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in

Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.).
New approaches for grassland research in a context of climate and socio-economic changes

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102

2012
pages 87-92

Competition in an alfalfa-tall fescue mixture under Mediterranean conditions

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Abstract. The focus of the current study was to evaluate the competitive ability of two forage species (alfalfa- *Medicago sativa* L., and tall fescue- *Festuca arundinacea* Schreb.) grown in dry and disturbed soils either in mixture (1:1) or in monocultures, for capture of sunlight. Two levels of water regimes were used: a) frequent irrigation by sprinkler to the point of field capacity and b) no irrigation (drought) conditions. The plants were cut in about 20 day time intervals, at height of 7 cm above soil surface. Measurements of the leaf area and the dry weight of leaves and stems were conducted during two successive growing seasons, and the leaf area ratio (LAR), the leaf weight ratio (LWR) and the leaf area index (LAI) were calculated. Our results showed that: mixture reduced significantly LAR and LAI of alfalfa only under irrigation, while these indices were unaffected in tall fescue; under both water regimes, the alfalfa LAI was higher to the corresponding tall fescue LAI; drought and mixing did not affect LWR, which remained higher in tall fescue compared to alfalfa during the season of experimentation. We conclude a lower competition ability of alfalfa to tall fescue under irrigation and therefore lower productivity.

Keywords. Alfalfa – Tall fescue – Competition – Mixture – Leaf area.

La concurrence dans une mélange de luzerne et de fétuque élevée dans des conditions méditerranéennes

Résumé. *L'objectif de cette étude était d'évaluer la capacité concurrentielle de deux espèces fourragères (luzerne-* Medicago sativa *L., et fétuque élevée-* Festuca arundinacea *Schreb.) cultivées dans des sols secs et perturbés, soit en mélange (1:1) soit en monoculture, pour la capture de la lumière solaire. Deux niveaux d'approvisionnement en eau ont été utilisées: a) irrigation fréquente par aspersion au point de la capacité au champ, et b) aucune condition d'irrigation (sécheresse). Les plantes ont été coupées à un intervalle de 20 jours environ, à hauteur de 7 cm au-dessus de la surface du sol. Les mesures de la surface foliaire et du poids sec des feuilles et des tiges ont été menées au cours de deux saisons successives, et ils ont été aussi calculés le ratio surface foliaire (LAR), la proportion du poids des feuilles (LWR) et l'indice de surface foliaire (LAI). Nos résultats ont montré que: le mélange a réduit de manière significative le LAR et le LAI de la luzerne en irriguée, tandis que ces deux indices ne sont pas influencés chez la fétuque élevée; dans les deux régimes hydriques, le LAI de la luzerne était plus élevé par rapport à la fétuque, la sécheresse et le mélange n'a pas influencé LWR , qui est resté plus élevé chez la fétuque élevée par rapport à la luzerne au cours de la saison de l'expérimentation. Nous concluons que la luzerne a une capacité inférieure de concurrence par rapport à la fétuque élevée sous l'irrigation, et pour cette raison la productivité est plus faible.*

Mots-clés. *Luzerne – Fétuque élevée – Concurrence – Mélange – Surface foliaire.*

I – Introduction

In the Mediterranean areas, the use of legumes in mixtures in degraded lands and under variable conditions could be essential to achieve persistent and high quality pasture swards (Porqueddu *et al*., 2004). The long-term usefulness of a grass-legume mixture depends on the ability of each species to persist in the mixture. Compatibility of grasses with legumes depends on

their morphological and physiological characteristics (Springer *et al*., 2001). Ecological conditions such as the abiotic environment, herbivory, and the presence, absence or identity of neighbors alter the morphological phenotypes of plants. This phenotypic plasticity alters the sign and magnitude of interactions among plants (Callaway *et al*., 2003).

The main resources, for which species compete, are water in dry environments and light in humid environments. Differences in the ability of the partner species to capture the sunlight could explain the competitive ability of the species in the mixture. This ability mainly depends on leaf area of the plant, which is considered an important factor of canopy photosynthesis and therefore, the main determinant of its growth rate (Barnes *et al*., 1990). Leaf characteristics are strongly influenced by neighbors. The presence of interspecific neighbors may lead to differences in growth and allocation patterns of plants in mixtures as compared with monocultures. Leaf area could be described in terms of leaf area ratio (LAR), leaf area index (LAI) and leaf weight ratio (LWR), which shows the biomass allocation to leaves (Callaway *et al.,* 2003; Poorter *et al*., 2009).

This study assesses the leaf area expansion as a response to species interactions in a field grown alfalfa/tall fescue binary mixture subjected to drought.

II – Materials and methods

The field experiment was conducted in the farm of Tobacco Institute of Drama, Northern Greece (41°09'N, altitude 130 m above sea level. The climate of the area is semi-arid with a mean annual temperature of 15.2°C and mean annual precipitation of 589 mm. The soil was degraded, the textural class was silt loam and at establishment of the experiment the pH was 7.6. The used species were *Festuca arundinacea Schreb.* cv festorina (tall fescue), sown by seeds introduced from USA and *Medicago sativa* v. Yliki (alfalfa), sown by seeds produced in the Institute of Forages of Larisa (Greece).

Monocultures and binary mixture of the two species, in proportionality 1:1, were established in autumn. The sowing rate was 4 g m^{-2} for alfalfa, 4.5 g m^{-2} for tall fescue and the half of them for the mixture. The sowing was expanded around the plot to avoid edge effect. A fertilizer, containing 22% N and 11% P_2O_5, was applied once just before sowing. Herbicides were not used during the experiment and the weeds were removed by hand.

The experimental area was separated in two field areas in a distance of 5 meters, each of them representing one watering treatment. In both field areas the design was completely randomized with four replicates for each treatment. All stands were irrigated until the plants were well established. After the first cut in spring, two water regimes were applied: a) irrigation by sprinklers to maintain field capacity (I); b) rainfed, the most of the period the plants were grown under drought (R). The plants were cut at 7 cm from the soil surface. Cutting was applied when the first inflorescences appeared, at about 20 day intervals (four to five cuttings in the measuring season). Thus, we had the following treatments: FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture.

The cut plant material of the entire plot (1mx1m) was hand-separated in the two component species and weighed; samples of each species from monocultures and mixtures were separated in leaves and stems. The leaf area was measured by an Area Measurement System (Delta-T-Devices). The leaves and stems were oven dried at 75°C for 48 hours and weighted. The Leaf Area Ratio (LAR), as leaf area per above ground dry biomass of plant, in $dm^2\ g^{-1}$; the Leaf Area Index (LAI), as leaf area per soil surface, and the leaf weight ratio (LWR), as leaf weight per above ground dry biomass of plant, were also calculated for each cut data.

Measurements were repeated for two successive years (1996-1997), from April to July, when yields of rainfed plots approximated zero.

III – Results and discussion

Leaf area ratio (LAR), an index of photosynthetic area to total above ground plant tissues, is illustrated in Fig. 1. Tall fescue presented higher LAR during summer in relation to spring months, which probably is associated with the leaf weight ratio (LWR) (Fig. 2). During the same period, alfalfa presented lower LAR, which contributes to transpirational surface reduction. The effect of drought (rainfed conditions) on LAR is not clear. This result differs from other publications, which report reduction of the LAR under drought (Poorter *et al.,* 2009). Moreover, in a previous publication it was shown that under the same conditions and under more intensive cutting (at 3 cm height) drought reduced LAR in both species (Lazaridou and Noitsakis, 2002).

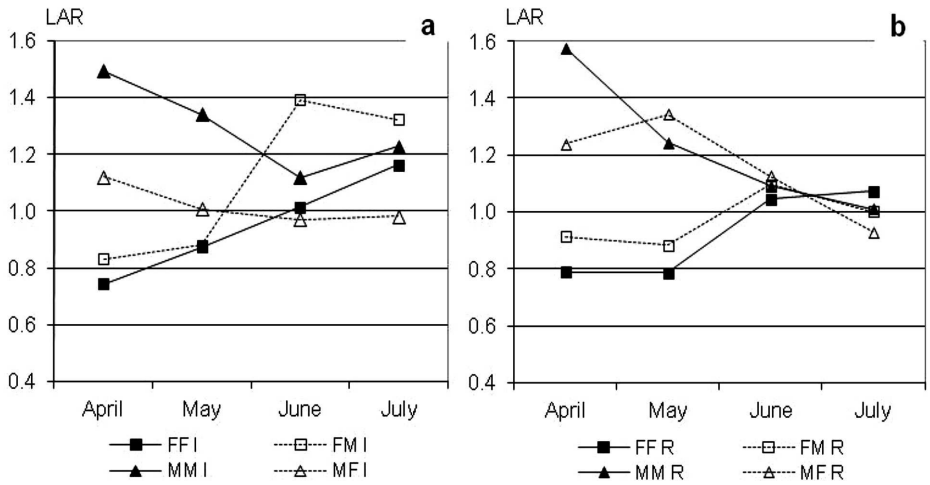

Fig. 1. Seasonal changes of leaf area ratio (LAR) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

The effect of mixture on LAR depended on species and on water regime (Fig. 1). The mixture affected the LAR only in the irrigated treatment, although in different way for the two species (Fig. 1a). The values of LAR of mixed tall fescue in relation to its monoculture were significantly higher; while the values of LAR of mixed alfalfa in relation to its monoculture were lower. This result could be attributed to shading of tall fescue from alfalfa (Poorter *et al.,* 2009).

The values of LAR depend on the leaf thickness and/or the leaf weight ratio (LWR), indicating the fraction of above ground plant weight allocated to the leaves (Poorter and Remkes, 1990).

LWR is considered being the main allometric index, affected by growth stage in grasses (Sheaffer *et al.* 2000). The values of LWR in tall fescue during summer indicate proportionally more biomass allocation to leaves, at rates higher than 95%, which explains the LAR increase (Fig. 2). This finding could be attributed to the fact that plants remain in the vegetative stage and they do not enter in the flowering stage, during which the stems elongate. In alfalfa LWR remains more or less stable during the season. Both drought and mixing did not affect the LWR of the two species. Therefore, we might conclude that changes in LAR resulted from changes in the thickness of leaves (Poorter and Remkes, 1990).

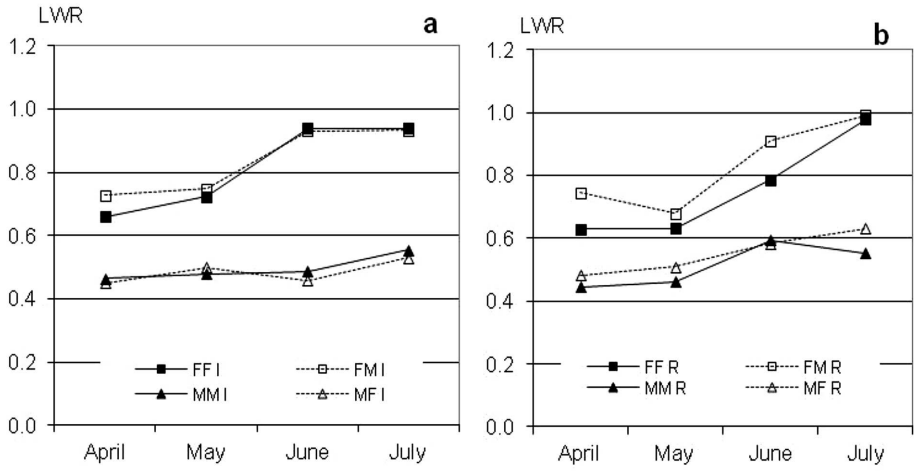

Fig. 2. Seasonal changes of leaf weight ratio (LWR) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

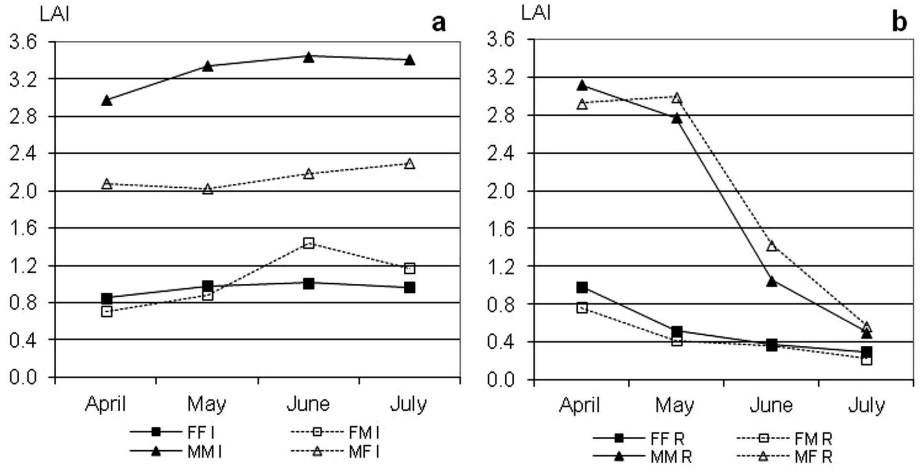

Fig. 3. Seasonal changes of leaf weight ratio (LAI) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

Leaf Area Index is as indicator of canopy density and light acquisition. As a general rule, plant canopies with high LAI absorb higher light quantities, resulting in accelerated plant growth rates and a significant competitive advantage (Barnes *et al*., 1990). LAI is illustrated in Fig. 3a for irrigated and Fig. 3b for rainfed plants. LAI of alfalfa was much higher than that of tall fescue, suggesting higher growth rate and productivity. Drought decreased the canopy density as expressed by LAI in both species. The reduction was higher in alfalfa, especially during the drought summer season. The mixture did not affect the LAI of tall fescue but the LAI of alfalfa increased under drought in relation to its monoculture, probably due to LAR reduction, as LWR was not reduced.

IV – Conclusions

In an alfalfa-tall fescue mixture, grown under Mediterranean conditions, we expect a low competitive ability of alfalfa reported to tall fescue under irrigation. It is because of lower LAR and LAI compared to its monoculture. Instead, the higher LAR and LAI values of alfalfa under drought show a higher competitive ability compared to tall fescue.

Acknowledgement

This research was funded by Kavala Institute of Technology (TEI).

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