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Drought and Defoliation Effects on Recovery of Two Mediterranean *Medicago* Shrubs

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Abstract: Soil water availability is one of the main limiting factors of growth and plant production in dry lands. A field experiment was carried under Mediterranean climate. *Medicago arborea* and *Medicago citrina* plants were subjected to irrigation and rain fed conditions and two modes of management plants along the year: non-physically disturbed plants (NDP) and defoliated plants (DP).

A clear effect of drought, plant management and seasons on dry matter of shoots, stems, leaves, seeds production and leaf area. A similar pattern of two growing periods along the year was observed for both species and management modes; an important one in spring and a reduced one in autumn. *M. arborea* suffered total leaf senescence in summer, but *M. citrina*, with a better adaptation to drought period, increases shoots production with water availability. In semi-arid conditions, *M. citrina* is a more promising foraging species than the widely used *M. arborea*.

Keywords: Growth, *Medicago* shrubs, Mediterranean climate

1. Introduction

Drought affects plant growth and development processes, and seriously reduces forage production and its seasonal availability. This phenomenon is frequently accompanied by overgrazing, which causes impoverishment and erosion of soils. Fodder shrubs constitute excellent craving resources with a high food value, and easy to integrate in agro-pastoral systems (Le Houérou, 1993). *Medicago arborea* L. is one of the three *Medicago* species included in the section *Dendrotelis* (Vassilcz) Lassen. This species, together with *M. strasseri* Greuter, Matthäs & Risse (Endemic from Crete), is native to coastal areas and islands of the eastern Mediterranean. *M. arborea* is widely used as forage species, but it is sensitive to drought. The remaining species of the section, *M. citrina* (Font Quer) Greuter, is endemic of the western Mediterranean (Balearic Islands, Spain).

Shoot production depends on the soil water availability and the plant management. On the one hand, under drought, physiological limitations, as reductions in photosynthesis and in transfer of assimilate, affect plant growth. In this context, morphological modifications are adopted as alternative indicators of water stress (Escós *et al*., 2000). On the other hand, plant defoliation represents a limitation for carbon resources, and that affects shoots growth, but several authors suggest that defoliation improves the plant water status, consequently improving the plant growth (Páez and González, 1995).

The aim of this work is to study the effect drought and defoliation on growth, dry matter allocation, and shoot production for *Medicago arborea* and *Medicago citrina* plants.

2. Materials and Methods

M. arborea and *M. citrina* were studied at the experimental field of the University of Balearic Islands (Spain) on two years-old plants. A parcel of *M. arborea* and *M. citrina* plants, in inserted lines (1.5/1.5 m), was maintained under irrigation regime to keep the soil at 100% of field capacity. A second parcel was maintained under rain fed conditions (230 mm/year, without irrigation). Along the year, the soil water content was measured with the TDR instrument (Time Domaine-Reflectometry) for two soil horizons (0-0.5 m and 0.5-1 m of depth) on four tubes located at 0.5 m from the plant. Soil water availability (SWA) was calculated after calibration of TDR values with respect to all measurements of soil moisture, taking into account the soil water content at the permanent wilting point (12.8%).

Four randomly selected plants were defoliated every 45 days to study the growth of shoots. The capacity of recovery was studied for both species, under irrigated and drought regimes. For two-year-old non-physically disturbed plants (NDP), shoots (Edible biomass: leaves and stems) were cut. After each

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sampling, shoots, for the same plant, were again defoliated (DP) after 120 days, according to Corleto *et al.* (1993). Leaves, stems, and seeds were separated and dried in a ventilated oven (85 ˚C/48 hours). The dry matter of shoots per plant (B), stems (SDM), leaves (LDM) and seeds production (Y) was calculated. The Delta-T Devices instrument (ΔT Area Meter) was used to calculate the plant leaf area (PLA, m^2 $plant^{-1}$) using the specific leaf area. The meteorological data show a typical Mediterranean climate spring-summer period, with high temperature (18-27 ˚C) and low relative humidity that generate a considerable water loss by evapotranspiration (6.35 mm j^{-1}) during summer. Data were submitted to the analysis of variance (ANOVA) with a factorial fixed model.

3. Results and Discussion

Under irrigation regime, the soil water availability (SWA) was superior to 80% along the year, but under rain fed conditions, SWA reached 45 and 50% in spring, against 30 and 20% in summer for *M. arborea* and *M. citrina*, respectively. This latter has the capacity to extract water from deeper horizons (Lefi *et al*., 2004). The general pattern of variation of shoots and these components depends on water supply, plant management and seasons. The soil water deficit affects all studies parameters for both species (**Figs. 1**, **2** and **3**).

In the field, both species showed very similar values for all measured parameters in NDP under drought. Slightly standing out were the higher seeds production for *M. arborea* in summer (Fig. 2). On the other hand, *M. citrina* showed higher LDM in spring and summer. These seeds would respond to the characteristics of the flowering period of *M. arborea,* aimed to have a maximum of seeds yield in summer, a common pattern in many Mediterranean species. The reproduction phase is crucial in starting leaf senescence for *M. arborea* under drought. Oppositely, *M. citrina* produced a lower seeds yield, and never suffered total leaf senescence during the summer (Figure 3a). Leaf maintenance in summer must respond to the positive energetic balance of the maintenance of leaves (Gulías *et al*., 2002).

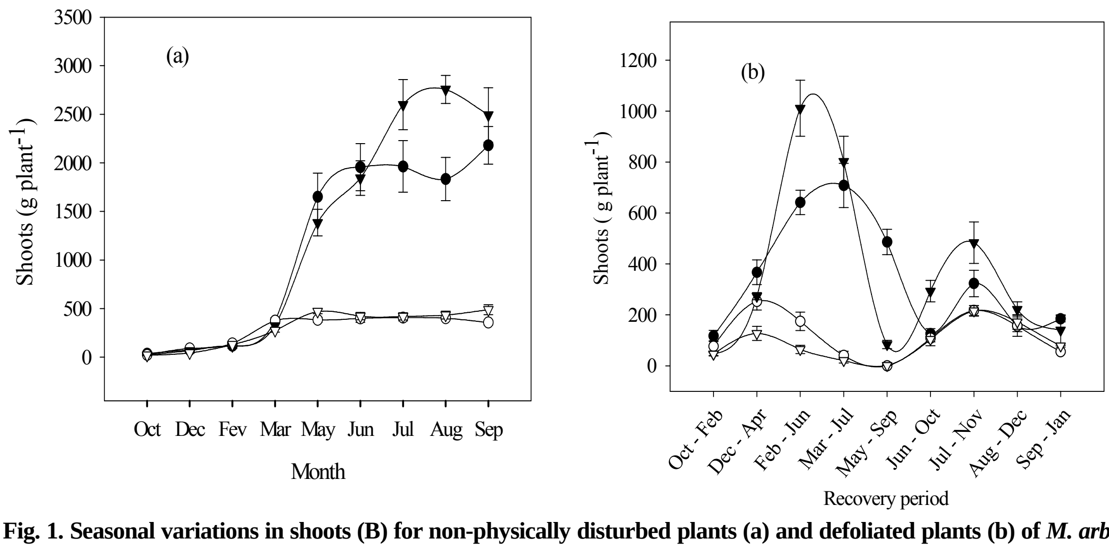

Fig. 1. Seasonal variations in shoots (B) for non-physically disturbed plants (a) and defoliated plants (b) of *M. arborea* (circle) and *M. citrina* (triangle) under irrigation regime (closed symbol) and rain fed conditions (open symbol).

3.1 Effects of the irrigation treatment on plant production

Dealing with the irrigation regime for NDP, B was improved ($P<0.001$). This would illustrate the aptitudes of *Medicago* species for crop management, increasing their production with water availability. Seeds yield of *M. citrina* doesn't show any improvement under irrigation (Figure 2a and b). In contrast, *M. arborea* showed a very conspicuous increase in Y from May to July.

Therefore, for NDP under irrigation, B reported differences between species in summer, raising *M. citrina* as the most productive (Figure 1a and b). The lower B in summer corresponded to a high Y, and the

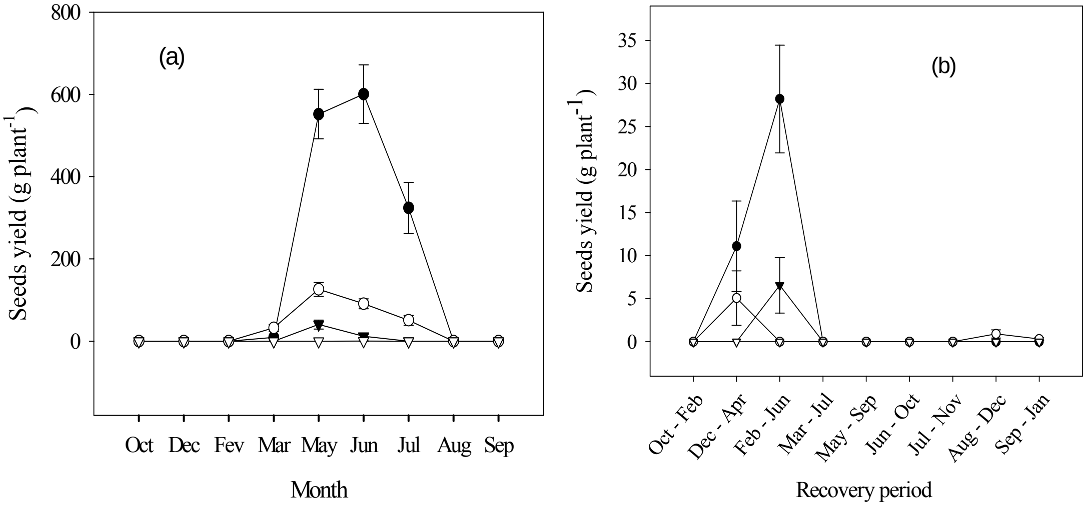

Fig. 2. Seasonal variations in seeds yield (Y) for non-physically disturbed plants (a) and defoliated plants (b) of *M. arborea* (circle) and *M. citrina* (triangle) under irrigation regime (closed symbol) and rain fed conditions (open symbol).

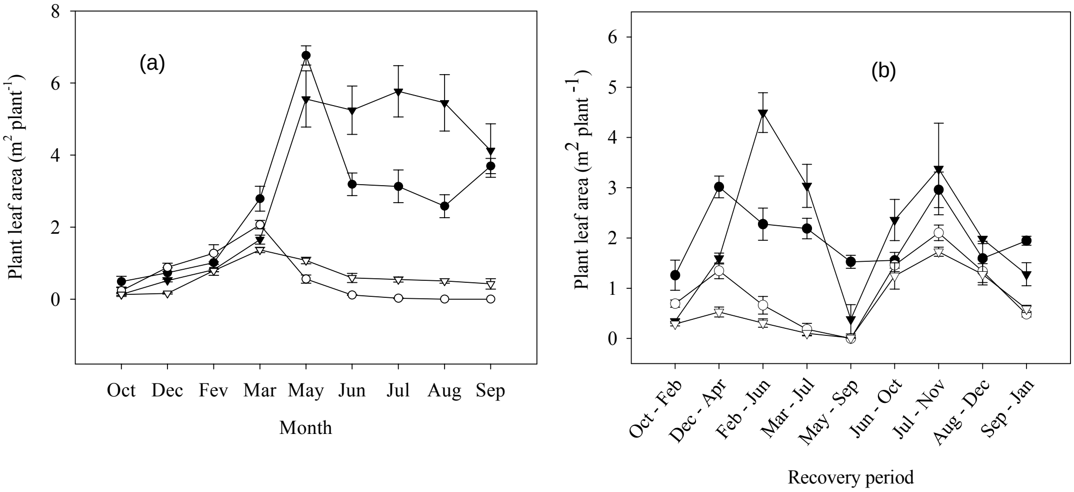

Fig. 3. Seasonal variations in plant leaf area (PLA) for non-physically disturbed plants (a) and defoliated plants (b) of *M. arborea* (circle) and *M. citrina* (triangle) under irrigation regime (closed symbol) and rain fed conditions (open symbol).

plant is focusing resources on seeds prior to summer latency, rather than in plant growth, and inversely than *M. citrina*. This difference was also observed for SDM, being higher for *M. citrina*. This latter has also high PLA for NDP under irrigation (Figure 3), responding to the common spring growth in most plants. *M. arborea* showed a reduction in PLA (50%) in summer conditions (Figure 3a), but not to water deficit.

Finally, as stressed above, the seeds yield was more conspicuously different for species in NDP under irrigation, since water availability in summer induced a nearly six-fold seeds yield under irrigation compared to drought for *M. arborea*. Under drought, *M. citrina* showed a low flowering during the year, especially for defoliated plants (Figure 2b).

3.2 Plant foraging production improvement through defoliation

Woody shrubs can respond to defoliation in concrete year periods showing an increase of produced biomass, this is the case of *M. arborea* and *M. citrina.* However, responses of both species are different with regards to the dry matter allocation. Along the year, defoliated plants, for both species, showed a very similar pattern for all parameters. As a rule, two maximum periods were observed: a higher one in spring showing more differences between species and treatments, and a lower one in autumn with more similarities in values between species and treatments.

As for B, defoliation produced a higher shoots for *M. citrina* than for *M. arborea* in spring. Concerning the components relationship of shoots, *M. arborea* showed a high ratio leaves/stems in winter, reaching the 80% in spring. Similarly, for *M. arborea,* Corleto *et al*. (1993) reported ratios of 120, 80 and 60%, at frequencies of defoliation of 60, 120 and 180 days, respectively.

Under irrigation, the results for LDM and for SDM showed a similar pattern to those for B and no differences between species were shown. Under drought, *M. arborea* showed a slightly better performance than *M. citrina* in spring.

4. Conclusions

In semi-arid conditions, *M. citrina* is a more promising foraging species than the widely used *M. arborea*. This is mainly due to its higher water use efficiency and leaf biomass (Lefi *et al*., 2003). Moreover, its recovery capacity was considerable with water availability and it presented several morphological traits favoring its adaptation to drought against *M. arborea*, as the water extraction from deeper horizons (Lefi *et al*., 2004). All these productive, morphological and physiological traits confer to *M. citrina* a particular agronomical and ecological interests.

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