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## **Biostimulant seed treatment to enhance germination, symbiosis establishment and early growth of soybean subjected to low temperature**

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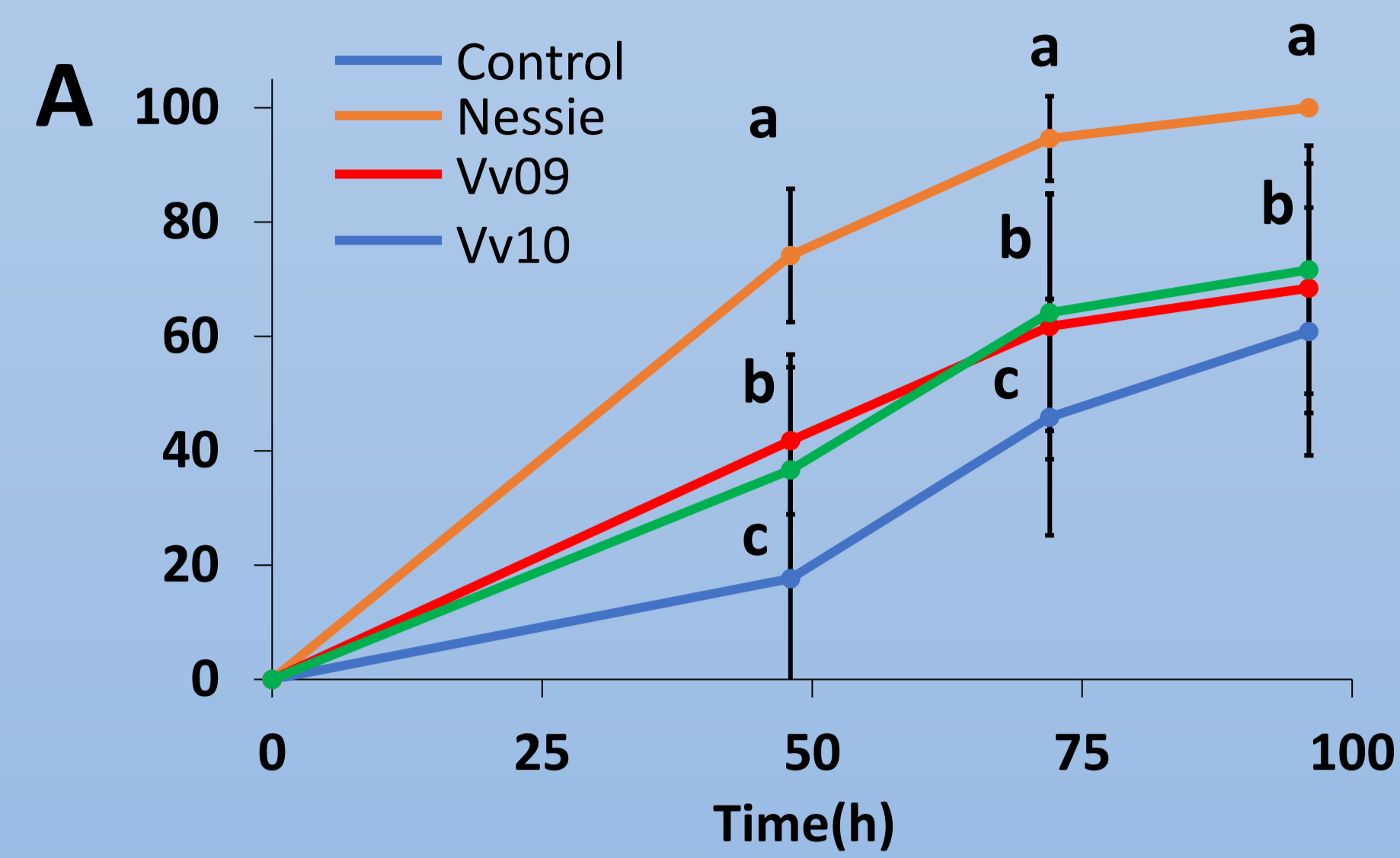


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## Introduction

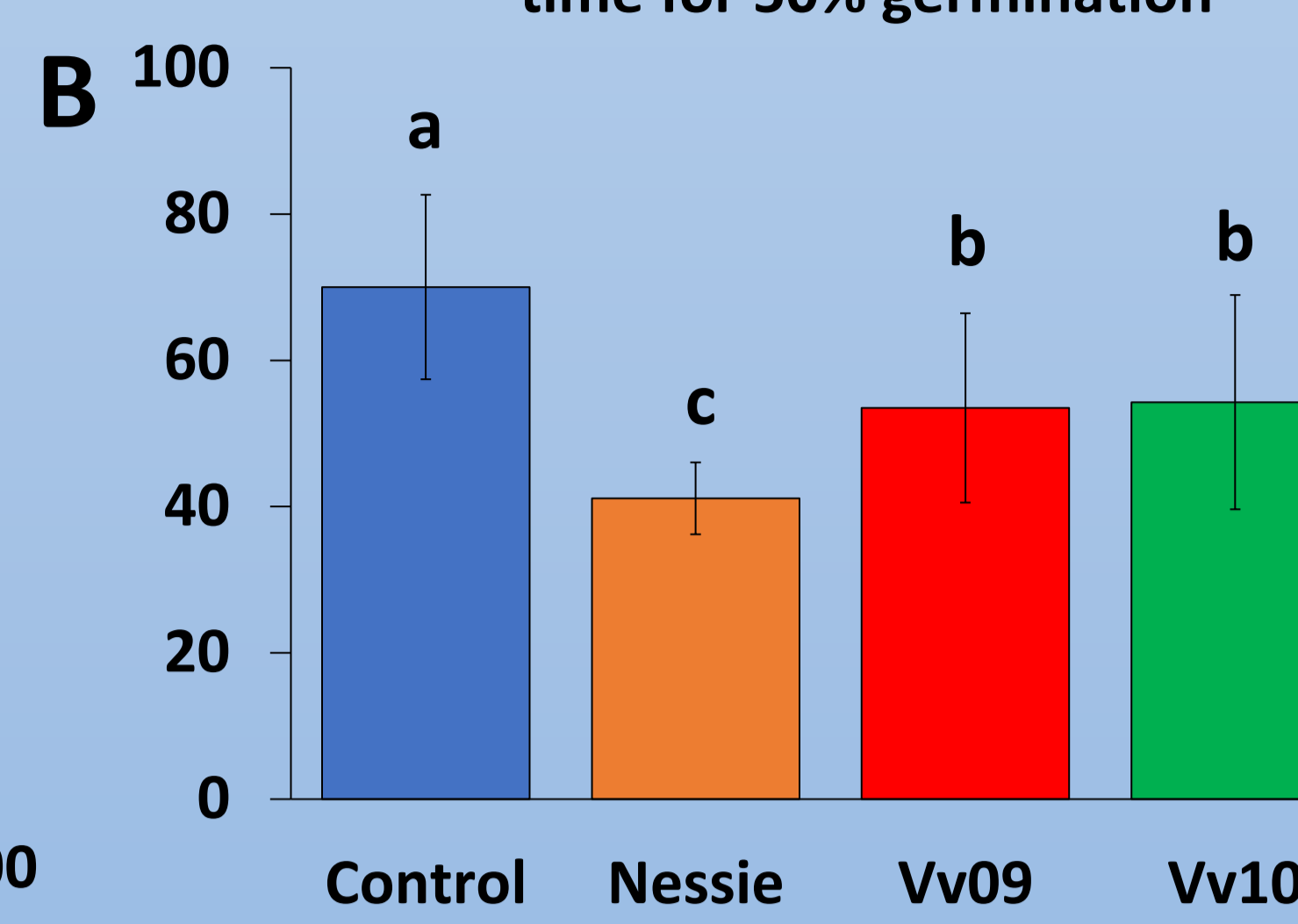
Normandy's climate in France has low temperatures in early spring, which can be very detrimental for soybean germination and sprouting in the field. These adverse conditions can lead to a poor culture development and ultimately, yield loss. Biostimulant seed treatment is a novel approach by which adverse environmental conditions effects during germination can be tempered. In this study, we coated soybean seeds with three different biostimulants and studied their effects on soybean germination, early development and symbiosis when exposed to low temperatures.

## 12°C greenhouse



Soybean seeds coated with biostimulants Vv09 or Vv10 (containing bio-available micronutrients) stimulate germination rate (A) and T 50 (B) at 12°C compared to the control and mimics a cold tolerant untreated soybean variety (Nessie)

## T50 (hours) time for 50% germination



## Biostimulant effects on ES Comandor



### Germination rate and T 50

Imbibition?

Hormone balances?



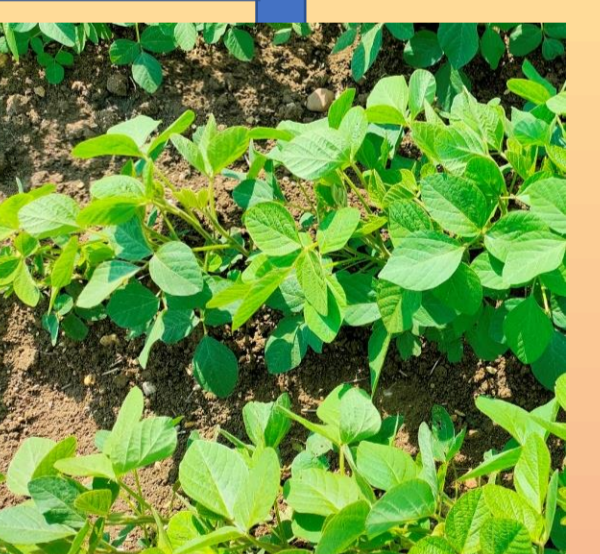
### Germination proteomics

Biochemistry?



### Plant N status

Soil biology?



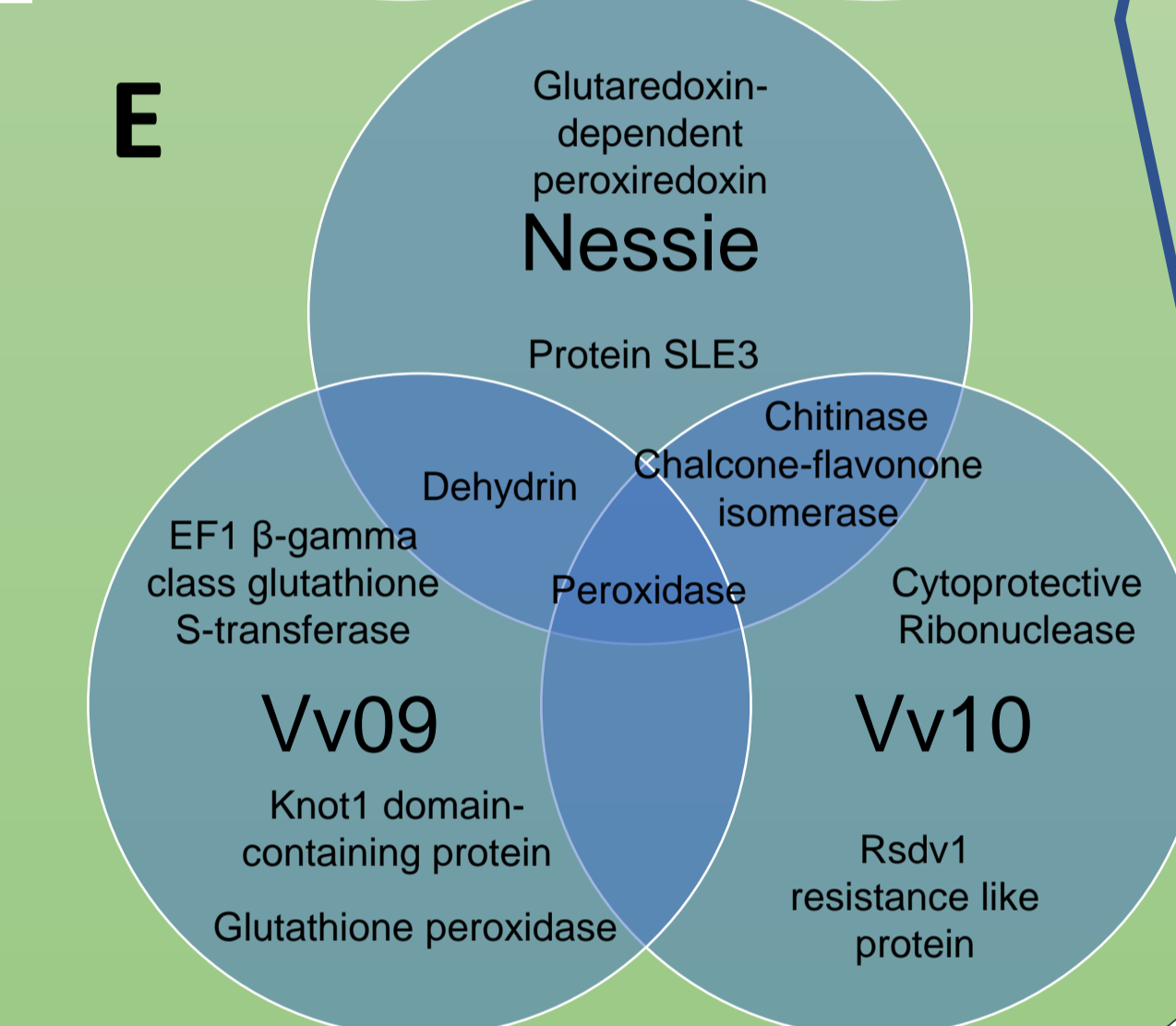
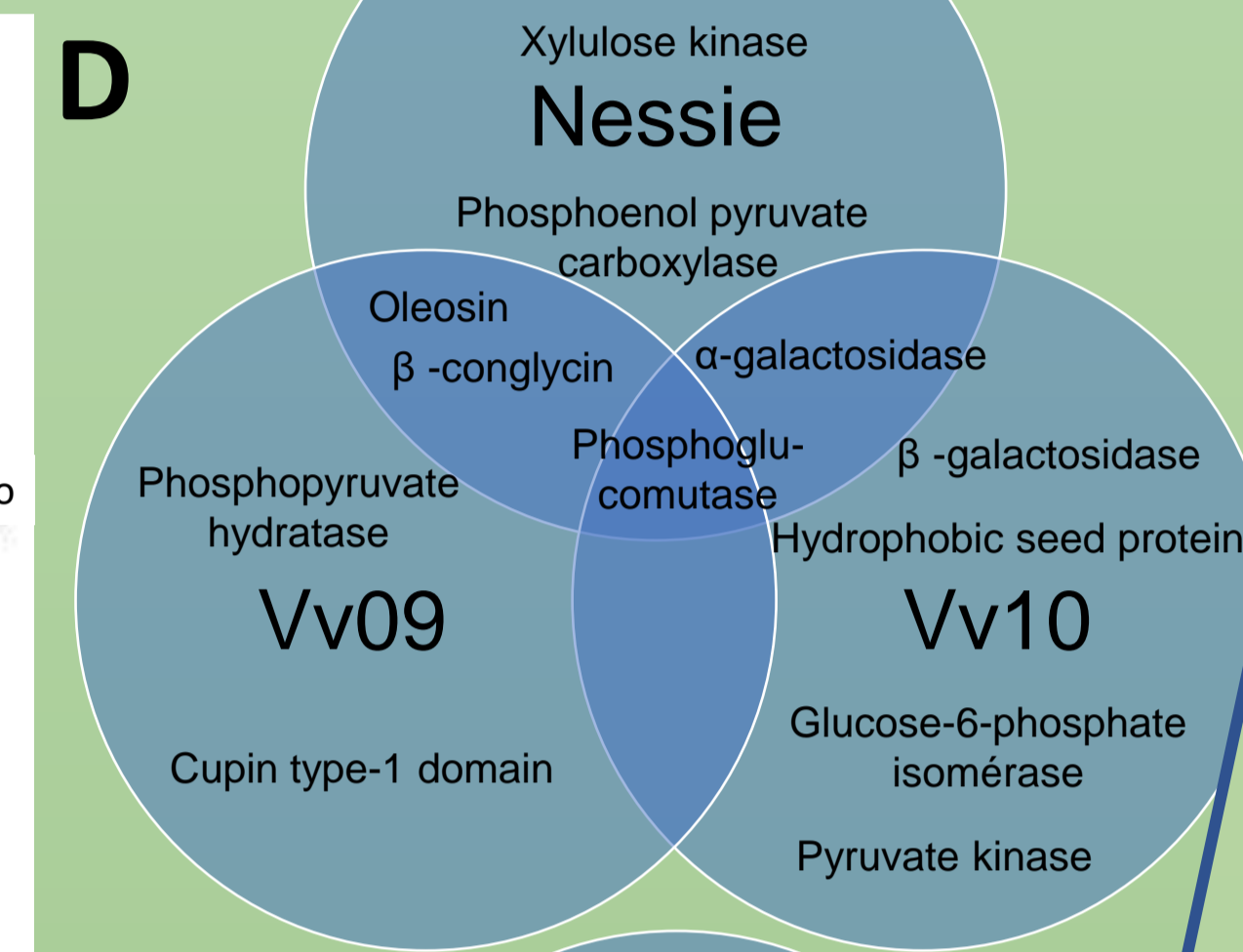
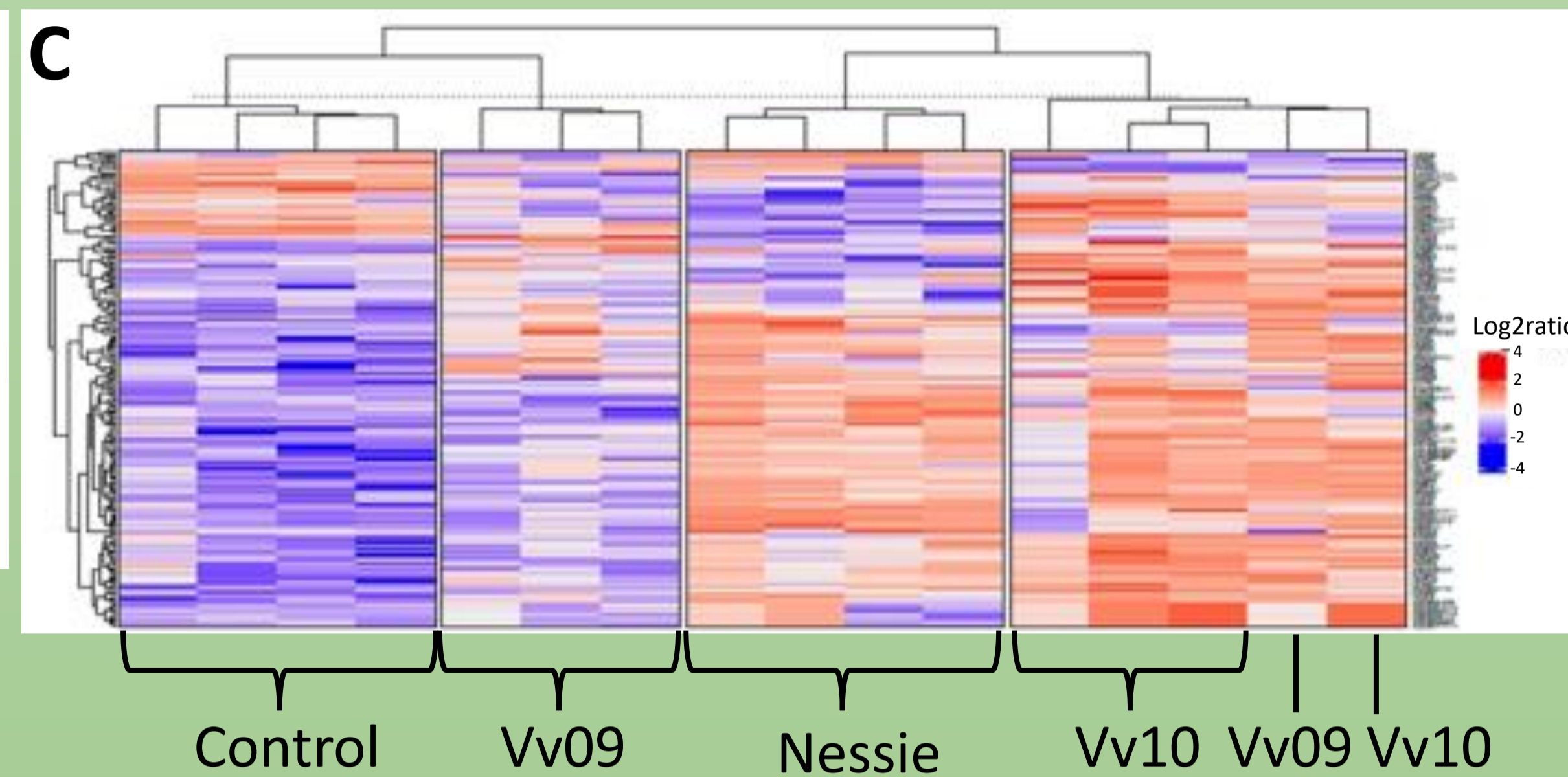
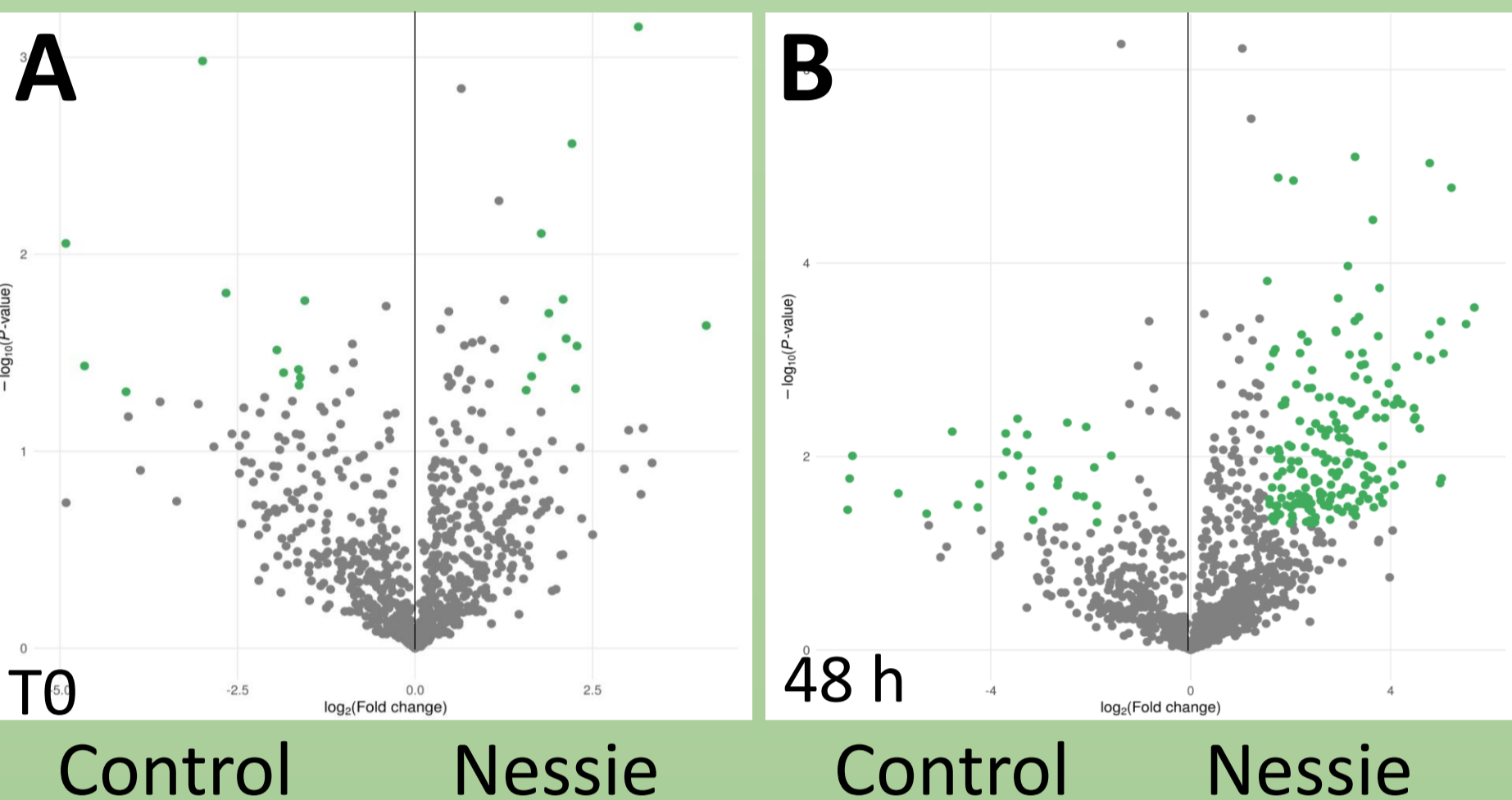
### Plant vigor and Seed yield

Plant proteomics?

Seed quality?



## 12°C greenhouse



Control and Nessie mature seeds have a similar protein pattern (A). Untreated Nessie germinated seeds have a faster metabolic awakening compared to the untreated control 48h after sowing at 12°C (B). Germinated seeds treated with Vv10 and to a lesser extent Vv09 have a similar protein pattern compared to Nessie 48h after sowing (C). Compared to the control, overexpressed proteins of untreated Nessie, and Vv09- or Vv10-coated germinated seeds include phosphoglucomutase (N and C metabolism: D) and peroxidase (response the environment metabolism: E).

## 12°-19°C greenhouse

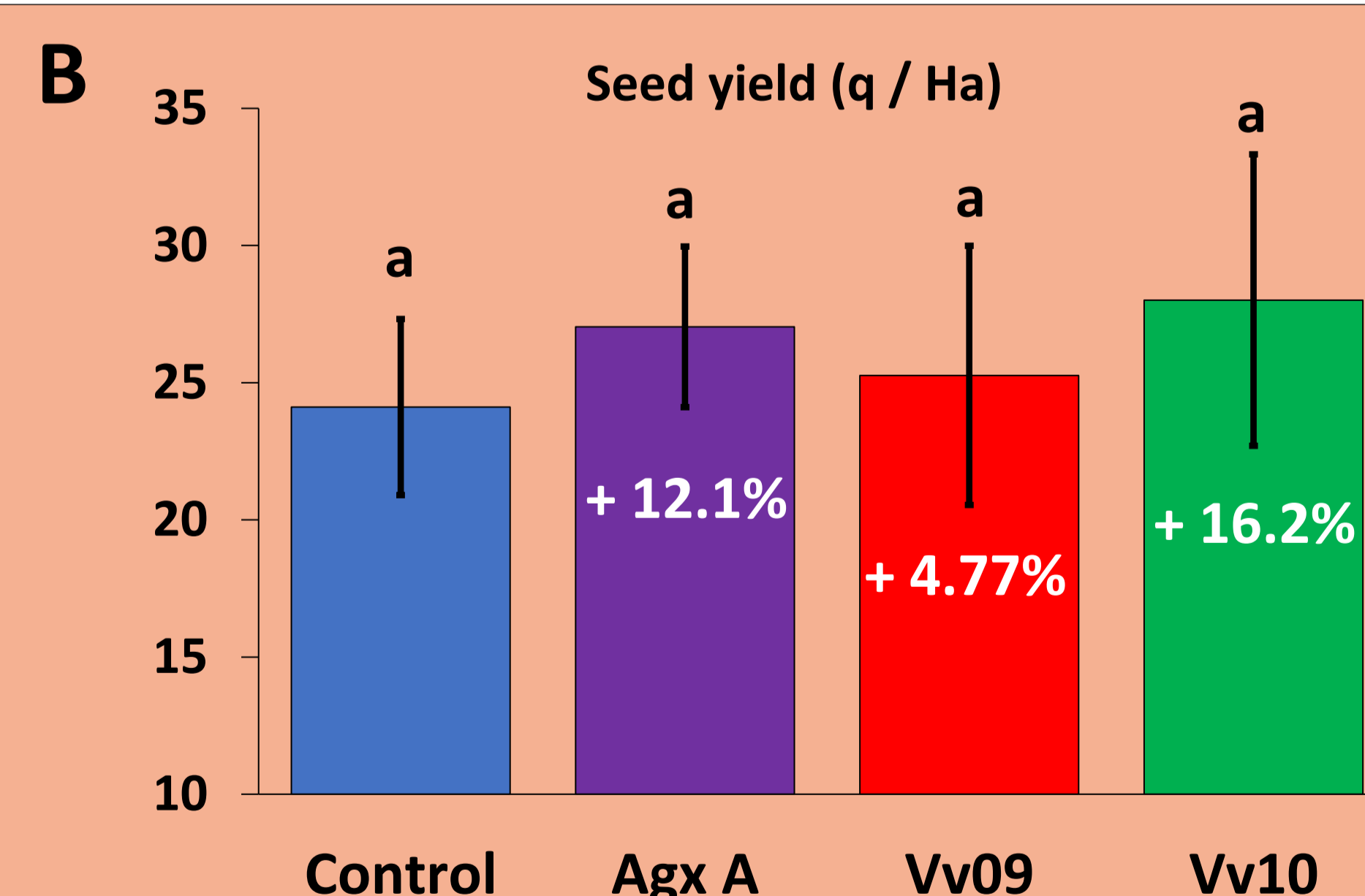
	DW shoots (mg)	DW roots (mg)	DW nodules (mg)	Nodules number	Leaf area (cm <sup>2</sup> )	%N Leaf	%N stem	%N roots	N shoots (mg)	N leaf (mg)	N roots (mg)
Control	520 a	190 ab	8 a	2.143 b	104.9 a	2.231 b	0.690 a	1.506 a	66.88 a	7.493 b	2.866 a
Vv09	533 a	210 a	15 a	<b>9.500 a</b>	116.6 a	<b>2.845 a</b>	0.800 a	1.558 a	65.15 a	<b>10.57 a</b>	3.317 a
Vv10	506 a	148 b	12 a	2.800 b	108.5 a	2.230 b	0.714 a	1.506 a	61.29 a	7.469 b	2.244 a

Plants coming from Vv09-coated seeds show a higher nodules number and N in leaves compared to the control suggesting a better nodulation

## Field

A	DW per plant (g)	%N shoots	N shoots (mg)	Chlorophyll Index (V4)
Control	7.099 b	2.275 b	165.5 b	30.86 b
AgxA	<b>10.07 a</b>	2.647 ab	<b>266.8 a</b>	<b>35.86 a</b>
Vv09	8.515 ab	2.640 ab	223.9 ab	32.82 ab
Vv10	7.840 ab	<b>2.800 a</b>	220.0 ab	<b>34.49 a</b>

Plants coming from AgxA- (a yeast-based biostimulant) and Vv10-coated seeds showed a higher leaf N status, biomass and chlorophyll index compared to the control (B). Seed yield was slightly but not significantly increased for these two treatments (C).



## Conclusions and perspectives

- In controlled conditions, Vv10 and to a lesser extent Vv09 stimulate soybean germination and metabolic awakening at 12°C.
- Vv10- and Vv09- coated germinated seeds mimicked an untreated, cold tolerant soybean variety in terms of germination rate, and protein pattern 48h after sowing.
- Plants coming from Vv09- coated seeds showed a higher N status and increased nodules number.
- In the field an increased N status, was also observed for plants coming from Agx A- and Vv10- coated seeds,
- These plants also had an increased plant biomass and leaf chlorophyll index suggesting a better plant vigor.
- Seed yield from AgxA and Vv10 plants was 14% higher on average (not significant).
- Further analyses are necessary to understand biostimulant mechanisms during germination (hormone balance and biochemistry in seeds) plant development (transcriptomics, proteomics) soil microbiome (bacterial and fungal metabarcoding, enzymatic activities) and seed quality (seed nitrogen, ionome and proteomics).