

Early growth stages of *L. Cuneata* are a factor in its ability to colonize in tallgrass prairies

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Abstract

Invasive species have colonized native tallgrass prairies throughout the Mid-West since European settlement. One such species, Lespedeza cuneata, has proven resistant to traditional management techniques such as fire and mowing. L. cuneata contains many traits that allow it to out compete native prairie species, however many questions still remain concerning factors in its early growth stages that allow for this domination. To answer some of these questions and continue the search for better management techniques, we measured dry root and shoot mass of L. cuneata and its native counterpart Lespedeza capitata under high and low light for three weeks, thus isolating growth factors specific to the invasive species. Throughout the study significant factors affecting development changed weekly. Most interestingly, in the third week L. cuneata developed a larger root system, while maintaining shoot mass growth. This strong root system is a known factor in L. cuneata's ability to out compete native prairie species. Light significantly affected growth for both species, but not differently, and therefore management techniques that manipulate light are not effective in controlling L. cuneata. Further studies researching development of this root system and other traits that allow L. cuneata to dominate would be helpful in creating effective management techniques.

Introduction

Invasive species have been colonizing tallgrass prairie sites throughout the Mid-West since European settlement, changing balances within ecosystems by dominating native species and thus threatening the biodiversity of these ecosystems (Smith and Knapp, 2001). One species that has been identified as particularly problematic is *Lespedeza cuneata* (Ohlenbusch and Bidwell, 2001).

Troublesome invasive species can easily colonize the native population due to a variety of factors such as lack of major competitors in the area or well-equipped adaptations to local conditions that native species do not have. For example, *Lespedeza cuneata* shares the same legume family as the native prairie plant *Lespedeza capitata* but possesses a few traits allowing domination over many native species. *L. cuneata* weakens surrounding species growth both by releasing allelopathic chemicals that "poison" native C4 grasses, and a large plant structure which shades out plants in its vicinity. Also, the species has an extensive root system not possessed by most native prairie plants, allowing it to dominate by better surviving periodic droughts. (Ohlenbusch and Bidwell, 2001)

Lespedeza cuneata originated in Asia and was originally planted in 1886 by the North

Carolina Agricultural Experiment Station for its perceived erosion control, forage quality, nematode resistance and wildlife cover (Ohlenbusch and Bidwell, 2001), and was introduced to the Mid-West in the 1930s for many of the same reasons (Smith and Knapp, 2001). At Conard Environmental Research Center (CERA), where we examined the situation and collected seeds from the *Lespedeza capitata*, *L. cuneata* has spread extensively and there is fear that it may gain a foothold into other areas (Mottl personal communication). Traditional management techniques such as fire and mowing have not proven successful in controlling this species. A study at CERA found that *Lespedeza cuneata* actually increased in density in mowed plots and showed no significant difference between burned and unburned plots (Diller, 1999). Herbicide is the only known effective solution and is undesirable as it is time consuming, expensive, and environmentally questionable for long-term use.

Because *L. cuneata* is so resistant to traditional management techniques, it is necessary to find new approaches in controlling this plant. Therefore, the goal of this study was to discover more about the development of the *L. cuneata* so that management techniques can be created and used effectively to stunt the species growth. Because our study occurred only during early stages of development, it focused on the

development of the root system over other distinguishing features such as allelopathic chemicals and effects of shading. By measuring both root and shoot mass we attempted to isolate growth factors that allow *L. cuneata* to out compete many native plants.

Direct studies examining the effects of specific factors, such as light, have not previously been conducted on *Lespedeza cuneata*; only the effects of certain management techniques have been studied. We sought to find both if light affected the ability of *Lespedeza cuneata* to dominate, and to study differences in development between the two species that give a competitive advantage to *L. cuneata*.

Methods

We measured the early growth of two species of *Lespedeza*: *Lespedeza cuneata* (invasive), and *Lespedeza capitata* (native) under two different levels of light. We collected seeds for the native *Lespedeza* from plants at CERA on October 9, 2002, and used invasive *Lespedeza* seeds that were collected in fall 2001. To break the seed coat and allow optimum germination, we scarified the seeds between two pieces of sand paper and to induce growth we stratified the seeds at approximately 10 degrees Celsius between two pieces of Whatman no. 2 filter paper. Then using Jiffy Mix potting soil, we planted them in a growth chamber on campus.

To create two different levels of light, we put half of the seventy-six pots which each contained four cells with one plant on a higher shelf closer to the light bulbs, and half the pots on a lower shelf. We also placed a piece of cloth between the two levels to filter a percentage of the light from the bottom level. The levels of light were not equally dispersed on each shelf. On the bottom shelf we measured 26.15-27.84 mmolm⁻²s⁻¹, with the strongest being in the middle. On the top shelf, the range was 172.49-243.3 mmolm⁻²s⁻¹, the strongest levels were also in the middle. To compensate for this difference, we rotated and watered the individual cells three times a week. After a week of growth we weeded each cell down to one plant to prevent competition. We randomly selected plants every seven days for three weeks. We separated the roots from the shoots, dried the samples for at least forty-eight hours and weighed them individually to determine where each species was directing its energy in the early stages of growth.

We analyzed the species and light treatments of our data using a general linear model of ANOVA.

Results

After one week of growth, the shoot mass of *L. cuneata* was significantly greater than that of *L. capitata* (F= 10.29, P= .005; Table 1, Fig. 1). Also, *L. cuneata* had significantly higher total mass than *L. capitata* (F= 8.95, P= 0.007; Table 2, Fig. 2).

Table 1: Significance of main effects in ANOVA on each week's shoot mass. All interaction effect were nonsignificant.

	Significant Variable	F	P
Week 1	Species	10.29	0.005
Week 1	Light Level	1.03	0.324
Week 2	Species	0.53	0.468
Week 2	Light Level	7.52	0.008
Week 3	Species	0.65	0.424
Week 3	Light Level	32.17	0

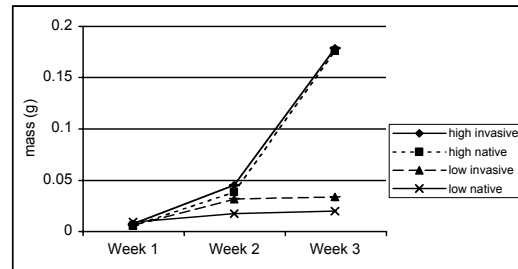


Figure 1: Average shoot mass of invasive and native *Lespedeza* under two different light levels. All standard error bars are too small to be seen.

After two weeks of growth, light level was the only significant factor. It was significant for both root mass (F= 9.15, P= .004; Table 3), shoot mass (F= 7.52, P= .008; Table 1), and total mass (F= 11.18, P= 0.001; Table 2) regardless of species.

Table 2: Significance of main effects in ANOVA on each week's total mass. All interaction effect were nonsignificant.

	Significant Variable	F	P
Week 1	Species	8.95	0.007
Week 1	Light Level	1.23	0.282
Week 2	Species	0.69	0.41
Week 2	Light Level	11.18	0.001
Week 3	Species	0.25	0.619
Week 3	Light Level	37.01	0

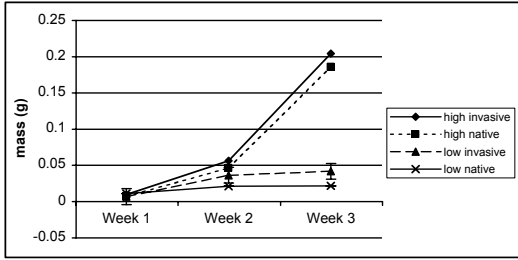


Figure 2: Average total mass of invasive and native *Lespedeza* under two different light levels. All standard error bars are too small to be seen.

After three weeks of growth, high levels of light created significantly greater root mass ($F=19.94, P=0$; Table 3, Fig. 3), shoot mass ($F=32.17, P=0$; Table 1, Fig. 1), and total mass ($F=37.01, P=0$; Table 2, Fig. 2) for both species. Most interestingly, the invasive species had a significantly greater root mass ($F=6.93, P=.011$; Table 3, Fig. 3).

Table 3: Significance of main effects in ANOVA on each week's root mass. All interaction effect were nonsignificant.

	Significant Variable	F	P
Week 1	Species	0.37	0.551
Week 1	Light Level	0.79	0.384
Week 2	Species	0.28	0.597
Week 2	Light Level	9.15	0.004
Week 3	Species	6.93	0.011
Week 3	Light Level	17.94	0

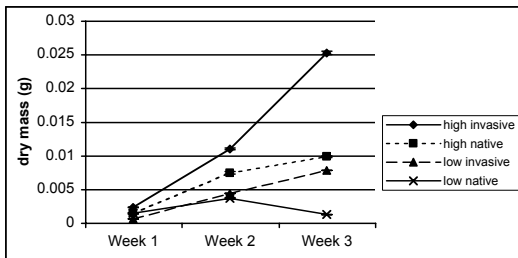


Figure 2: Average root mass of invasive and native *Lespedeza* under two different light levels. All standard error bars are too small to be seen.

Discussion

Our study confirms prior thought that *Lespedeza cuneata* maintains strong shoot mass growth while developing a larger root system even as early as the third week of growth (Ohlenbusch and Bidwell, 2001). Our hypothesis that *L. cuneata*'s root system is one factor in its ability to dominate tallgrass prairie ecosystems was substantiated by our study.

Although light level became the deciding factor in plant productivity after weeks two and three, it was not yet a factor in week one because most of the development at this early stage was a result of energy from the seed and not energy from light.

Week three was the most conclusive of our study, at this point not only was light level a significant factor but species was also a significant factor for root mass but not shoot mass (Tables 1-2). Root and shoot mass for both species were significantly affected by light, however *L. cuneata* was able to equal *L. capitata* in shoot mass productivity while still exceeding it in root mass productivity. One theory derived from our data is that because the invasive species has a higher level of shoot mass productivity in week one more of the plant conducts photosynthesis which creates more energy for further development of the plant. This added energy allows the plant to build a greater root mass while maintaining a competitive shoot mass. We have not yet discovered what feature of the invasive allows it to do this, but it is possible that each seed is equipped with greater amounts of energy than native prairie species seeds.

If the study were to carry on, our prediction would be that this week three trend would continue. *L. cuneata*'s more extensive root system is a factor in its ability to colonize areas even in times of drought, as it is able to utilize water from lower depths (Ohlenbusch and Bidwell, 2001).

Light significantly affected growth for both species but not differently (Tables 1-3) (Figs. 1-3), therefore practices such as burning and mowing that manipulate light will not be useful in controlling or eradicating *Lespedeza cuneata*. We recommend that individuals confronted with *L. cuneata* should continue to spray with permitted herbicides in an effort to control current outbreaks of the species, and prevent it from spreading to other areas. In conjunction with this, methods of management that promote biodiversity should be employed in areas that are potential sites of future domination by *L. cuneata* as it has been proven that factors such as species richness and crowding by native plants prove effective in grassland resistance to invasive species (Kennedy et al 1987).

One method of management not used at CERA that could prove useful is grazing. Although *L. cuneata* is unpalatable to cows late in the season because of its increased tannin composition (Ohlenbusch and Bidwell, 2001),

early season grazing could prove useful in reducing total biomass of this species. Reducing total biomass could decrease *L. cuneata*'s competitive ability (Smith and Knapp, 2001). However, the effects on the whole biotic community need to be examined before such a practice is employed and because early season mowing has been proven to increase the density of *L. cuneata*, a long term experiment needs to be conducted before widespread grazing is implemented (Diller, 1999).

To this date no native species has been found that can out compete *L. cuneata*, however no competition studies have been conducted. With the intention of finding a native species that could out compete *L. cuneata*, we suggest that long term competition studies be performed investigating native species and their competitive abilities against *L. cuneata*. Potential candidates for such a study could include native species with deep roots (3 to 4 feet deep or longer) that could equal *L. cuneata*'s ability to use water at great depth (Ohlenbusch and Bidwell, 2001). Such a study should use either a legume or forb because C₄ grasses are unable to resist the allelopathic chemicals that *L. cuneata* is thought

to produce (Ohlenbusch and Bidwell, 2001). We also recommend that a longer study concerning the root and shoot development of *L. cuneata* could be performed to see what trends continue or develop.

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References

- Diller A. 1999. The effects of burning and mowing on the growth of *Lespedeza cuneata*. *Tillers*. 1.
- Kennedy TA, Naeem S, Howe KM, Knops JMH, Tilman D, Reich P. 1987. Biodiversity as a barrier to ecological invasion. *Nature*. 417: 636-638.
- Smith MD, Knapp AK. 2001. Physiological and Morphological traits of exotic, invasive exotic, and native plant species in tallgrass prairie. *International Journal of Plant Science*. 162(4): 785-792.
- Ohlenbusch PD, Bidwell T. 2001. *Sericia Lespedeza: History, Characteristics, and Identification*. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.