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Influence of seed source on the performance of three common prairie grasses in grassland restorations

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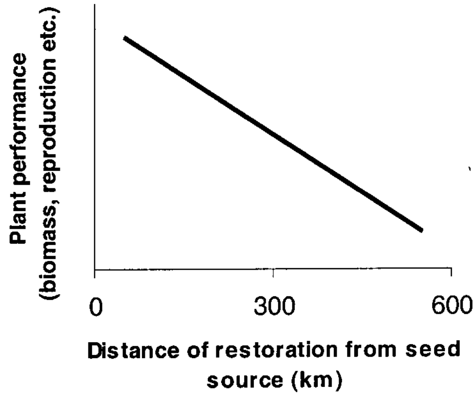
Introduction

Tallgrass prairie once covered 250 million acre of the Midwestern U.S; now less than one percent of this original area is left. In recent years the restoration and reconstruction of tallgrass prairie has become more popular throughout the prairie region. The interest in preserving and restoring prairies came about in the early 1900's when people began to see these vast tracts of land disappear to the steel moldboard plow (Shirley 1994). Prairie restoration focuses on returning a community to a target configuration; often the target community is defined as one that existed during pre-European settlement (Thompson, 1992).

The goal of prairie restoration, or any type of restoration, is to construct a community in such a way that the long-term persistence of these once common plant communities is ensured once the causes of degradation are removed (Procaccini and Piazzi, 2001). One of the primary issues in restoration is deciding where to get seed material for the restoration. In theory, local populations would be adapted to the conditions within the site and would be more likely to generate sustainable populations (Millar and Libby 1989; Knapp and Rice 1994). This idea has led many restorationists to only use seed from sources located within 150-200 miles from the reconstructed community (Shramm 1978). However, sources of local seeds are often very limited or may be unavailable in a given area. Furthermore, most large-scale restorations depend wholly on seed from commercial suppliers, which may be several states removed form the target community and may overlook genetic quality when producing seeds (Visser and Reheul, 2001). The use of seed from geographically distinct areas has caused concern about local adaption and maintenance of genetic integrity of existing native populations (Millar and Libby 1998, Linhart 1995).



Hypothesized relationship between plant performance and geographic distance from the restoration site to the seed source.

Prairie restorationists throughout the United States have made great strides in restoring the species composition and structural components of the tallgrass prairie (Gustafson et al., 2001), but the importance of local genotypes to the success of a restoration has never been studied explicitly. One study found that non-Illinois *Andropogon gerardii* individuals were prone to more insect damage, were shorter and had fewer culms when compared to local genotypes grown in the Illinois (Gustafson et al. 2001). While researchers routinely mention the risks of the use of seed sources net ecologically distance to the restoration site (Montalvo et al., 1997; Gordon and Rice, 1998; Knapp and Dyer, 1998). However, these issues have rarely been tested. The goal of this project was to specifically test the importance of seed provenance in establishing healthy, functioning plant populations within a restoration context.

Methods

Common garden experiments were used to compare the reproductive and vegetative output of three common prairie grass species. Seeds were collected from four or five locations (central Illinois, northern Illinois, Kansas, Iowa, North Dakota) for each species and planted in two separate gardens in northern and east-central Illinois. The gardens allowed comparison of performance between northern and east-central Illinois for local genetic variation and seed for more geographically distinct larger scale variations.

FIELD EXPERIMENT. Half of the plants were grown in the seed production area of Midewin National Tallgrass Prairie (MNTP), located in Wilmington, IL. The other half of the plants were grown on a privately held site in Charleston, IL. Ten replicates of each ecotype were planted at both garden sites. Plants were started from seed in the EIU greenhouse and transplanted to garden sites in early June. A layer of mulch was applied to both gardens to prevent evaporative water loss and limit weed growth – a common restoration practice.

All aboveground parts were harvested before seeds were dispersed to determine seed mass and total plant biomass. To assess the ability of each genotype to establish a viable population in a restoration setting, the seeds produced by each plant were further examined to determine seed viability (See below). This last measure, above all will determine the success of these genotypes in a restoration setting. All data were analyzed with ANOVA to determine the importance of seed provenance on plant performance.

SEED GERMINATION EXPERIMENT. All, or up to one hundred seeds were randomly selected from each individual, placed in groups of twenty-five and put in a growth chamber to germinate. The seeds were placed on Watman 100™ filter paper in 100 mm Petri plates. The plates were placed into two gallon zipping plastic bags to prevent the filter paper from drying out. The growth chamber was set at 30 °C for 10 hours of light and 26 °C for 14 hours of darkness. The seeds were checked several times a week for germinating individuals. Germination rate was very slow and non-existent in many cases. Some of the seeds were in the chamber for up to 2.5 months with no germination; in these cases seeds were assumed to be dead and not viable.

Mean percent germination was figure for each individual based on the number of replicates. Mean percent germination was compared for each seed source and garden location using ANOVA.

Results

FIELD EXPERIMENT

Andropogon gerardii Total biomass of A. gerardii varied significantly with both seed source and garden location. Total biomass was greater at the Coles Co. garden location than at Will Co and northern seed sources (northern Illinois and North Dakota) had lower total biomass than all others (Iowa, Kansas, and central Illinois). Total seed mass did not vary with either seed source ($p=0.133$) or garden location ($p=0.249$).

Since there were significant differences in total biomass across seed sources, total biomass was related to geographic distance between seed source and garden location by comparing the latitude and longitude of the locations. Multiple regression on both variables showed that degree difference in latitude had a significant relationship, where seeds from sources that were farther north performed worse when moved south, while difference in longitude was non-significant.

Sorghastrum nutans Total biomass of *S. nutans* varied significantly with both seed source and garden location. Total biomass was greater at the Coles Co. garden than at in Will Co and northern seed sources (North Dakota) had lower biomass than all others (Kansas, northern Illinois, and Iowa). Seed mass showed no significant effect of either seed source ($p=0.098$) or garden location ($p=0.181$)

Since there were significant differences in total biomass across seed sources, total biomass was related to geographic distance between seed source and garden location by comparing the latitude and longitude of the locations. Multiple regression on both variables showed that degree difference of both latitude and longitude between seed source and garden location had a significant relationship, where the farther south and east a seed was moved, the lower the total biomass.

Panicum virgatum Total biomass of P. virgatum did not vary significantly across seed source ($p=0.597$) or garden location ($p=0.718$). After initial mortality only individuals from three seed sources were harvested in sufficient numbers; Iowa, northern Illinois, and Kansas. No other tests were on total biomass due to a lack of significant differences in the analysis of variance. There was no significant variation of seed mass across seed source ($p=0.101$) or garden location ($p=0.665$)

SEED GERMINATION EXPERIMENT

Mean percent germination did not significantly differ across seed source locations or garden location for any species. Overall seed viability was consistently low across all species, seed sources and garden locations.

Discussion

Significant variation in vegetative growth and seed production across seed source locations existed, even though there were little to no differences among genotypes when grown in the greenhouse (unpublished data). This clearly indicates that the growth and reproduction patterns found are the result of direct genotype-environment interactions, rather than certain genotypes being inherently faster growers under all conditions.

We did not find a gradient in plant performance as originally hypothesized, but rather found that latitudinal movement of genotypes was much more important than east-west movements. Plants from more northern populations (Northern Illinois and North Dakota) consistently performed poorly in Central Illinois, while more southern populations did very well. In fact, Kansas' populations did very well, and might even prove to be too aggressive in a restoration setting. These trends of vegetative performance have held through the second growing season in the central Illinois site (unpublished data).

Seed germination rate was not a useful metric to determine genotypic success in the common gardens. Overall low seed germination probably reflects the predominance of vegetative reproduction in these prairie grasses and the overall low probability of grass seedling establishment in established prairies. Low seed viability may also be related to the age and small size of the plants, which may have had too few resources to produce viable offspring.

Conclusions

Our experiment largely suggests that in the selection of seed sources for prairie restoration, it is much more important to select seeds from a similar latitude than from similar longitude. While we were unable to determine a critical threshold of distance, future studies should focus on north-south movement of seeds as this type of movement has the greatest impact on plant performance.

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