

Soil Characteristics and Microbes Influencing Establishment of Prairie Species

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ABSTRACT

Illinois is known as the Prairie State, however prairie that once covered 22 million acres of the state now occupies a mere 0.01% of the original. Restoration of tallgrass prairies often is impeded by failure to establish diverse native prairie species because of soil characteristics including both physical and microbial factors. In Coles County (IL) attempts to establish prairie species in one area between a bike trail and a road have failed, yet prairie remnants and restored prairie exists at other nearby sites. Hence the objective of this study was to determine if soil characteristics or microbes affect emergence of prairie species from soils collected at these three sites (remnant prairie, restored prairie, and attempted restoration site). Soil was collected from each site, and analyzed to determine texture, pH, moisture, organic matter and nutrients. Half of the soil was autoclaved and the other half was not. Three common prairie species (*Chamaechrista fasciculata*, *Dalea purpurea*, and *Monarda fistulosa*) were planted in each type of soil in trays. Weekly observations were made for emergence, leaf number and height of planted species. Plants from seed bank also were counted weekly. After four weeks, mass and leaf area were measured. Soil had more clay, lower organic matter and higher pH at the restoration site than at remnant or restored prairies. The remnant prairie had higher moisture, phosphates and sulfates than the other sites. Plants in autoclaved soil tended to have greater emergence and faster plant development than those in non-autoclaved soil. Grass and forb emergence in autoclaved soil was reduced relative to not autoclaved soil. Plants grown in soil from the remnant prairie developed more rapidly than those in soil from the other two sites. Hence, problems with establishment at the restoration site may relate to soil characteristics.

INTRODUCTION

The original tallgrass prairie remaining in Illinois is scattered in small remnants along railroad tracks, in cemeteries and in restored areas. Prairies began to diminish when European settlers started to build railroads and houses, stopped using fire, and began to farm the fertile soil (Miller, 1997; Sampson and Knopf, 1996). In the 20th century, ecologists realized that tallgrass prairies in the Midwest were diminishing, and restoration of these historic grasslands began (Allison, 2002; Curtis and Greene, 1949). Soil conditions are essential to prairie vigor. Microorganisms including both beneficial ones (mycorrhizal fungi and nitrogen fixing bacteria) and harmful plant pathogens (fungi and bacteria) are found in soil (McClain, 1997). In Coles County (IL), attempts to establish prairie species in one area between a bike trail and a road have failed, yet prairie remnants and restored prairies exist at other nearby sites. The purpose of this study was to determine if soil characteristics or microbes affect emergence of prairie species from soils collected at these three sites. Information gained will aid with prairie restoration efforts.

RESULTS

Soil Traits for Different Sites

SITE	SOIL TEXTURE	ORGANIC MATTER (1-5)	% MOISTURE	pH
Remnant	sandy loam	4.8	43	5.85
Restored	loam/silt loam	4.7	22	5.38
Attempted	clay/sandy clay	2.5	24	5.99
	NITRATES	CARBONATES	PHOSPHATES	SULFATES
Remnant	absent	absent	medium/low	medium
Restored	absent	present	low	low
Attempted	absent	absent	high	low
	AMMONIUM	MAGNESIUM	CALCIUM	POTASSIUM
Remnant	present	medium/low	present	absent
Restored	present	medium	present	absent
Attempted	absent	low	present	absent

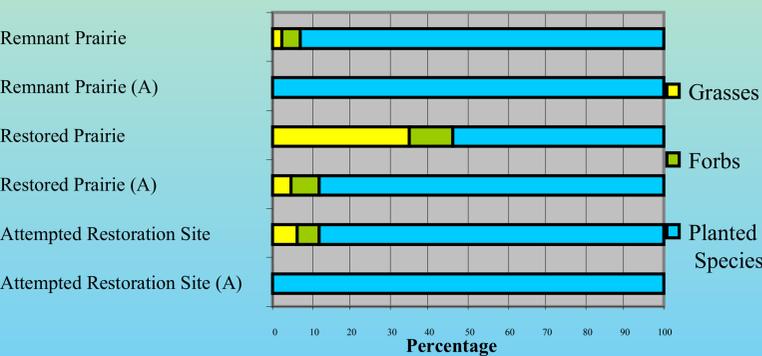
? Soils of remnant & restored prairies were lower in clay & higher in organic matter than soil of the attempted restoration site.

? Moisture was highest in the remnant prairie.

? pH was highest at the attempted restoration site.

? Soil nutrients at these sites exhibit no consistent patterns.

Emergence of Grasses, Forbs and Planted Species



A denotes Autoclaved soil

? Restored prairie had a higher percentage of grasses and forbs emerge than other sites.



Remnant Prairie



Restored Prairie



Attempted Restoration Site

Remnant Prairie Soil



Restored Prairie Soil



Attempted Restoration Site Soil

Plant Growth: Soils from Different Sites

SITE	<i>Dalea purpurea</i>	<i>Chamaechrista fasciculata</i>	<i>Monarda fistulosa</i>
	EMERGENCE (%)		
Remnant	12.5 a ^z	6.3 a	4.2 a
Restored	6.2 b	5.0 a	1.2 b
Attempted	6.3 b	6.2 a	1.0 b
	NUMBER OF LEAVES (per plant)		
Remnant	4.5 a	? ^y	4.0 a
Restored	4.4 a	?	3.2 a
Attempted	5.0 a	?	1.2 a
	HEIGHT (cm) per plant		
Remnant	3.0 a	3.2 a	1.0 a
Restored	2.1 b	2.7 a	0.3 b
Attempted	1.7 b	2.5 a	0.3 b
	FRESH MASS (mg) per tray		
Remnant	333 a	662 a	118 a
Restored	101 b	472 a	10 a
Attempted	108 b	528 a	5 a
	DRY MASS (mg) per tray		
Remnant	68 a	88 a	13 a
Restored	23 b	66 a	2 b
Attempted	23 b	70 a	1 b
	LEAF AREA (cm ²) per tray		
Remnant	3.2 a	29.4 a	0.9 a
Restored	0.9 b	10.8 a	0.4 a
Attempted	1.0 b	12.2 a	0.1 a

MATERIALS AND METHODS

? The remnant prairie is along an old railroad that is now a bike trail, the restored prairie was an agricultural field restored to a prairie, and the attempted restoration site is near a bike path & highway.

? 15 soil cores (15-35 cm deep and 2 cm wide) plus 3 shovelfuls of soil were collected from each site.

? Percent soil moisture, soil nutrients, and organic matter were determined using protocol from "The Science Source", Waldoboro, Maine, Chemical Composition of Soil #2000.

? Soil texture was determined by shaking 5 ml soil, 30 ml distilled water, and 3 drops dispersing solution (Lamotte Chetertown, Maryland). After 1 week, heights of sand, silt and clay were measured to calculate percentages of each. Then a soil triangle was used to determine texture.

? pH was measured with a soil water-slurry mixture using a Corning pH meter Model 7.

? For plant development studies, half of the soil was autoclaved for 3 hours and half was not.

? For each site and autoclave treatment, three trays (10 X 20 X 6 cm) were planted with 20 seeds each of *Chamaechrista fasciculata*, *Dalea purpurea*, and *Monarda fistulosa*.

? Trays were placed in growth room with light intensity of 78.3 ± 9 μmol/m²/sec at 25.0 ± 2.1°C.

? Plant species emerging from the seed bank were recorded as either grasses or forbs.

? After 4 weeks, emergence, height, leaf number, leaf area, and fresh and dry masses were measured.

? Data were analyzed using two-way analysis of variance followed by mean separations using Duncan's multiple range test at 5% level where appropriate.

SIGNIFICANCE

? Overall growth for *Dalea purpurea* and *Monarda fistulosa* was greater when planted in soil from the remnant prairie than other sites.

? Growth for *Chamaechrista fasciculata* was not affected by site.

? Plants in autoclaved soil grew significantly better or similar to those in not autoclaved soil.

Plant Growth: Soils with Different Autoclave Treatments

Autoclave	<i>Dalea purpurea</i>	<i>Chamaechrista fasciculata</i>	<i>Monarda fistulosa</i>
	EMERGENCE (%)		
yes	11.1 a ^z	6.2 a	2.8 a
no	5.5 b	5.4 a	1.4 a
	NUMBER OF LEAVES (per plant)		
yes	4.8 a	? ^y	3.3 a
no	4.4 a	?	2.4 a
	HEIGHT (cm) per plant		
yes	2.7 a	3.3 a	0.6 a
no	1.8 b	2.2 b	0.4 a
	FRESH MASS (mg) per tray		
yes	239 a	692 a	38 a
no	123 b	416 a	51 a
	DRY MASS (mg) per tray		
yes	48 a	98 a	7 a
no	29 b	52 b	4 a
	LEAF AREA (cm ²) per tray		
yes	2.3 a	24.0 a	0.8 a
no	1.1 b	10.9 a	0.1 a

^z Means within a column for a growth parameter that have different letters are significantly different based upon ANOVA at 5% level.

^y Means not shown because a significant interaction between autoclave treatments and site was found.

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