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Daily growth evaluation of an irrigated lucerne crop

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Abstract. The daily growth of a lucerne cv 'Aragón' crop was determined under irrigated conditions in Zaragoza (Spain) during the period 2006-2009. Forage yield and crude protein percentage were evaluated every eight days as average on seven vegetation cycles per year applying the method of Corrall and Fenlon. The productive period of lucerne was from the beginning of March to the end of November. The annual maximum dry matter yield was 15.901 kg ha^{-1} in the third year, and the maximum growth was reached on 30 June 2008, 119.5 kg ha^{-1} day^{-1}. The crude protein percentage decreased from 22.9% at mid-April to 15.5% at mid-July; later, it increased up to 24.5% at the middle of November. These results represent a contribution to the optimization of lucerne crops management.

Keywords. *Medicago sativa* L. – Daily growth – Harvest – Dry matter – Irrigation.

Évaluation journalière de la croissance d'une culture de luzerne en conditions d'irrigation

Résumé. *La croissance journalière d'une culture de luzerne cv 'Aragón' a été déterminée dans des conditions d'irrigation à Saragosse (Espagne) lors de la période 2006-2009. La production fourragère et la teneur en matières azotées totales ont été évaluées avec une périodicité moyenne de huit jours sur sept cycles de végétation par an en utilisant une adaptation de la méthode de Corrall et Fenlon. La période productive de la luzerne est comprise entre début mars et fin novembre. La production annuelle maximale de matière sèche a été de 15.901 kg ha^{-1} la troisième année. La croissance journalière maximale a été atteinte le 30 juin 2008, 119,5 kg ha^{-1} $jour^{-1}$. Le pourcentage de matières azotées totales a diminué de 22,9 % en mi-avril à 15,5 % en mi-juillet. Plus tard, il a augmenté jusqu'à 24,5 % en mi-novembre. Ces résultats représentent une contribution à l'optimisation de la gestion des cultures de luzerne.*

Mots-clés. Medicago sativa *L. – Croissance journalière – Récolte – Matière sèche – Irrigation.*

I – Introduction

Lucerne (*Medicago sativa* L.) is the second forage crop in Spain in terms of surface and the first one in terms of yield. In 2009, 159,014 irrigated ha and 86,952 rainfed ha were cultivated producing more than 10,000,000 t fresh forage yield. The main use of forage (94% of surface) was for hay or dehydrated purposes (MAPA, 2009).

The importance of this crop is due to its high dry matter (DM) and crude protein (CP) yield under irrigation conditions. In addition, it is a crop with a high capacity for fixing nitrogen and improving soil structure. For this reason, lucerne is frequently used as an alternative to other crops in basic pH soils.

Studies aiming to the improvement of this crop such as a better understanding of the distribution of forage yield and its CP contents along the harvesting time will benefit its efficiency. This work studies the evolution of daily growth and CP contents according to the date of cutting in an irrigated lucerne stand.

II – Materials and methods

The study was carried out in a flood irrigated plot in Zaragoza (Spain) in the period 2006-2009. The annual mean temperature of the test period was 14.4 ºC and the extreme monthly mean temperatures 0.3 ºC and 33.3 ºC, remarking the absolute daily minimum, -8.6 ºC. The annual mean rainfall was between 241.1 and 450.6 mm. The plot was located on an alluvial, loamy, non saline soil, 0.24 dS m^{-1} (CE 1:5); pH in water (1:2.5), 8.20; organic matter, 1.99%; P Olsen 7.03 mg kg^{-1} and K (ammoniac acetate extract) 134 $mgkg^{-1}$.

Daily growth of lucerne was evaluated according to the Corrall and Fenlon method (1978). This method developed in grasses establishes the daily growth curve using four plots rotationally harvested every week. Corral and Fenlon (1978) assume that the daily growth corresponding to week t is presented by the formula $(A_1Y_t+ A_2Y_{t+1}+ A_3Y_{t+2}+ A_4Y_{t+3})/28$, where Y_t, Y_{t+1}, Y_{t+2} e Y_{t+3} are the forage yield at the end of the weeks t, t+1, t+2 y t+3, and $A_1= A_2=A_3= A_4=1/4$ when a lineal growth rate was assumed. However if a simple quadratic approximation was assumed, the A coefficients used by these authors are: $A_1=7/16$, $A_2=5/16$, $A_3=3/16$ y $A_4 =1/16$. Cuts were performed every eight days in the first five productive cycles and every ten days in the sixth and seventh cycles, according to previous studies (Delgado *et al*., 2011).

Four 10 m^2 plots (2 x 5 m) distributed in random blocks with three replications were used. Sowing took place on 4 October, 2006, using the cv. 'Aragón' at 30 kg ha^{-1} sowing dose. As basic dressing 600 kg complex 8-24-8 ha^{-1} were applied the first year and 500 kg ha^{-1} of the same complex in winter in the following years. The plot was flood irrigated at a minimum rate of 12 days in the summer months.

The average cut date for the beginning of the study was 11 April and for the end was 20 November. The estimation of DM yield was made by cutting two 0.5 m^2 per plot. The cut forage was dried at 60ºC in a forced ventilation stove till reaching a constant dry weight. Then samples were ground and their CP contents evaluated by Dumas method (AOAC, 1990).

The statistical analysis to compare DM weekly yield was made using the ANOVA procedure of SAS statistical package (SAS, 2003), considering the cutting date as treatment. The comparison of means was made by the LSD test.

III – Results and discussion

Seven cuts per plot were performed along the year. The lucerne daily growth in the three years of study is shown in Fig. 1. When analysing the curves designed assuming a lineal growth, we can observe that growth started at the beginning of March and stopped at the end of November, the daily maximum being reached on 30 June 2008, and 119.5 kg DM ha^{-1} day^{-1}. Growths higher than 90 kg DM ha^{-1} day^{-1} appeared between 10 April and 27 July. The curve designed assuming a simple quadratic growth was very similar to the lineal one, reaching the daily maximum on 30 June 2008, that is 126 kg DM ha^{-1} day^{-1} and growths higher than 90 kg DM ha^{-1} day^{-1} took place from 10 April to 1 August.

Annual yield was significant ($P<0.001$) between years, outstanding the third year with 15,901 kg DM ha^{-1}, followed by the second one with 14,702 kg DM ha^{-1}, and lastly, the first year with 12,354 kg DM ha^{-1}.

These results differ from others in the bibliography under similar conditions (Hidalgo, 1966; Lloveras *et al*., 1998; Delgado, 2003; García Criado *et al*., 2010), where the highest annual yields were obtained the second year after sowing. In general, there were six productive cycles in previous studies. In this study there were seven due to the close cutting dates, cuttings being performed some times at early phenological stages, thus increasing one cycle.

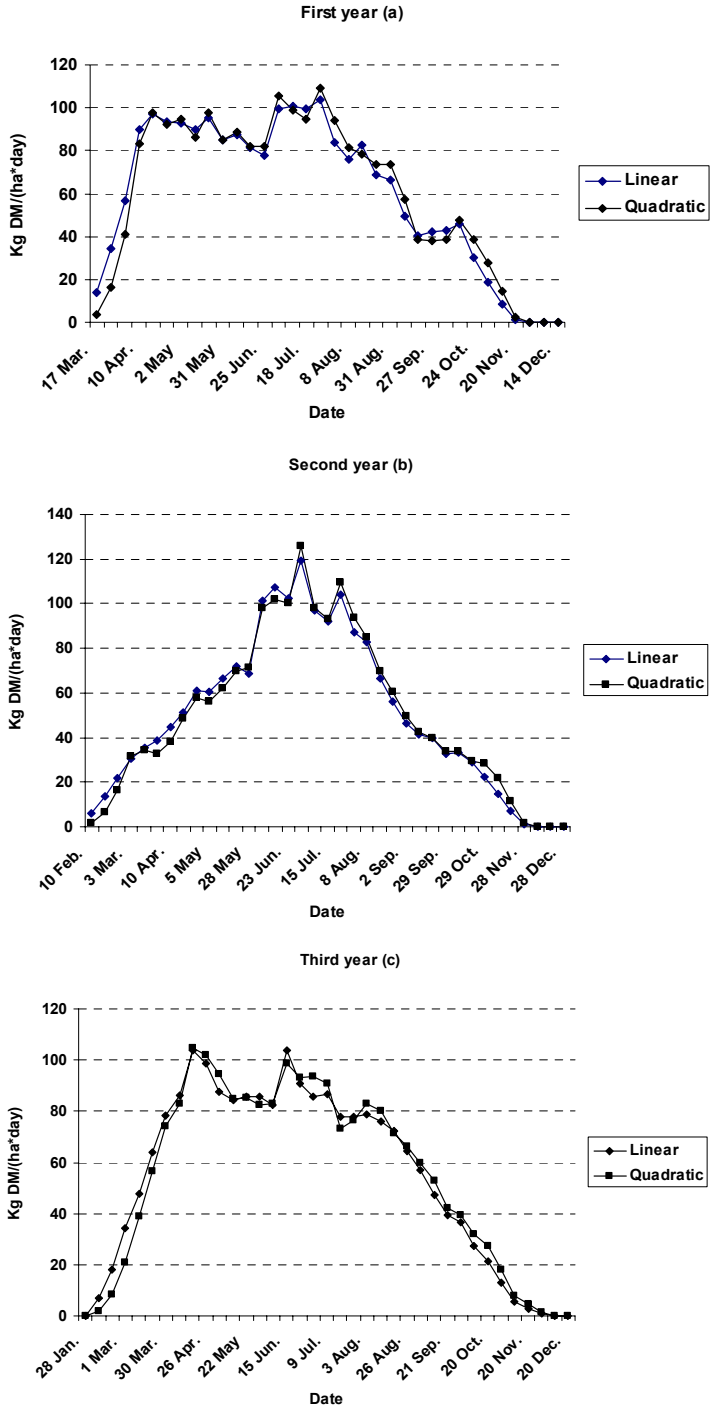

Fig. 1. Daily growth curves of lucerne cv 'Aragón' (a, b, c) and evolution of the CP contents (d) at cutting (mean of three years) under irrigation, Zaragoza (♦, lineal; ■, quadratic).

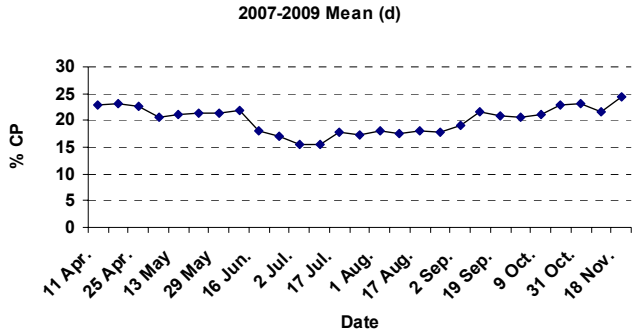

Fig. 1. (Cont.) Daily growth curves of lucerne cv 'Aragón' (a, b, c) and evolution of the CP contents (d) at cutting (mean of three years) under irrigation, Zaragoza (♦, lineal; ■, quadratic).

The evolution of the CP mean contents in the three years of the study is shown in Fig. 1. It decreases from 22.9% in the first cut at the middle of April to 15.5% at the beginning of July. Then it increases to 24.5% at the middle of November. This fact could be related to the phenological stage at cutting time, vegetative or flower bud at the beginning of the spring and at the end of summer, and between 10% and 50% flowering along the summer. This response was similar to other studies (Andueza et al., 2001).

IV – Conclusions

In the conditions of this study, the productive period of lucerne took place between the beginning of March and the end November. The maximum DM annual yield was obtained the third year, 15,901 kg ha^{-1}, and daily growths were higher than 90 DM kg ha^{-1} day^{-1} in spring, reaching the maximum one on 30 June 2008, 119.5 kg ha^{-1} day^{-1}. The CP contents decreased from 22.9%, analysed at the beginning of April to 15.5% at the beginning of July, increasing afterwards till reaching 24.5% at the middle of November.

Acknowledgements

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