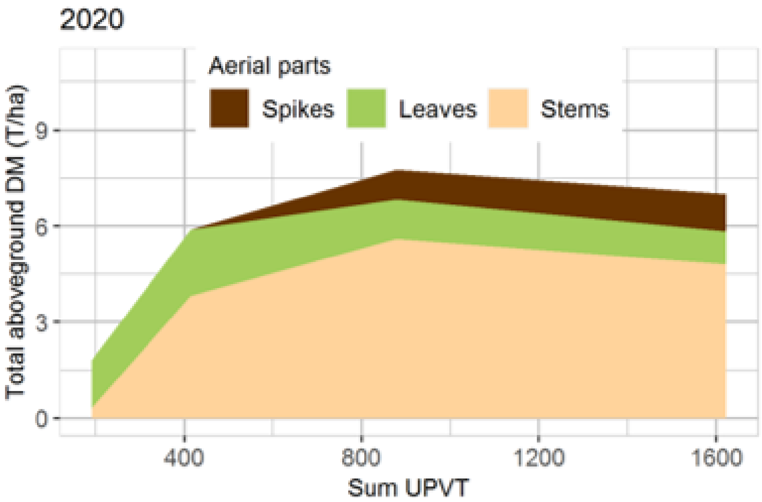
- Reduced level of N nutrition of *Th. Intermedium* compared to C3 or C4 species
- Similar behavior as the one reported for perennial crop (e.g. : Miscanthus, vineyard)

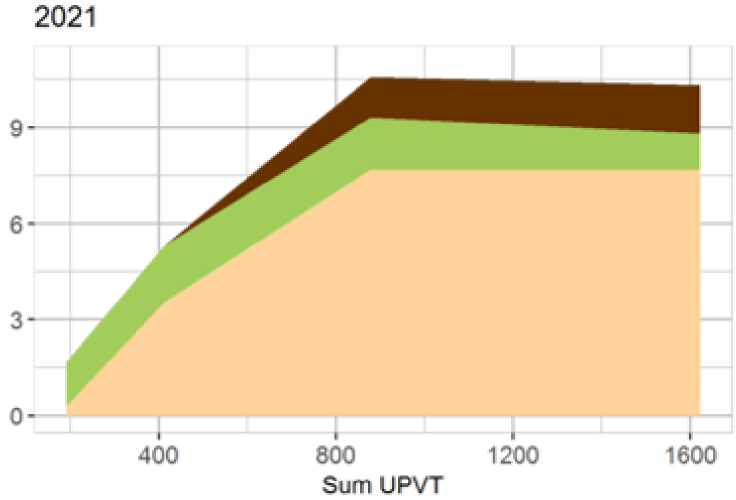


Fagnant et al., in prep.

Discussion

- Low CNDC could be associated to the decrease of the leaf/stem ratio during growing season
  - Leaves DM ratio drops significantly after BBCH 30 (Fagnant *et al.*, in prep.)
  - High proportion of stems vs leaves – in opposition to commonly cultivated species such as ray-grass, alfalfa, wheat, etc. (Chen *et al.*, 2019, Hgca, 2008, Lemaire *et al.*, 1985)
  - Similar behavior reported for Miscanthus (Zapater *et al.*, 2017).



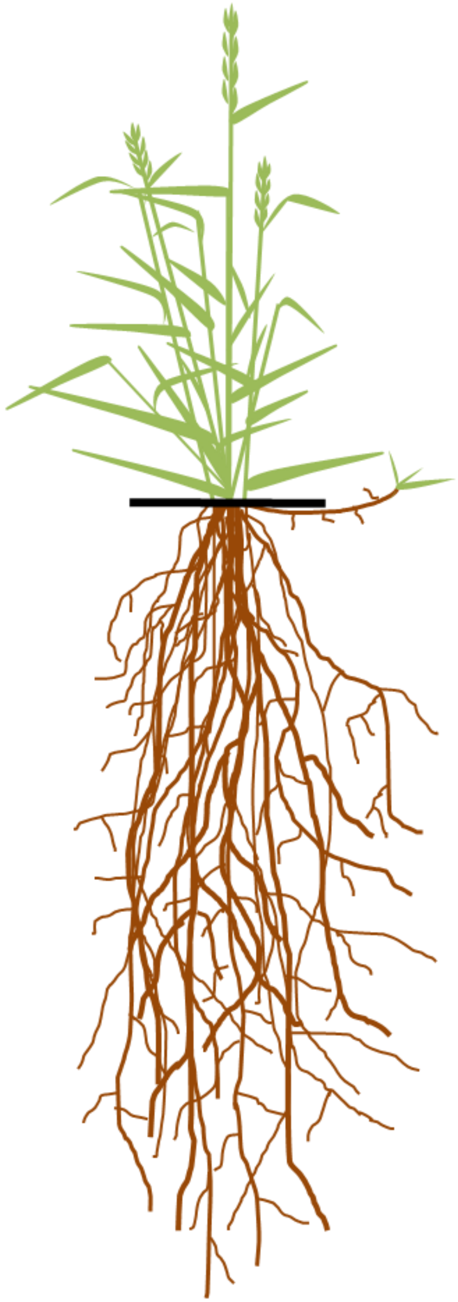


Fagnant et al., in prep.

Discussion

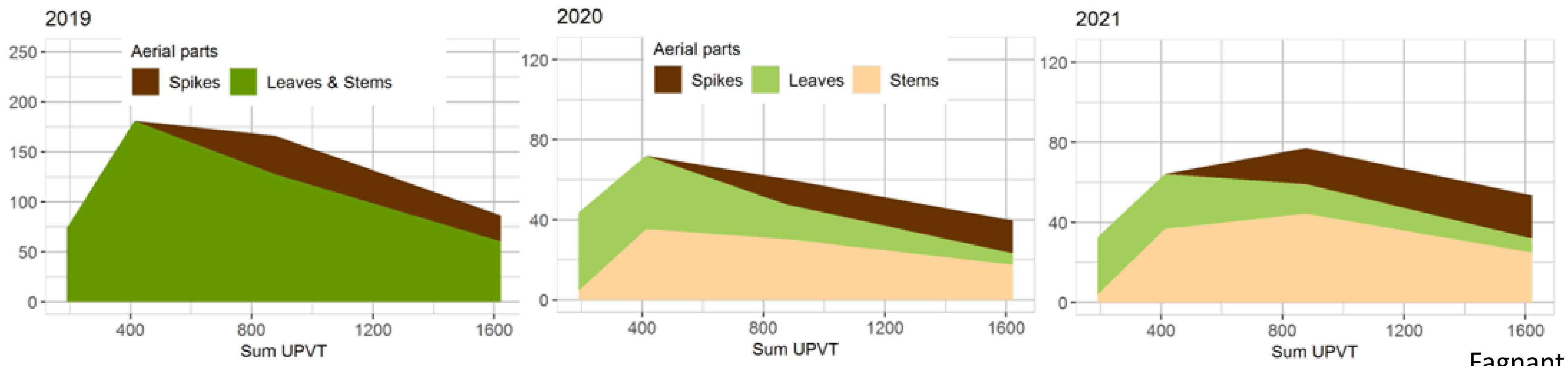
This behavior might also be linked to following growing patterns :

- High absorption efficiency (Jungers *et al*, 2019)
  - Deep and dense root system
- High N use efficiency (Sprunger *et al*., 2018)
  - Important above- and belowground DM production per N aplied



Discussion

- 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
  - Possible resource conservation strategy – Hypothesised by Duchêne *et al.*, 2020
  - Potential storage within stem bases ? – Reported in other perenial grasses by White (1973).



Fagnant et al., in prep.

Conclusions

- *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

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THANKS FOR YOUR ATTENTION

QUESTIONS ?

FAGNANT L., DUCHÊNE O., CELETTE F., DAVID C., BINDELLE J., <u>DUMONT B</u>.
LAURA.FAGNANT@ULIEGE.BE

Table with CNDC coefficient

Plant species	*a*-coefficient	*b*-coefficient	References
C3 crops	5,70	-0,50	(Greenwood *et al*., 1990)
C4 crops	4,09	-0,50	(Greenwood *et al*., 1990)
Lolium perenne L. (Perennial ryegrass)	6,36	-0,71	(Gislum *et al*., 2009)
Solanum tuberosum L. (Potato)	5,37	-0,45	(Ben Abdallah *et al.*, 2016)
Triticum aestivum L. (Wheat)	5,35	-0,44	(Justes *et al*., 1994)
Beta vulgaris subsp. *vulgaris* var. alba L. (Fodder beet)	4,9	-0,52	(Chakwizira *et al*., 2016)
Festuca arundinacea Schreb. var. Clarine (Tall fescue)	4,79	-0,32	(Lemaire *et al*., 1987)
Linum usitatissimum L. (Linseed)	4,69	-0,53	(Flénet *et al*., 2006)
Medicago sativa L. (Alfafa)	[4,6; 5,5]	[-0,36; -0,29]	(Lemaire *et al*., 1985)
Zea mays L. (Maize)	3,41	-0,39	(Herrmann *et al*., 2004)
Miscantus giganteus & *Miscanthus sinensis*	2,70	-0,48	(Zapater *et al*., 2017)
Vitis vinifera L. (Grapevine)	[2,38 ; -3,20]	[-0,17; -0,44]	(Celette & Gary, 2013)