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Combined effects of irrigation and cutting regimes on lucerne forage production

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Summary – The critical role of water on lucerne (*Medicago sativa* L.) plants combined with clipping on shallow, infertile soils of a sub-humid Mediterranean environment are still under consideration. The total above ground biomass (AGB_t) of lucerne plants and the seasonal distribution of the AGB were studied under different combination of clipping and irrigation treatment at the first two years since the establishment. The results showed that though the influence of water shortage was more drastic at the first year, it was less evident at the second. The seasonal AGB production of the irrigated lucerne plants was distributed more uniformly as compared to the unirrigated. Also, the clipping intensity did not significantly affect the AGB production of the first year. The unclipped and unirrigated plants were favoured in the second year.

Key-words: lucerne, clipping, irrigation, above ground biomass, Mediterranean grasslands

Résumé - *Le rôle critique de l'eau sur les plants de luzernes (*Medicago sativa*) soumis à une défoliation reste une question à résoudre dans les sols peu fertiles en zone subhumide méditerranéenne. La phytomasse aérienne totale et sa distribution saisonnière ont été étudiées pour différentes combinaisons de défoliation et d'irrigation pendant les deux premières années après installation. Il est montré que le déficit en eau a un effet beaucoup plus marqué la première année que la seconde. La distribution saisonnière de la production est plus uniforme dans les traitements irrigués. L'intensité de défoliation n'affecte pas de façon significative la production la première année alors que les plantes non défoliées ont un meilleur rendement la deuxième année.*

Mots-clès: *luzerne, défoliation, irrigation, phytomasse aérienne, prairie méditerranéenne*

Introduction

Lucerne (*Medicago sativa* L.) is one of the most widely used perennial legumes for hay production not only in Greece (Kontsiotou, 1997), but generally in the world (Frame *et al.*, 1998). Water availability is usually the main factor controlling yield of lucerne (Frame *et al.*, 1998). Although drought reduces its yield, lucerne has the greatest yield potential in dry conditions among perennial legumes (Peterson *et al.*, 1992). Its high adaptation to drought is explained by several morphological plastic responses (Carter and Sheaffer, 1983; Peterson *et al.*, 1992).

Considering that clipping imitates grazing, Brummer and Bouton (1992) and Frame *et al.*, (1998) have found that the storage of a large amount of non-structural carbohydrates in the roots and crowns and the ability of lucerne to maintain leaf area below the clipping height are related to its ability to withstand grazing.

There have also been many studies on lucerne performance under different fertilizing practices (Hall, 1993; Frame *et al.*, 1998), although Koukoura *et al.* (1997) have found that lucerne is well adapted on infertile soils, too. Nevertheless, it is still under consideration the combined effect of irrigation and clipping on forage production and its seasonal distribution when plants grow in unfertilized soils.

The objective of this study was to determine the effect of water shortage combined with different clipping treatments on the above ground biomass of lucerne and its seasonal distribution when plants grow on unfertilized soils.

Materials and methods

The experiment was conducted in a homogenous soil of the farm of Tobacco Institute of Drama, northern Greece (41°09' latitude N, 24°09' longitude E, 130 m a.s.l.). The mean annual temperature of the region is 15,2°C and the mean annual precipitation is 616 mm. The soil is medium textured and at establishment the pH was 7.5. The variety used was Yliki, which was produced at the Forage Crops and Pastures Institute of Larisa, in Greece.

In the autumn of 1995, lucerne plants were established in completely randomised field plots (1m x 1m), with a sowing rate of 4 g m^{-2}. In order to secure the well establishment of the seedlings they were adequately irrigated. The plants were subjected in the combined effects of two irrigation treatments (namely U, and I) and three clipping intensities (namely L, H, and C). After the first clipping in the spring of 1996, no more water was applied on the half of the plots (U), while the other half was continuously irrigated by sprinklers to maintain field capacity (I). The clipping intensities were: light (L, at 7 cm above the soil surface), heavy (H, at 3 cm) and control (C, cut once at the stage of full maturity). The clipping was repeated four times during the growing season (at 20 days time intervals approximately), when the first inflorescence appeared (10% bloom), as Stylopoulos and Vaitsis (1987) have suggested. Each of the plots was subjected in one specific combined treatment. Finally, there were used 24 field plots (2 irrigation treatments x 3 clipping intensities x 4 replications). The same treatments were applied in 1997.

The cut material was oven dried at 75°C for 48 hours and the total above ground biomass (AGB in g m^{-2}) was determined each time the plants were clipped. Seasonal changes of the absolute AGB values were recorded and the total AGB (AGB_t), obtained by the sum of all clippings was calculated for the first two years after the establishment (1996 and 1997). Least squared differences for a=0.05 were used to compare the mean values.

Results and discussion

Mean total biomass (AGB_t)

In the first year, no significant statistical differences were found in AGB_t values between clipping treatments in both irrigation regimes (Table 1). The AGB_t values were 2.68, 2.30 and 1.86 times higher in the irrigated than in unirrigated lucerne plants in C, L and H clipping intensities respectively.

In the second year, the AGB_t values were significantly different between the clipping treatments in the irrigated and in unirrigated lucerne plants (Table 1). The mean AGB_t value of the IC plants did not significantly differ either from IH or from IL plants. On the contrary the mean value of the IL plants (1312.7 g m^{-2}) was significantly higher than this of IH (1090.0 g m^{-2}). The AGB_t value of the IL plants was the highest one recorded during the experimental period. When the lucerne plants remained unirrigated, the significantly highest mean AGB_t value was obtained by UC plants (1129.1 g m^{-2}). The other two clipping treatments did not differ between each other. In the second year the AGB_t values are 1.60, 1.24 and 1.08 times higher in the irrigated than in the unirrigated lucerne plants for L, H and C clipping intensities, respectively. The fact that these relative values are lower than the ones obtained in the first year is due to the compensatory growth observed in the unirrigated lucerne plants during the second year, which produced higher leaf area values (data not shown). Hall (1993) also observed compensatory growth in lucerne plants when they were released from periods of drought stress.

The AGB_t values obtained by these treatments were generally lower than the ones reported by other researchers (Carter and Sheaffer, 1983; Hall, 1993; Frame *et al.*, 1998), who however applied fertilizers in their trials.

Table 1. AGB_t values (g m^{-2}) of lucerne plants under the combined treatments of irrigation and clipping in the first (1996) and the second (1997) year since establishment (I: irrigated, U: unirrigated, C: unclipped (control), H: heavily clipped and L: lightly clipped).

	I		U		I/U	
	1996	1997	1996	1997	1996	1997
C	957.6a*	1216.8a,b	357.9a	1129.1a	2.68	1.08
H	725.0a	1090.0a	389.8a	877.7b	1.86	1.24
L	898.6a	1312.7b	390.1a	820.0b	2.30	1.60

*Columns with different letters are significantly different at a=0.05.

The AGB_t differences between the unclipped lucerne plants growing under irrigated and unirrigated conditions were expected. According to Frame *et al.* (1998) the AGB production of lucerne is positively related to the available water of the soil. Differences in AGB_t values of lucerne plants between the first and the second year since establishment were also observed by Stylopoulos and Vaitsis (1987) and may be attributed to a widely expanded root system (almost doubled in volume in the second year), thus resulting in enhanced acquisition rates of water and nutrients (Johnson *et al.*, 1998). Especially for dry conditions, other researchers have found an increased amount of photosynthetic products transported to the roots (Carter and Sheaffer) and a higher deposition rate of non-structural carbohydrates in the root system of lucerne (Hall *et al.*, 1988). On the other hand, the frequent clipping practices that lucerne plants experienced during the first year since establishment affected the AGB_t values of the subsequent year only when the plants were irrigated. In this case the intraspecific competition is expected to be higher, resulting in significantly lower AGB_t values, especially when the plants were heavily clipped. On the contrary, when lucerne plants were unirrigated there were not such differences between the different clipping treatments, apparently because the critical resource (water) was in shortage.

Seasonal pattern of AGB changes

The seasonal pattern of the AGB changes indicates that in the first year of the experiment the values started to decline after the second clipping (middle of June) in the UH and UL plants, while in the IH and IL plants in the third clipping (early of July) (Fig. 1a). The fourth subsequent clipping resulted in lower AGB values in both irrigation treatments. In the second year, the seasonal AGB pattern was quite different than the first one (Fig. 1b). The AGB values of the first clipping were significantly higher than in the first year of the experiment and the AGB values of the IL and UL plants started to decline after the second clipping (late of May), while the AGB changes of the IH and UH plants started to decline after the first cutting.

Metochis and Orphanos (1981) and Saeed and El-Nadi (1997) found that lucerne yield remained high during the relatively cool wet months and started to decline with the beginning of the dry hot season, due to the water deficit and the high temperatures. This fact is also supported by the present results.

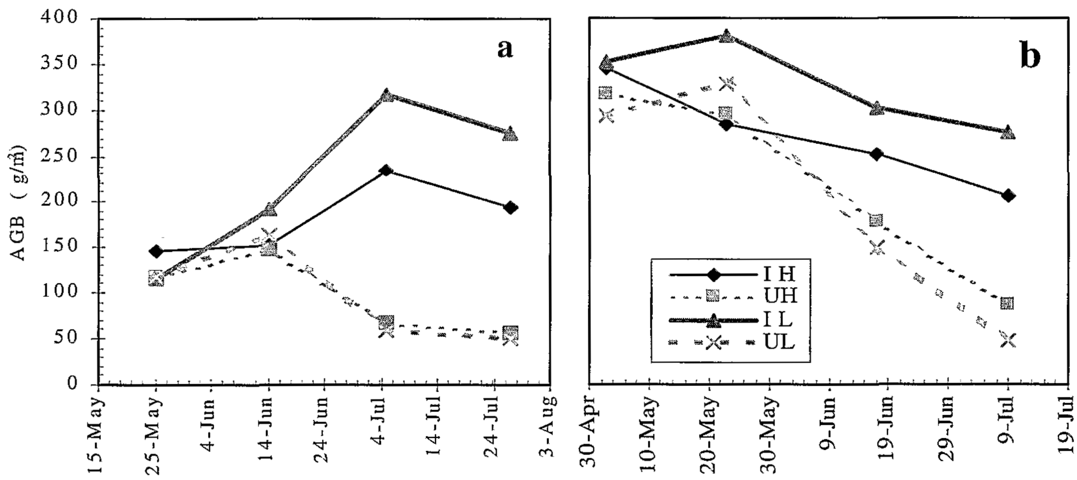

Fig. 1. Seasonal changes of AGB values of lucerne plants in 1996 (a) and 1997 (b).

When the available water of the soil was in excess, the response of the lucerne plants to the clipping was satisfactory as the dry summer conditions demanded. The plants were able to sustain high AGB values until early of July. Also, as the pattern of the AGB changes was quite similar between the clipping intensities under the same irrigation treatment, it is concluded that there was not any apparently different response of the lucerne plants to clipping.

Conclusions

The evaluation of irrigation and clipping treatments on the lucerne establishment suggests that:

1. The highest total AGB values were measured in the second year since establishment. The increase of production was higher in unirrigated treatment.
2. The application of a light clipping intensity (at 7 cm from the soil surface) gave higher production on irrigated lucerne plants.
3. Under irrigated conditions the plants sustained high AGB values until July, while under unirrigated conditions the production start to decline since late of May.

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