Differential effects of nitrogen, phosphorus and water addition on native grassland seasonal ANPP stability

Jaurena M[1*], Nabinger C[2], Giorello D[1], Fedrigo J[2], Lattanzi F[1]
[1]National Institute of Agricultural Research, INIA, Uruguay.[2]Federal University of Rio Grande do Sul, UFRGS, Brasil.
[*]Corresponding author: mjaurena@inia.org.uy

Introduction

Aboveground net primary productivity (ANPP) changes in response to temporal fluctuations in weather (Polley et al. 2013) and soil nutrients (Harpole et al 2011). ANPP variations could potentially affect every ecosystem processes, thus detect changes in ANPP temporal stability has great importance in the design of strategies for grassland management and conservation. The whole research on grasslands ANPP stability has been focused on year-to-year basis, however test the seasonal stability could be very relevant for forage budget and the provision of ecosystem services. Changes in the factors controlling ANPP, such as nutrient and water addition, could cause contrasting responses in ANPP stability in different seasons of the year due to their specific climatic conditions. However, to date, there is no evidence from field experiments to reveal different seasonal stability responses.

Materials and methods

An experiment was carried out from 2011 to 2015 in Tambores-Uruguay, on a subtropical Basaltic grassland dominated by C4 perennial grasses. In the spring of 2011, we established a factorial experiment combining two water managements with six fertilization treatments in a split plot design with three replications. On the main plots (24 x 16 m) supplementary irrigation (SI) and rainfed (RF) treatments were located. On the subplots (8 x 6 m), we assigned six fertilization treatments consisting of P rates of 0 and 35 kg phosphorous (P) ha-1 year-1 combined with 0, 100 and 200 kg nitrogen (N) ha-1 year-1. Each subplot was harvested twice in spring and summer, and once in autumn and winter. Temporal ANPP stability was determined as the ratio between the mean and standard deviation of each subplot as defined by Lehman and Tilman (2000). Additionally, we calculated the mean and standard deviation (SD) relative changes as natural-log response ratios (LRR) comparing each treatment with the control (rainfed-without fertilizers) at each block. ANPP temporal stability relative changes were calculated as the difference between LRR mean and LRR SD according to Hautier et al. (2015). An ANOVA mixed model was used to test the treatment effects on the ANPP stability relatives changes of each season.

Results and Discussions

The effects of resource additions on the relative changes of ANPP stability varied with the season of the year (Table 1). Outstandingly, in winter there was a positive effect of N on ANPP temporal stability (Fig. 1A). However, in spring there was a significant N x P interaction explained mainly by a positive effect of P addition on stability in absence of N, by an increased negative effect on stability of N dose, and by a further decreased stability when P was combined with the higher N dose (Fig. 2A). Instead, in summer there was a significant N x irrigation interaction explained by a general negative effect of the higher N dose on stability and by a positive effect of the irrigation, which was weakened by N addition, while in the rainfed condition there was only a negative effect of N (Fig. 3A). In autumn there was a significant N x irrigation interaction, explained by a lower stability of the higher N dose at irrigation, meanwhile at rainfed conditions all treatments effect were similar (Fig. 4A). Overall, our findings reveal a pattern of seasonal effects that suggests a transition from N increasing stability under winter low growing conditions, to N-P regulation under the best growing conditions in spring, and then to water and N control in summer and autumn when there is larger probability of water deficit.

Conclusions

We found evidence that the resources regulating ANPP temporal stability of native grassland change throughout the year with clear a seasonal pattern, which is hidden in year-to-year analysis. A striking result of our study was the discovery of positive or negative effects of both N and P addition on ANPP stability, which were dependent on the season of the year and the interaction between N and P. In this sense, further investigations of inter-annual variations of seasonal ANPP could provide new insights of the mechanisms involved in regulating grassland ANPP responses to global change factors.

Bibliografía

Harpole, W.S., Ngai, J.T., Cleland, E.E., Seabloom, E.W., Borer, E.T., Bracken, M.E. et al. 2011. Nutrient co-limitation of primary producer communities. Ecology Letters, 14(9), 852-862.

Hautier, Y., Tilman, D., Isbell, F., Seabloom, E.W., Borer, E.T., Reich, P.B. 2015. Anthropogenic environmental changes affect ecosystem stability via biodiversity. Science, 348, 336-340

Lehman, C.L., Tilman, D. 2000. Biodiversity, stability, and productivity in competitive communities. American Naturalist 156, 534-552.

Polley, H.W., Isbell, F.I., Wilsey, B.J. (2013). Plant functional traits improve diversity-based predictions of temporal stability of grassland productivity. Oikos 122(9): 1275-1282.

Table 1. Summary of ANOVA for Nitrogen (N), phosphorus (P), water (W) and their interactions effects on relative changes of ANPP temporal stability of different seasons of the year.

	N	P	Water	N x P	N x Water	P x Water	N x P x Water
Winter	**	NS	NS	NS	NS	NS	NS
Spring	**	*	NS	**	NS	NS	NS
Summer	**	NS	*	NS	*	NS	NS
Autumn	NS	NS	NS	NS	**	NS	NS

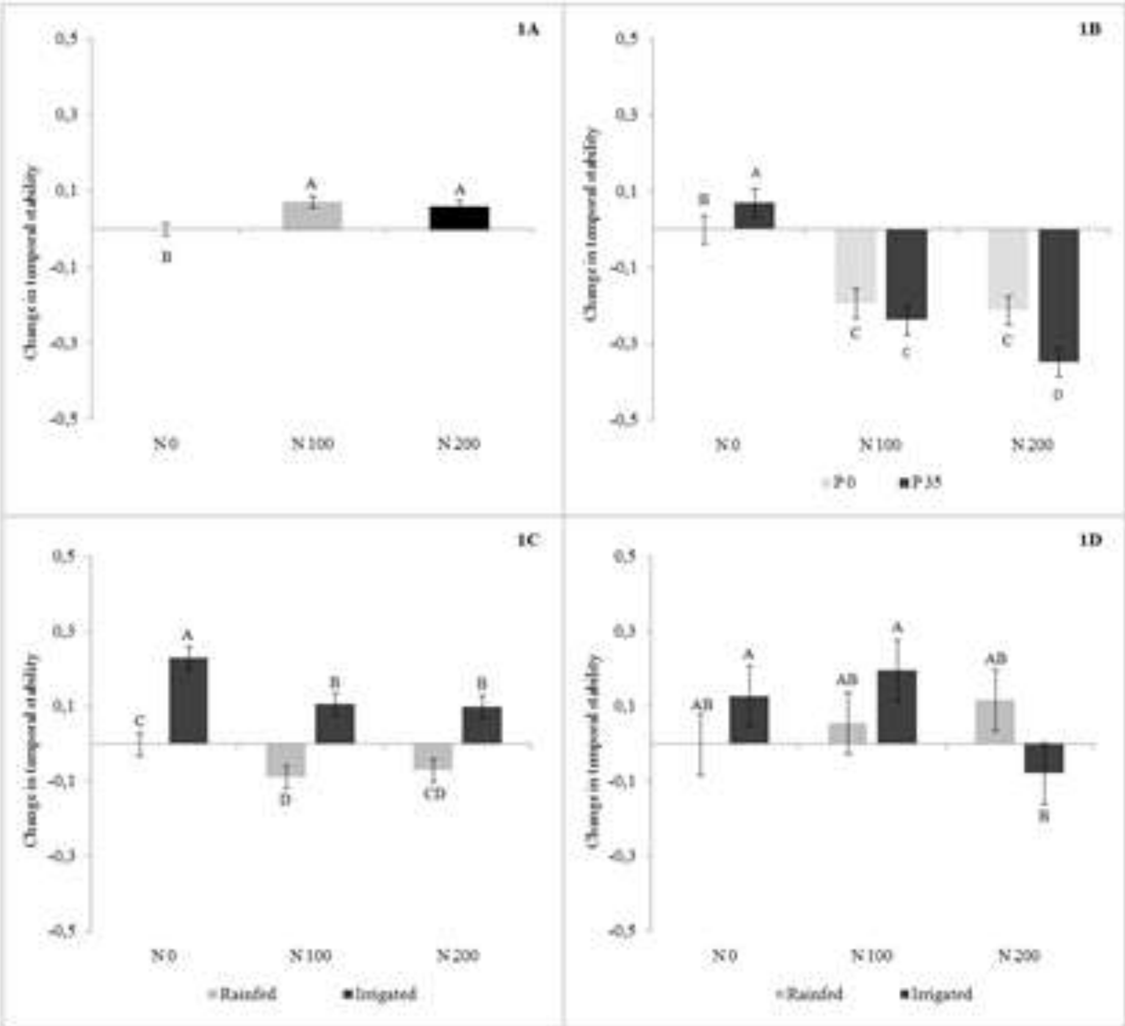

Figure 1.Effects of nitrogen (N), phosphorus (P) and water addition on relative changes of ANPP temporal stability in: A) winter; B) spring; C) summer; d) autumn. Bars represent mean ± SE (n = 3).