Calibration and validation of the STICS crop model to simulate the growth and development of Kernza, a promising perennial grain crop.

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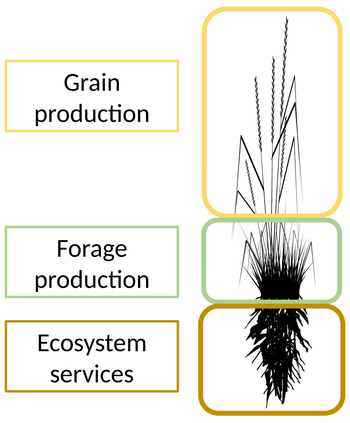
What is Kernza ?

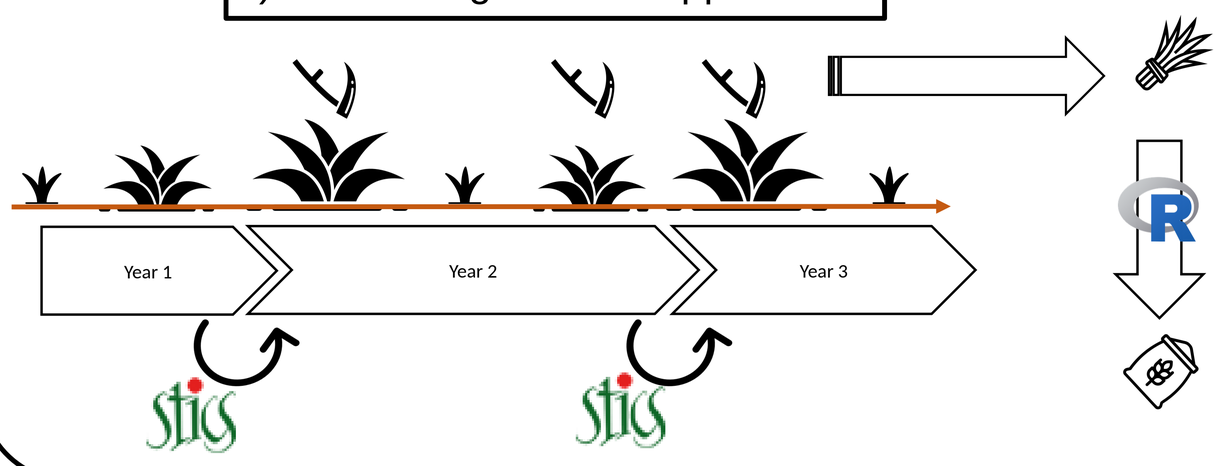


- Variety of *Thinopyrum intermedium* (Host) Barkworth & D.R. Dewey selected for grain production.
- A potential solution to enhance environmental protection and mitigate the harm caused by actual farming practices.
- Dual purpose forage/grain production during the same year.
- Third production of ecosystem services by soil carbon storage and permanent ground cover.
- Selection by The Land institute since 20 years to improve grain yield.

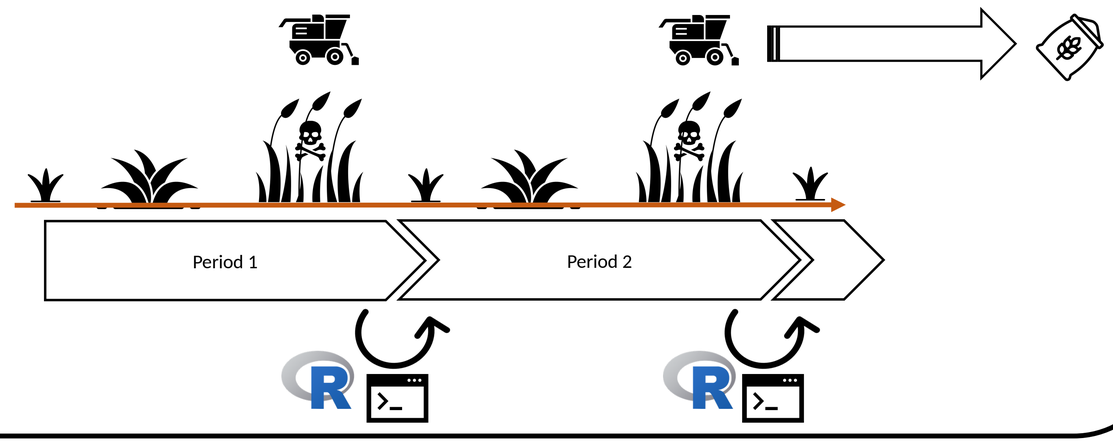
Modeling Kernza

- The 9.2 version of STICS was used to simulate Kernza.
- STICS was not able to simulate a grassland producing grain, two approaches were used :
  1) Perrennial grassland that is cut for forage. Grain yield is simulated with an harvest index applied to the harvested above ground biomass, this harvest index was calibrated like a parameter of the model.
  2) Annual grain crop that is harvested for grains but not cut for forage. Simulation from harvest to harvest, output of a period are used as input for the next period.
- Order and variables calibrated: phenology, leaf area index, aerial dry matter, grain yield, nitrogen uptake, root biomass.
- Calibration and validation data from two Belgian independant field experiments :
  - **Calibration :** field sown in 2017 testing a gradient of nitrogen fertilization crossed with or without forage cut, four years data.
  - **Validation :** field sown in 2019 testing a combination of sowing dates and inter row spacing, two years data.
- **Parametrisation** : - Phenology parameters : Duchene et *al.* (2021)
  - Nitrogen nutrition : Fagnant et *al.* (2023)

1) Perennial grassland approach



2) Annual cereal approach



Results for annual cereal approach

	Calibration			Validation		
	RMSE	EF	ND	RMSE	EF	ND
Phenology	9,6	0,94	0,015	7,6	0,96	0,011
Leaf Area Index	1,5	0,32	0,057	2,4	-0,213	0,31
Biomass production	1,6	0,80	0,034	3,1	0,64	0,126
Grain yield	0,077	0,74	0,033	0,51	0,27	0,186
N uptake	13,74	0,55	0,08	11,52	0,79	0,031
Root biomass	4,52	-15,5	1,6	2,3	-0,42	0,39

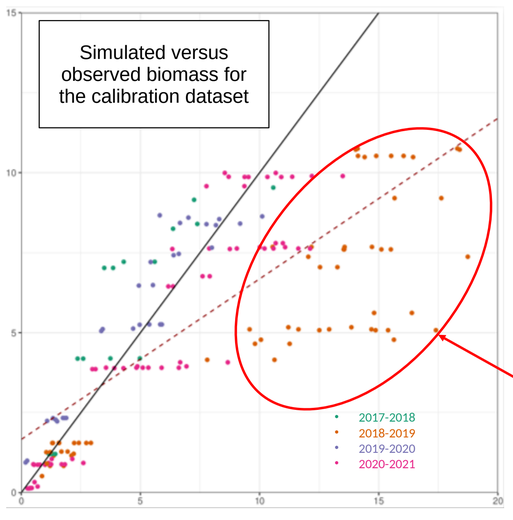
Table 1 : Results of the calibration and validation.

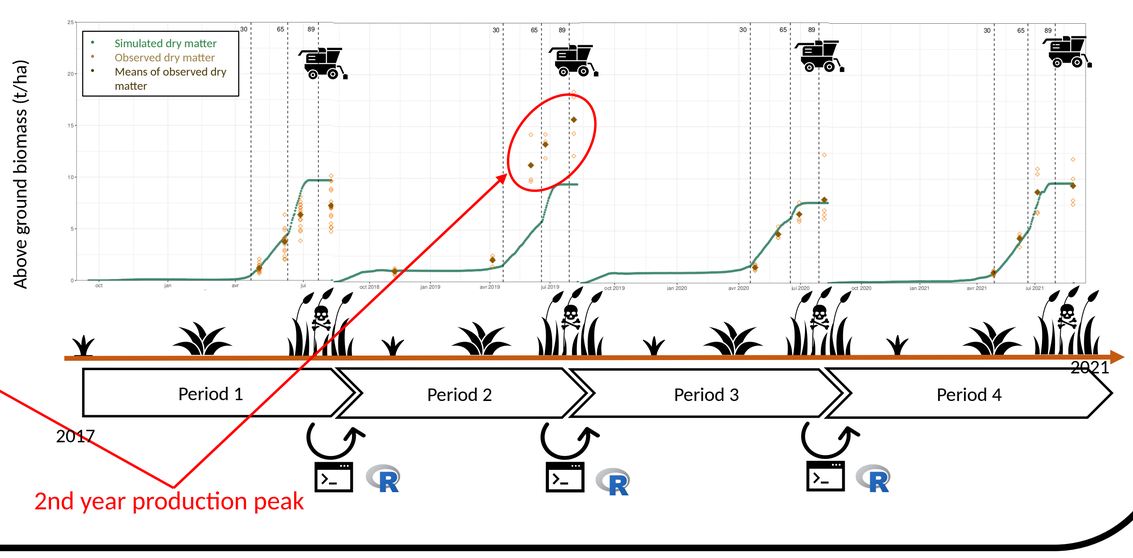
- Perennial grassland approach didn't yield good results (not shown in the table).
- Root biomass performed badly in the two approaches.
- Result in *table 1.* show the calibration without the second growth year.
- Second production year always underestimated .

- Dynamic LAI graphs (LAI over time) show good trends.
- Some heavily and early fertilized crops show poor fit.
- STICS « one leaf » formalism is not perfectly adapted for this crop.

- Simulated LAI
- Observed LAI
- Means of observed LAI

Illustration of the second year production peak for the above ground biomass





Discussion

- Despite some problems, STICS seems promising to simulate Kernza. The new formalisms introduced by the 10th version of the model will hopefully resolve some of issues.
- The systematic underestimation of the second year production peak will need further eco-physiological investigations in order to understand the underlying mechanism and try to simulate it with STICS.
- Root simulation always badly performed, this is mainly due to the formalisms used, further investigation and testing on the new formalisms will hopefully yield better results.

What comes next ?

- Calibration and validation will be performed on the 10th version of STICS
- The new calibration and validation process will be done with more data coming from Belgium, France and Sweden.
- The calibrated model will be spatialized at the European level to assess the potential of the plant in future climates thanks to an aggregation of soil and climate databases.
  - Soil database : 5 horizons, soil horizon texture and chemical content , 250m x 250 m tiles
  - Climate database : 25 km x 25 km tiles, 3 time ranges (1979-2010, 2040-2069, 2070-2099), 5 models and 3 RCPs per model, daily values.