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in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 213-217

Setaria pumila (Poir.) Roem. e Schult affects grassland botanical composition and forage nutritive value

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Abstract. Meadows and pastures are increasingly threatened by invasive grasses (especially *Setaria pumila* (Poir.) Roem. e Schult) as a consequence of human actions and climate change. In the surveys performed by Agridea (PRAMIG project) in Canton Ticino (CH) an anomalous production peak was observed on lowland pastures during summer. In 2012 a study was carried out to better understand the phenomenon. We measured: (i) biomass; (ii) botanical composition; and (iii) chemical composition. To test the hypothesis that *S. pumila* development during summer is related to specific climate conditions, meteorological data (temperature, precipitation) were collected. We assessed the relative effect of climatic variables and of *S. pumila* competition by Generalized Linear Mixed Model (GLMM). We found that *S. pumila* abundance is inversely correlated with rainfall and with the presence of other species, and it is positively correlated with temperature increase. The summer peak of the seasonal growth curve could be attributed to *S. pumila*, when other species are less competitive because of drought conditions. Beside the high *S. pumila* biomass production a reduction of forage quality was observed.

Keywords. *Setaria pumila* (Poir.) – Generalized Linear Mixed Model – Meadows – Forage quality – Drought.

Setaria sp. ***affecte la composition botanique des prairies et la valeur nutritive du fourrage***

Résumé. *Les prairies et les pâturages sont de plus en plus menacés par des espèces envahissantes (surtout* Setaria pumila *(Poir.) Roem. e Schult) comme une conséquence des actions humaines et des changements climatiques. Dans les relevés réalisés par Agridea (projet PRAMIG) dans le canton du Tessin (Suisse), un pic de production anormal a été observé en été sur les pâturages de plaine. En 2012, une étude a été réalisée pour comprendre ce phénomène. On a mesuré: (i) la biomasse; (ii) la composition botanique; (iii) la composition chimique des prairies. Pour tester l'hypothèse que* S. pumila *se développe pendant l'été en lien avec les conditions climatiques, des données de température et de précipitations ont été collectées. On a évalué l'effet des variables climatiques sur la présence de* S. pumila *avec un Modèle Mixte Linéaire Généralisé (MMLG). On a constaté que* S. pumila *est inversement corrélée à la pluviométrie et à la présence d'autres espèces, mais qu'elle est positivement corrélée avec l'augmentation de la température. Le pic d'été de la courbe de croissance est attribué à* S. pumila*, quand d'autres espèces sont moins compétitives en raison de la sécheresse. La grande production de biomasse de* S. pumila *était en revanche accompagnée d'une réduction de la qualité de fourrage.*

Mots-clés. *Setaria pumila* (Poir.) – Generalized Linear Mixed Model – Prairies – Qualité de fourrage – Sécheresse.

I – Introduction

In the last decades grassland are increasingly threatened by C4 summer-grass weeds as a consequence of human action and climate change (Tozer *et al*. 2008). In the Southern side of the Alps a rapid increase of *Setaria pumila* (Poir.) Roem. e Schult. was observed in terms of presence and biomass.

The interest of ecologists and experts in the biological invasion of these herbaceous species has recently incremented with the aim of gaining further insight on patterns of invasion and mechanisms driving them along the elevation gradient (Alexander *et al*. 2011). In the summer period, characterized by increasing temperature, high light intensity, and drought, the more efficient carbon fixation by C4 plants would provide competitive advantages over the less efficient C3 ones, with consequences on botanical composition and probably also on forage nutrient value. For an adequate conservation of natural forage resources, so important for pastoral activities in the plain and at the bottom of valleys, it is necessary to implement the knowledge about the phenomenon of invasion of meadows and pastures by summer grass weeds.

II – Materials and methods

The study was conducted between May 2012 and December 2012 in Canton Ticino (Italian Switzerland), on the Southern side of Alps, at two different sites: Cadenazzo (203 m a.s.l.), in the plain of Ticino river, and Semione (370 m a.s.l.), at the bottom of the Blenio Valley.

In summer and autumn 2012, surveys were carried out, to assess the biomass and the forage production, with a modified Corral Fenlon method (Corral and Fenlon, 1978) revised as regard the number of plots (two instead of four) and as regard the time interval between two cuts (14 days instead of one week), in three different parcels: two located in Cadenazzo (hereinafter referred to as Cad. meteo and Cad. stallone) and one in Semione. At each site the experimental design consisted in two plots of 6.6 m^2 (6 m X 1.10 m) mowed alternatively every 14 days, from mid-April until mid-October. Beside biomass forage production, the botanical composition was also identified in the plot before each mowing, according to linear point quadrat method (Daget and Poissonet, 1969) along a transect of 6 m, 25 intercept were collected. Moreover 53 mown grass samples were collected to verify the nutrient variation along growing season analysing the grassland nutritive value, expressed in NEL (Net Energy for Lactation) with a NIRs instrument.

To test the hypothesis that *S. pumila* development during summer is related to specific climate conditions, meteorological data (temperature, precipitation, and evapotranspiration) were collected at the end of the 2012 from two stations nearby the study sites, one located in Cadenazzo and one in Malvaglia, near Semione.

With the aim of quantifying the amount of *S. pumila*. in terms of production, the total biomass was divided into *S. pumila* and other species, considering *S. pumila* specific contribution (CS%), calculated for each botanical survey, multiplied to the biomass measured in the plot. To analyse the effects of climate and the presence of the other species on the abundance of *S. pumila* in terms of biomass, we chose a Generalized Linear Mixed Model (GLMM) with temperature, precipitation and other species biomass as independent variables. Thermal time (Tt, °C*day), Total precipitations (TP, mm*day) and Evapotranspiration (ET, mm*day) were calculated for each time interval between two cuts, from the beginning of the growing season. Evapotranspiration was excluded from the analysis because of its correlation to thermal time. In the model a gamma distribution was specified for the continuous dependent variable *S. pumila* abundance, as normality assumption was not met (normality tested with Kolmogorov-Smirnoff test).

GLMM was preferred to GLM to check, in addition, for non-independence of each survey value given by the location of the plot (the site), considered in the model as normally distributed random factor. Analyses were performed with R software, version 2.15.3 (R Foundation for Statistical Computing, 2013) with the "glmmADMB" package (SVN revision 231).

III – Results and discussion

Examining data on forage production during the growing season an anomalous production peak was observed in summer 2012, especially in Cadenazzo (Fig. 1), when the growth should be lower than in spring.

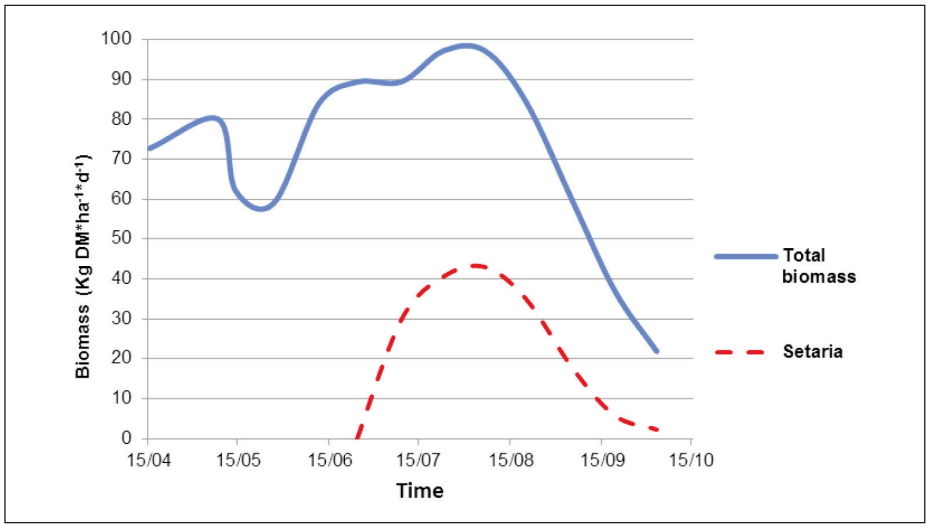

Fig. 1. Total biomass and *Setaria*'s growth curve in the parcel Cad. meteo in summer 2012.

In the study sites the abundance of *S. pumila* was thoroughly quantified by botanical surveys. They show the evolution of the botanical composition in the plots during the growing season. The maximum presence of *S. pumila*, expressed in percentage on total botanical composition (46% in Cad. meteo, 44% in Cad. stallone, 24% in Semione), occurred in all plots at the beginning of August, in correspondence of the summer production peak of the seasonal growth curve (97 kg DM*ha^{-1}*d^{-1} for Cad. meteo, 103 kg DM*ha^{-1}*d^{-1} for Cad. stallone, 71 kg DM*ha^{-1}*d^{-1} for Semione).

Table 1. GLMM summary with *S. pumila* abundance related to other species biomass, thermal time and total precipitation

GLMM parameters	Estimate	*p* value	Std. error	Signif.†
Intercept	5.201	< 2^{e-16}	0.136	***
Biomass (kg DM)	-0.802	4.0^{e-05}	0.195	***
Thermal time (°C*day)	2.060	5.9^{e-16}	0.255	***
Total precipitations (mm*day)	-0.592	0.0014	0.185	**

† *** P<0.001, **P<0.01, *P<0.05, .P<0.1.

The GLMM results showed that the abundance of *S. pumila* was inversely correlated with rainfall and with the presence of other species, but it was positively correlated with temperature increase. Beside the high *S. pumila* biomass production, a reduction in forage quality was observed. In fact, in correspondence of the maximum quantity of C4 plants the net energy for lactation (NEL, MJ/kg DM) decreased considerably (Fig. 2).

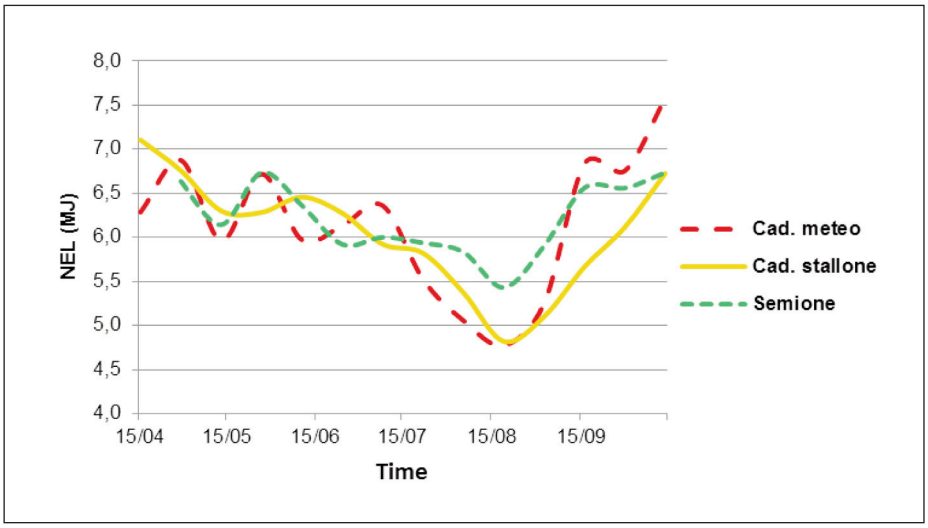

Fig. 2. Grass energy content (NEL – Net Energy for Lactation) during the growing season.

IV – Conclusions

Results show a correspondence between *S. pumila* presence and the summer production peak of the seasonal growth curve. This species is probably more competitive because of climate conditions than other species with regard to drought and to high temperatures, thanks to its C4 carbon fixation cycle. Thus, during *S. pumila* increase we could observe an increase of the sward biomass, which, however, corresponded to a strong reduction of the nutritive value.

The result of this research raises the concern about upward spread of invasive plants, consequence of climate warming and human pressure in mountain systems. Monitoring existing population is important but preventing the introduction of pre-adapted species is a more urgent goal. Special attention should be given to herbaceous species (as *Setaria* sp.) which can flower over a short time period and later in the season (Barni *et al*. 2012). The results allow the adaptation of the grassland management to limit *Setaria* sp. development in meadows and pastures, to enhance competition of desirable pastures species (Tozer *et al*. 2008).

Acknowledgments

Data collection and analyses were conducted with the partnership of AGRIDEA, ACW Agroscope Changins and APF, who cooperated during PRAMIG project from 2009 to 2011.

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