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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 551-554

Comparative evaluation of winter forage legumes under Mediterranean rain-fed conditions

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Abstract. Forage production of adequate quantity of the proper quality is a timeless goal for ruminant production farming systems. Climatic conditions in semi-arid Mediterranean areas set a limit to this goal. With the aim to evaluate a range of forage legumes a trial was set up at the Agricultural University of Athens, where seeds were sown in a randomized design with two replicates. Forage species sown were: *Trifolium spumosum* (cv Bartolo), *Trifolium hirtum* (cv Hykon), *Trifolium dasyurum* (cv Sothis), *Trifolium glanduliferum* (cv Prima), *Trifolium michelianum* (cv Paradana), *Trifolium subterraneum* (Dalkeith), *Biserulla pelecinus* (Cashbah), *Ornithopus sativus* (Margurita), *Ornithopus compressus* (Santorini) *Medicago polymorpha* (Cavalier, Scimitar), *Medicago littoralis* (Angel). Quantity and quality characteristics (ash, crude protein, crude fiber as well as NDF and ADF contents) of the forage produced were recorded. It was observed that *M. polymorpha* (Scimitar) and *Trifolium dasyurum* (cv Sothis) were the most competitive against weeds and productive in forage DM, while nutritional characteristics were similar between species. It was concluded that productivity and competitiveness of a forage species (or cultivar) is a crucial factor for the production of rain-fed forage material of adequate quality under Mediterranean conditions.

Keywords. Forage legumes – Rain-fed crops – Harsh conditions – Nutritional quality.

Évaluation comparative des légumineuses fourragères d'hiver dans des conditions pluviales méditerranéennes

Résumé. *La production de fourrage en quantité suffisante et de qualité appropriée est un objectif intemporel pour les systèmes de production de ruminants. Les conditions climatiques dans les zones Méditerranéennes semi-arides limitent cet objectif. Dans le but d'évaluer une gamme de légumineuses fourragères, un essai a été mis en place à l'Université d' Agriculture d'Athènes, où des graines ont été semées de manière aléatoire, avec deux répétitions. Les espèces fourragères semées étaient:* Trifolium spumosum *(cv Bartolo),* Trifolium hirtum *(cv Hykon),* Trifolium dasyurum *(cv Sothis),* Trifolium glanduliferum *(cv Prima),* Trifolium michelianum *(cv Paradana),* Trifolium subterraneum *(Dalkeith),* Biserulla pelecinus *(Casbah),* Ornithopus sativus *(Margurita),* Ornithopus compressus *(Santorini),* Medicago polymorpha *(Cavalier, Scimitar),* Medicago littoralis *(Angel). Les caractéristiques quantitatives et qualitatives (cendres, protéines brutes, fibres brutes ainsi que les teneurs en NDF et en ADF) du fourrage produit ont été recueillies. Il a été observé que* M. polymorpha *(Scimitar) et* T. dasyurum (cv Sothis) *étaient les plus compétitives contre les mauvaises herbes et productives en matière de MS fourragère, alors que les caractéristiques nutritionnelles étaient similaires entre les espèces. Il a été conclu que la productivité et la compétitivité d'une espèce fourragère (ou d'un cultivar) est un facteur crucial pour la production de matériel fourrager pluvial de qualité adéquate dans des conditions Méditerranéennes.*

Mots-clés. *Légumineuses fourragères – Cultures pluviales – Conditions difficiles – Qualité nutritionnelle.*

I – Introduction

Livestock in Mediterranean areas, mainly sheep and goats, constitutes a major source of income for the rural population and contributes greatly to farmers' family subsistence through their products (meat, milk, skins wool etc.). They provide a range of ecosystem services such as support of biodiversity, protection of water and soil resources, recreational values, carbon sequestration, to list a few (Varela and Robles-Cruz, 2016). Although an important source of feed for these animals

is the grazed material of extensive rangelands, cereal straw and stubble, as well as grains cropped locally do so too (Porqueddu *et al*., 2017). However, there is often a shortage of good quality forage feed and in particular of protein content. Sown swards can effectively supply a substantial part of the productive ruminant's nutritional requirements. Moreover, the growing market for organic products is guiding animal farmers to increase the availability of grazed material (Doyle and Topp, 2003). This is more important in Mediterranean areas where pedoclimatic conditions are often marginal (Hadjigeorgiou, 2011).

Such shortages can be mitigated by cropping legume species adapted to drought and poor soils and integrating them into the mixed crop-livestock or agro-pastoral farming systems, as multi-purpose crops, to improve seasonal supply of quality feed and soil productivity (Baxevanos *et al*., 2017). Concrete knowledge of the cultivation and utilization of leguminous forages (either through grazing or as preserved feed) has increased greatly over the last few decades in temperate regions. Progress in plant selection and improvement has led to new species and advanced varieties of leguminous forages as well as the economic dimension of the cultivation of forage legumes has also been more fully understood (Rochon *et al*., 2004). Mediterranean climatic conditions and the poor soils are known to hamper productivity of conventional temperate species crops (Porqueddu *et al*., 2017). The information gap on growing efficiently forage legumes in Mediterranean is still large and the scientific basis for information is relatively inadequate to give practical advice on the whole range of farming cases (Gintzburge & Le Houerou, 2002; Ates *et al*., 2012) therefore new knowledge has to be added. A comparative study was undertaken to test, under marginal pedoclimatic conditions, forage legume germplasm of Mediterranean origin, which was mostly selected and produced in Australia.

II – Materials and methods

1. Growing the legume forages

At the Agricultural University of Athens (N 37º59'10'', E 23º42'29'', altitude 24 m a.s.l.), a comparative test was carried out, through a randomized two repetition design, which included 12 legume forage species and varieties thereof. The species tested (cultivar in parenthesis) were: *Trifolium spumosum* (Bartolo), *Trifolium glanduliferum* (Prima), *Trifolium michelianum* (Paradana), *Trifolium hirtum* (Hykon), *Trifolium subterraneum* (Dalkeith), *Trifolium dasyurum* (Sothis), *Biserulla pelecinus* (Cashbah), *Ornithopus sativus* (Margurita), *Ornithopus compressus* (Santorini) *Medicago polymorpha* (Cavalier, Scimitar), *Medicago littoralis* (Angel). Plots of 2.25 m^2 area (1.5 x 1.5 m), separated by corridors of 0.5 m were sown on 30/11/2017, with a density of about 200 seeds m^{-2}, after fine surface soil preparation and a light P_2O_5 fertilization. No herbicides or irrigation was applied on this trial.

2. Analytical methods

Forage material was harvested during mid-May 2018 from an area of 0.25 m^2 at the centre of each plot and dried at 60 ºC for 48 hours. Forage quality was assessed on the dried material after it was pre-ground with a hammer mill to pass a 6 mm sieve and then finely ground on a laboratory mill using a 1 mm screen. Analyses were conducted for moisture (AOAC method 930.15), crude protein concentration (CP) by the Kjeldahl method (AOAC method 984.13), ash content (Ash) by ashing overnight at 550º C (AOAC method 942.05), crude fiber (CF), Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) on an ANKOM 220 (AOAC 978.10, AOAC 2002:04 and AOAC 973.18, respectively).

3. Statistical analysis

All data were subjected to a one-way Analysis of Variance (ANOVA) and Least Significant Difference (LSD) at 0.05 level was applied to define significantly different means among the species. Statgraphics Centurion 16 statistical package was used for this task.

III – Results and discussion

The soil on the site was characterised of a light type (SL), with low organic matter (OM) and Total N, alkaline (pH: 7.84) with high Ca. In fact Soil characteristics of the area were analysed as follows: pH 7.84, organic matter (OM) 1.48%, total nitrogen 0.243 %, $CaCO_3$ 26.2 %, phosphorus (P) 15.69 ppm, potassium (K) 180 ppm. Climatic conditions were characterised by low rain (230 mm during growth period) and mild air temperatures (no frost, an average of 10ºC at start and 25ºC at the end of trial, while average temperature during the whole period was maintained at 15.3ºC.

Table 1. Legume forage DM production and the crude chemical composition (Ash, crude protein, crude fiber and the fiber fractions (NDF, ADF), for the species tested (g/ 100 g of DM)

Species and varieties trialed	Herbage (g DM/m^2)	Ash (% DM)	CF (% DM)	NDF (% DM)	ADF (% DM)	CP (% DM)
Biserulla pelecinus (Cashbah)	411.2^{cd}	9.75^{ab}	27.55^{ab}	45.85^{bc}	29.98^{a}	11.85^{ab}
Medicago littoralis (Angel)	307.2^{abc}	9.89^{ab}	36.60^{f}	61.42^{g}	36.42^{de}	11.19^{ab}
Medicago polymorpha (Cavalier)	377.8^{c}	7.86^{a}	30.18^{cd}	51.21^{de}	33.62^{c}	10.63^{ab}
Medicago polymorpha (Scimitar)	722.0^{e}	7.60^{a}	28.08^{bc}	49.56^{cd}	31.81^{b}	11.52^{ab}
Ornithopus compressus (Santorini)	197.5^{ab}	14.46^{c}	26.72^{ab}	50.87^{d}	29.75^{a}	13.15^{bc}
Ornithopus sativus (Margurita)	182.7^{ab}	11.07^{abc}	28.64^{bc}	41.65^{a}	37.52^{ef}	8.67^{a}
Trifolium dasyurum (Sothis)	527.7^{d}	7.74^{a}	33.29^{e}	55.68^{f}	35.92^{d}	13.88^{bc}
Trifolium hirtum (Hykon)	185.2^{ab}	8.38^{ab}	32.18^{de}	55.29^{ef}	34.19^{c}	12.85^{bc}
Trifolium glanduliferum (Prima)	324.5^{bc}	8.82^{ab}	32.22^{de}	55.60^{f}	37.87^{f}	10.56^{ab}
Trifolium michelianum (Paradana)	415.3^{cd}	9.77^{ab}	27.67^{ab}	51.57^{def}	29.09^{a}	12.33^{b}
Trifolium subterraneum (Dalkeith)	174.6^{a}	12.10^{bc}	25.52^{a}	44.03^{ab}	29.11^{a}	11.96^{ab}
Trifolium spumosum (Bartolo)	395.9^{cd}	9.81^{ab}	28.81^{bc}	51.81^{def}	32.08^{b}	16.27^{d}
s.e.	13.6	0.365	0.232	0.389	0.131	0.337
P	0.0001	0.0634	0.0000	0.0000	0.0000	0.0542

The earliest flowering species were *Medicago littoralis* (Angel) and *Medicago polymorpha* (Scimitar and Cavalier) which started at 105 days. The herbage DM produced, on day 160, by each of the 12 legume forages varied widely between species. *Medicago polymorpha* (Scimitar) was the most productive, followed by *Trifolium dasyurum* (Sothis) (Table 1). At the same time *Trifolium subterraneum* (Dalkeith), *Trifolium hirtum* (Hykon) and *Ornithopus sativus* (Margurita) produced the least, thus demonstrating the vulnerability of the system.

Herbage nutritional characteristics varied also widely between species. CP content was higher for *Trifolium spumosum* (Bartolo), followed by *Trifolium dasyurum* (Sothis) and *Ornithopus compressus* (Santorini). An opposite pattern was observed for CF, NDF and ADF contents. The different legume forages matured at different times, while at sampling time not all species crops were at full maturation, therefore such differences are naturally expected.

IV – Conclusions

All legume forages tested produced hay of good quality for feeding of small ruminants, although at a range of productivity. However, some of them did mature quite early, which resulted in becoming able to complete their life cycle before drought period. It is advisable to try to persuade farmers testing new species in an effort to shift their crops to those that are more productive and to confront the adverse effects of the climate change phenomenon through fast growing species tolerant of warm weather.

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