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in

López-Francos A. (ed.), Jouven M. (ed.), Porqueddu C. (ed.), Ben Salem H. (ed.), Keli A. (ed.), Araba A. (ed.), Chentouf M. (ed.).
Efficiency and resilience of forage resources and small ruminant production to cope with global challenges in Mediterranean areas

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 125

2021
pages 271-275

Extending forage production using mixtures in a Mediterranean rainfed environment

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Abstract. Forage mixtures based on perennial grasses and legumes have a considerable interest for farmers in Mediterranean rainfed livestock systems, in order to extend the grazing season and establish temporary grasslands. Currently, in South European rainfed farming systems based on annual forage crops, some gaps in forage availability are experienced during early autumn and late spring. With the aim to assess dry matter production and forage availability along seasons and years, forage mixtures based on lucerne and perennial grasses (tall fescue and cocksfoot) were tested for three years in an experimental field in Sassari (Italy). The erect type of lucerne, both in pure stands and in binary mixtures, showed the highest productions among treatments (up to 12 t of dry matter per year). It also had the best seasonal forage distribution, being able to grow during the summer in rainfed conditions and during winters characterised by mild temperatures.

Keywords. Perennial legume-grass mixtures – Lucerne – Tall fescue – Cocksfoot – Forage yield – Drought tolerance.

Étendre la production fourragère avec des mélanges légumineuses-graminées en conditions pluviales méditerranéennes

Résumé. *Les mélanges fourragers à base de graminées et de légumineuses pérennes ont un intérêt considérable pour les agriculteurs dans les systèmes d'élevage pluvial méditerranéen, pour prolonger la saison de pâturage. À l'heure actuelle, dans les systèmes d'agriculture pluviale d'Europe du Sud fondés sur les cultures fourragères annuelles, certaines lacunes dans la disponibilité des fourrages sont présentes au début de l'automne et à la fin du printemps. Dans le but d'évaluer la production de matière sèche et la disponibilité de la biomasse au fil des saisons et des années, des mélanges de fourrage à base de luzerne et de graminées pérennes (fétuque élevée et dactyle) ont été testés pendant trois ans dans un champ expérimental (Sassari – Italie). Le type érigé de luzerne, à la fois dans les peuplements purs et dans les mélanges binaires, a montré les productions les plus élevées parmi les traitements (jusqu'à 12 t de matière sèche par an). Il a également montré la meilleure distribution saisonnière du fourrage, étant capable de croître pendant l'été dans des conditions pluviales, ainsi que durant les hivers doux.*

Mots-clés. *Mélanges de légumineuses-graminées pérennes – Luzerne – Fétuque élevée – Dactyle aggloméré – Rendement fourrager – Tolérance à la sécheresse.*

I – Introduction

In Mediterranean rainfed livestock systems, the use of annual forage crops for grazing is common. In these systems, some gaps in forage availability are present in late spring, summer and early autumn. Growing forage mixtures based on perennial grasses and legumes is one of the available strategies to reduce the forage gap during critical seasons. In fact, grasses are able to produce forage in early autumn, after the first rains, and perennial legumes, i.e. lucerne, boost forage production in late spring and summer. Unfortunately, there is scarce availability of suitable materials for grazing, and of germplasm adapted to drought-prone environments (Porqueddu *et al*., 2016). The objective of our study was to assess the performances of perennial grass-lucerne mixtures based on improved native grass and legume species and varieties in a drought-prone environment in Sardinia.

II – Materials and methods

The field trial was established in October 2013 in the experimental field of CNR-ISPAAM (latitude; 40° 46' N; longitude: 8° 28' E) in Sassari (Sardinia, Italy). The climate of the area is typically Mediterranean with mild winter, characterized by a long-term average annual rainfall of 554 mm, prevailingly distributed in the autumn and winter months, and a mean annual air temperature of 16.2 °C. The soil is alluvial and calcareous, with pH 7.4.

A completely randomized block design with four replications was used. Plots measured 3 x 4 m. Grazing– and drought– tolerant accessions of lucerne ('*Surigheddu*' or L1, erect type; '*Bulk*' or L2, semi-erect type) and grasses (cocksfoot cv '*Kasbah*' or C, true summer dormant type; tall fescue cv '*Flecha*' or F, incompletely summer dormant type) were tested. Their binary (L1C, L1F, L2C, L2F) and 4-component (L1L2CF) mixtures were compared to their respective monocultures (L1, L2, C, F) for dry matter yield (DMY). The seed rates were 25 kg ha^{-1} in lucerne monocultures, 30 kg ha^{-1} in grasses monocultures, half the amounts of each component in binary mixtures and a fourth in the 4-component mixture. In the year of establishment, only one cleaning mowing was carried out. Seasonal cuts were carried out in 2014-2015 (year 1), 2015-2016 (year 2), and 2016-2017 (year 3). The first cut was carried out when lucerne was at the full blooming stage, the following cuts every month. Samples of forage were taken from 2 quadrats (1 m^2 each) in each plot. Samples were weighted and dried up to constant weight in a ventilated oven. The DM was then calculated.

Data were analysed by multifactorial ANOVA. Means were discriminated by the Tukey test ($P<0.05$).

III – Results and discussion

Total rainfall (from September to August of each season) was 469 mm, 418 mm and 436 mm, in year 1, year 2 and year 3, respectively. These values were always below the average annual rainfall. Rainfall was unevenly distributed in the different seasons, with dry and mild winters. Drought lasted at least five months, from April or May to September or October (Figure 1). The average value of mean temperatures in the spring months (March-April) increased from 2014 to 2016 (11.8, 12.2 and 12.4 °C, respectively). This was mainly due to the increase in maximum temperatures (18.3, 19.3 and 20 °C, respectively) while minimum temperatures were similar in 2014 and 2015 (5.2 and 5.3 °C) and lower in 2016 (4.7 °C).

Annual DM yield ranged from 6.9 to 12.7 t ha^{-1} year^{-1} in mixtures, from 7.3 to 11.5 t ha^{-1} year^{-1} in lucerne monocultures, and from 3.5 to 7.1 t ha^{-1} year in grass monocultures. Non statistically significant interactions were found between year and sward type (Table 1). This means that sward productions were almost constant for each treatment during the three experimental years. For this reason, DMYs are reported as three-years DMY averages (Figure 2).

Table 1. Analysis of Variance (F values and significance) for the effects of crop and year and their interactions for sown DMY

Source of variation	F-Ratio
Sward type	22.67***
Year	2.72^{ns}
Sward type x Year	0.48^{ns}

*** = $P<0.001$; ns = not significant.

Several differences were found for DMY among treatments. In pure stands, L1 performed better than L2. DMYs were higher, on average, for Tall fescue F than for cocksfoot C. The latter showed the lowest DM yield among all plots and treatments.

Mixtures based on lucerne L1 showed higher DMYs than L2-mixtures, reaching similar DMYs than L1-pure stands. The L1L2CF mixture yield was statistically similar to L1, L1C and L2F.

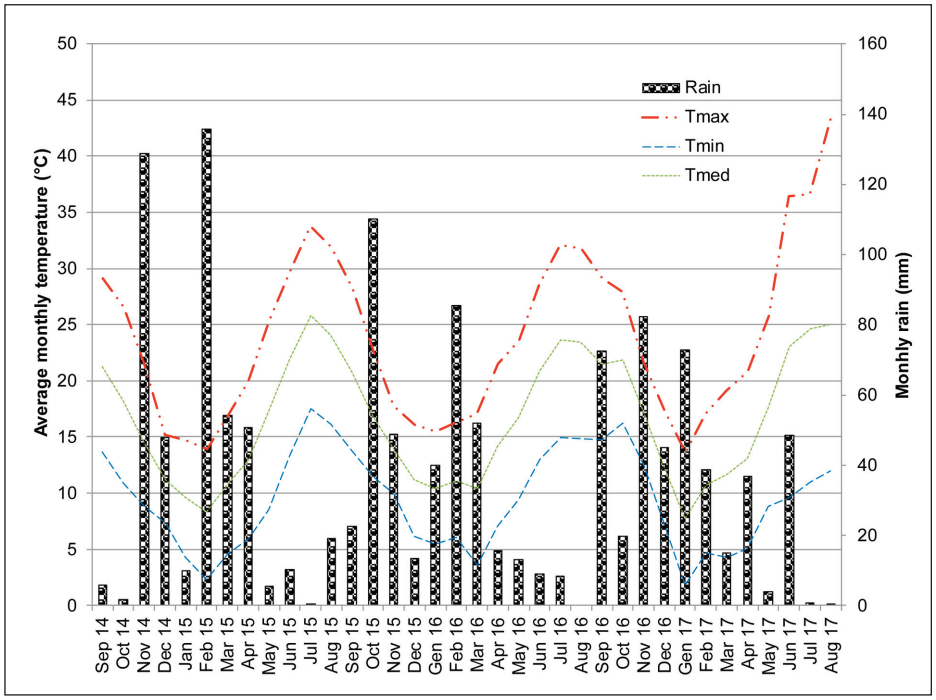

Fig. 1. Meteorological pattern during the three-year experiment.

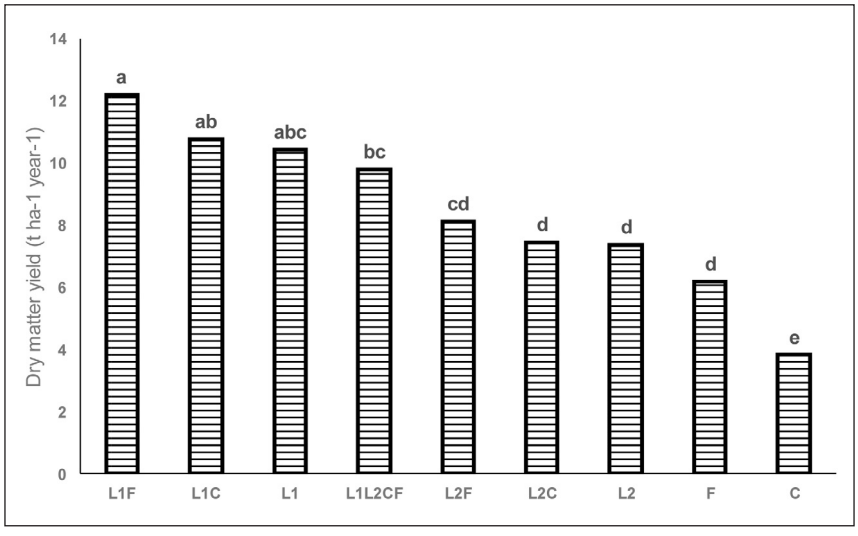

Fig. 2. Three-year average annual DM yield of lucerne and grasses in pure stands and mixtures. Means with same letters are not different at 5% level.

The distribution of forage production among seasons was different in the three experimental years and treatments (Figure 3). L1 produced some DM during the milder winters (year 1 and 2). The contribution of the winter yield was about 30% of the entire annual production of the plot in year 2. Unfortunately, cuts were not carried out in the subsequent spring due to the insufficient forage production. This was shown also in plots where L1-based mixtures were cultivated. Lucerne L2 did not grow in the winter, except for a small forage production in year 1, its growth was mostly concentrated in spring and summer. On average, lucerne monocultures showed the lowest productions in autumn (0.9 t ha^{-1}), when grasses showed the best DMYs (2.3 t ha^{-1}). Despite this, the lucerne-based binary mixtures with F showed similar yields to grasses pure stands (2.4 t ha^{-1}). In winter, no differences were found for DMYs among pure stands and mixtures (1.1 t ha^{-1} in average). In summer, the highest yield was shown by L1 (4.5 t ha^{-1}) and its binary mixtures (4.3 t ha^{-1}), followed by the L1L2CF mixture (3.46 t ha^{-1}) and L2 (3.4 t ha^{-1}) and its binary mixtures (2.2 t ha^{-1}).

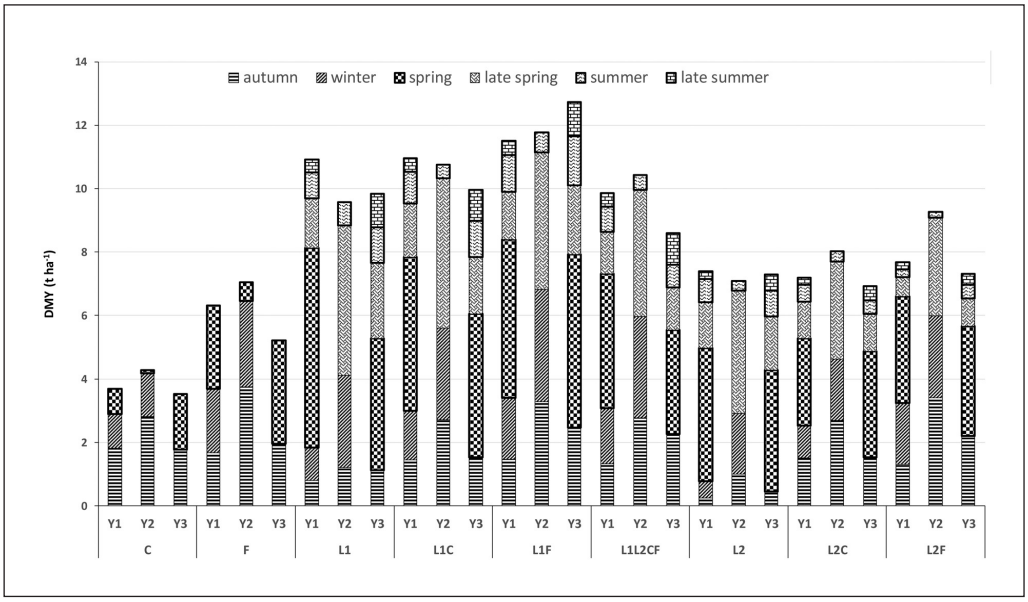

Fig. 3. DM yield distribution in each season and experimental year of pure stands and mixtures of lucerne and grasses.

IV – Conclusions

The potential agronomic advantages of sowing mixtures of forage species and cultivars were confirmed, the main reasons being (i) stabilization of forage production within and between seasons; (ii) achieving a more sustainable grassland management. Moreover, grasses can utilize the nitrogen symbiotically fixed by legumes when grown in mixtures with them, leading to increases also in forage protein yield. Mixtures of summer-dormant and summer-active perennial species provide an opportunity for stable grassland mixtures by exploiting available soil moisture throughout the year (Norton *et al*., 2012). In the plains and low hills with good arable lands of northern Mediterranean basin under rainfed conditions (>450-500 mm), the use of mixtures based on drought-tolerant lucerne and summer dormant perennial grasses improved the seasonal distribution of forage production, increasing the availability of forage during summer and extending the grazing season. Moreover, mixtures are adapted to a mixed use, being suitable for grazing in autumn-winter and for harvesting to produce hay in the spring-summer months.

Acknowledgments

The authors are grateful to the Italian Minister of Agriculture for funding the ARIMNET project REFORMA and the research described in this paper.

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