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Combining wheat and prairies using functional diversity to promote positive ecological interactions and a better regulation of C and N cycles in agroecosystems

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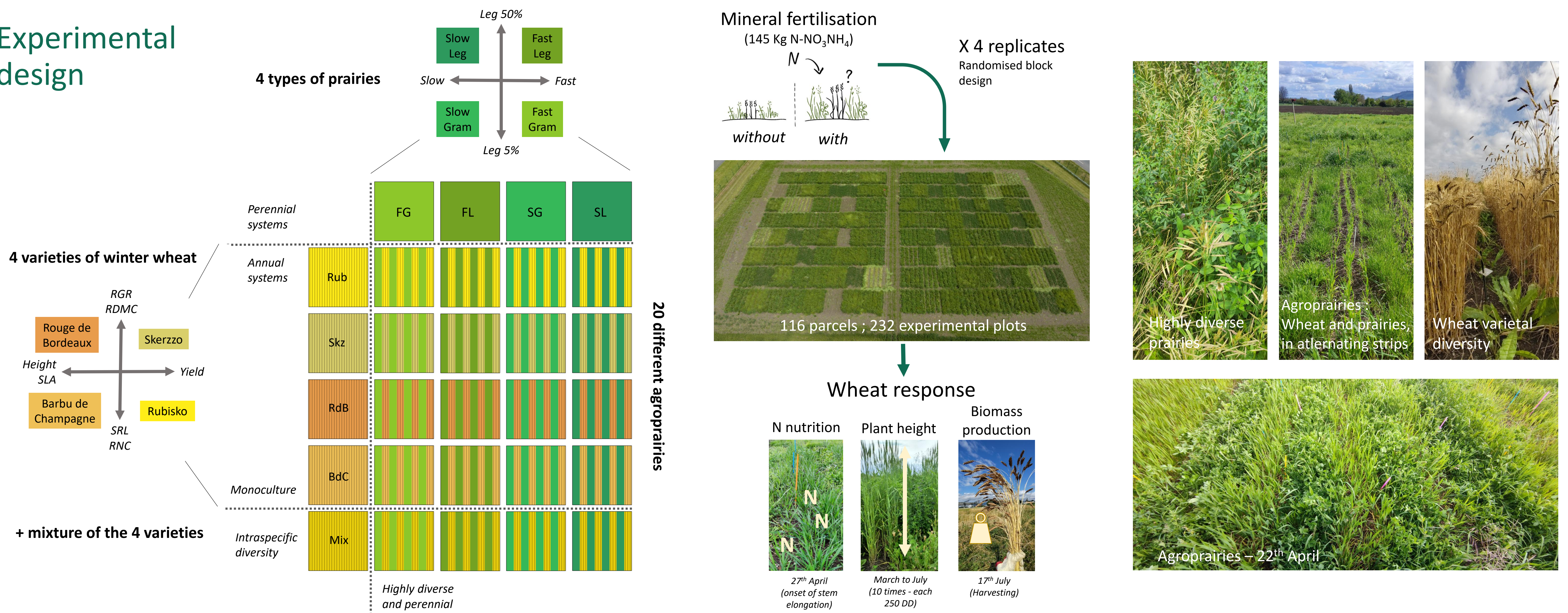
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Context

Plant functional diversity interacts with soil microbial communities, resulting in a heterarchical network that drives soil biogeochemical cycles¹⁻³. In permanent and diverse temperate prairies, these interactions generate a tight coupling between soil carbon (C) and nitrogen (N) cycles and a coordination between plant nutrient demand and soil offer, that favours the resource use efficiency⁴. This emerging property could be used in highly diversified agroecosystems to increase the biomass production of a target species while improving carbon storage and nutrient recycling. To explore this opportunity, we combined an annual crop (winter wheat) with permanent and diverse prairies cultivated in alternating strips, in new agricultural systems called "agroprairies". However, diversification also implies plant-plant interactions that are driven by plant functional traits as well as by management practices, and that will affect the final performance of a target species^{5,6}.

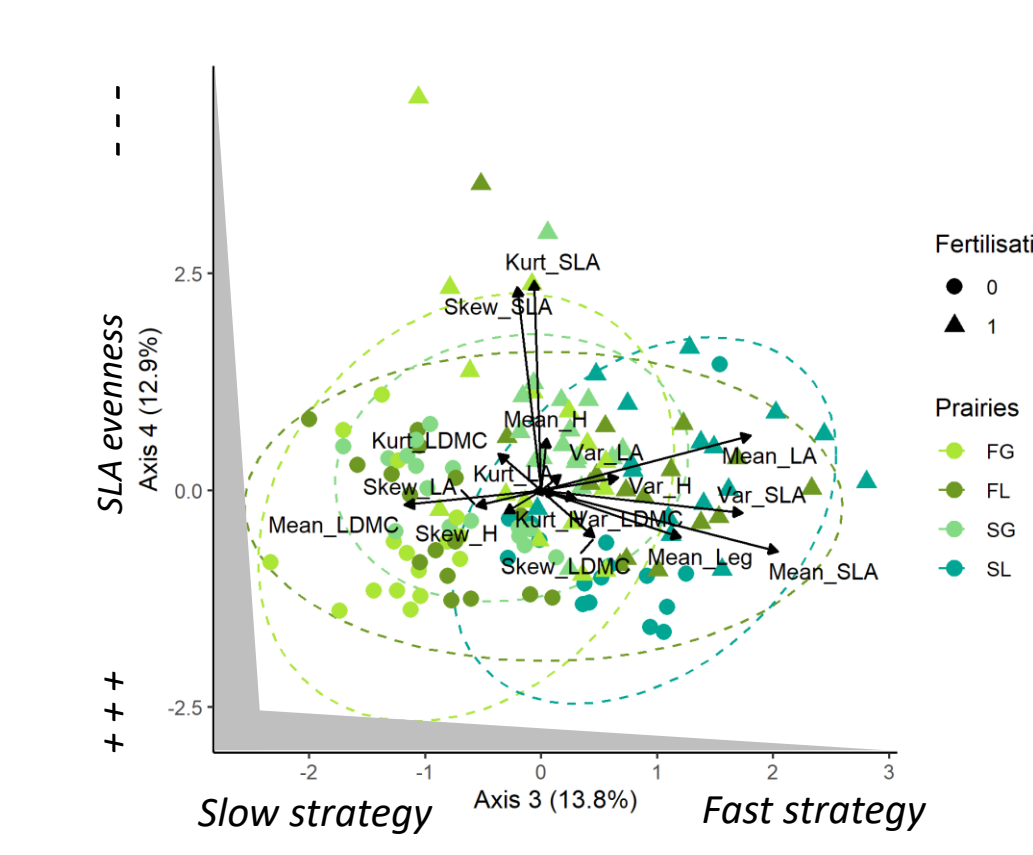
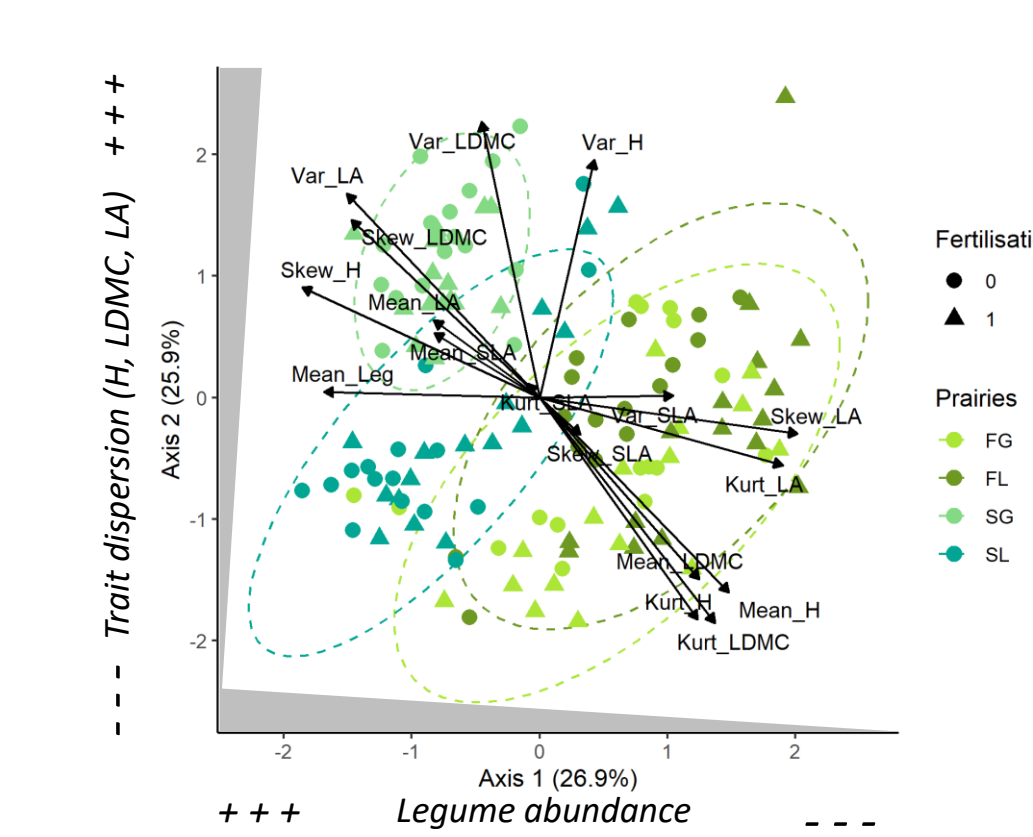
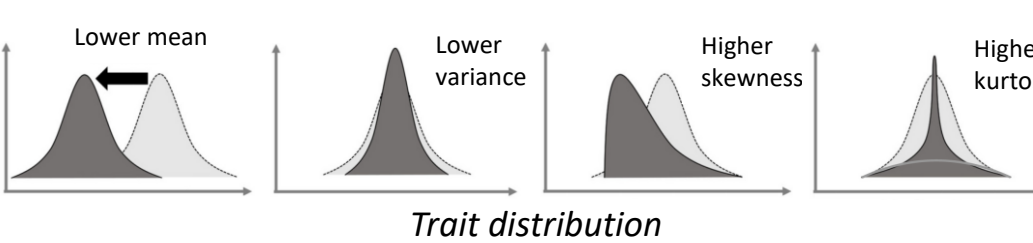
How to promote positive plant-plant interactions and reduce competition in highly diverse agroecosystems, with the help of functional traits distribution ?

Experimental design



Prairie functional structure (SLA, LA, LDMC, Height)

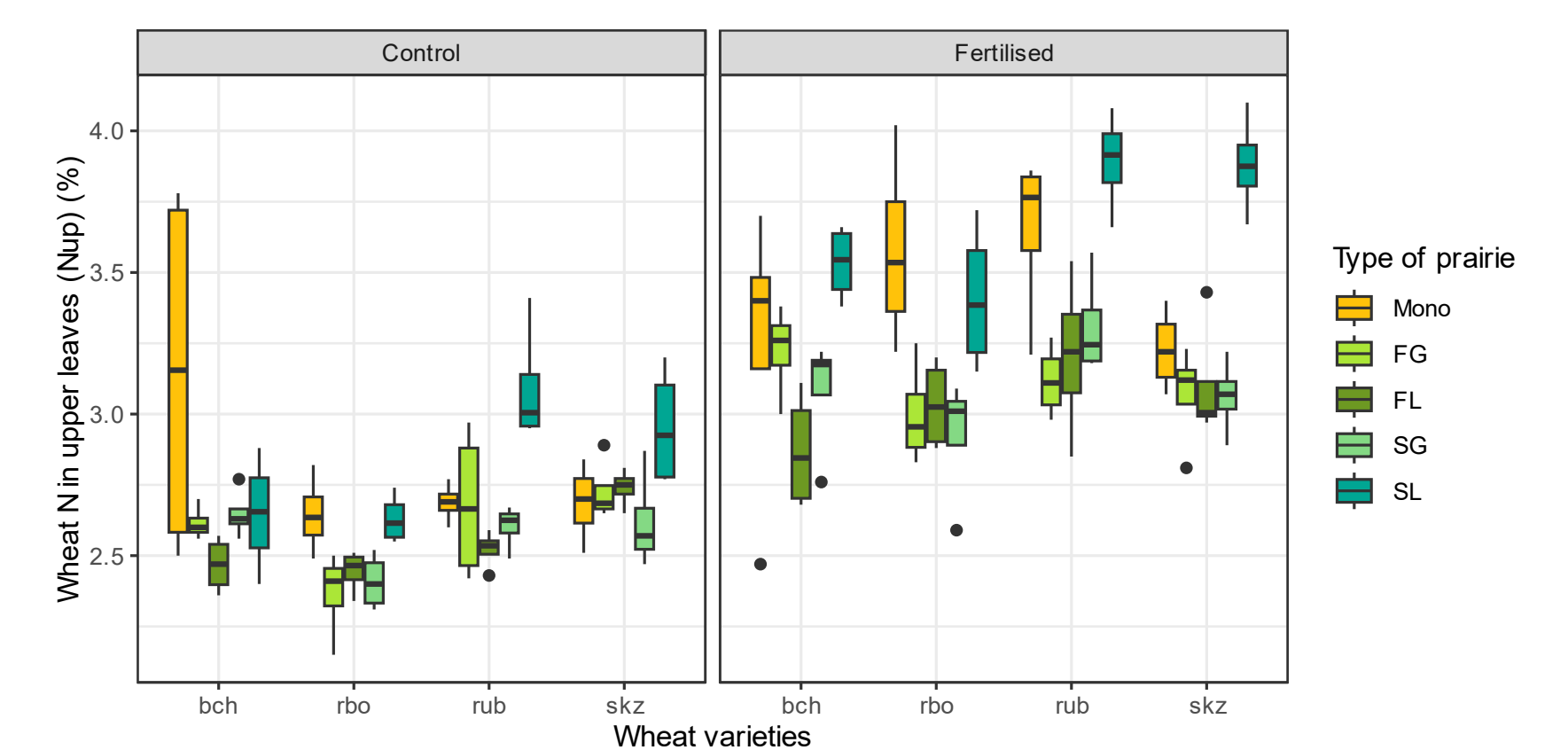
Prairie functional structure were defined by the mean, variance, skewness and kurtosis of their traits^{7,8}



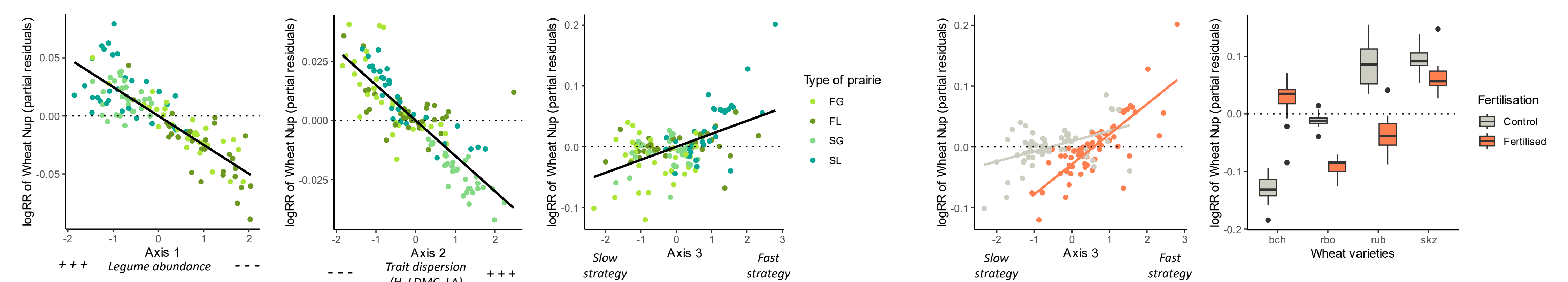
What is the effect of prairie functional structure, fertilisation management and wheat variety on wheat nutrition at the onset of stem elongation ?

Main Results

- Variable effect of prairies was observed on wheat N_{up} (N in upper leaves) : 43 plots with a positive effect, 117 plots with a negative effect
- Wheat response to prairies was highly impacted by wheat variety and its interaction with fertilisation (23.2 and 22.5% of variance explained), with a significant effect of prairie functional characteristics
- We observed an overall positive effect of legume abundance and fast growing strategy, and a negative effect of trait dispersion (LA, LDMC, H) on wheat response to prairies
- The positive effect of fast growing strategy on the N_{up} response in Wheat was lowered by fertilisation and differed between wheat varieties.



Variable	df	F value	p value	% var explained
Block	3	2.99	0.03	2.51
Wheat variety	3	27.69	2.93E-13	23.23
Fertilisation	1	3.38	0.07	0.95
Axis 1	1	19.92	1.99E-05	5.57
Axis 2	1	6.82	0.01	1.91
Axis 3	1	22.27	7.15E-06	6.23
Wheat variety : Fertilisation	3	26.86	4.67E-13	22.54
Wheat variety : Axis 3	3	3.84	0.01	3.22
Fertilisation : Axis 3	1	8.97	0.003	2.51
Axis 1 : Axis 2	1	1.73	0.19	0.48
Axis 1 : Axis 3	1	2.36	0.13	0.66
MODEL				Adjusted R²
AIC = -302.4	20	12.56	1.83E-19	63.36

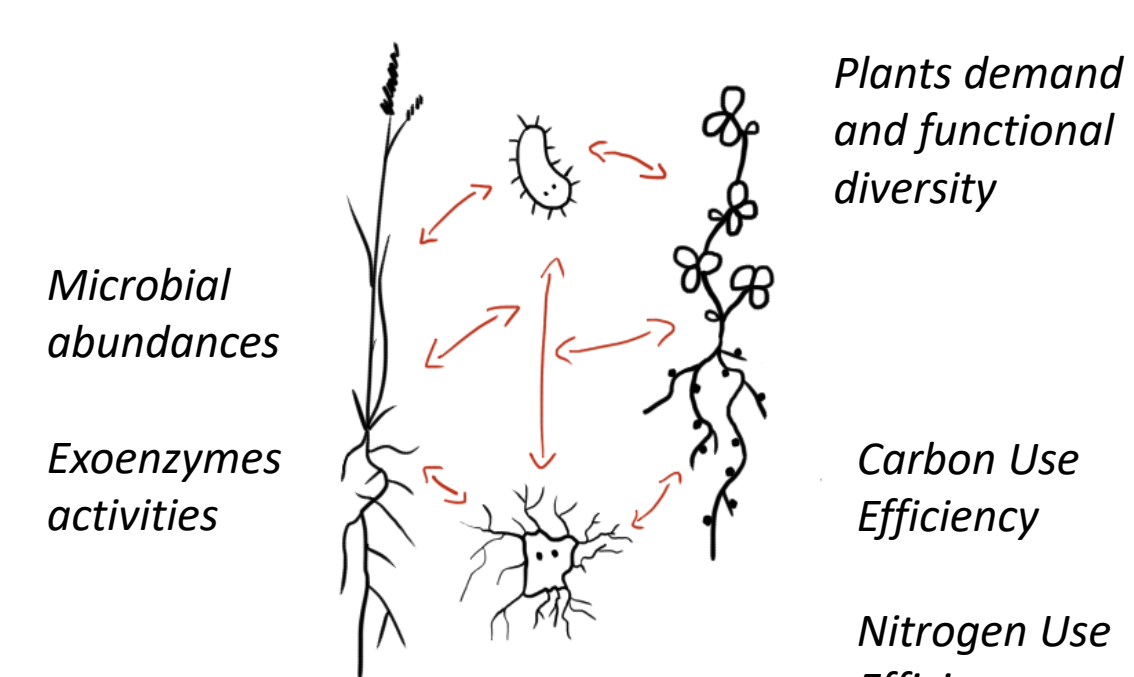


Conclusion

Our results showed a variable and significant effect of prairie functional structure on the response of wheat nutrition at the onset of stem elongation, depending on N management. Together with forthcoming data on height and biomass production, our study provides first insights into the potential benefits of combining an annual crop with diverse prairies, along with key factors that will help to design agroecosystems that maximise the benefits of functional diversity while minimising negative interactions.

Are the effects of prairies mediated by changes in biogeochemical cycles ?

Prairies growth strategy and functional structure interact with soil microbial communities to modulate N and C cycles, nutrient availability and C storage



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