



Interdisciplinary Phenotyping as a Method of Varietal Selection for Lupin in the EU

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Problem

There is growing pressure for self-sufficiency of plant proteins within the EU, and indeed an emphasis on legume crop diversity. Planting underutilised crops such as chickpeas, faba beans, broad beans, and lupins will contribute to maximising protein production across the variety of pedoclimatic zones across the EU.

The lupin cropping area in the EU fell sharply during the late 20th century, in spite of its ability to grow in different climate and soil conditions, including sandy soils. Up to 42 % of farmers reported droughttolerant cultivars as an absolute necessity for an increase in lupin cultivation, illuminating the importance of climate stress-tolerance phenotyping and further breeding efforts. It has been shown that there is a large pool of unexplored genetic diversity in *L. angustifolius* accessions, and thus a potential for further improvement in climate resilience and yield.

Opportunity

- Climate change represents a strong incentive for transformation of the European cropping systems towards more sustainable plant-based protein production for human consumption.
- With the EU currently importing approximately 75% of its plant protein, the focus on plant-based protein production in the EU would strongly contribute not only to lowering its CO₂ footprint, but also to its protein production self-sufficiency as per the recently published EU Protein Plan (see 4.1.7)
- Typical projects focused on evaluating climate stress tolerance on crop performance focus mostly in terms of biomass production, yield components, and plant physiology. However, with legume grains expected to have high protein content as well as capped contents of anti-nutritionals, the target performance becomes more complex.

Solution

In light of the complex target performance of ideal future-proof legume varieties, traditional climate tolerance phenotyping studies must expand their scope. These studies will include the additional dimension of grain nutritional composition, along with physiological and biochemical analyses in response to various abiotic stressors. The interdisciplinary nature of such phenotyping allows for a more nuanced and relevant selection of legume varieties, through a scientific approach more robust and unique to the current phenotyping landscape but which is equally focused on the needs of the food processing industry. The efforts of plant phenotyping have until now primarily focused on plant performance from the perspective of biomass production and physiological functioning. However, a heat stress trial at the Department of Food Science of Aarhus University clearly showed the pronounced varietal effect of supra-optimal temperatures Figure 2C, where the varieties Primabella and Primadonna were more sensitive to heat stress relative to the rest of the tested varieties. Primabella and Primadonna also perform poorly in terms of yield (Figure 2D). A significant reduction in the carbohydrate content in grains of heat-stressed plants relative to controls was also seen (Figure 2E). Notably, Mirabor was the only variety capable of maintaining its grain carbohydrate concentration after heat stress treatment. On the other hand, the grain protein concentration increased substantially as a response to heat stress (Figure 2F). However, only in varieties with sensitive photosynthetic apparatus, Primabella and Primadonna. The rate of CO₂ assimilation showed a strong correlation with the grain carbohydrate and protein concentration at maturity, indicating the viability of physiological and biochemical measurements as predictors of grain nutritional composition (Figure 2G, H).

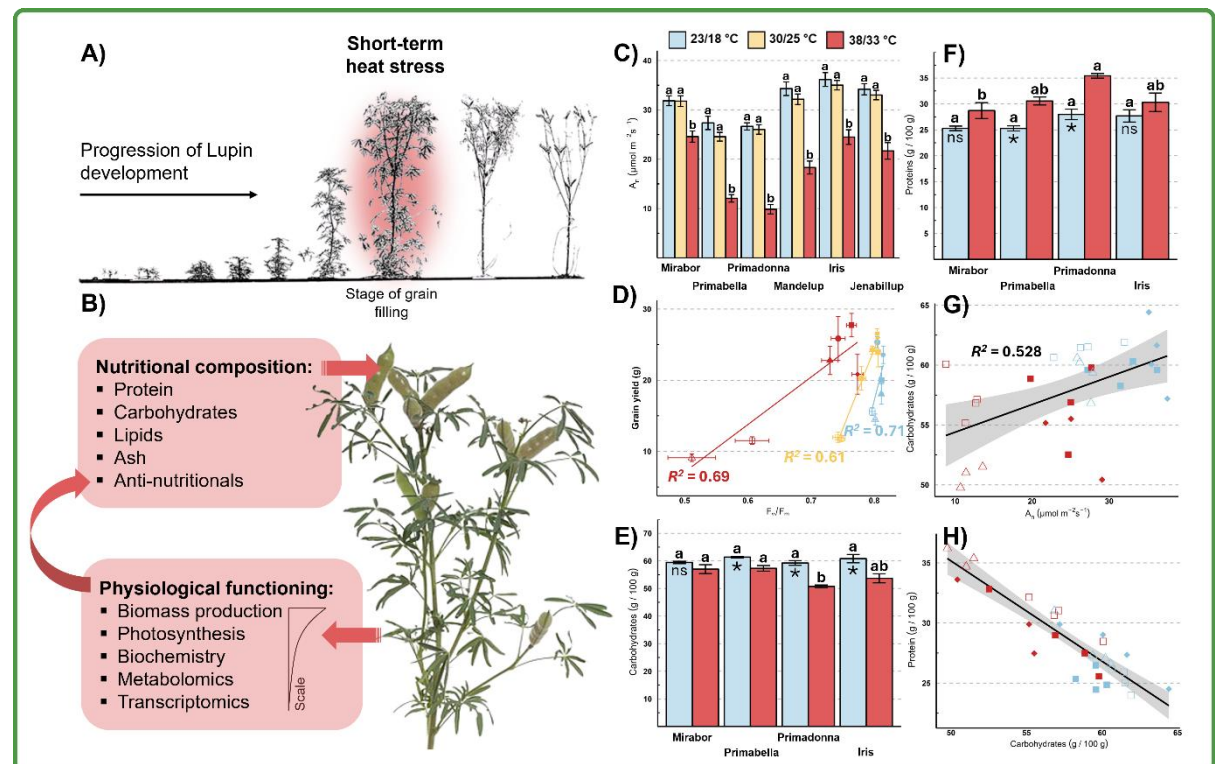


Figure 2. Effect of short-term heat stress on the physiological functioning of *Lupinus angustifolius* and its connection to grain nutritional composition at maturity. A) Progression of *L. angustifolius* developmental phases and timing of the heat stress in a controlled environment. B) Connection between the physiological functioning during stress and the associated downstream effects on yield as well as nutritional composition of grains at maturity. C) An of the six tested varieties in

response to three temperature treatments; the compact letter display (CLD) indicates statistical differences between the temperature treatments within the varieties. D) Relationship between the Fv/Fm and the grain yield, for each of the three temperature treatments and the associated Pearson correlation coefficients (R^2). E) Carbohydrate concentration in grains of control and heat-stressed plants of selected varieties. F) Protein concentration in grains of control and heat-stressed plants of selected varieties. In figures E) and F) the CLD indicates statistical differences between the tested varieties within the treatment, while stars indicate significant differences between treatments within varieties. G) Relationship between the An and carbohydrate concentration in grains of control and heat-stressed plants and R^2 . H) Relationship between the carbohydrate and protein concentration in grains of control and heat-stressed plants and R^2 . In scatter-plots, the varieties are represented by the following symbols: ■ (Mirabor), □ (Primabella), △ (Primadonna), ▲ (Mandelup), ◆ (Iris), ● (Jenabillup).

Benefits

- Varietal selection based on a deep understanding of crop performance under various abiotic stress scenarios, combined with knowledge of the spatial distribution of dominant climate stresses across the EU, can enhance production efficiency and improve yield quality under future climate. This approach can lead to increased agricultural output, providing greater value from the land for EU farmers.
 - Data presented here clearly demonstrate the connection between physiological performance and nutritional composition under both optimal and abiotic stress conditions. Allowing for the development of a robust, interdisciplinary, high-throughput phenotyping protocol.
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Practical recommendations

- Yield Optimisation: Selection of stress-resilient cultivars, based on data from controlled climate trials, will secure a more robust production under future climate.
 - Reliable production of plant protein: Selection of cultivars best suited for regions with different prevailing climate stresses.
 - Improved understanding of the interaction between climate stress, yield and quality is needed to improve the commercial use of lupine.
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Environmental Impact

More robust crops secure a more stable production under fluctuating climate conditions so the losses will be lower.

Weblinks

<https://valpropath.eu/>

https://agriculture.ec.europa.eu/farming/crops/cereals/reducing-plant-protein-deficit-eu_en

<https://www.sciencedirect.com/science/article/pii/S2667064X26000199>

<https://pubmed.ncbi.nlm.nih.gov/40848642/>

About this practice abstract and VALPRO Path

These practice abstracts were elaborated in the VALPRO Path project based on the EIP AGRI abstract format. VALPRO Path, a Horizon Europe project spanning 4 years, from September 2022 until August 2026. With the participation of 22 partners from 9 countries, VALPRO Path is developing fresh possibilities, validating and showcasing ways to enhance plant protein production for food and feed in the EU.



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Project website: <https://valpropath.eu/>