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Germination rate, length, and weight differences in native and non-native *Ratibida pinnata* and *Sorghastrum nutans* seeds

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Abstract

An important aspect of tallgrass prairie reconstructions is the origin of the seeds being planted. Our experiment questions whether or not there is a difference in the lengths, weights, and rates of germination in native and non-native Ratibida pinnata *(Gray-headed Coneflower) and* Sorghastrum nutans *(Indiangrass) seeds. We collected samples from the Conard Environmental Research Area (CERA) near Kellogg, Iowa, which we then measured, weighed, and incubated to test their rates of germination. The results showed that the total weight and length of the non-native* S. nutans *was significantly greater, and the total weight of the non-native* R. pinnata *was significantly higher, but the mean length and germination rates of the latter were not significant. The significant variations in seed length and total seed weight support conservationists' claims that only local seeds should be used in tallgrass prairie reconstruction.*

Introduction

Restoration of tallgrass prairies has existed for almost a hundred years since remnant prairies became more fragmented due to agricultural conversion. Not until the 1970's has prairie reconstruction become an important environmental concern (Mutel 2007). In recent years, biologists have begun to plant non-local seeds in attempts to increase diversity and plant performance within reconstructed prairies. Wimp et al. (2005) argue that a greater genetic diversity of a dominant plant is beneficial for the entire ecosystem. However, Gustafson (2004) states that genetic differences and ecological performance among local and non-local seeds are more of a concern than diversity. In many prairie remnants, there can already be a great amount of genetic diversity (Gustafson, et al 2004). Therefore, the aim of prairie reconstructions should be the success of the populations, not the genetic diversity of the prairie as a whole (Mutel 2007).

Seed origin not only affects the genetic composition of the population; it also affects the success of the population as a whole. Sanders and McGraw (2005) found that plant populations consisting of seeds from only one source are, on average, more successful, growing larger rhizomes and having a greater leaf area. This result illustrates how prairie reconstructions that use seeds from multiple sources, including non-local sources, could be hindering plants' net primary production (NPP).

We chose to study two plants species that are present in both prairies: *Ratibida pinnata* (Gray-headed Coneflower), a forb plant, which is commonly found in dry prairies, and *Sorghastrum nutans* (Indiangrass) which also commonly grows in dry prairies, open savannahs, pastures and fields. *R. pinnata* and *S. nutans*' growing seasons allowed us to collect their seeds because they extend into fall (Ladd and Oberle 2005). Also, *S. nutans* is a C4 grass commonly found in tallgrass prairies, making our study more relevant to tallgrass prairie reconstructions (Damhoureyeh and Hartnett 2002). *R. pinnata* has a short germination period which allowed for the completion of our study (Smith 1980).

The *S. nutans* seed and *R. pinnata* seedhead samples were collected from the reconstructed Lab Prairie (formerly agricultural land) and the Remnant Prairie at the Conard Environmental Research Center (CERA) located outside of Kellogg, Iowa. The seeds and seedheads from these two prairie sites experienced the same environmental disturbances such as spring fires that occur every three years. The reconstructed prairie used non-local seeds because there were no cultivars nearby in Iowa at the time of the reconstruction in 1987. The grass seeds, for example, were imported from Nebraska (Brown 2009).

In our study, we tried to determine whether the origins of a *S. nutans* seed or a *R. pinnata* seedhead has an effect on the seeds' weight, length, or rate of germination and if these variables indicate significant differences between local and non-local seeds and seedheads. Variances in seeds' weight, length, or rate of germination would indicate that seeds from one origin are genetically stronger than the other (Wulff 1986, Stanton 1984). We hypothesize that there will be differences in the lengths, total weight, and the percentage rates of germination

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of native and non-native seeds and seedheads, because tallgrass prairie seeds' genotypes have evolved over time to specifically suit different environments (Kurtz 2001).

Methods

On the 8th and 10th of October, 2009 we took random samples of *R. pinnata* seedheads and *S. nutans* seeds from the reconstructed and the remnant prairies in CERA. Then, we measured and weighed the seeds and seedheads of all samples. Finally, we measured the samples' rates of germination.

On each prairie we created five systematically assigned transects and randomly selected sampling points along these transects. Seeds and seedheads were collected from the plant closest to the sampling point. Twenty-six *R. pinnata* seedhead samples from the remnant prairie were collected using the haphazard sampling method due to the scarcity of the plant while twenty-six *R. pinnata* seedhead samples from the reconstructed prairie were collected using random sampling. *S. nutans* seeds were collected from twenty sample plants using random sampling on both remnant and reconstructed prairies.

From the twenty collected *S. nutans* samples, we took 10 seeds at random, digitally photographed them, and measured the seeds' lengths in millimeters using the program ImageJ. All of the seeds and seedheads were weighed separately by mother plant using an electronic balance. We also recorded the plant from which each seed originated in order to understand the effects of its genotype.

Finally, ten seeds were randomly selected from each *R. pinnata* and *S. nutans* sample and placed in a Petri dish lined with filter paper. Next, 1.5 ml of distilled water was added to each Petri dish. The Petri dishes were then sealed with Parafilm, and placed in a drawer to be incubated at approximately 23.5˚C. The samples were observed each day in order to record their percentage rate of germination per mother plant.

Before germinating, many seeds require cold stratification, the process of simulating natural conditions that a seed must endure prior to germination (Nelson n.d.). Cold stratification is not required for the seeds of the *R. pinnata* to grow; however, *S. nutans* seeds do require cold stratification (Smith and Smith 1980).

T-tests were used to determine whether the differences between seeds of different origins were significant. We calculated the difference between mean seed lengths of native and non-native seeds and seedheads, as well as the difference between mean seed weight of native and non-native seeds. We also calculated the difference between the percentages of *R. pinnata* seeds germinated per Petri dish. However, we did not perform a T-test on *S. nutans* germination percentages because none of the seeds germinated.

Results

Non-native *S. nutans* seeds have 11.53% larger mean lengths than native seeds (Figure 1, T = 11.76, P < 0.001). The mean weight of non-native *S. nutans* seeds is significantly greater (37.56%) than native seeds (Figure 2, T = -3.63, P = 0.001).

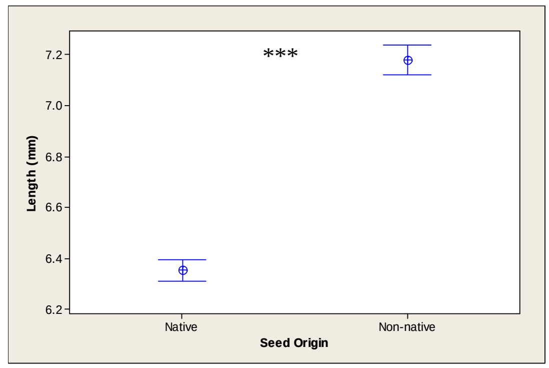

Figure 1. Mean length of *S. nutans* seeds. (+/-1 S.E., n= 40). *** → P<0.001

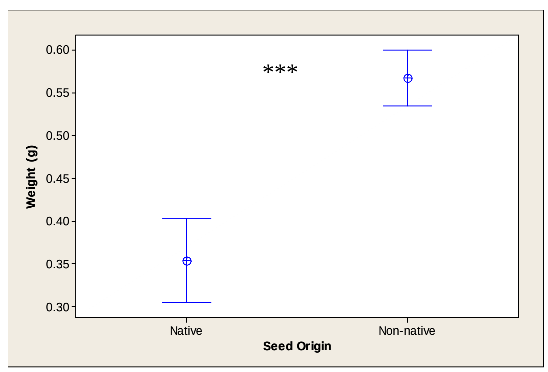

Figure 2. Mean total weight of *S. nutans* seeds. (+/-1 S.E., n= 40). *** → P<0.001

The difference of the mean lengths of *R. pinnata* seedheads is not significant (Figure 3, T = -1.42, P = .159). The mean weight of non-native seedheads was greater (71.03%) than that of native seedheads (Figure 4, T = -6.94, P < 0.001).

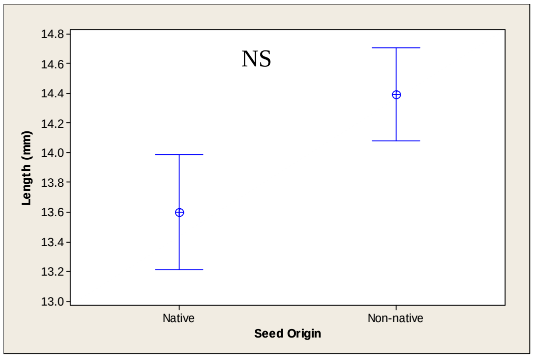

Figure 3. Mean length of *R. pinnata* seedheads. (+/-1 S.E., n= 52). (t = 1.42, p= 0.159).

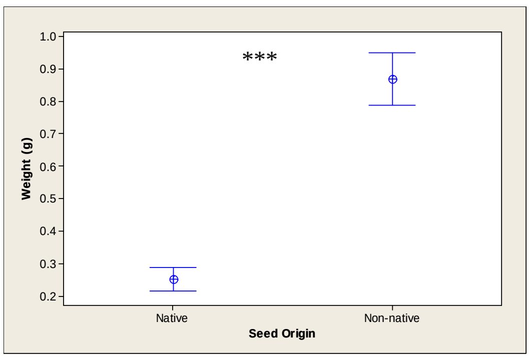

Figure 4. Mean weight of *R. pinnata* seedheads. (+/-1 S.E., n= 52). *** → P<0.001

For the first two days of incubation, none of the *R. pinnata* seeds had germinated. The total germination percentage for non-native *R. pinnata* (8.46% germinated) seeds was double the germination percentage for native seeds (4.23% germinated). Although the percentage of germinated non-native seeds per Petri dish was 33.5% greater than the percentage of native germinated seeds per Petri dish, this difference was not significant (T = 1.37, P = 0.195). No data is available on the germination rates of *S. nutans* seeds, because none of the seeds germinated within the 10 day period of our study.

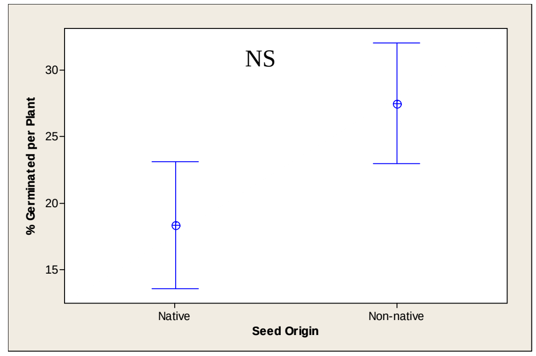

Figure 5. Percentage of *R. pinnata* seeds germinated per plant. (+/-1 S.E., n= 52). (t = 1.37, p= 0.195).

Discussion

We hypothesized that there would be differences in the lengths, total weights, and rates of germination between the native and non-native seeds of *R. pinnata* and *S. nutans*. The mean weights of both non-native *R. pinnata* seedheads and *S. nutans* seeds were significantly greater than that of native ones (Fig. 2, Fig. 4). Only the difference in the lengths of *S. nutans* seeds proved to be significant, while the lengths of *R. pinnata* seedheads did not (Fig. 1, Fig. 3). This evidence points to a variation in the physical characteristics of both species of seeds. However, our data regarding the germination rates of native and non-native seeds was not statistically significant.

Non-native *R. pinnata* and *S. nutans* seedheads and seeds have greater mean weights than native seeds and seedheads. This data implies that the *R. pinnata* and *S. nutans'* seeds either weigh more individually or that the plants themselves produce more seeds. Previous research shows that heavier seeds have less concentrated energy than lighter seeds, yet they have equal amounts of nitrogen (Gross and Kromer 1986). Therefore, both lighter and heavier seeds have equal potential for germination. Our results show that seed weights have little effect on germination because both native and non-native seeds germinated. There may have been some variability in our results, because seedheads from each

Table 1. Percentage of the total *R. pinnata* seeds germinated.

	11/14/09	11/15/09	11/16/09	11/17/09	11/18/09	11/19/09	11/20/09	11/21/09
Native	.769	1.54	1.923	2.69	4.23	4.23	4.23	4.23
Non-native	2.69	3.85	4.62	5.38	8.46	8.46	8.46	8.46

R. pinnata plant were weighed together to find the total weight of each plant's seeds. Thus, some samples had the potential for having more seedheads than other samples.

Our data on non-native *S. nutans* seeds showed greater mean lengths, reflecting a difference between native and non-native seeds. Such difference may be due to the origin of non-native seeds, some genetic variation between the native and non-native seeds, or a healthier mother plant (Gross and Kromer 1986). Tallgrass prairie seeds of the same species can differ genetically within prairie fragments and between distant locations (Gustafson, et al 2004). Research has shown that seed size is positively correlated with the performance of seedlings (Baker, et. al 1994). Our data shows that the non-native seeds of *S. nutans* were significantly longer, which could give them an advantage over the native seeds in the long term as they grow, but not necessarily in germination.

The total percentage of germinated non-native seeds doubles that of the germinated native seeds. However, the results of our seed germination experiment were not significant which may have been caused by an abundance of seeds placed in each experimental Petri dish. The overcrowding of seeds may have hindered germination by limiting the water resources necessary for each seed. When the germination results are compared per experimental units (Petri dishes) our results are still statistically inconclusive. Had our results been significant, they could have been the outcome of a genetic difference of non-native seeds or a healthier mother plant (Gross and Kromer 1986). The trend seen in our results regarding native and non-native *R. pinnata* seeds' germination led us to believe that these two types of seeds have adapted to two different environments. A previous study demonstrated local adaptation in prairie plants, especially to soil conditions (Schultz, et al. 2001).

Our results in terms of seed dimension and weight, in the case of *S. nutans*, support the claims of certain ecological conservationists that native and non-native seeds differ significantly. Thus, only one type of seed should be used in the reconstruction of tallgrass prairies if the goal is to preserve a specific species variety and have a healthy population. If instead the goal is to preserve an entire ecosystem then the seeds can have multiple origins and benefit other populations (Sanders and McGraw 2005). Some non-native seeds may compete with native seeds and become the dominant genotype because of their increased performance (Baker, et. al 1994). Future studies regarding the use of native versus non-native seeds for prairie reconstruction or restoration may look at how competition between local and non-local plants affects each species in prairies. Also, the growth rate of these species when planted in on one another's environment could be measured, along with their biomass, height etc. Since we germinated our seeds under identical conditions, future studies could account for the effects of soil nutrients, weather conditions, and local predators on plants' growth.

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