Alfalfa to get back into planetary boundaries

2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

Alfalfa-based cropping systems in sustainable land-use for livestock production

Liu N. & Labanca H

Plenary session 5

FROM 03 › TO 06 nov. 2025

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Genetic and phenotypic diversity of lucerne for optimising its role as a living mulch in agroecological systems

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FROM 03 TO 06 nov. 2025

✓ Context: Living mulch systems

- Living mulch is a cover crop grown simultaneously with the cash crop and maintained during and between growing seasons to provide continuous ecosystem services.

Benefits

- Reduces soil erosion and nutrient losses
- Improves soil structure and fertility
- Suppresses weeds and supports biodiversity

Challenges

- Competition for light, water, and nutrients

- Strength of these interactions depends on species choice, growth dynamics, and management conditions

✓ Lucerne as a living mulch

- Legume/cereals mixtures are widely recommended because of their physiological complementarity : legumes fix nitrogen, while cereals efficiently capture it.
- In this study, we focus on **lucerne** (*Medicago sativa*) as the legume component and **wheat** (*Triticum aestivum*) as the non-legume crop.

Lucerne as a model

- Lucerne is a perennial legume providing strong nitrogen fixation, deep rooting, and long-term ground cover.
- However, current cultivars are too vigorous, leading to intense competition with wheat and yield losses up to 50%.
- There is currently a necessity for mechanical or chemical control, which limits system sustainability.

✓ Hypothesis & objectives

- The large genetic diversity within the *Medicago sativa* complex constitutes a valuable reservoir for designing lucerne ideotypes adapted for use as living mulch.

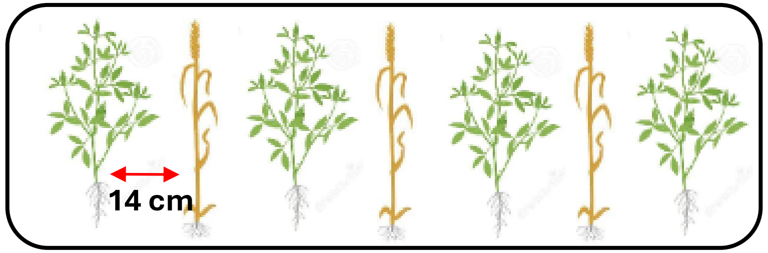
1) Identify the key lucerne traits controlling coexistence with wheat and ecosystem service provision
2) Assess the efficiency of indirect selection based on these traits
3) Evaluate the accuracy of genomic prediction to support selection for living mulch ideotypes

Breeding Lucerne living mulch ideotypes

✓ Experimental design

30 Lucerne accessions + 1 wheat variety

Experiment 1: living mulch



x3

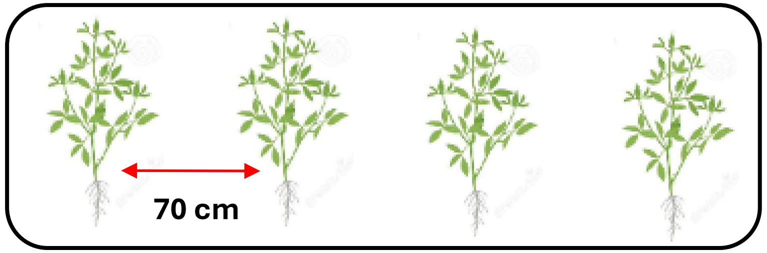
Lucerne: dormancy, height, lodging
Wheat: dominance, biomass, nitrogen status
Weeds: abundance

⇩

1) Interdependence between lucerne traits, wheat performance, and weed control

2) Lucerne trait genetic correlations and G × M interactions

Experiment 2: Nursery/ spaced



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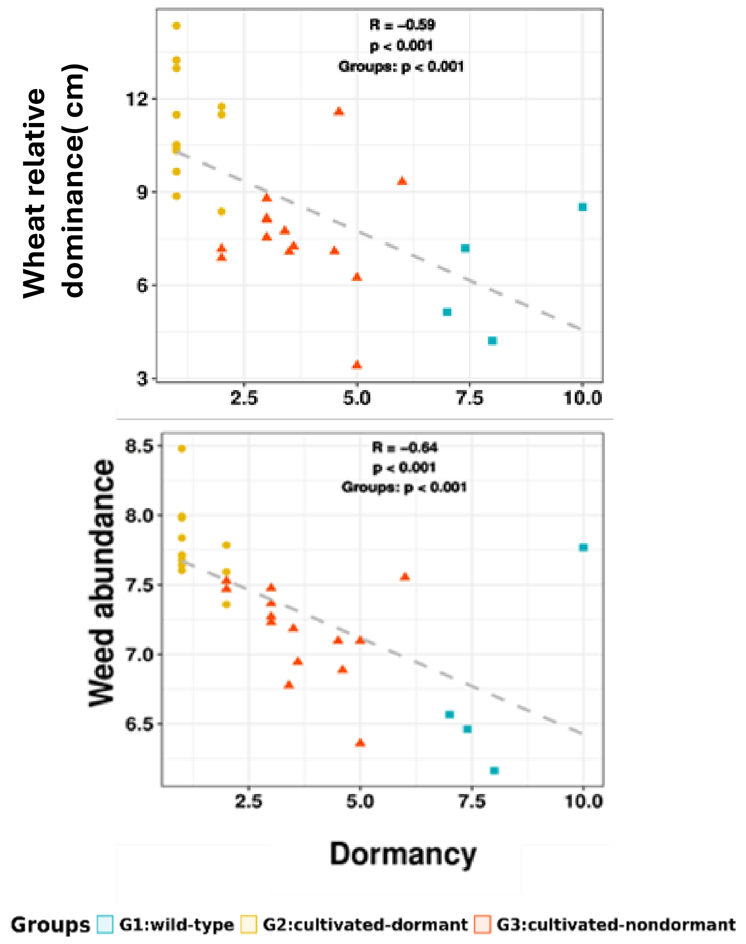
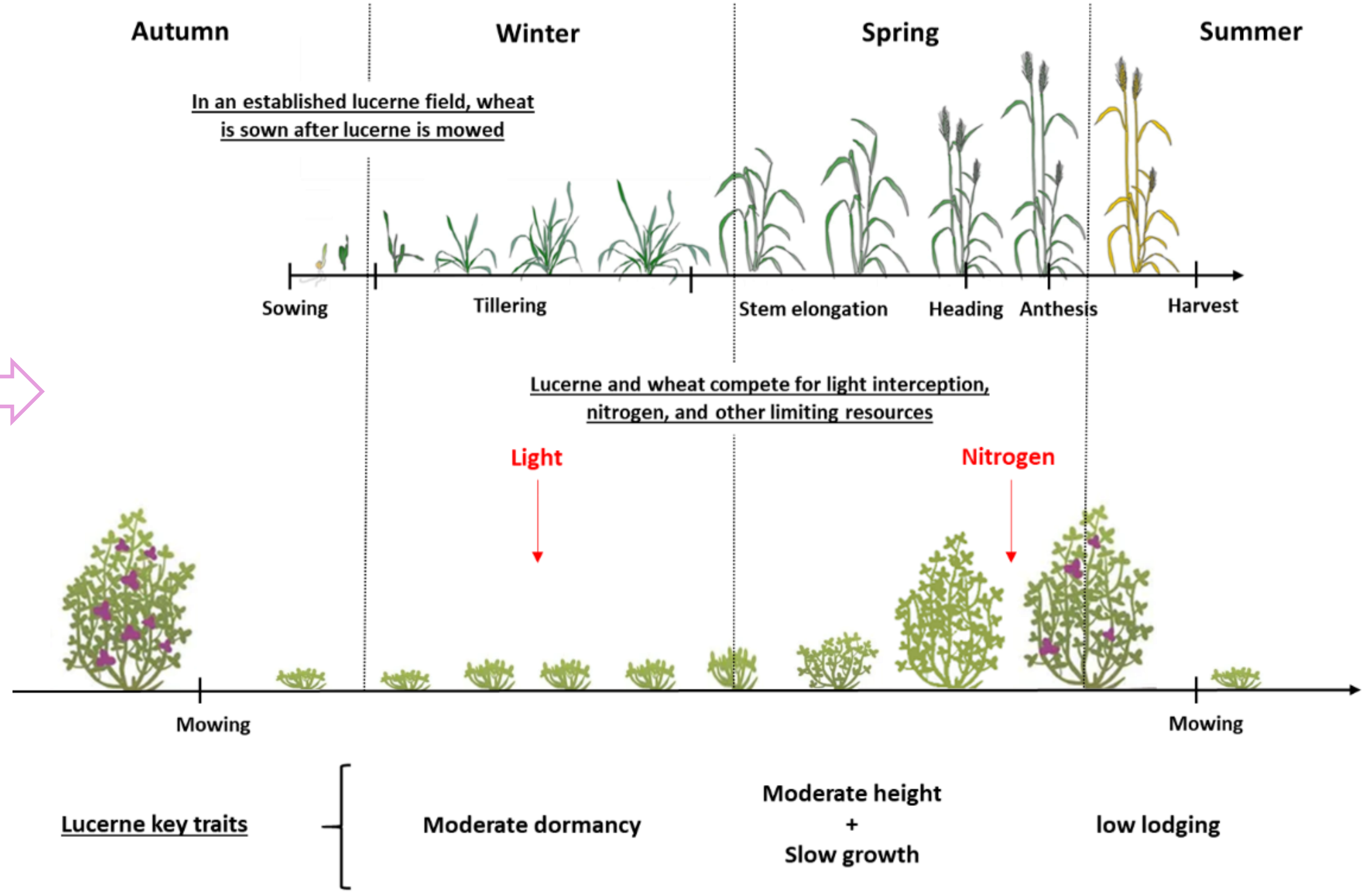
1200 plants evaluated: 40 × 30 accessions
Phenotyping: dormancy, height, lodging
Genotyping: GBS (111K SNP)

⇩

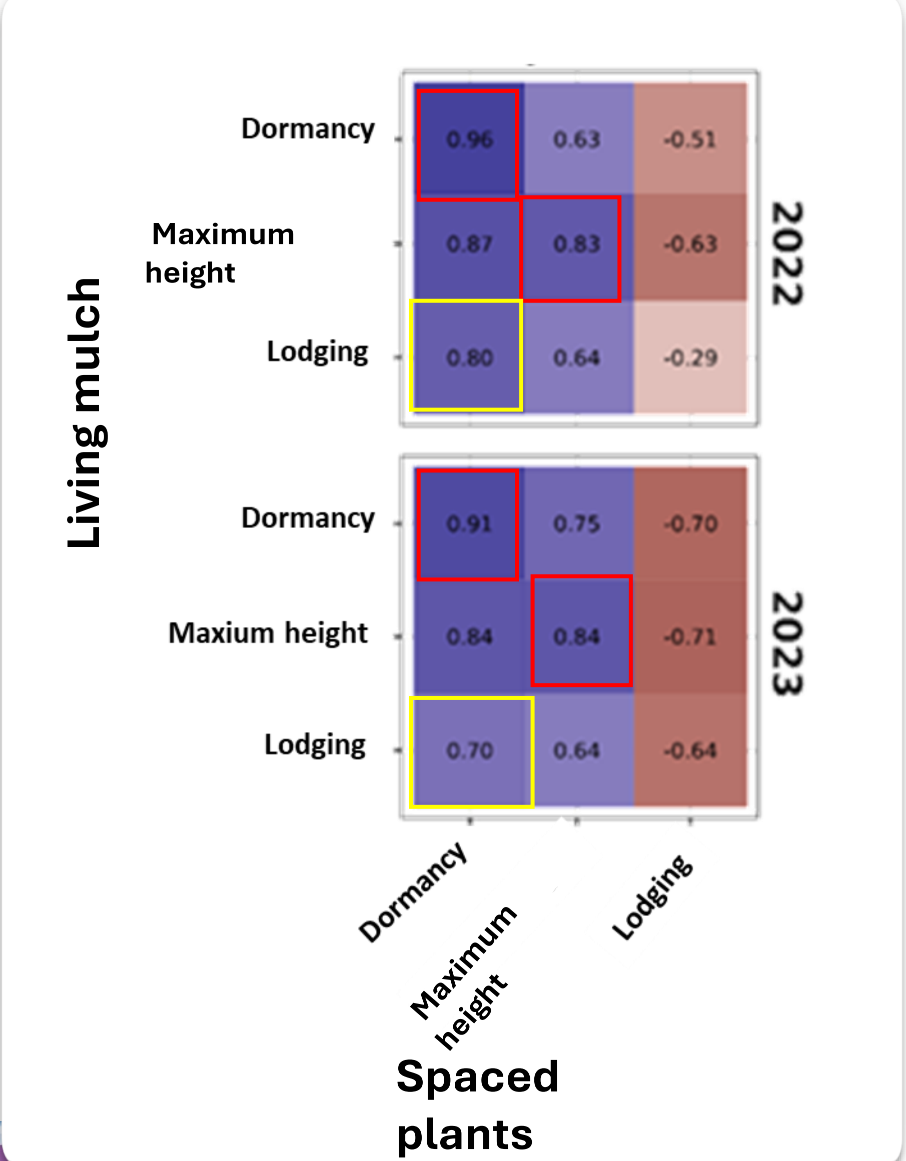
3) Genomic prediction (GBLUP)

1) Lucerne key traits





2) Indirect selection efficiency

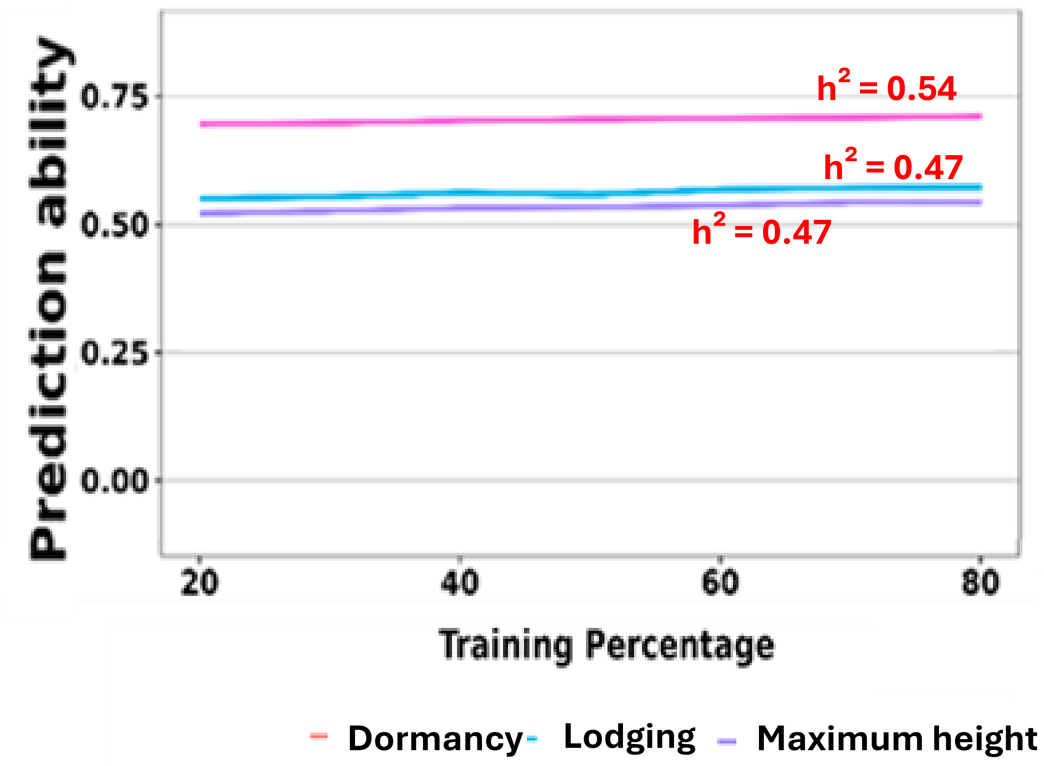


- **Dormancy** and **maximum height** showed a strong genetic correlation between living mulch and spaced design.
- **Breeding implication**: traits can be selected directly in spaced nurseries.

- **Lodging** was not correlated, likely because spaced plants do not capture neighbouring interactions.
- Strong correlation between dormancy in pure stand and lodging in living mulch

Trait-based selection: combining early screening in spaced nurseries with targeted evaluation under living mulch conditions.

3) Genomic prediction



- **Dormancy** showed high predictive accuracy, making genomic selection reliable for this trait.
- **Height** and **Lodging** showed moderate but useful accuracies, remaining effective for early selection in breeding programs.

Genomic prediction can effectively support early selection for key lucerne traits.

✓ Conclusion

- Lucerne as living mulch offers agroecological benefits but current varieties are too competitive

- Ideotype : intermediate autumn dormancy, slow and moderate height, low lodging
- No accession combines all desirable traits, breeding is required

- Breeding should be conducted in a trait-based selection, integrating:
  - Early selection in spaced-plant nurseries for dormancy and height (proxy traits).
  - Evaluation under living mulch conditions for lodging.

- Coupling this approach with genomic prediction will accelerate selection, reduce phenotyping cost, and support the development of lucerne ideotypes adapted to living mulch use

Thank you for your attention