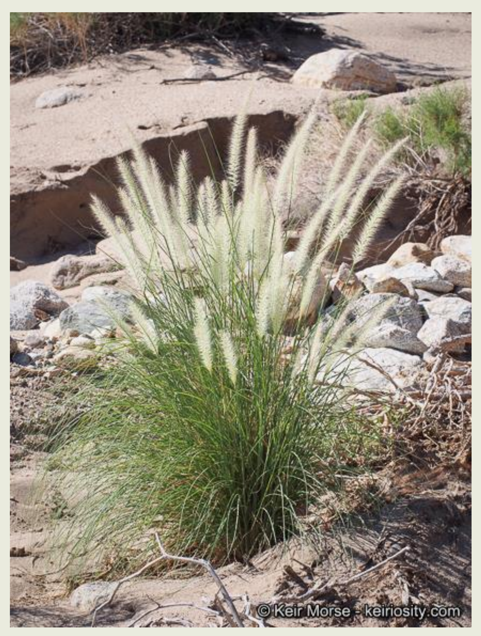
The effects of phosphorus and nitrogen on the health of *Pennisetum setaceum*, African fountain grass

Glen R. Morrison and Erin J. Questad, PhD

Questad Lab, Dept. of Biological Sciences; Cal Poly – Pomona

Introduction

- *Pennisetum setacuem* (Forssk.) Chiov., fountain grass, is a perennial C4 bunchgrass native to Africa. The species is invasive on the Hawaiian Islands (1) and in some of the western United States (2).



- Fountain grass typically colonizes young substrates like lava flows and eroded hillsides (2, 3). Soil on these substrates have been shown to have high phosphorus availability (4, 5).
- Recent research has found positive effect of mixed nutrient fertilization on fountain grass health (6).
- Response of fountain grass to nitrogen addition is known (7), but a response to phosphorus has not been demonstrated.

Research questions

1) How does fountain grass respond to elevated soil phosphorus availability?
2) How do possible effects of phosphorus compare to the effects of nitrogen?

Methods

Experimental Design

- Forty fountain grass plants were grown from seed (sowed 12/7/15) and randomly assigned to four treatment groups (table 1): phosphorus added, nitrogen added, phosphorus and nitrogen added and no added nutrients (control).
- Fertilization treatments began on March 1, 2016, and continued at regular intervals until the end of the experiment (June 17, 2016).

Nutrient	Source	Mass applied (g)	Frequency
P	0-46-0 triple superphosphate	1.6	once a week
N	16-0-0 calcium nitrate	13.6	once a month

Table 1. Experimental fertilization protocol.

Measurements

- Biomass data were collected once a month using a quadrat point intercept method.
- Specific leaf area (SLA) and chlorophyll fluorescence data were taken in May, 2016 and final chlorophyll fluorescence data on June 17, 2016 .
- Final flower counts were taken and plant materials were harvested on June 17, 2016.

Statistical Analyses

- Data were fit with generalized linear models and analyzed by analysis of deviance when assumptions were met, otherwise data were analyzed with the non-parametric Kruskal-Wallis test and Dunn's test for multiple comparison.
- Statistical analyses were performed in the R computer language.

Results

Nitrogen strongly affected growth, while phosphorus had a weaker effect

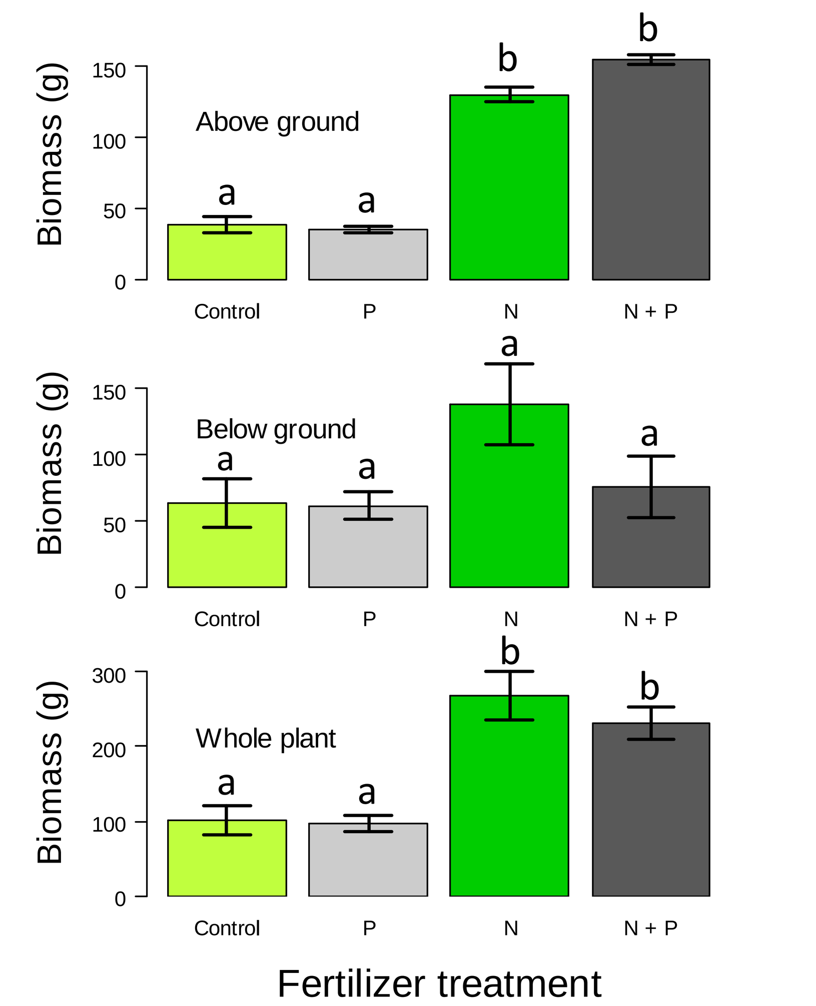


Fig 1. Mean final biomass by fertilizer treatment for portions above and below ground, and whole plants. Error bars are one standard error. Letters indicate Tukey groups at p < 0.01.

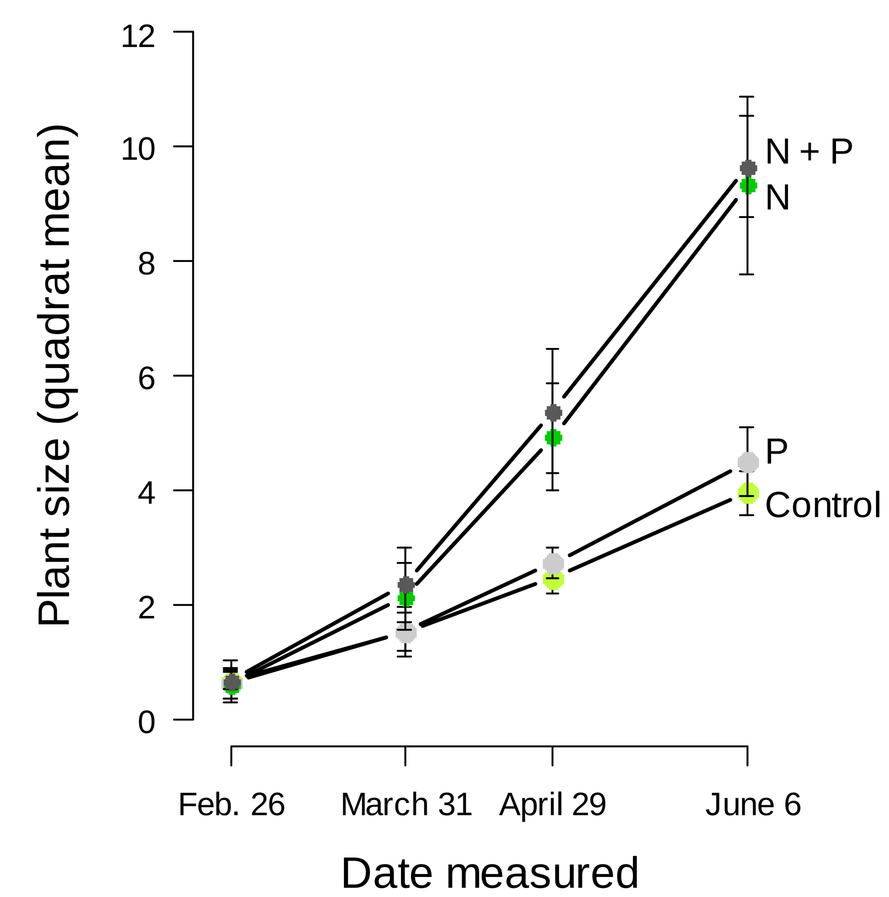


Fig 2. Mean plant size (as measured by mean number of quadrat touches per plant) of fertilizer treatment groups over the length of the experiment. Error bars are one standard deviation.

Nitrogen affected flower production and timing of flowering

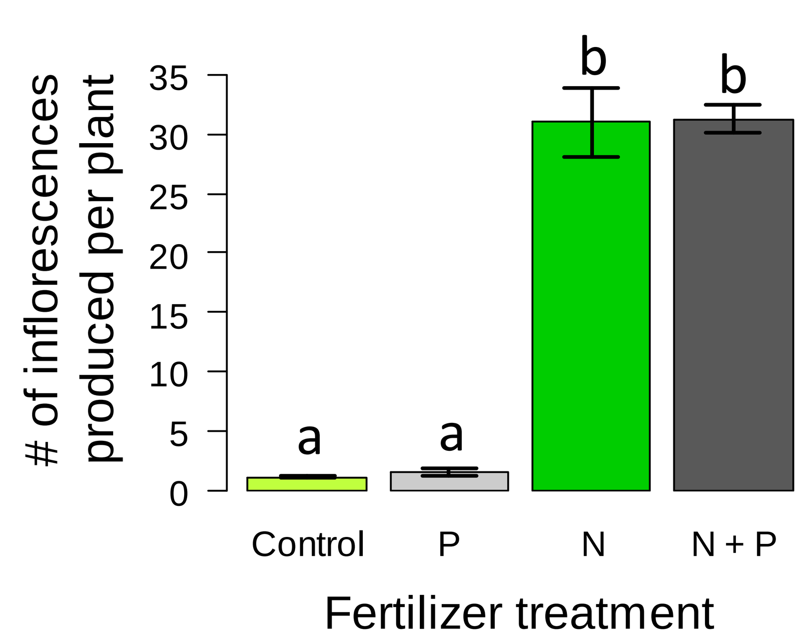


Fig 4. Mean number of flowers produced per plant by fertilizer treatment. Error bars are one standard error. Letters indicate Tukey groups at p < 0.01.

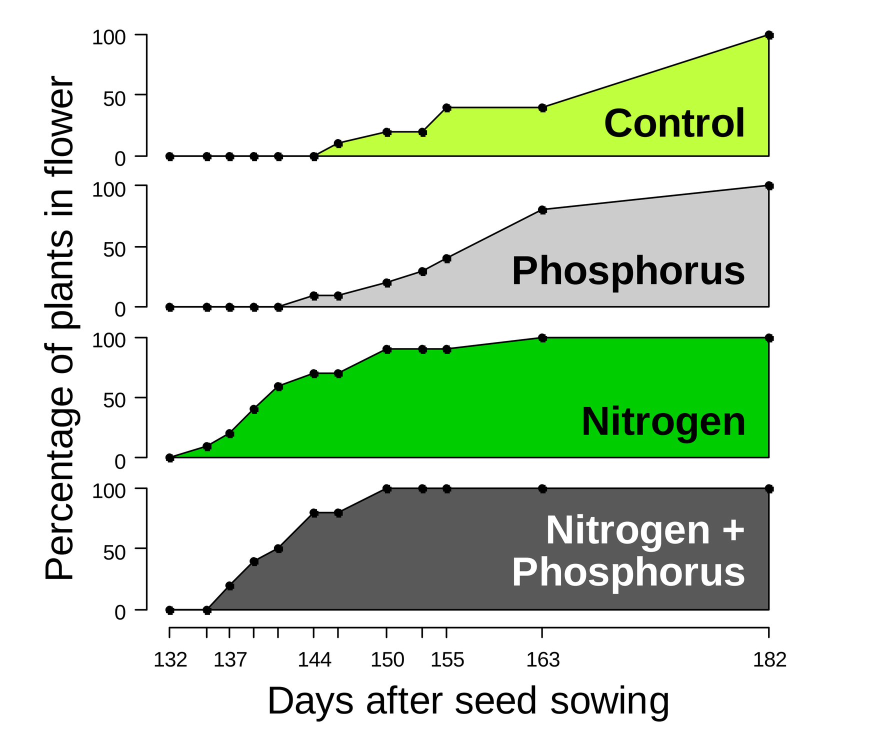


Fig 3. Percentage of plants in flower for each treatment group over time. Tick marks along the x-axis indicate days plants were censused for flowering.

Nitrogen reduced plant stress

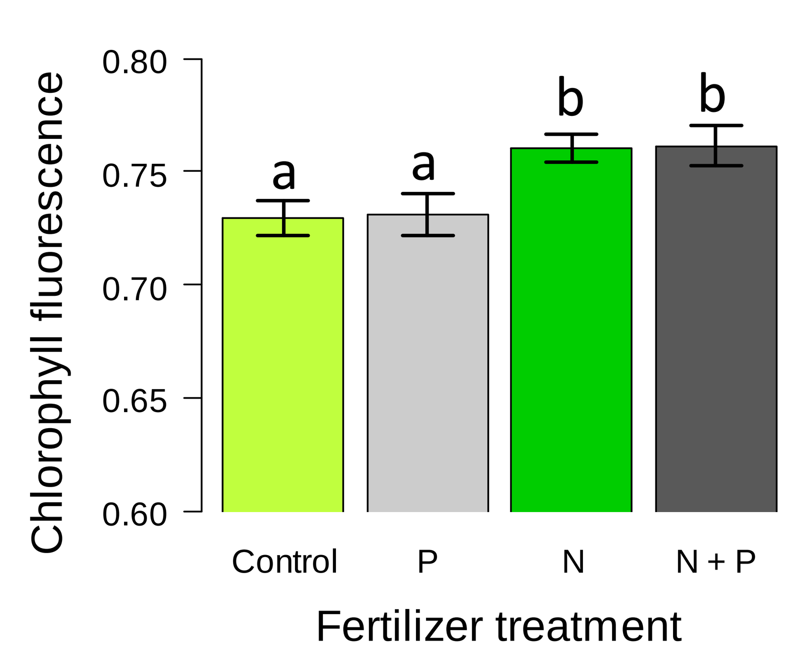


Fig 5. Mean final chlorophyll fluorescence by fertilizer treatment. Error bars are one standard error. Letters indicate Tukey groups at p < 0.05.

Fig 6. One plant from each of the four treatment groups. Each shows characteristics typical of plants in each treatment group. Not

Results cont.

Factor	Plant size	Number of inflorescences	Chlorophyll fluorescence
Phosphorus (P)	0.001831 **	0.7835	0.4063
Nitrogen (N)	< 2.2e-16 ***	<2e-16 ***	<2e-16 ***
P:N	0.65298	0.4556	0.8563
Date	< 2.2e-16 ***	NA	0.1656
P:Date	0.885711	NA	0.7896
N:Date	< 2.2e-16 ***	NA	0.1705

Table 2. P-values from analysis of deviance for GLMS on plant size, number of inflorescences and chlorophyll fluorescence. Poisson (log link) GLM for plant size and number of inflorescences and Quasibinomial (logit link) GLM for chlorophyll fluorescence. *** p < 0.001, ** p < 0.01, * p < 0.05.

Factor	Above ground	Below ground	Whole plant
Phosphorus	0.5980	0.22384	0.4494
Nitrogen	<2e-16 ***	0.03532 *	5.951e-12 ***
P:N	0.1198	0.26558	0.7089

Table 3. P-values from analysis of deviance for GLMs on biomass. Gamma (log link) used for all three analyses. *** p < 0.001, ** p < 0.01, * p < 0.05.

Results summary

- Both phosphorus and nitrogen increased plant growth (fig 1 , fig 2, fig 6, table 2), though nitrogen had a stronger effect.
- Together, nitrogen and phosphorus increased above ground biomass and decreased below ground biomass, relative to nitrogen alone (fig 1, table 3).
- Nitrogen, but not phosphorus, increased flower production (fig 3, table 3) and affected timing of flowering (fig 3).
- Nitrogen reduced plant stress and increased chlorophyll fluorescence (fig 5).

Conclusion

- While phosphorus affected the vegetative health of fountain grass, nitrogen played a much stronger role on vegetative, reproductive and physiological health.

References

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