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Soil Nitrogen Influences Early Root Allocation of *Lespedeza cuneata*

E.M. Guenther & J.M. Roberts
Biology Department, Grinnell College, Grinnell, IA 50112, USA

Abstract

Invasive species such as Lespedeza cuneata *are out-competing native prairie species and hindering prairie restoration efforts.* L. cuneata *has proved tolerant to "natural" forms of prairie management such as burning. Because fire reduces the amount of nitrogen in soil, the goal of our study was to test the effects of varying soil nitrogen levels on* L. cuneata. *We measured stem height and root, shoot, and total biomass of* L. cuneata *for three weeks using four different soil nitrogen treatments. Our results show no significant differences in the height or total biomass of* L. cuneata *caused by the different nitrogen levels. Our data did, however, show a significantly higher percentage of root biomass in the treatment with no added nitrogen. This suggests that L. cuneata may allocate a higher percentage of energy to root biomass in soils with lower nitrogen content.*

Introduction

In the past decades, Midwestern conservationists have been making concerted efforts to restore plots of land to their pre-European conditions of tallgrass prairie (Howe 1995). *Lespedeza cuneata,* a non-native legume, is one of the invasive species most detrimental to restoration efforts. It weakens native species by shading out other plants, and its extensive root structure allows it to withstand drought. *L. cuneata* also releases allelopathic chemicals that disturb the growth of native C4 grasses (Bidwell and Ohlenbusch 2001).

Disturbances are a commonly used technique in controlling invasive and non-native species in prairie restoration because, when used appropriately, they offset the effects of succession and promote heterogeneity and species richness. However, disturbances can have negative effects on restoration if they allow non-native species to enter the ecosystem and thrive, pushing out native plants (Hobbs 1992). *L. cuneata* has proven to withstand the traditional practices of species management, burning and mowing (Diller 1999). The only method of deterrence that has proven somewhat successful is burning in the summer season, when *L. cuneata* is in the middle of its growing season (Dingman et al 2003). The reasons why *L. cuneata* withstands spring burning so well are as yet unclear.

Prairie burns result in lower total nitrogen availability and mineralization (Johnson and Matchett 2001). Because of legumes' natural ability to fix atmospheric nitrogen, it is possible *L. cuneata* will thrive in nitrogen-poor conditions such as those created by burning (Ritchie and Tilman 1995). Theoretically, because *L. cuneata* can fix atmospheric nitrogen in its early growth stages, the amount of nitrogen in the soil will have no effect on its biomass. We tested this prediction by varying soil nitrogen content influenced the early-growth stages of *L. cuneata*.

Methods

For our experiment, we used *L. cuneata* seeds that had been harvested from CERA. We scarified the seeds and then stratified them between two layers of water-soaked Whatman no. 2 filter paper which we kept in a Petri dish at about 10°C.

After ten days we separated the seeds into four treatments, each of which had twenty-four replicates. We allowed the seeds seven days to germinate before watering each treatment with a different concentration of ammonium nitrate. Treatment one had no added nitrogen, treatment two had 50 ppm ammonium nitrate, treatment three had 100 ppm, and treatment four had 200 ppm.

We planted seven seeds in each replicate, pulling any sprouts that germinated after the first three. All replicates were in groups of four, and each treatment was present in a random position in each. We also randomized the placement of each unit by rotating the trays each week.

After allowing our seeds to germinate for a week, we began watering the plants with the appropriate aqueous ammonium nitrate solutions. We watered the plants with 10 mL of the appropriate solution and measured each sprout's height twice a week. If no seeds sprouted in a replicate, the replicate was not included in the averages, because their failure to sprout was not a function of our experiment. After the fifth day of measuring, we pulled each grouping of plants from their cell, removed any excess dirt with

Table 1. Significance of treatment levels in ANOVA on each measurement day's shoot height of *L. cuneata*. All variation was non-significant.

Days After Planting	F value	P value
7	0.99	.402
12	0.66	.580
14	0.42	.737
19	0.75	.526
21	1.22	.309

water and dried the plants at 60°C for 36 hours, and massed both root and shoot.

We used a one way ANOVA test to compare the stem heights for the four treatments on each testing day, and we used both one way ANOVA tests and Tukey's Multiple Comparison Test to analyze the biomass data.

Results

There was no significant variation in shoot height among nitrogen treatments on any measurement day (Table 1/Figure 1). A one-way ANOVA reveals significant variation among the root biomasses of all treatments (Table 2/Figure 2). Specifically, Tukey's Multiple Comparison Test shows that the root biomass of treatment one is significantly greater than the root biomass of treatments two, three, and four (Figure 2/Figure 3). All treatments consistently allocated more energy to their shoot biomass than their root biomass (Figure 3).

Discussion

Our data suggest that the shoot height and total biomass of *L. cuneata* are not affected by varying nitrogen content in the soil during its early growth stages. This could imply that one of the reasons *L. cuneata* re-colonizes well in most burned areas is that it can withstand changes in soil nitrogen content, possibly because of its ability as a legume to fix atmospheric nitrogen (Ritchie and Tilman 1995).

Treatment one had significantly greater root biomass than the treatments with added nitrogen without having significantly less biomass in its shoot system than the other treatments. It is possible that, in nitrogen-rich soil, *L. cuneata* allocates a higher percentage of its energy to growing shoot biomass (Figure 3) in order to

Table 2. The f and p values for the variance in root, shoot, and total biomass in a one way ANOVA test.

Biomass	F value	P value
Root	10.80	0.000
Shoot	00.90	0.443
Total	02.21	0.092

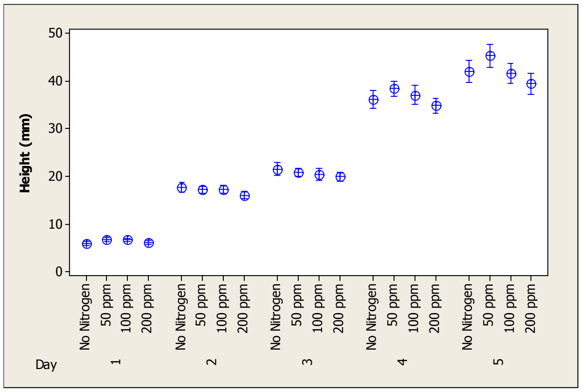

Figure 1. Average height (+/- S.E.) of each *L. cuneata* treatment for number of days after planting.

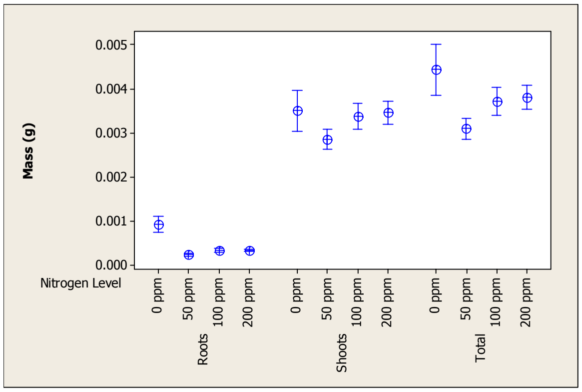

Figure 2. Average mass (+/- S.E.) of root, shoot, and total biomass organized by treatment.

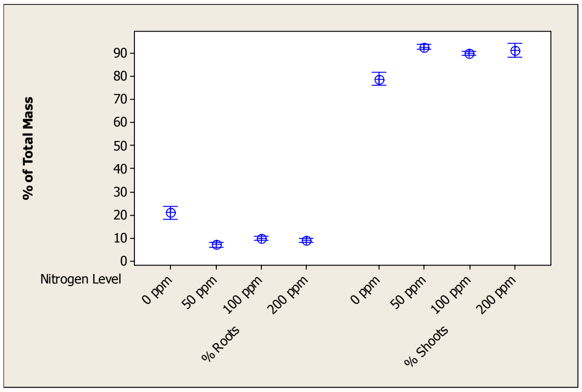

Figure 3. The average percent of the total biomass (+/- S.E.) that is taken up by root biomass and shoot biomass respectively.

out-compete other plants for light, which allows it to cast shade over other species, hindering their growth (Blair and Fleer 2002). However, in nitrogen-poor soil, *L. cuneata* already has an advantage over non-legume species that need more soil nitrogen to grow (Ritchie and Tilman 1995). It also has an advantage over its native legume counterpart, *L. capitata*, which grows more slowly under similar conditions in its early-growth stages (Blair and Fleer 2002). Blair and Fleer suggest that *L. cuneata* uses the energy provided by their large shoot masses via photosynthesis in its early growth stage to grow larger root biomasses, something that plants which do not thrive in nitrogen-poor soil are unable to do. We would expand on this theory by suggesting that in nitrogen rich soil, *L. cuneata* allocates a higher percentage of its total biomass to its shoot biomass in order to out-compete surrounding species for light.

The original design for this experiment called for a comparison between the invasive *L. cuneata* and its native counterpart *Lespedeza capitata*, but the latter failed to germinate with very few exceptions. This was most likely because the seeds were harvested at different times in the year. A comparative study between the two species, similar to ours in design, would help better understand why *L. cuneata* is able to out-compete *L. capitata* by highlighting possible differences in the ways that they allocate root and shoot biomasses in early growth stages.

Future research could also include a longer experiment that compares *L. cuneata* and *L. capitata* to see if these trends continue in the later growth stages. We would also like to see the results of an experiment designed to test the effects that grazers have on *L. cuneata,* because many herbivores may prefer legumes in nitrogen poor soils because of their higher nitrogen content (Ritchie and Tilman 1995). Grazing, in this context, cannot be replaced by mowing, which a study by Diller (1999) showed actually increased *L. cuneata*'s density.

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