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Fire has positive effects on seed reproduction in *Andropogon gerardii* but negative impacts on *Ratibida pinnata* seed reproduction

J. R. Logan, I. H. Luby, and I. A. McCallum-Cook
Biology Department, Grinnell College, Grinnell IA 50112, USA

Abstract

Fire plays an important role in tallgrass prairie ecology and as such, many prairie plants have evolved mechanisms to cope with or take advantage of its effects. We examined the effects that fire has on seed reproductive potential in Andropogon gerardii *(Big Bluestem),* Sorghastrum nutans *(Indiangrass), and* Ratibida pinnata *(Grey-headed Coneflower) by measuring the number of seed heads, net seed production per plant, and germination success between seeds in annually spring burned plots and unburned plots of tallgrass Iowa prairie. We found significantly higher numbers of seed heads for* A. gerardii *in burned plots and a significantly greater number of seed heads and net seed weight in* R. pinnata *in unburned plots. We also found a trend towards higher germination of* R. pinnata *in unburned plots. Our study suggests that grasses invest more energy into reproduction via seeds after fires, perhaps because they are better able to colonize a greater area of exposed land, and that certain forbs produce fewer seeds after fire. We suggest that grass seeds used in restoring prairies come from burned prairies and* R. pinnata *seeds come from unburned areas.*

Introduction

Although fires are historically commonplace in tallgrass prairies, their effects on plant populations are far from detrimental. Many prairie plant species are well suited for quick recovery after these events, and in many cases, fire has positive effects on their reproduction (Reichman 1987). Prairie grasses are usually the first and most vigorous species to respond following a fire. Grass rhizomes, kept safe underground, support rapid clonal re-growth despite the loss of aboveground biomass. Fires have also been found to aid this clonal growth by stimulating the production of lateral shoots following the destruction of apical meristems above ground (Reichman 1987; Wade et al. 2000). Fire appears to benefit grass reproduction by seed as well. Prominent prairie grasses *A. gerardii* and *S. nutans* in particular exhibit increased germination rates in recently burned plots (Rohn and Bragg, 1989). Forb species however, do not display such vigorous re-growth immediately following fires (Hulbert 1969).

Prairie plant reproduction however, ultimately hinges on the presence of an existing population. In areas where cultivation has disturbed native species composition, ploughed up networks of shoots and sublateral meristems, and destroyed the seed bank, prairie plant species are unable to recover. Reintroducing plants is only practical using seeds. Transplanting meristems and individual plants is not only an exhaustive task, it also requires disturbing existing soil. The fitness and reliability of seeds from prairie plants therefore, is of utmost importance to prairie restoration. According to Diboll (1997), seed quality along with seed germination rates and reliability are crucial factors in seeding reconstructions. Our study indicates from which conditions these seeds should be taken to best aid restoration efforts.

To answer this question, we examined how seed count, weight, germination percentage and number of seed bearing heads per plant differ between annually burned and unburned plots in reconstructed prairies. The major prairie grasses *A. gerardii* and *S. nutans* were used in this study because of their dominance in the Iowan tallgrass prairie (Reichman 1987; Diboll 1997). Additionally, we examined *R. pinnata* because of its short germination period and as a representative of forbs (Kartesz 2002). In prairie restoration, a mix of seeds from both the dominant grasses and forbs is necessary for planting reconstructions (Diboll 1997). We hypothesized that burning would lead to more seeds and more seed bearing heads in grasses and fewer in *R. pinnata*; germination would be better for each species in burned plots than unburned plots.

Although it may not be the primary means of grass reproduction (Reichman 1987), seed production remains an important reproductive strategy of all three species in our study and is essential to restoration. Because seeds are the only way in which prairie reconstructions are established, a study of the seed fertility and success of significant prairie plants is necessary and appropriate.

Methods

We conducted our study at Grinnell College's Conard Environmental Research Area in Jasper County, Iowa during October 2009. We obtained samples from twenty 10 x 10 meter plots of restored tallgrass prairie alternating between annually spring-burned and unburned plots, sampling at four separate random points in each plot. Each sample point was selected as the intersection of two transects along the length and width of each plot.

At each transect intersection we identified the closest plant of each species to the sampling point. To avoid edge effects, we excluded plants within .5 meters of the plot's border from our sampling. We counted the number of seed heads—clusters of seed-bearing material with a common stalk—per plant and then collected all of the seeds on each. We determined the net seed count and seed head count for both of the grasses. For *R. pinnata*, we measured average seed weight per plant, instead of seed count, because each head has too many seeds for individual counting to be practical.

After counting and weighing seeds, we randomly selected 3 seeds per species per sample point for germination trials, giving us 12 seeds for each species per plot. We then cooled and dried *S. nutans* and *A. gerardii* seeds in a refrigerator at 4° C for 12 days. For all seeds, we used the Petri dish germination procedure employed by Keeley and Fotheringham (1998). We placed 12 seeds from each plot into 60 5.5cm Petri dishes containing 1.5mL of de-ionized water and one piece of Whatman #1 filter paper. We sealed these with parafilm and placed them in a dark drawer at 23.5° C, checking every 24 hours over an 11 day period (for *A. gerardii* and *S. nutans*) or 9 day period (for *R. pinnata*) for signs of germination.

We used Minitab 15 to conduct two-sample t-tests and construct interval plots comparing treatment averages (net seed count [or seed weight], seed heads per plant, and successful germination percentage).

Results

We found no significant difference in net seed production per plant between the treatments for *A. gerardii* (t=0.63, p=0.535) and *S. nutans* (t=-0.68, p=0.508). However, Figure 1 shows significantly higher seed production (40.7% heavier) in unburned plots than in burned plots for *R. pinnata* (t=-3.67, p=0.004).

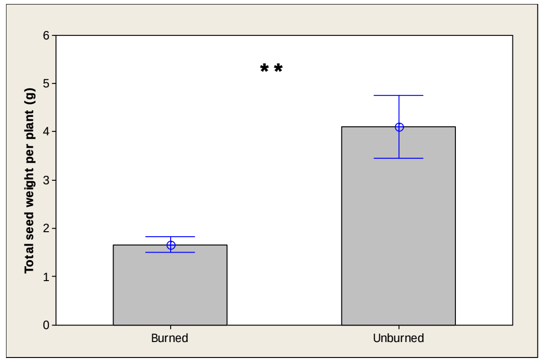

Figure 1. Mean seed weight per plant in burned (n=10) and unburned (n=10) plots for *Ratibida pinnata*. Error bars represent ±1 SE; p=0.004.

Figure 2 shows significantly more seed heads per plant between the treatments in *R. pinnata* (t=-5.57, p<0.001) and *A. gerardii* (t=7.16, p<0.001); *R. pinnata* had 48.6% more seed heads in unburned plots and *A. gerardii* had 61.3% more seed heads in burned plots. There was no difference in the number of seed heads for *S. nutans* as individuals only produce one seed head per plant regardless of their conditions.

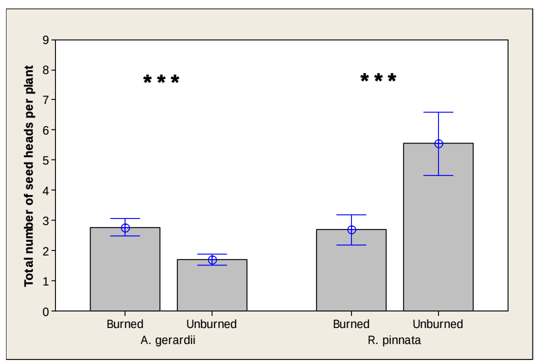

Figure 2. Mean number of seed heads per plant in burned (n=10) and unburned (n=10) plots for *A. gerardii* (p<0.001) and *R. pinnata* (p<0.001). Error bars represent ±1 SE.

Data on success of germination demonstrated a trend, though not significant (t=-1.61, p=0.129) for *R. pinnata* towards more successful germination in unburned plots (Figure 3). We could not determine a difference in germination for either of the grasses because many of the seeds molded during the course of observation which prevented proper germination.

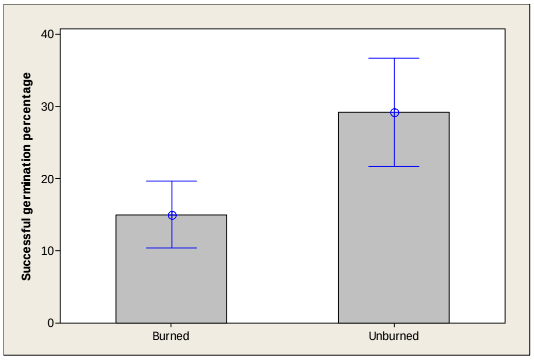

Figure 3. Percentage of seeds with successful germination after 9 days in burned (n=10) and unburned (n=10) plots for *R. pinnata*. Error bars represent ±1 SE; t= 1.61 p=0.129.

Discussion

Grasses tend to do better than forbs after fires because the removal of other competitors places them in a better situation to exploit the resources available—mostly sunlight (Hulbert 1969). Grasses that reproduce only by rhizomes after fires are only able to colonize areas directly adjacent to them; those that invest energy in seed production after fires will be able to colonize a greater area of cleared space. This places an evolutionarily selective pressure to invest in seed reproduction after fire. Forbs don't have the same selective pressure to produce more seeds after fires because they are later succession plants. By the time they start growing, the dominant grasses would have already filled in much of the area making the spatial conditions of the burned prairie similar to those of an unburned prairie. In other words, both burned and unburned prairies are relatively crowded by the time the forbs begin growing. This could explain why we found a significantly higher average number of seed heads per plant in burned plots for *A. gerardii* but not for *R. pinnata*.

The benefits of fire on C4 grasses include benefits for the plant's seed production capabilities. *R. pinnata*'s significantly fewer seed heads in burned plots suggests that it does not invest as much energy into seed production after a fire. The lack of significant differences in total seed count and germination success rates—and subsequent reliance on seed head number as a measure of reproductive potential—limits the conclusions we can make for grasses. However, Rohn and Bragg (1989) found *A. gerardii* and *S. nutans* seeds were more successful in germinating when they came from burned plots illustrating a strong relationship between the presence of fire and better seed reproduction in prairie grasses.

Our study has applications in the field of prairie restoration by suggesting certain seeds be used in establishing restored prairies. We suggest that because of their trend towards more successful germination, *R. pinnata* seeds collected from unburned prairies should be used when seeding. Based on the significantly greater abundance of *A. gerardii* seeds in burned plots than in unburned plots and the results of other studies (Rohn and Bragg 1989), we also recommend that *A. gerardii* seeds used in restoration practice come from burned prairies. The greater number of seeds in burned prairies makes seed collection from them more efficient than from unburned prairies.

Further study is needed to determine exactly which mechanisms in plants are affected by fire and how. Studying other forbs besides *R. pinnata* is necessary to better understand the effects of fire on prairie plant reproduction in general. Determining fire's effect on the frequency of grass reproduction by seed as compared with reproduction by rhizomes would also prove a useful focus of study. It would also be beneficial to measure the viability of any prairies established with seeds exclusively from either burned or unburned plots.

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