The effects of N addition on drought sensitivity of productivity varied with drought period

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Introduction

- **In the absence of changes in total precipitation amount, the effect of rainfall variability on grassland ecosystem function may become more significant as within-year drought episodes increase in duration.**
- **Soil N enrihment through agricultural management and atmospheric N deposition can influence grassland community responses to precipitation variability**
- **We still do not have a clear understanding of the effects of N addition on grassland recovery immediately after drought events or at longer timescales.**

We hypothesized that：

a) **Grassland productivity and C exchange will nonlinearly decrease as drought duration continues。**
b) **The N-induced enhancement of drought response in productivity will increase with drought duration.**
c) **Long-term N addition will not accelerate recovery following drought because of drought-induced injury to plant tissues.**

Study site

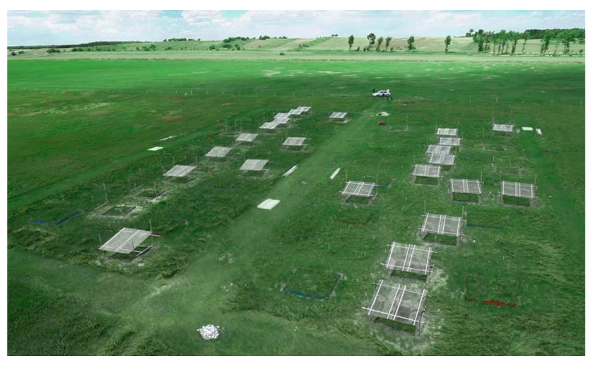
The field component of this study was carried out at the Jilin Songnen Grassland Ecosystem National Observation and Research Station, Jilin Province, China (44◦34′25′′, 123◦31′6′′E). With a semi-arid continental climate, the average growing season precipitation of this area is 411 mm. The mean annual temperature is 6.4℃.

Methods

We manipulated different drought events (15, 30, 45 and 60 days) in both unfertilized and fertilized (10 g yr^{-1}) plots to test the effects of the N addition on drought sensitivity of productivity.

C	15D	30D	45D	60D
N	15D-N	30D-N	45D-N	60D-N

×4



Response variables included aboveground biomass (AGB), ecosystem net carbon exchange (NEE), and leaf net carbon assimilation rate (A).

The response ratio of productivity to drought was calculated as the ratio of differences in AGB or NEE between the drought and ambient precipitation plots to the AGB or NEE in ambient precipitation plots:

$$RR_{AGB} = \frac{Mean(AGB_D) - AGB_D}{Mean(AGB_A)} \times 100\% \ \& \ RR_{NEE} = \frac{Mean(NEE_D) - NEE_D}{Mean(NEE_A)} \times 100\%$$

Results

- **For the drought plots, SWC decreased rapidly for the first 30 days and remained constant there after. SWC for the natural precipitation plots were highly influenced by rainfall events.**

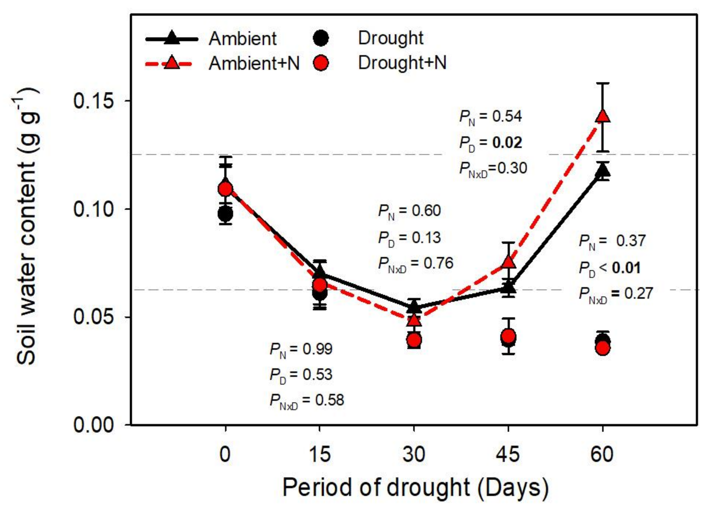


Figure 1 Variation in soil water content during the drought treatment period.

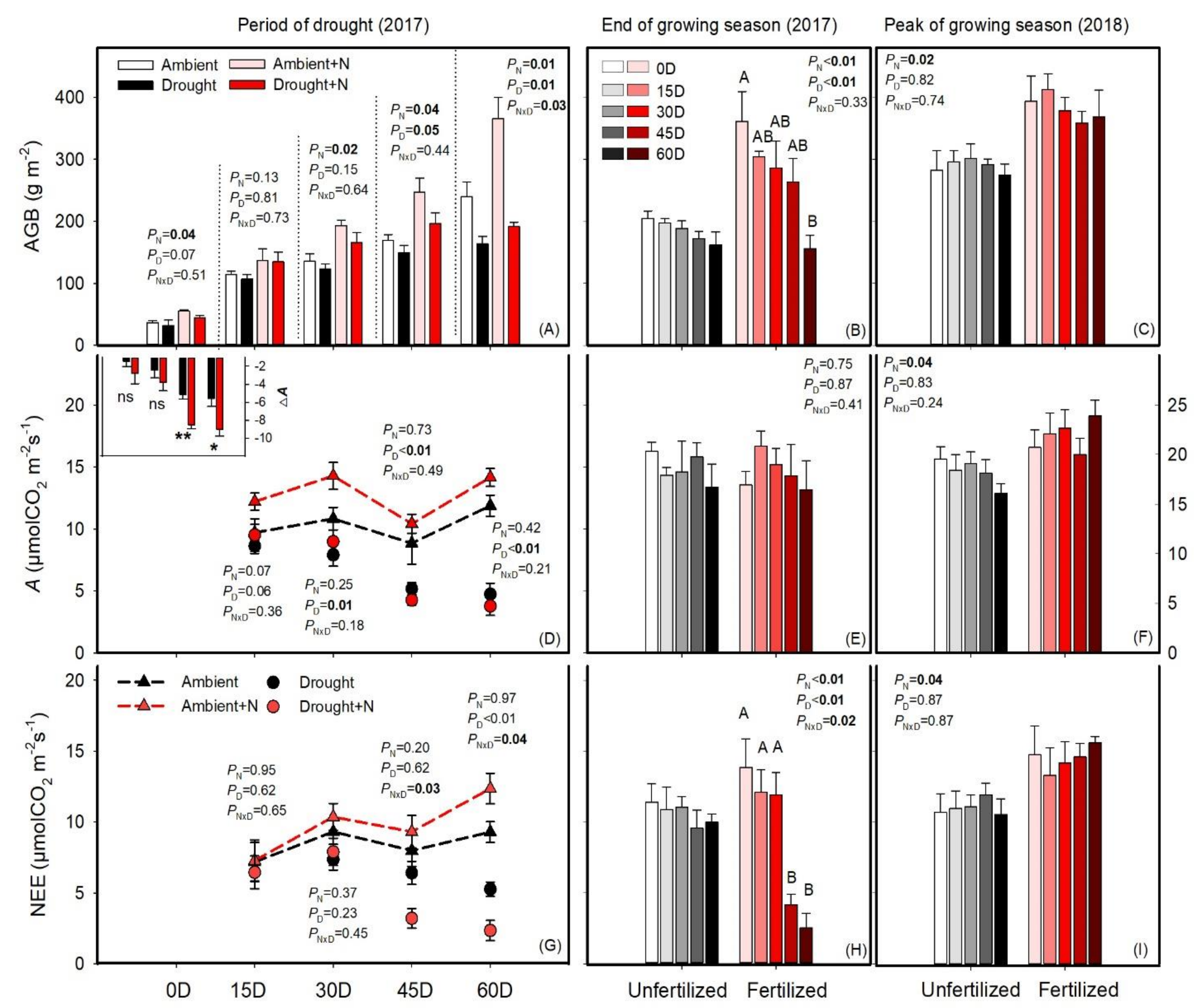


Figure 2 Responses of (A, B, C) aboveground biomass, (D, E, F) leaf net carbon assimilation rate and (G, H, I) short-term net ecosystem C change to the four treatment combinations during drought treatments, at the end of growing season in 2017, and the peak of following growing season (2018).

- **Relative to ambient precipitation plots, AGB declined progressively under prolonged drought .**
- **N addition increased the sensitivity of AGB and NEE to drought, and N-induced enhancement of the drought response increased as drought duration increased, and there were significant interactions between these two effect.**

- **Although our results are consistent with studies showing drought sensitivity to be co-regulated by N and water, we did not observe any positive effects, as hypothesized, on post-drought recovery in N addition plots.**
- **Nitrogen addition and drought interacted to alter (reduce) the density of the dominant species, and there were greater proportions of dead leaves in the drought-N treatment than drought-only treatment after 60 days of drought**

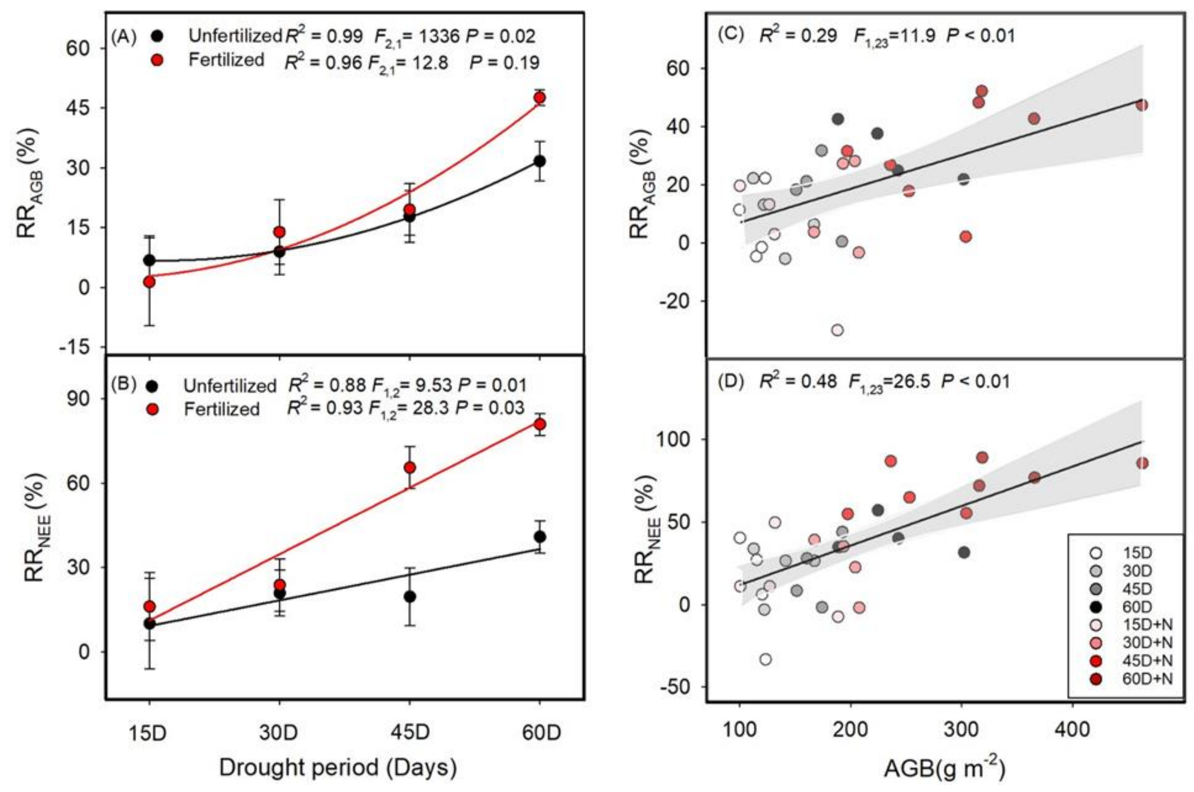


Figure 3 Regression analysis of (A) the drought response ratio of AGB and (B) the drought response ratio of NEE during drought treatments. The relationships between (C) drought response ratio of AGB and AGB in ambient precipitation treatments, as well as (D) drought response ratio of NEE and AGB.

- **Our results indicated that the increased productive potential may have led to greater sensitivity to drought, and may explain the positive effects of N addition on productivity responses to drought we observed. These results also highlight the importance of productive potential, which is altered by N addition, and consequences for drought response.**
- **Although these results indicate that the decrease in R/S ratio partially explained greater drought sensitivity in the fertilized plots, rapid adaptive adjustments in biomass allocation stimulated by drought can also act as a counterbalance that enhances ecosystem stability.**

Conclusions

- **Our results provide experimental evidence that enhanced soil nitrogen availability leads to greater drought-induced declines in grassland productivity and CO_2 exchange, and that this effect increases with duration of growing-season drought.**
- **Nitrogen impacts on drought sensitivity and recovery appear to be a consequence of the simultaneous increases in productive potential and declines in belowground biomass allocation that we observed.**
- **For many grasslands, both climate and N cycling are changing in tandem, which has important implications for estimating future grassland productivity and carbon balance.**

Acknowledgements

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