BIOdiversity of soils and FArming Innovations for improved Resilience in European wheat agrosystems
BIOFAIR

Coordinated by

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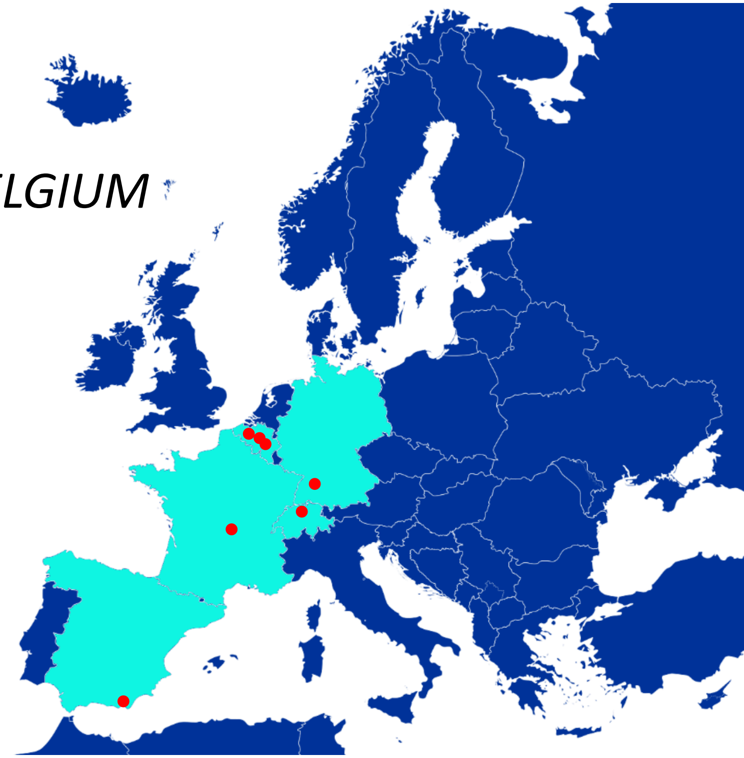
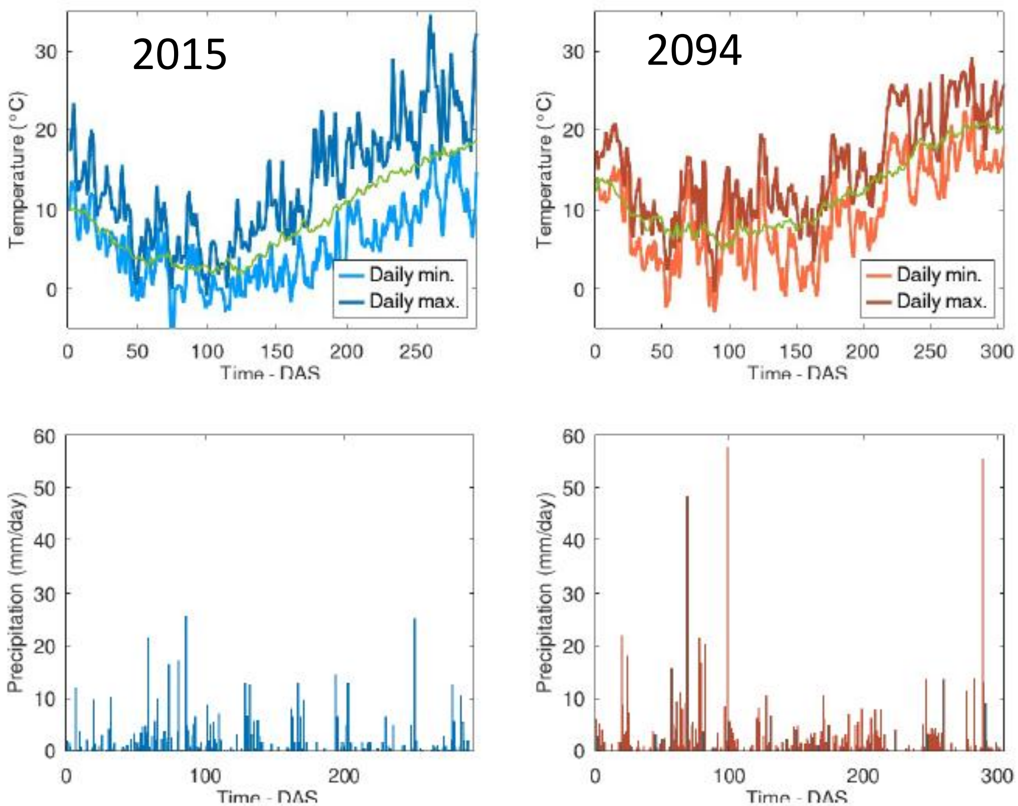


SCIENTIFIC OUTCOMES

1. Impact of CC on wheat performance and quality

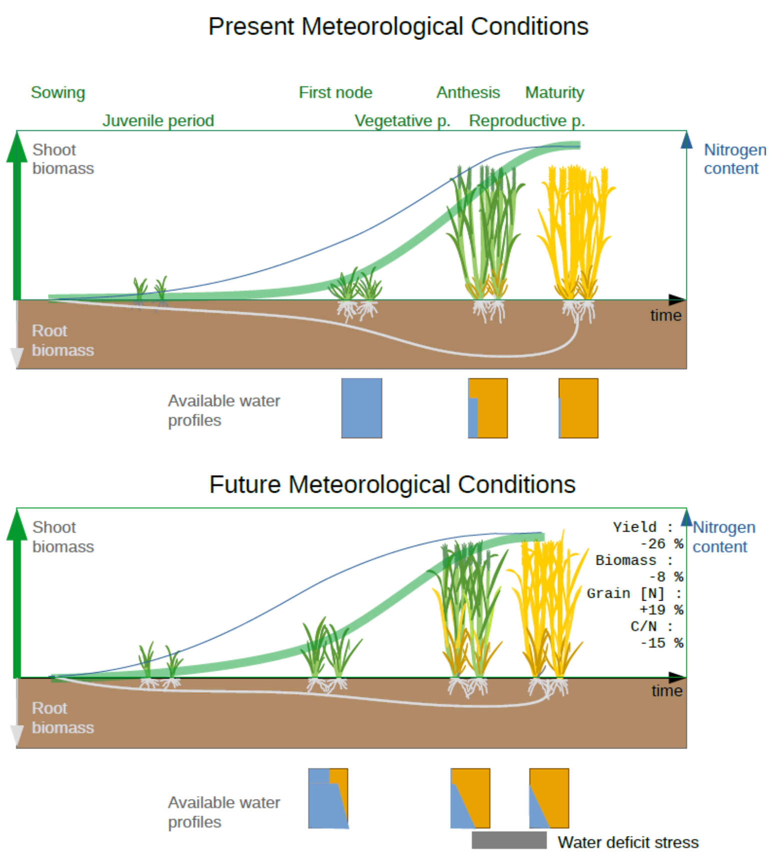
SCIENTIFIC OUTCOMES

1.1. The Seminal Ecotron Experiment



SCIENTIFIC OUTCOMES

1.1. The Seminal Ecotron Experiment

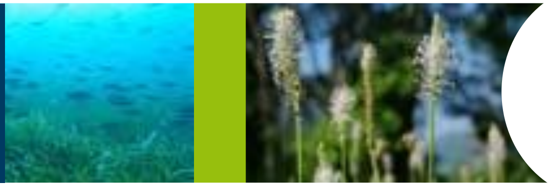


- Higher temperatures in Winter allowed a higher biomass production that limited the tillers number due to the competition for light and thus the amount of ears and nodal roots.
- Larger availability of soil water and nitrogen during the juvenile and vegetative periods under future climate conditions
- Higher sensitivity to water deficit stress due to a limited root growth

SCIENTIFIC OUTCOMES

1.2. Drought & enhanced CO_2 level impacts

BIOFAIR @ Pheno3C platform INRAE Clermont-Ferrand, France and Drossche Mills, Ghent, Belgium

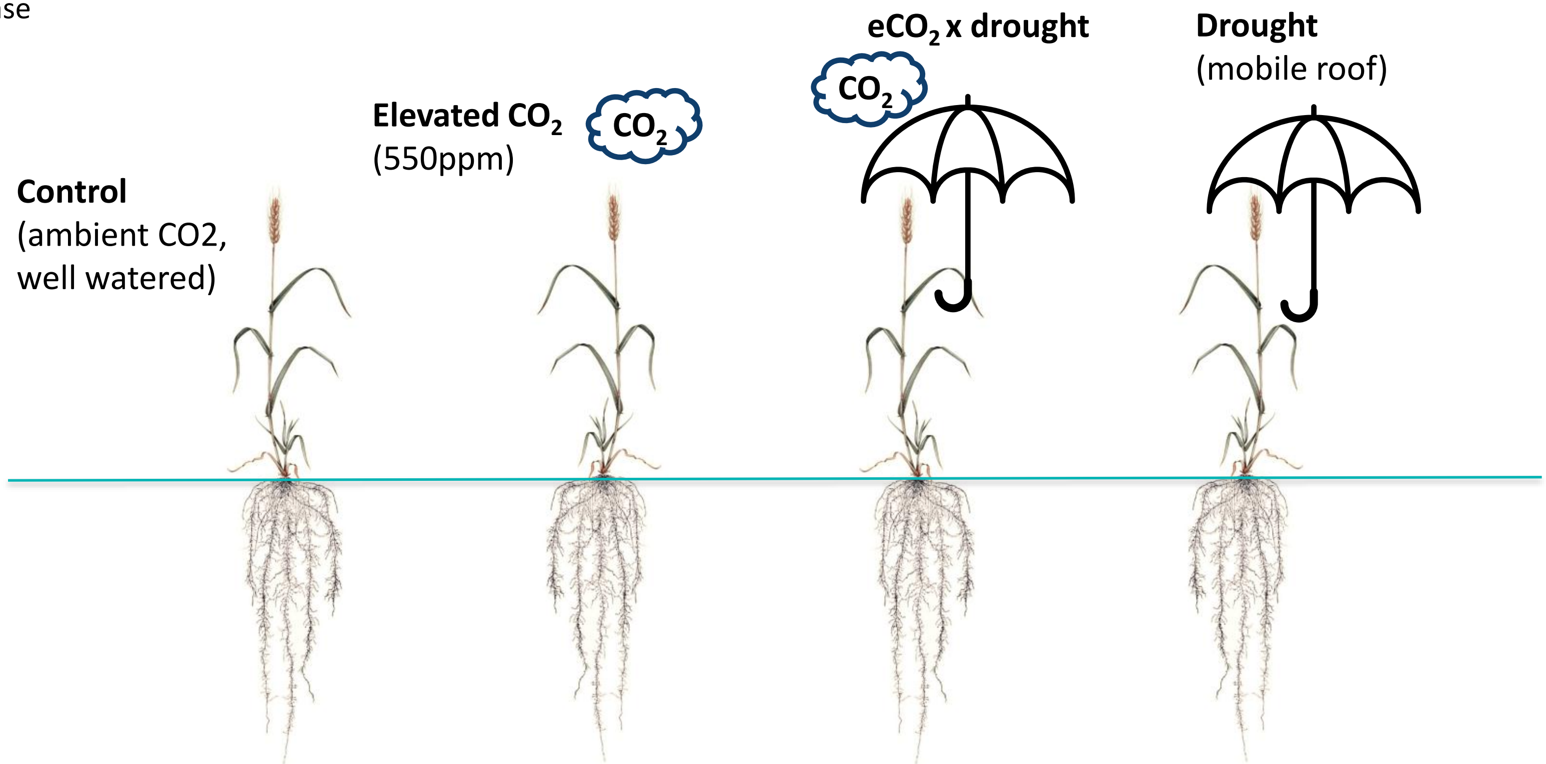


SCIENTIFIC OUTCOMES

Experimental design: 2 factors (climate and wheat variety) with 4 levels each

4 wheat varieties

- Asory
- KWS Extase
- Sahara
- Trapez



SCIENTIFIC OUTCOMES

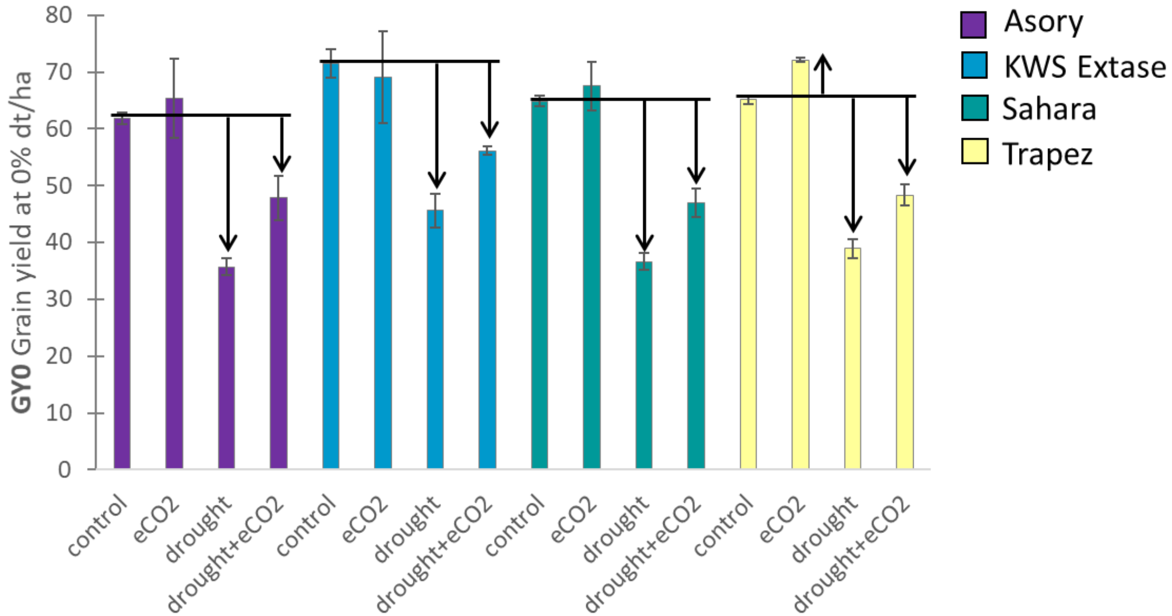
Grain yield

All varieties

- Yield under eCO_2 ≈ control
- Strong yield decrease under drought
- Drought yield decrease partly compensated by eCO_2

On average

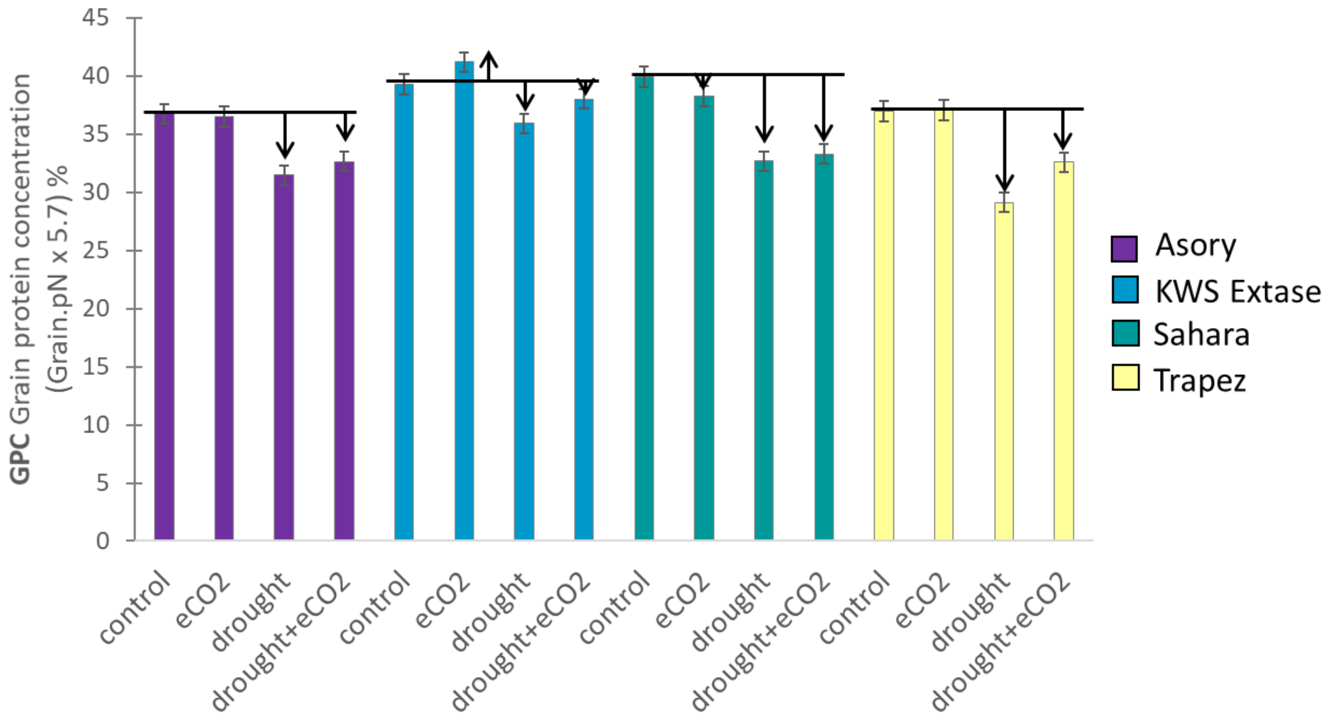
Elevated CO_2: +4.1%
Drought: -40.4%
Drought x elevated CO_2: -24.3%



SCIENTIFIC OUTCOMES

Grain protein content

- All varieties: Grain protein decreased under drought and drought x eCO_2
- Only minor effect of elevated CO_2 (550ppm)

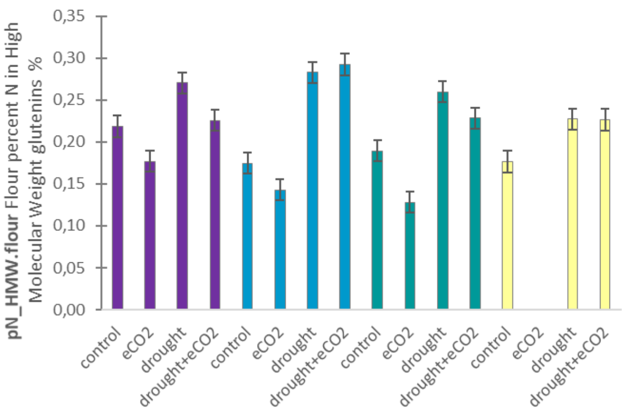


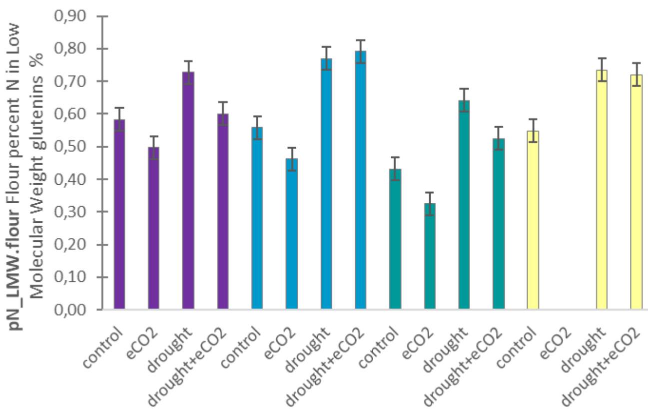
SCIENTIFIC OUTCOMES

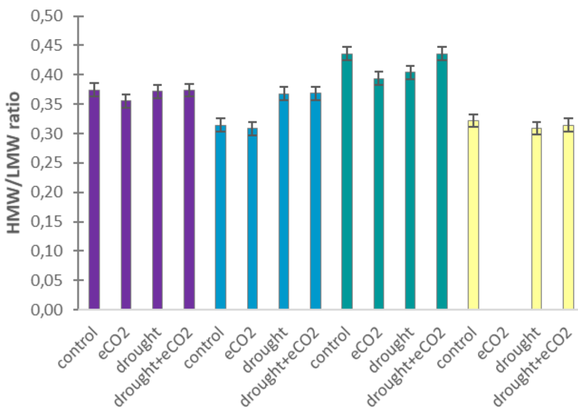
Grain protein glutenins

- Asory
- KWS Extase
- Sahara
- Trapez

- All varieties: Climate treatments affect %N in High vs Low Molecular Weight glutenins similarly
- Decrease of %N in HMW and LMW under elevated CO_2
- Increase of %N in HMW and LMW under drought and drought x eCO_2
- No change to HMW/LMW ratio







*Method: ThermoFischer Scientific FlashSmart, corrrected for extaction yield

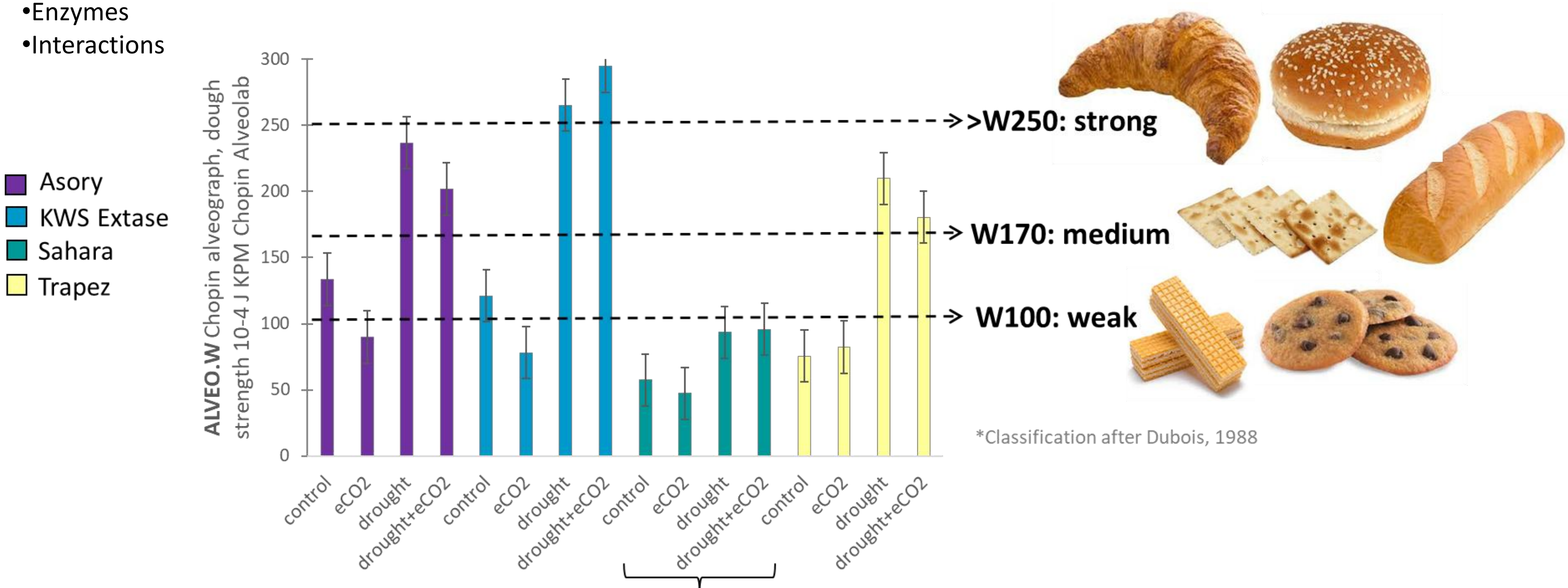
SCIENTIFIC OUTCOMES

Dough quality: dough strength

Medium to weak dough baking strength for controls and eCO_2, increased under drought and drought x eCO_2

Dough baking strength depends on:

- Protein quantity and quality
- Starch damage
- Enzymes
- Interactions

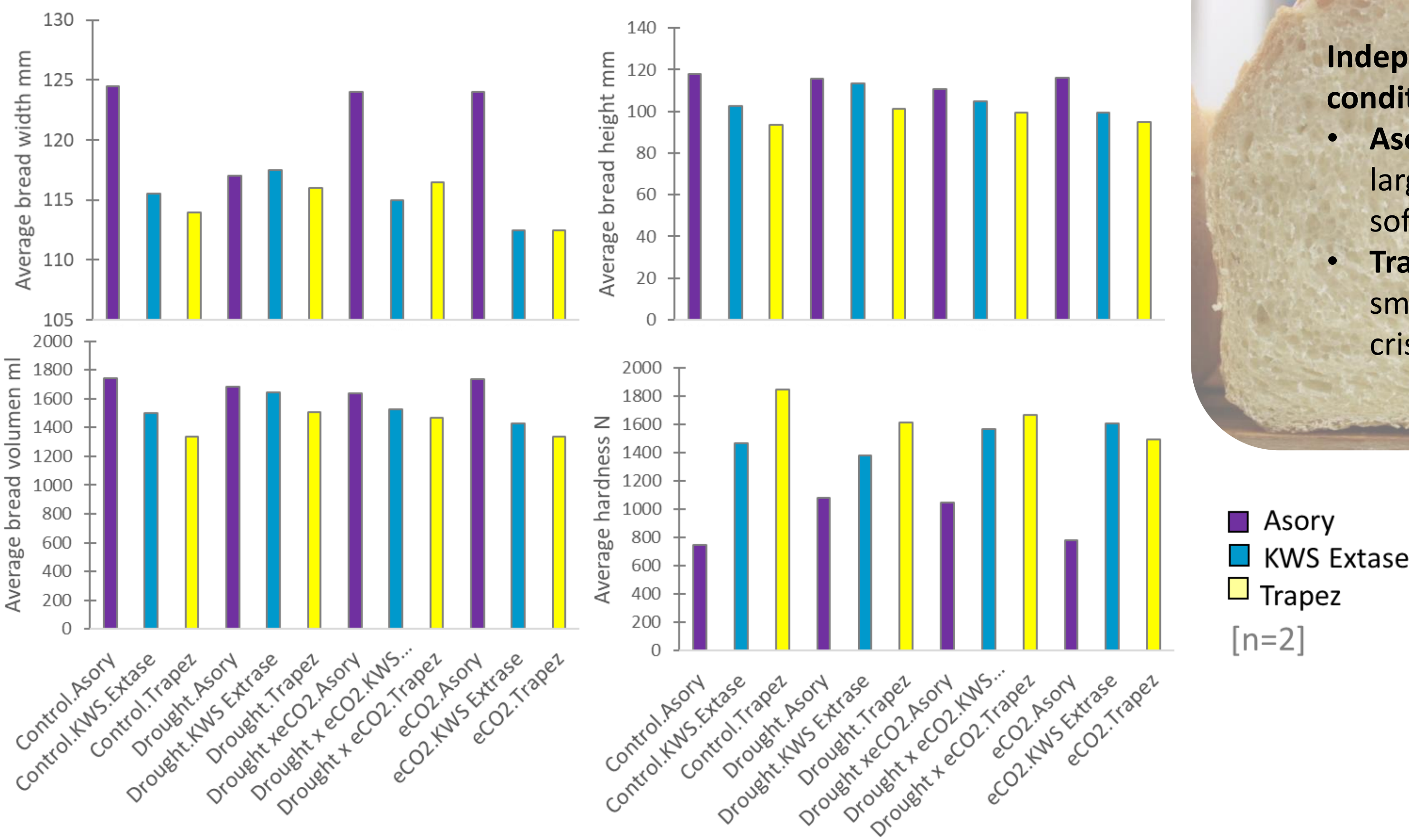


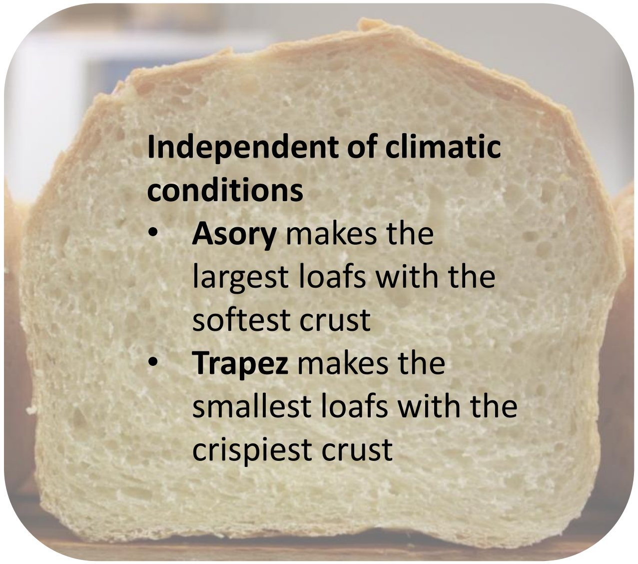
*Classification after Dubois, 1988

*Sahara no longer listed as bread baking variety

SCIENTIFIC OUTCOMES

Bread baking test





Independent of climatic conditions

- **Asory** makes the largest loafs with the softest crust
- **Trapez** makes the smallest loafs with the crispiest crust

SCIENTIFIC OUTCOMES

1. Impact of CC on wheat performance and quality

WHAT DID WE LEARN?

- Under future climate conditions (2094), earlier biomass accumulation // water and nitrogen availability
- Root foraging ability remains pivotal to cope with transient water stress
- Drought has negative impacts on yield, and induces a penalty in protein concentration.
- Elevated CO_2 level lead to several impaired technological properties
- Field accessibility can be impaired by CC, which leads to sowing problems for spring crops

RECOMMENDATIONS

- Extreme events should also be considered (simulated climatic scenario)
- Close future (max 20 years in the future) scenario seem more relevant for the breeders but also from a soil microbiological point of view
- Speed breeding and close connection with modelling should be implemented
- Vernalization requirement should be adapted to forecasted conditions

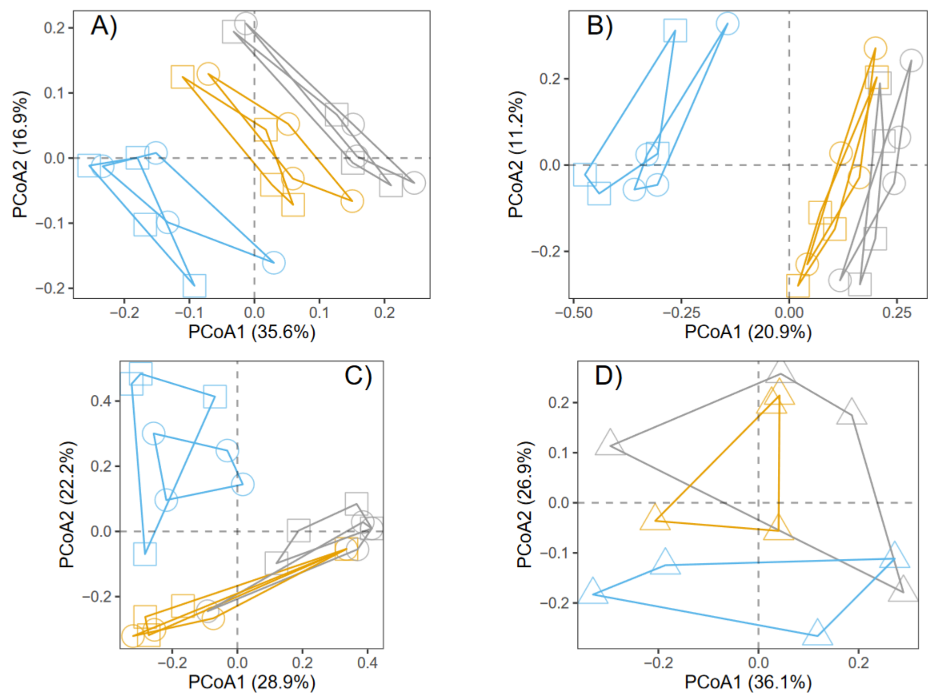
SCIENTIFIC OUTCOMES

2. Impact of farming practices on soil biodiversity and functioning

SCIENTIFIC OUTCOMES

Tillage intensity shaped community structure of microbes, nematodes and acari

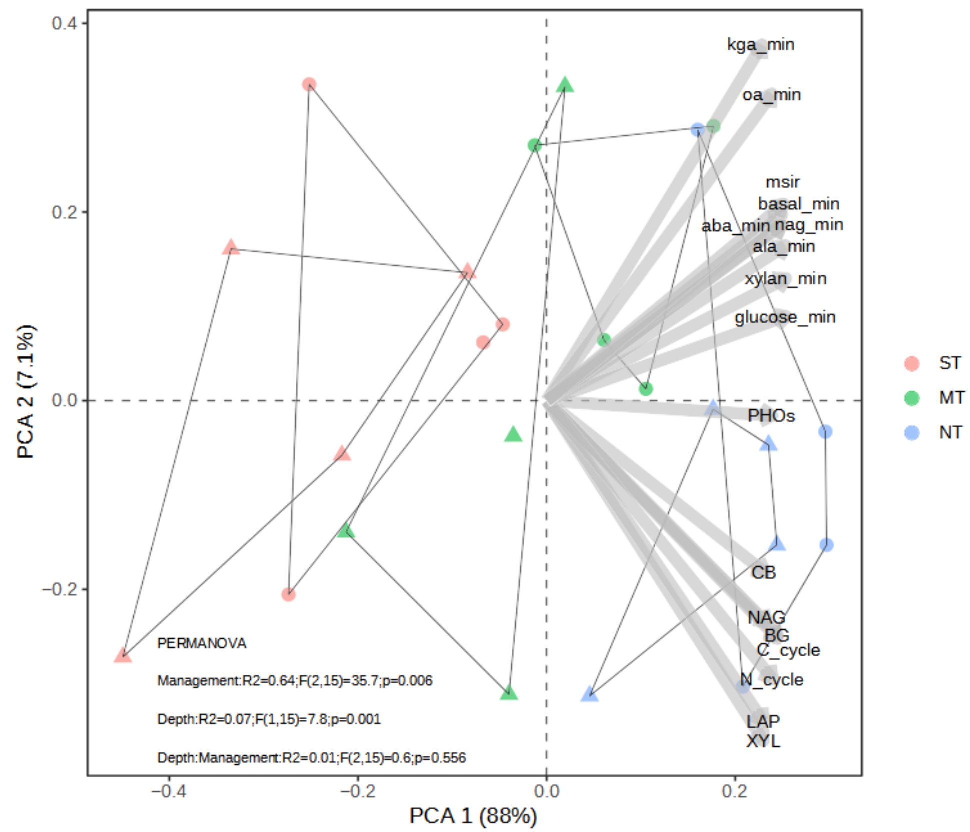
→ Community structure analysis revealed that tillage strongly influenced bacterial, fungal and acari community composition, reflecting a gradient of soil disturbance intensity.



SCIENTIFIC OUTCOMES

Enhanced microbial activity and functionality under reduced tillage

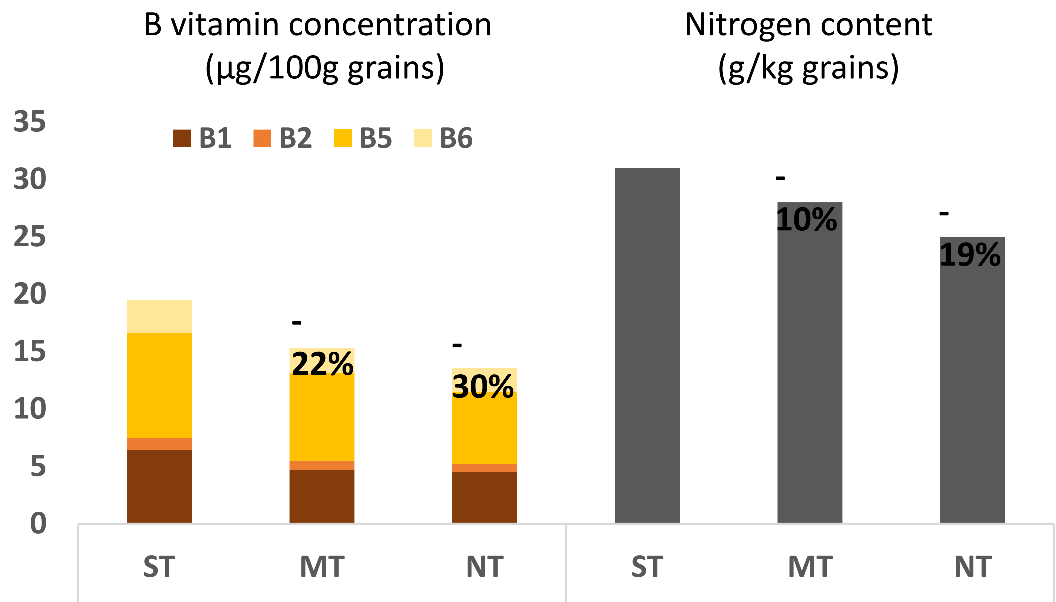
→ Reduced tillage increased microbial activity and soil functionality along the disturbance gradient.



SCIENTIFIC OUTCOMES

Reduced tillage impaired wheat quality and changed technological grain properties

- More B vitamins and nitrogen in wheat grains under ST
- Shift in A- and B-type starch distribution → more A-type starches under ST
- More Gliadins and Glutenins under ST



SCIENTIFIC OUTCOMES

2. Impact of farming practices on wheat performance and quality

WHAT DID WE LEARN?

- Spain tillage trial: reduced tillage lead to lower yield and lower concentration of some nutrients (similar to Krauss, 2022).
- Germany N fertilization trial: nitrate is still the best performing fertilizer, also encompassing disease resistance, using commonly used varieties.

SCIENTIFIC OUTCOMES

2. Impact of farming practices on soil biodiversity and functioning

WHAT DID WE LEARN?

- Spain tillage trial: reduced tillage increased soil functioning as reflected by higher nutrient cycling potential and substrate use capacity, biota abundance and induced shifts in community composition of microorganisms (bacteria, fungi) and mesofauna (mites and springtails)

- Germany tillage trial: reduced tillage increased soil functioning, the total abundance of nematodes and mesofauna and induced a shift in microbial community composition.

- Germany N fertilization trial: Type of N fertilizer did not affect soil functioning and the abundance of organisms, but only induced a small shift in fungal community composition.

SCIENTIFIC OUTCOMES

2. Impact of farming practices on soil biodiversity and functioning

RECOMMENDATIONS

Strategies to enhance wheat growth under reduced tillage

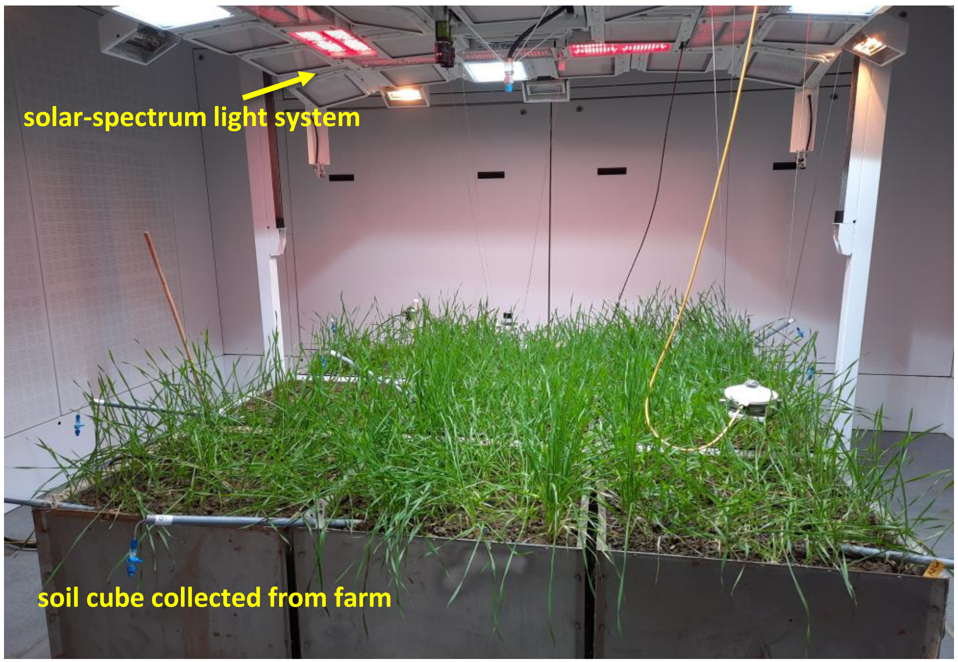
- Cultivation of deep rooting inter-crops like radishes, rye, or alfalfa that have deep, strong roots
- Subsoiling: break up the compacted layer without disturbing the entire soil profile
- Breeding for wheat varieties with root systems adapted to no-tillage conditions.

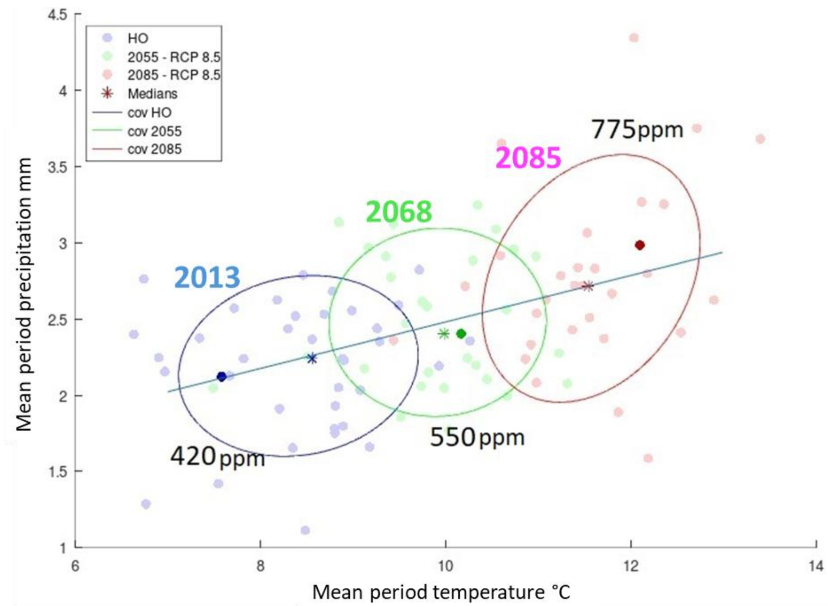
SCIENTIFIC OUTCOMES

3. Impact of farming practices on CC resilience and environmental impact

SCIENTIFIC OUTCOMES

Ecotron experiment at Gembloux Agro-Bio Tech





Harvest year	Mean temperature (°C)	Mean precipitation (mm)	Hydro-thermal Index (HI)
2013	7.59	2.12	3.99
2068	10.17	2.40	4.49
2085	12.10	2.98	4.74

SCIENTIFIC OUTCOMES

Two soil types

Two geographically close soil types with identical soil classification[a] (Aba(b)0), silty loam, C:N = 10.5, pH = 8) but **long-term contrasting management history** were compared. Soil One is «low input» and conventionally managed, while Soil Two is «high input» and increasingly adapting organic farming principles.

a www.geoapps.wallonie.be

50°38’35.1474”N
4°37’22.0123”E

50°39’12.8668”N
4°38’10.7664”E

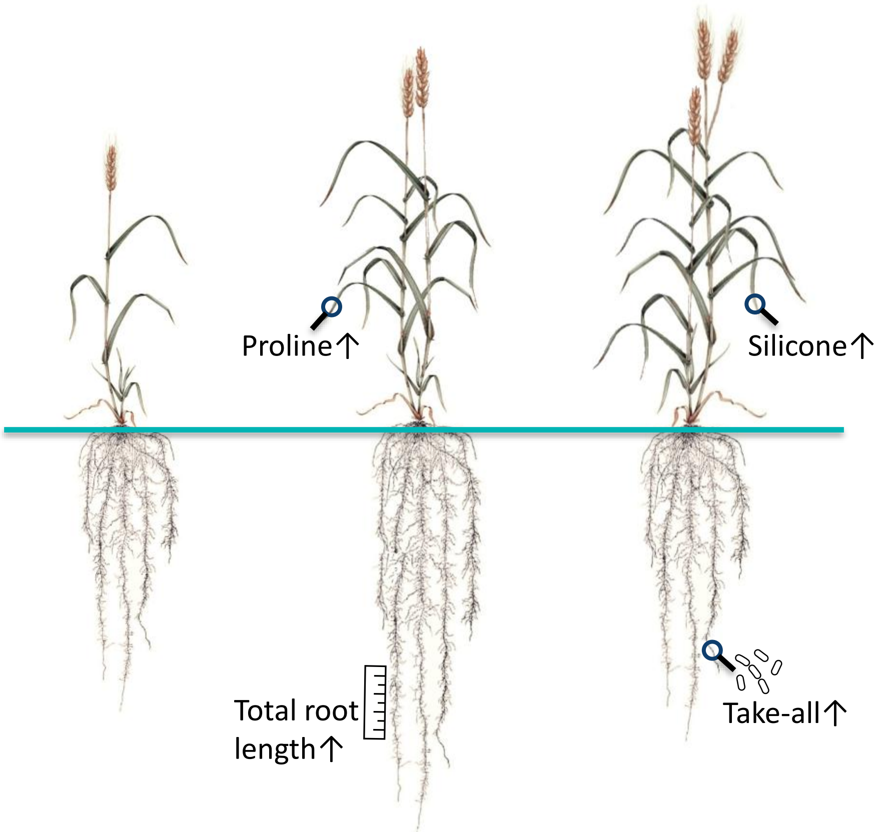
Physicochemical characterisation of the two soil types at the beginning of the experiment

	C (g kg^{-1})	N (g kg^{-1})	C:N	P (mg 100g^{-1})	K (mg 100g^{-1})	Mg (mg 100g^{-1})	Ca (mg 100g^{-1})	pH (H_2O)	Humus (%)	Clay (%)	Silt (%)	Sand (%)	Classifi-cation
Soil One (S1) “low input”	9.92	0.94	10.5	13.60	31.20	8.37	218.31	8.04	1.98	12.15	67.13	20.72	Silt loam
Soil Two (S2) “high input”	22.01	2.09	10.5	39.79	72.51	14.70	534.42	8.08	4.23	13.55	78.85	7.60	Silt loam

SCIENTIFIC OUTCOMES

Yield (t ha^{-1})

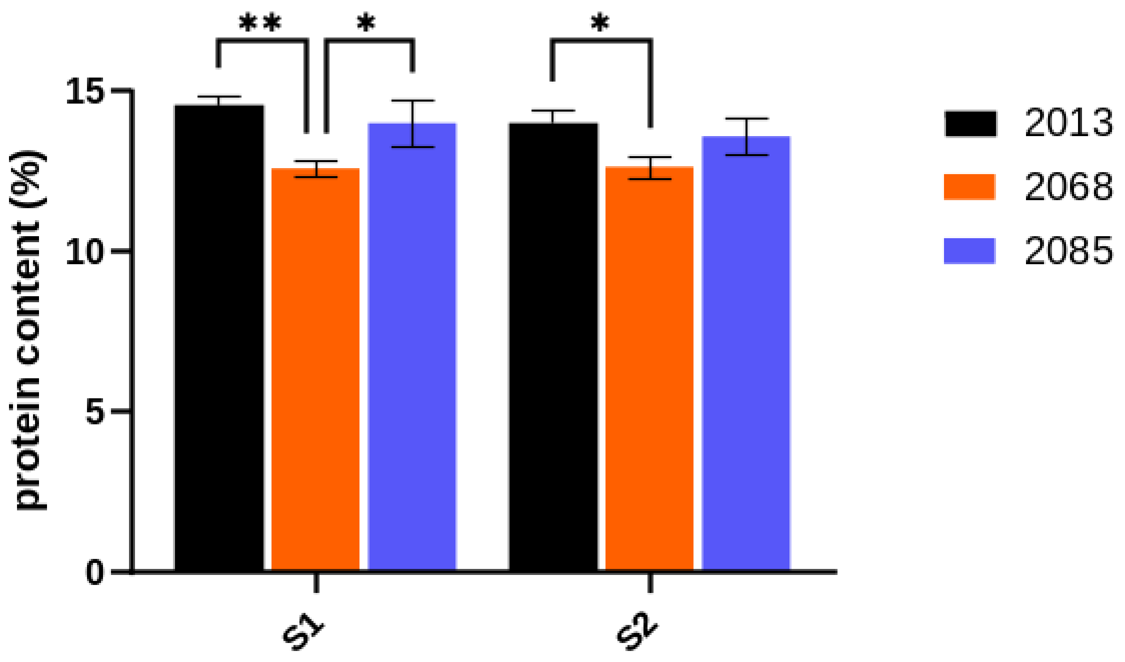
2013	2068	2085
S1: 3.79±0.51	S1: 4.76±0.37 (+26%)	S1: 5.09±0.50 (+34%)
S2: 3.50±0.34	S2: 3.71±0.32 (+6%)	S2: 3.05±0.59 (-13%)



Agronomic performance & environmental impact

- Wheat plants grew faster, taller and with larger leaves in the future (phenological advance)
- Total root length was mostly increased in 2068
- Yield constantly increased in the future for soil S1 (always S1>S2)
- Abiotic stress was defeated with increased foliar proline and silicone in 2068 and 2085 respectively
- Take-all disease (*Gaeumannomyces graminis* var. tritici) increased in the future, most strongly in soil type 1 in 2085
- Potential soil CO_2 emissions increased (always S2>>S1), N_2O decreased
- Increased risk of nitrate leaching in the future (esp. S1)

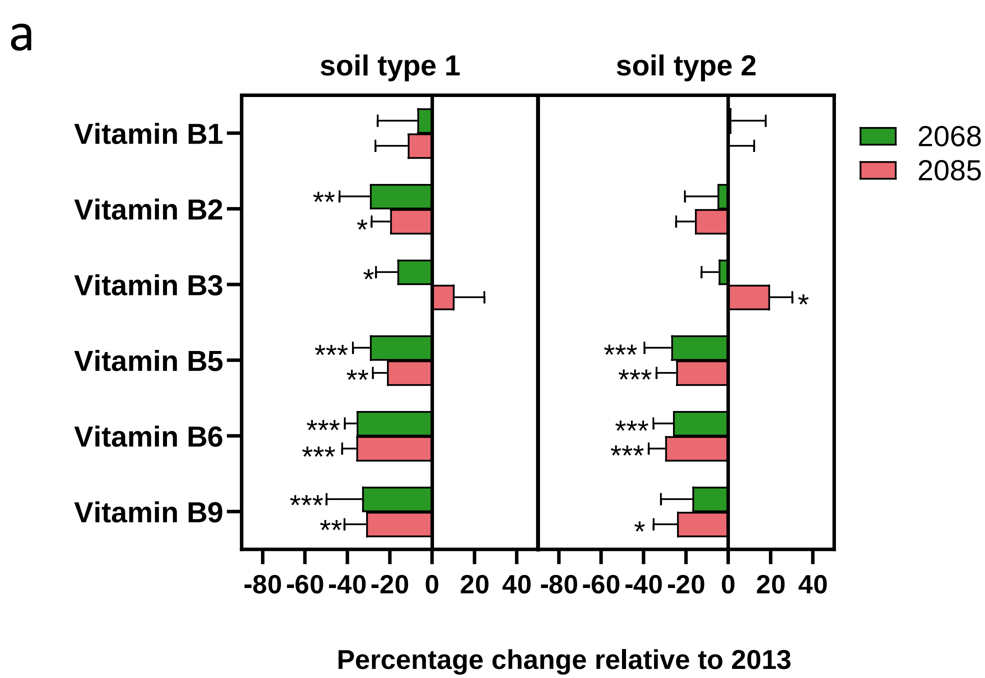
SCIENTIFIC OUTCOMES

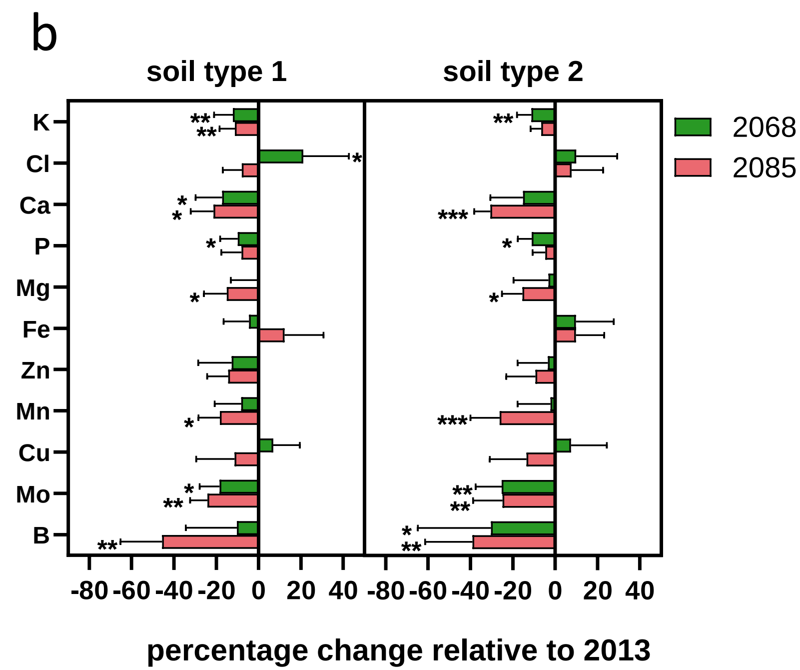


- Significant decrease in protein content in 2068 (vs 2013), whatever the soil type

SCIENTIFIC OUTCOMES

Relative changes of B vitamins and mineral contents in wheat grains harvested under three different meteorological conditions.



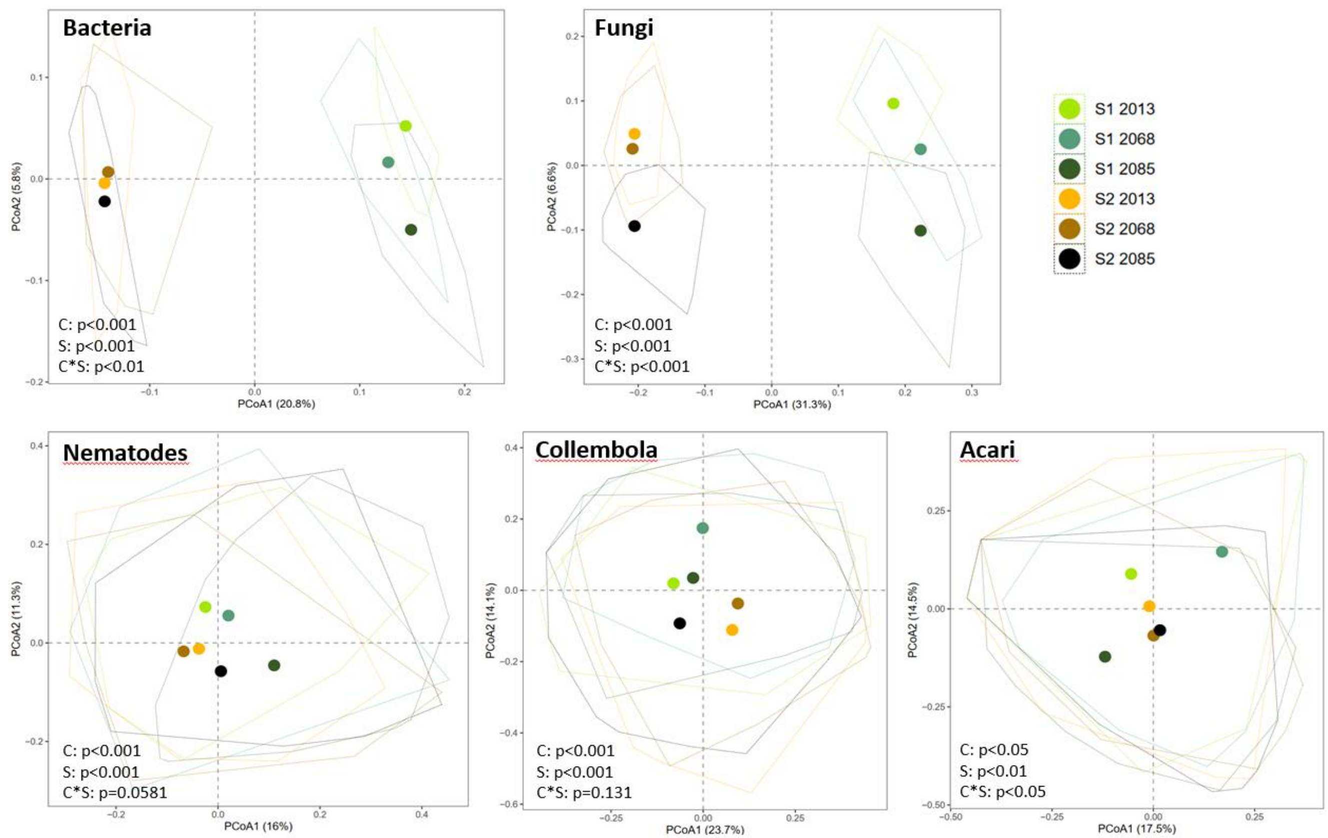


- Overall decline in B vitamin content
- Overall decline in mineral content

SCIENTIFIC OUTCOMES

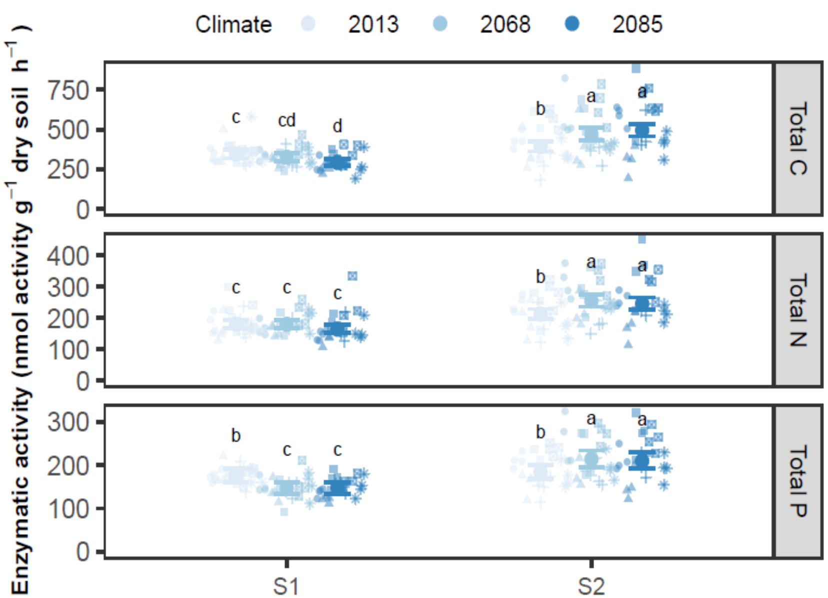
Belowground communities are more stable in organic-rich soils under future climate conditions

- Shift in community composition are less pronounced in S2 compared to S1 for bacteria, fungi, nematodes and acari



SCIENTIFIC OUTCOMES

Organic-rich soils promote nutrient cycling potential under future climatic conditions



Nutrient cycling potential decreased in S1 and increased in S2 under future climatic conditions → higher nutrient cycling possibly due to a higher abundance of microbes in S2 than in S1, a more stable microbial community composition and more SOM in S2 than S1 which provides energy.

SCIENTIFIC OUTCOMES

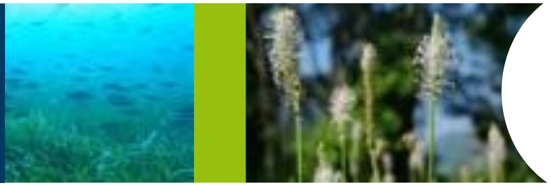
3. Impact of farming practices on CC resilience and environmental impact

WHAT DID WE LEARN?

- The crop management (e.g. SOM management) has significant impacts on CC resilience.
- Higher emergence of pathogens in future climates (in scenario with higher CO_2 and rain precipitation)

  → Need for adapted genotypes, disease managements and crop rotation.
- Reduction of nutrient (proteins, minerals and B vitamins) concentrations under future climate conditions
- The crop management history impacts (1) the belowground communities structure and stability, (2) the take-all disease symptoms, and (3) nutrient turn-over rates under future climatic conditions
- No significant change in soil suppressiveness indexes.

SOM: Soil Organic Matter



SCIENTIFIC OUTCOMES

3. Impact of farming practices on CC resilience and environmental impact

RECOMMENDATIONS

- Biofortification could provide an efficient approach for solving the nutrient concentration problem.
- Future crop improvement strategies should not only focus on crop yield but also grain quality.
- Necessity to link taxonomy / abundance to function
- ‘Who does what and when‘ approach bringing together identification with metabolites and dedicated functional assays
- Systemic / integrated approaches are mandatory
- Plant performance and ecosystems services (e.g. GHG emission and NO_3^- leaching) should be considered

ACKNOWLEDGEMENT

This project is funded by:

- *FWO Research Foundation (Flanders)*
- *F.R.S. – FNRS (Wallonia)*
- *SNSF (Switzerland)*
- *ANR (France)*
- *AEI (Spain)*
- *DLR-PT (Germany)*