DIVERSify Factsheet no. 5

AGRONOMY

Grassland production systems: traditional plant teams reinvented

ABSTRACT

Many forage production systems are traditionally species-rich and make use of 'plant teams'. However, as with all agricultural systems, they are facing new challenges to achieve sustainable production with fewer inputs and minimised environmental damage. A better understanding of the potential synergistic benefits of plant-plant interactions under environmental constraints will be fundamental to overcoming these challenges.

Below, we describe work in the field in Portugal to compare **complex annual forage mixtures** (4-6 different plant species, comprising legumes and grasses) with their component monocrops. Significant differences in yield and nutritive value among mixtures and components were found. Furthermore, under controlled conditions, significant differences were also detected among mixtures and individual components in root dry weight and photosynthetic performance. The results indicate that forage mixtures can be optimised in relation to species composition and to consider management (single vs multiple cuts).

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PEDO-CLIMATIC ZONE

Mediterranean

INTRODUCTION

Mediterranean grassland productivity and biodiversity are seriously affected by climate change[1]. A better understanding of the potential **synergistic benefits** – that is, the potential for the two or more components to produce a combined effect greater than the sum of their parts – **of plant-plant interactions** under environmental constraints will be fundamental to overcome these challenges. The team at ITQB NOVA Academic Research Institute worked with Fertiprado, a Portuguese seed company that are developing **pasture and forage plant mixtures rich in legumes**, to evaluate the effect of plant-plant interactions on the overall performance of grassland mixtures using traditional and innovative approaches in the field and under controlled conditions.

EXPERIMENTS AND TRIALS OF GRASSLAND MIXTURES

We compared 4 annual forage mixtures (with 4-6 legume and grass spp.), that are produced as biodiverse seed mixes by Fertiprado, against their respective 9 species components monocrops (*Trifolium incarnatum*, *T. michelianum*, *T. suaveolens*, *T. squarrosum*, *T. vesiculosum*, *Vicia villosa*, *Lolium multiflorum* (2n and 4n), *Avena strigosa*, and *Triticosecale*). Two management systems (single vs multiple cuts) were compared. Comparisons also included **controlled experiments** in growth chambers mimicking natural autumn conditions vs. **water limitation, with small pots or mesocosms** (0.15 m^2 pots) (both at ITQB NOVA, in Oeiras), complemented with **field experiments** (at Fertiprado) in the Portalegre region of Eastern Portugal. Field trials were conducted over two years, in a randomised complete block design, in 10m^2 plots. Traditional, e.g., crop biomass, yield and quality, as well as more innovative morphological and physiological trait measurements, such as photosynthesis performance or root architecture, were taken.

Fig. 1 Overview of the field experiment at Vaiamonte (Fertiprado, Portugal) comparing, in small plots, high complexity annual forage mixtures and the respective monocrop components under two different managements (multiple cuts vs. single cut)

YIELDS AND FEED QUALITY

With the most traditional agronomic traits (yield and feed quality) measured under field conditions, we found that:

- A **multi cut system produces less biomass than the single cut, but of higher quality** due to a better final balance among legume and grass species, and progressively better control of weeds.

- Under the **single cut production system, the mixtures yields were better than the legume monocrops** that suffered from a high weed infestation. Under this production system, the mixtures clearly benefited from the presence of the grass spp. which provide better competition with weeds than legumes. This provides further evidence of the potential of intercropping for weed control (more in DIVERSify Factsheet no. 3). The mixture yields were once again found to be **similar to the grass monocrops**.
- Under **multi cut system, mixtures provided very similar yields to clover monocrops** with better regrowing capacity (*T. michelianum* and *T. incarnatum*), and **as much as the grass monocrops**, these ones of much lower quality.
- The best mixture under both production systems (with an average of 7575kg DM/ha for multiple cuts and 12133 kg DM/ha in single cut) was a mixture containing 6 different species components, including *T. vesiculosum*, *T. suaveolens* and *V. villosa* (mixture 2). This mixture was the only one containing *T. incarnatum*.

ROOTS AND PHOTOSYNTHESIS

In the controlled experiments and water limited mesocosms, we found that:

- Root and photosynthesis related traits clearly differentiate among the mixtures and individual species components, with the **mixtures occupying an intermediate position** between legumes and grasses.
- The **aerial / root dry weight ratio was higher among legumes**. A prolific root system may be more advantageous for acquiring water and nutrients especially under deficit situations.
- Legumes, e.g., *V. villosa*, could be further differentiated, as well as the mixtures, by their **diverse root dry weight**. The mixture that showed a large amount of differentiation was the one which performed well under both production systems as described above (mixture 2). We found that *T. incarnatum* has the smallest root system of all other experimental legumes.
- Interestingly, not only *V. villosa* but also *T. vesiculosum*, *T. suaveolens* and more surprisingly, *T. incarnatum* appear as the **most resilient components under water stress**. In *T. incarnatum*, other non-root related traits are likely to contribute to its resilience to drought.
- **Legumes, as well as the best performing mixture (mixture 2), presented higher contents of photosynthetic pigments than grasses.** *T. incarnatum* showed high "chlorophyll a" and "b" contents which may indirectly be contributing to its resilience, as a result of a better predisposition for light capture and enhanced antioxidant capacity during plant stress.

Fig. 2 Two different views of forage mixtures evaluated in small plot and large plot trials

CONCLUSION

Optimisation of diverse grassland mixture composition will be achieved by balancing legume and grass species, and varieties, with complementarities in traits.

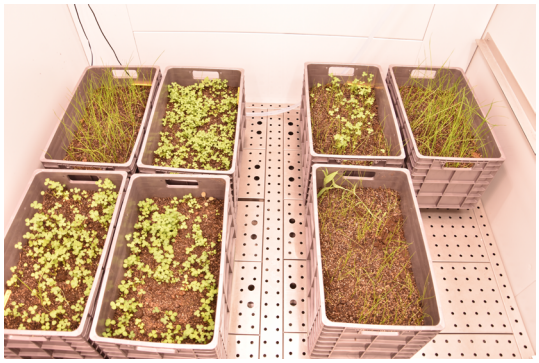

Fig. 3 Mesocosms experiments were conducted under growth chamber conditions at ITQB NOVA (Oeiras, Portugal) to compare high complexity annual forage mixtures and the respective monocrop components

Improvement of annual forage biodiverse mixtures for an optimal use in crop rotations must consider the associated management system (single vs. multiple cuts) taking into account the final species balance (legumes vs. grasses) as this is highly correlated with feed quality (% crude protein vs. % crude fibre).

Considering the increased frequency of extreme weather events in Mediterranean environments, such as drought, bigger and diverse root architecture/biomass as well as photosynthetic related parameters tested under limited water conditions, are likely to lead to increased resilience without reducing yield or nutritional quality.

REFERENCES

1. Henkin Z. *et al.* (2010) Vulnerability of Mediterranean grasslands to climate change: What can we learn from a long-term experiment? Options Méditerranéennes. Series A – Mediterranean Seminars 92:167–174.

FURTHER INFO

> Read on to discover more about how intercropping can contribute towards increased stress resilience and ecosystem service provision: DIVERSify Factsheet no. 6 - DIVERSify Factsheet no. 7 - DIVERSify Factsheet no. 8

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