Balancing performance and context

Identifying the 'right' legumes for introduction into a commercial Portuguese dairy farm context

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Introduction:

The EU depends on a limited number of cereal crops and imported soymeal to meet its feed requirements. Locally produced roughage contributes only 21% to the EU feed protein supply, while home-grown pulses contribute just 2%. **There is a need to diversify forage systems and an opportunity to do so with legume-cereal intercrops which are minimally adopted in Europe. There are a diverse array of legume types which may be used as forage, each with their own potential benefits and challenges. Consequently, co-designing experimental intercrops with farmers is critical to identify best-fit solutions for long-term adoption.**

Objective & Aim:

This investigated the codesign process, performance and adoption of legume-based intercrop options relative to conventional cereal/grass mixtures - on a commercial Northern Portugal dairy farm. This aimed to address the research question: *How can legume-based intercrops be introduced to optimise yield, and what lessons can we learn to better connect research and practice to maximise impact?*

Assessment through the RE-AIM framework

A framework for judging whether an intervention fits the context and can last (cf. Glasgow et al., 2019, Payne et al., 2019)

REACH

One Dairy farm - stakeholder context and challenges:

- **Vale de Leandro family run dairy farm:** 495 cows and approximately 40 bulls each consuming 50-53 kg of feed per day
- **Feed:** Grass (triticale & ryegrass) and maize silage grown on 60 ha of dispersed plots (1-3 ha each). Soy purchased to increase feed protein content
- **Challenges:** Wild radish infestation managed through herbicides | Acidic soils | Fertiliser dependence (140 kg.ha^{-1} of 40%N fertiliser) | Imported soy dependence for protein | Increasing seed prices

Pilot study design (proposed intervention): split plots of

- **Reference plot:** mixed field of triticale and ryegrass planted at a density of 60 kg.ha^{-1} (30% Triticale, 50% ryegrass)
- **Monoculture control trial plots:** broadcasted and then turned into the soil before cylinder compression. Sowing rates were:
  1. Triticale: 226 kg.ha^{-1}
  2. Fava: 298 kg.ha^{-1}
  3. White Lupin: 267 kg.ha^{-1}
- **Mixed legume plot:** mixed field of triticale, fava, and white lupin (63, 152, and 152 kg.ha^{-1} respectively i.e. 1764 706, 202 723, and 358 490 seeds.ha^{-1})

Motivations

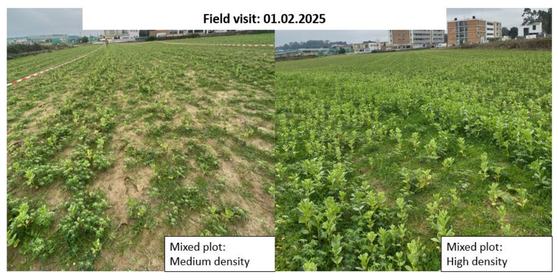
- Triticale intercropping necessary for ensiling
- High nitrogen fixing capacity
- Familiar to Portugal (primarily food)
- Legumes with comparable nutritional profile to soybean and existing proof-of-concept as whole-crop forage for silage

Effectiveness

Physiological performance and yield

Evolving crop stand density

- Broadcast seeding resulted in inconsistent crop stand-density specifically in triticale (observed)
- Fava sustained growth was supported by higher density intercropping



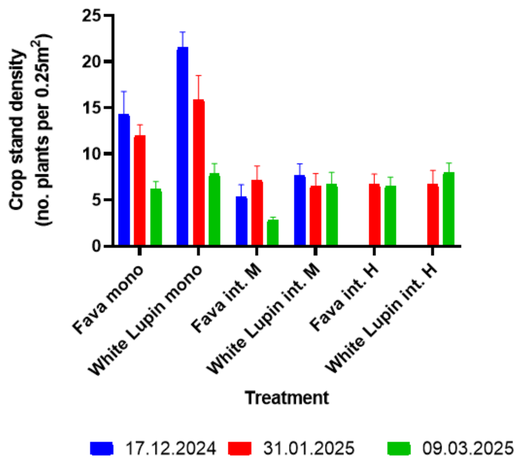


Fig. 1 Legume crop stand density across planting period

Height and SPAD meter readings

- White lupin and triticale showcased improved growth under higher density planting conditions however no significant difference in SPAD meter readings (crop health indicator).
- In contrast, Fava showed poor performance in the lower density intercrop yet higher SPAD meter readings.

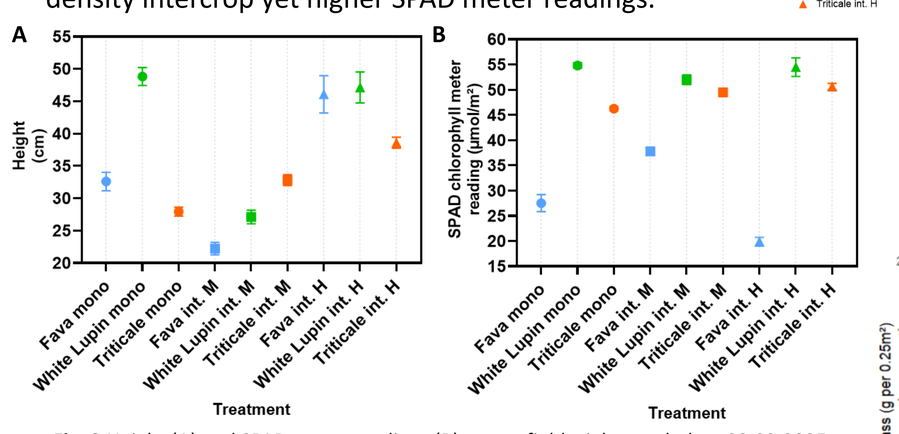


Fig. 2 Height (A) and SPAD meter readings (B) across field trial recorded on 09.03.2025

Nodulation Score (2026 Saskatchewan Pulse Growers)

- High density intercropping improved fava nodulation and consistency in white lupin nodulation

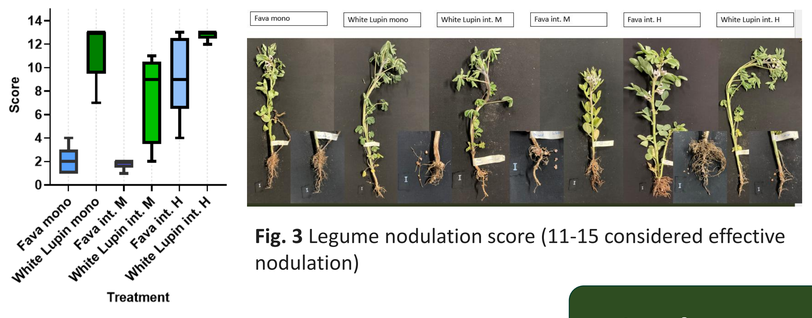


Fig. 3 Legume nodulation score (11-15 considered effective nodulation)

Yield and weed suppression

- Significantly higher yield for the high-density intercrop and monocultured white lupin
- Fava did not last through the season with no presence in the medium density intercropped region at harvest (02.05.2025)

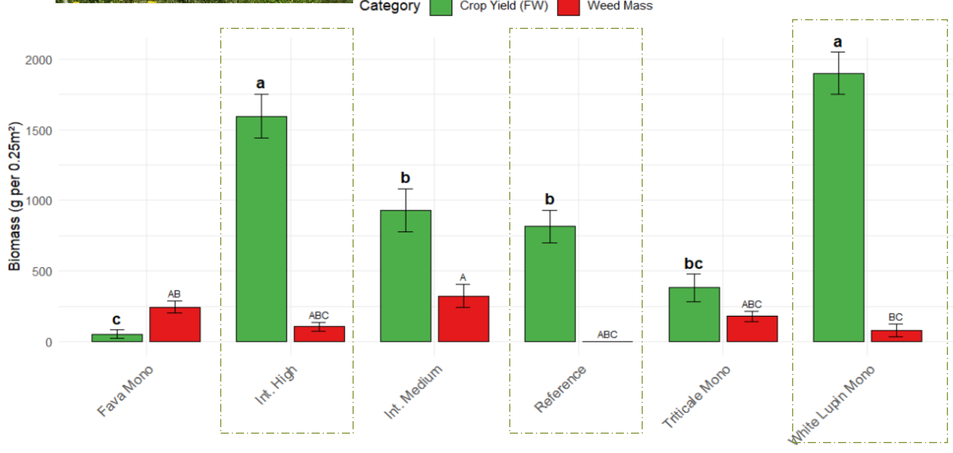


Fig. 4 Target crop biomass and weed infestation per plot (average fresh weight of four sample 0.25 m^2 quadrats)

Adoption

Participatory farmer response

- **Legume forage and silage not usable:** While the yield was high, white lupin fermented poorly and the stems were too tough for the cows to eat
- **Not compatible with existing machinery:** the white lupin, fava, and triticale seeds cannot be drilled (conventional system) due to differing seed size

Implementation

Trial management and constraints

- **Plant cutting prior to baling was not possible due to small area→** high internal stem moisture and poor fermentation
- **No inoculant added to the silage →** poor fermentation
- **Broadcast seeding →** uneven planting density

Maintenance

Would the farmer grow the intercrop again independently?

- **Not at this stage:** there is potential if a larger area is used to facilitate cutting the wholecrop into shorter pieces, and scepticism remains regarding sowing and ensiling.

Conclusions & future prospect

- **Performance:** White lupin outperformed fava indicating potential feasibility for introduction into Vale de Leandro cropping systems.
- **Operational Barriers**: Despite agronomic success, machinery and processing constraints deterred the farmer from future independent adoption.
- **Adaptive Design:** The trial now evaluates two commercial forage legume mixes, incorporating local agronomist expertise to ensure farmer-centric design.
- **Multidisciplinary Necessity: long-term legume adoption requires integrated muti-stakeholder assessment to align scientific goals with 'real-world' operational feasibility. Finding the 'right' solution requires an iterative/flexible approach.**

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