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The Effect of Tallgrass Prairie Burning on Soil Chemistry and *Raphanus sativus* Germination

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ABSTRACT

This research paper investigated the differences in soil chemistries between prescribed burnings in the late fall season (*Site A*) as opposed to the early spring season (*Site B*) and the correlation between these two burnings and the germination rate of the cherry belle radish (*Raphanus sativus*). These prescribed burnings were held at the Russell R. Kirt Prairie located at College of DuPage in northern Illinois. From each site, three samples of soil were collected and then tested for pH, nitrogen, potassium, and phosphorous for analysis of soil chemistry. Additional soil samples were collected from each site to plant four hundred cherry belle radish seeds (two hundred per site). Subsequently, from the data gathered from each site's soil chemistry and germination rate, it was determined that there was no significant difference between the soil chemistries of *Site A* and *Site B*, while there appeared to be a significant difference between the germination rate between *Site A* and *Site B* that was most probably influenced by environmental factors. Hence, it was deduced that the results supported our hypothesis, in part, which expressed that there would be no significant differences in neither the soil chemistries nor in the seed germination rates between *Site A* and *Site B*.

Keywords: Prescribed burning, Raphanus sativus*, tallgrass prairie, soil, soil chemistry, seasonal fires, germination rate, nitrogen, potassium, phosphorous, pH*

INTRODUCTION

In this research paper, we investigated the following: the differences in soil chemistries between prescribed burnings in the late fall season (*Site A*) versus the early spring season (*Site B*) of a tallgrass prairie in northern Illinois and the correlation between the aforementioned prescribed seasonal burnings and the plant germination rate of *Raphanus sativus*, the cherry belle radish.

In the *Germination Analysis* part of this study, the germination of *Raphanus sativus*—the cherry belle radish—was tested on the soil burned on late fall (*Site A*) and the soil burned in early spring (*Site B*). *Raphanus sativus* is in the family of *Brassicaceae*, which includes the species of broccoli, cabbage, cauliflower, and black mustard (Shirasawa et al. 2011). Originating from the coastal regions of the Mediterranean and Black Seas, this radish is typically used as a vegetable crop, most popularly in Japan (Shirasawa et al. 2011) and planted in spring due to its low tolerance for colder temperatures (George 2011). Therefore, because the cherry belle radishes grow in springtime, temperate environments—much like the tallgrass prairie used in this study—and germinate in a relatively short period of time, *Raphanus sativus* was chosen to simulate the germinating plants of the tallgrass prairie (George 2011).

Secondly, the *Soil Chemical Analysis* section of our investigation specifically applied to the chemistry of soil and how said composition changed after seasonal prescribed burnings. Kline (1997) described prescribed burning as a positive feedback system in which the prairie grass was the fuel for the fire and the fire as the growth stimulant for the prairie grass—hence, prescribed burning could be defined as the usage of fire to stimulate plant growth. Originally, prescribed burning was begun by the Native Americans, who used this frequently as a means to manage their habitat (Kline 1997). Eventually, prescribed burnings have come to the modern age due to relatively low cost in comparison to other habitat management techniques: mowing, herbicides, and chain-saw work, to name a few (Pauly 1997). Moreover, through this low-cost method, the combustion of organic matter on soil surface—such as plants and other organisms—released forthwith nutrients that would otherwise not be readily available to be uptaken by germinating plants (DeBano 1990). These nutrients are, among many others, nitrogen, phosphorous, and potassium. The nitrogen (in the form of nitrate and nitrite), phosphorous, and potassium were the soil chemicals that were tested in this study. DeBano (1990) determined the relationship between these nutrients and plant growth as follows:

Both nitrogen and phosphorous acted as limiting agents to plant growth. Phosphorous, in particular, however, was highly dependent on symbiotic relationships with mycorrhizae. Unfortunately, some mycorrhizae, especially those that were intolerant to heat, would have been destroyed in a prescribed burning, therefore hindering the available phosphorous for plant uptake. On the other hand, unlike nitrogen, phosphorous was not readily lost because of the prescribed burning—after a fire, it could be readily found in substantial amounts in ash and the topmost layer of soil. And, lastly, potassium—along with some other elements like calcium and magnesium—was found to have a direct role in controlling soil pH: The potassium concentrations—and, subsequently, the pH levels—that remained at a relatively constant level where the soil pH was kept at a range of 6 to 8 showed more plant growth.

Furthermore, prescribed burnings have been found to be both detrimental and beneficial, depending on the time of year. During times of drought, the fires increased the temperature of the soil to the extent that little to no plant growth occurred and soil erosion was heightened (Collins and Gibson 1990). However, particularly when the climate was moderately moist, prescribed burnings had been found to increase plant growth and nutrient content in the soil (Collins and Gibson 1990). Nonetheless, Collins and Gibson (1990) reported that—as found in studies held in mesic tallgrass prairies in Oklahoma, Kansas, and Iowa—prescribed burnings during different seasons of the year have shown no discernible effect on plant growth.

Hence, because previous research found no discernible patterns between prescribed burnings done in different seasons, it was hypothesized that the soil chemistry of the site burned in late fall (*Site A*) would present no significant difference to the soil chemistry of the site burned in early spring (*Site B*). Consequently, because of this predicted lack of difference between the soil chemistries of *Site A* and *Site B*, it was also hypothesized that there would be no correlation between the prescribed seasonal burnings and the biomass germination success of *Raphanus sativus*—in other words, it was predicted that *Site A* would not yield a significantly different number of germinated radishes than *Site B.*

METHODS

Field Methods

The study was held on the Russell R. Kirt Prairie located at the College of DuPage main campus. This prairie is a 7.3-hectare, restored tallgrass prairie located in northern Illinois. The sections of the prairie in which the study was conducted were planted between the mid-1980s to late-1990s. Generally, this location has a temperate climate with moderate humidity and rainfall and experiences cool to cold winters and hot, humid summers.

Recently, two areas of the Russell R. Kirt Prairie experienced prescribed burnings: one on November 12th, 2016 (*Site A*) and the other on March 3rd, 2017 (*Site B*). On March 21st , 2017, three samples of the top 4 to 5 centimeters of soil, approximately 0.7 kilograms, were collected from each site.

Soil Chemical Analysis

Each of the three soil samples taken from *Site A* and the other three taken from *Site B* were mixed with an acetic acid extract solution and chemically analyzed for pH and the following key nutrient elements: nitrite, nitrate, phosphorous, and potassium. The samples were analyzed using the LaMotte Company Soil Micronutrients and Macronutrients Test Kits.

Germination Analysis

The remaining soil not used for the *Soil Chemical Analysis* was used for a planting substrate. Two trays (each tray having a dimension of ca. 51 cm by 25 cm) were filled with soil from *Site A*, and another two were filled with soil from *Site B*. The soils were watered and subsequently planted with 100 seeds of *Raphanus sativus* in each tray (400 seeds total). Each seed was planted at a depth of 1 centimeter and spaced along each tray in rows of 20 by 5 seeds. The trays were covered with clear plastic wraps to prevent the soil from drying out. Subsequently, for seven days, the trays were placed within an environmental chamber, which was kept at 23 degrees celsius with 12 hours of light (10,000 lux) and 12 hours of darkness. The trays were watered accordingly once every 1-2 days in order to prevent the soil from drying out. After the seven-day period, the number of germinated plants were counted as a measure of germination success.

Statistical Analysis

Chi-square analysis, with Yate’s continuity correction, was used to compare germination rates of seeds planted in soil from *Site A* to *Site B*, and a two-sample, two-tailed Student’s t-test was used to analyze the differences in soil chemistry between *Site A* and *Site B*. Significance was determined at $\alpha = 0.05$. Means are reported as mean ± 1. S.E.

RESULTS

Observational Data

At the time when soil samples were collected at the Russell R. Kirt Prairie located at the College of DuPage on March 21, 2017, the temperature was at 10.6 degrees celsius and the soil was still moist from the previous day’s precipitation. Soil was dark-colored and appeared to consist of a heavy clay-loam. There was little, if any, vegetation cover.

Soil Chemistry

The amounts of potassium, nitrate, and nitrite, as well as the pH levels between both burn sites were fairly, if not equally, similar to each other (Table 1). The most variability was observed for phosphorous (Table 1) with slightly higher average amounts in the site burned in late fall as compared to early spring (Site A: 117. 69 ± 47.88 kg/ha; Site B: 104.61 ± 15.29 kg/ha) although they were not statistically different ($t = 0.4139$, $df = 3$, $P = 0.7067$).

Table 1. Soil chemistry analysis for Site A (late Fall prescribed Burning) and Site B (early Spring prescribed Burning).

Site A	Site B
Nitrite	Nitrite
1.12085	1.12085
1.12085	1.12085
1.12085	1.12085
Nitrate	Nitrate
11.2085	22.417
11.2085	11.2085
11.2085	22.417
Phosphorous	Phosphorous
168.128	95.2723
72.8553	84.0638
112.085	134.502
Potassium	Potassium
112.085	112.085
156.919	112.085
112.085	112.085
pH	pH
7.5	7.5
7.0	7.5
7.0	7.5

Notes:. Data presented as kilogram per hectare (kg/ha) for Nitrite, Nitrate, Phosphorous, and Potassium. Three samples were taken from each site for each category. Samples were analyzed using the LaMotte Company Soil Micronutrients and Macronutrients Test Kits.

Seed Germination Rate

Site A had 163 out of 200 radishes that successfully germinated, while *Site B* had 120 out of 200 radishes that successfully germinated. After performing a chi-square analysis, it was determined that there was a significant difference in the radish germination rate ($X^2 = 6.2332$, $df = 1$, $P = 0.01254$) between the soils that were burned in November (*Site A*) and in March (*Site B*). It is important to note that during the course of the experiment, soils from *Site B* tended to dry more quickly than soils from *Site A.*

DISCUSSION

Our hypotheses stated that the prairie areas with prescribed burning in late fall (*Site A*) and prescribed burning in early spring (*Site B*) would not present a significant difference between their soil chemistries and, consequently, in the germination rate of *Raphanus sativus*, the cherry belle radish. This was supported partially by our results as there was no significant difference in the soil chemistries between sites. This finding correlated with another study that had found that, although prescribed fires do in fact stimulate soil chemistry changes—as previously described by DeBano (1990)—there was no discernable differences in the soil chemistry among prescribed burnings done in different seasons (Seastedt and Ramundo 1990).

Contrary to our hypothesis, there was a significantly higher radish germination rate in soils of the late fall as compared to early spring prescribed burnings. Considering that the soil chemistries of both sites were statistically similar, the significant difference seen in the germination rates between *Site A* and *Site B* could be potentially attributed to the fact that the soil of *Site B* repeatedly dried out more quickly than *Site A*'s soil within the environmental chamber. In other words, the significant difference seen in the germination rates was not due to the soil chemistries of *Site A* and *Site B* but other factors influencing the soil moisture and, subsequently, the germination rates. Collins and Gibson (1990) found that plant germination had more to do with climatic conditions than the season of a prescribed burning. Given that the temperature, light, and watering schedules were equivalent among trays, variations in soil texture and compaction—possibly attributed to differences in clay content, which has a direct relationship with water retention (Easton and Bock 2016) may have contributed to observed differences in soil moisture and germination success. Evaluation of soil texture, density, and moisture content should be included in future comparable studies.

Although prescribed fires in different seasons appeared to not produce significant differences in either soil chemistries or seed germination rates, previous studies have found that the burning of tallgrass prairies was determined to be necessary in order to maintain the grass species and to stimulate plant germination (Seastedt and Ramundo 1990). Hence, for future studies, the effect of frequent, periodic prescribed burning of a tallgrass prairie on seed germination and soil chemistry can be determined versus the seed germination and soil chemistry of an unburned or infrequently burned tallgrass prairie. In this manner, the effects of fire can be truly established and, subsequently, whether these effects have a significant benefit for tallgrass prairies.

LITERATURE CITED

Collins, S. L., and D. J. Gibson. 1990. Effects of Fire of Community Structure in Tallgrass and Mixed-Grass Prairie. Pages 81-98 *in* S. L. Collins and L. L. Wallace, editors. Fire in North American Tallgrass Prairies. University of Oklahoma Press, Norman, Oklahoma, U.S.A.

DeBano, L. F. 1990. The Effect of Fire of Soil Properties. Symposium of Management and Productivity of Western-Montane Forest Soils GTR-INT-280.

Easton, Z. M., and E. Bock. 2016. Soil and Water Relationships. Virginia Cooperative Extension Publications BSE-194P.

George, R. A. T. 2011. Agricultural Seed Production. CAB International, Oxfordshire, United Kingdom.

Kline, V. M. 1997. Orchards of Oak and a Sea of Grass. Pages 3-22 *in* S. Packard and C. F. Mutel, editors. The Tallgrass Restoration Handbook: For Prairies, Savannas, and Woodlands. Island Press, Washington, D. C., U.S.A.

Pauly, W. R. 1997. Conducting Burns. Pages 223-244 *in* S. Packard and C. F. Mutel, editors. The Tallgrass Restoration Handbook: For Prairies, Savannas, and Woodlands. Island Press, Washington, D. C., U.S.A.

Seastedt, T. R., and R. A. Ramundo. 1990. The Influence of Fire on Belowground Processes of Tallgrass Prairie. Pages 99-117 *in* S. L. Collins and L. L. Wallace, editors. Fire in North American Tallgrass Prairies. University of Oklahoma Press, Norman, Oklahoma, U.S.A.

Shirasawa, K., et al. 2011. An EST-SSR Linkage Map of *Raphanus sativus* and Comparative Genomics of the Brassicaceae. DNA Research 18 (4): 221-232.