Lab 3: Plant Competition

Introduction

The ability of a species to compete for limited resources is often central to its ability to survive in a given environment. Different species possess differential competitive abilities, which are often dependent upon environmental conditions. For all organisms, the effects of competition become more pronounced with an increase in density because more organisms are searching for resources in the same areas, depleting the resources to continually lower levels.

One way that plants gain a competitive edge is by forming mutualistic relationships with other organisms, thereby working together to promote mutual survival. *Rhizobium* bacteria have a symbiotic relationship with the roots of legumes in which they fix atmospheric nitrogen and provide it to the plant in exchange for resources such as carbon (Begon, et al., 2003).

In this experiment we examined how the presence of *Rhizobium* affected the competitive ability of red clover (*Trifolium pretense*) which is a legume, when grown with red fescue (*Festuca rubra*) which is not leguminous. We hypothesized that *Rhizobium* form a mutualistic relationship with legumes and provide it with nitrogen, and from this we predicted that red clover would compete better against red fescue (a grass) in environments with *Rhizobium* present.

Results

Our results did not indicate a difference in competitive ability of red fescue in the presence or absence of *Rhizobium*. This is illustrated by the fact that the confidence intervals in the linear regression graphs are broadly overlapping (Figure 1). The R squared values for the *Rhizobium* and no *Rhizobium* treatments of .810 and .778 respectively indicate that the best fit lines in the graph are accurate representations of our data. The p-values of .038 and .048 for the R square data indicate that it is statistically significant, which means there is a significant relationship between target weight and neighbor density and hence that competition is occurring.

Discussion

Our results did not support our prediction that red clover would compete better in the presence of *Rhizobium*. One explanation for this is the possibility that we made some incorrect assumptions as part of our experimental model. One important assumption we made was that nitrogen was a limiting resource which both plant species were competing for, which in reality may or may not have been the case. The nitrogen concentration may have been high enough in the soil that the additional nitrogen provided by the Rhizobium did not provide any appreciable advantage to the red clover. If this were the case, then the Rhizobium may have actually hurt the clover's competitive ability by taking its resources without providing necessary nutrients in exchange. If we were able to do the experiment again, it would be helpful to test the nitrogen content of the soil to ensure that it is in fact a limiting resource.

Another important assumption we made was that red clover and red fescue shared the same traits apart from clover being a legume and fescue a grass. However, there is one other difference in that red clover is a dicot while red fescue is a monocot. Physiological differences, particularly in the root system, suggest that dicots are better at absorbing nutrients from the soil than monocots. Although this would imply that clover is still a better competitor, it is possible that there are other confounding factors which gave the fescue a similar competitive effect in the presence and absence of *Rhizobium*.

A more practical aspect of our experimental design that could be problematic is that we looked at the biomass of the part of the plant above the ground only, by clipping it at ground level and then weighing it. If the effects of competition led one plant species or the other to divert more resources to the roots and away from stems and leaves, our data could be misleading.

One other potential problem exists with our model in that it does not account for the proximity of plants to each other. While it is a logical assumption that with increasing density, proximity of plants increases, it is possible that in low density plots, seeds of competitors by chance happened to fall very close to the target seeds. The closer the plants are physically, the more their resource utilization areas overlap, and the stronger the effects of competition between them.

Aside from the aforementioned problems with the assumptions of our model, the additive design of our experiment seems to be the best way to examine competition between species. An additional experiment we could have performed is a replacement series in which the proportion of the two species is varied while keeping the total plant density the same. The problem with this approach is that it is impossible to distinguish between intra- and interspecific competition (Park et al., 2003). Since for this experiment we are looking specifically at the interspecific competitive effects, the additive design is the better approach.

Examining the competitive effects and responses of various plant species to interactions with other species has particular relevance to ecologists or conservation biologists trying to manipulate species composition. Over the long term, it would seem that competitive response is more important to a plant's ability to persist at a site. Unless the plant is the top competitor in an ecosystem, it is likely that with time other species which are good competitors will begin to grow at the same site and deplete the resource base to low levels. In order to persist, the plant will have to be tolerant of low resource levels; otherwise it will be outcompeted by plant species which are better able to absorb resources from the environment.

Although some plants that have a strong competitive effect also have a strong competitive response, the two do not necessarily go together. It is possible that a plant which has a strong competitive effect is good at hoarding resources at a particular site and simply survives by preventing other species from establishing there.

This experimental model also has relevance to the Lotka-Volterra model for competition. In order to test whether stable coexistence can occur (the effects of intraspecific competition are greater than interspecific), we would have to do an additional experiment in which the target and neighbor species were switched, because the current set-up only determines the effect of fescue on clover and not vice-versa. With data from both density experiments there are equations which make it possible to sort out the effects of intra- vs. interspecific competition (Park et al., 2003).

Establishing the effects of plant species interactions has a lot of implications for farming (weed-crop competition), plant conservation and the management of invasive species. By understanding how different environmental conditions affect these interactions, ecologists will be better able to use this knowledge to their advantage in creating environments which allow for a particular target species to have the greatest competitive advantage.

References

Begon, Michael, John L. Harper and Colin R. Townsend. *Essentials of Ecology*. Malden, MA: Blackwell Publishing, 2003.

Park, Sarah E., Benjamine R. Laurence and Andrew R. Watkinson. 2003. The Theory and Application of Plant Competition Models: an Agronomic Perspective**.** *Annals of Botany*. 92: 741-48

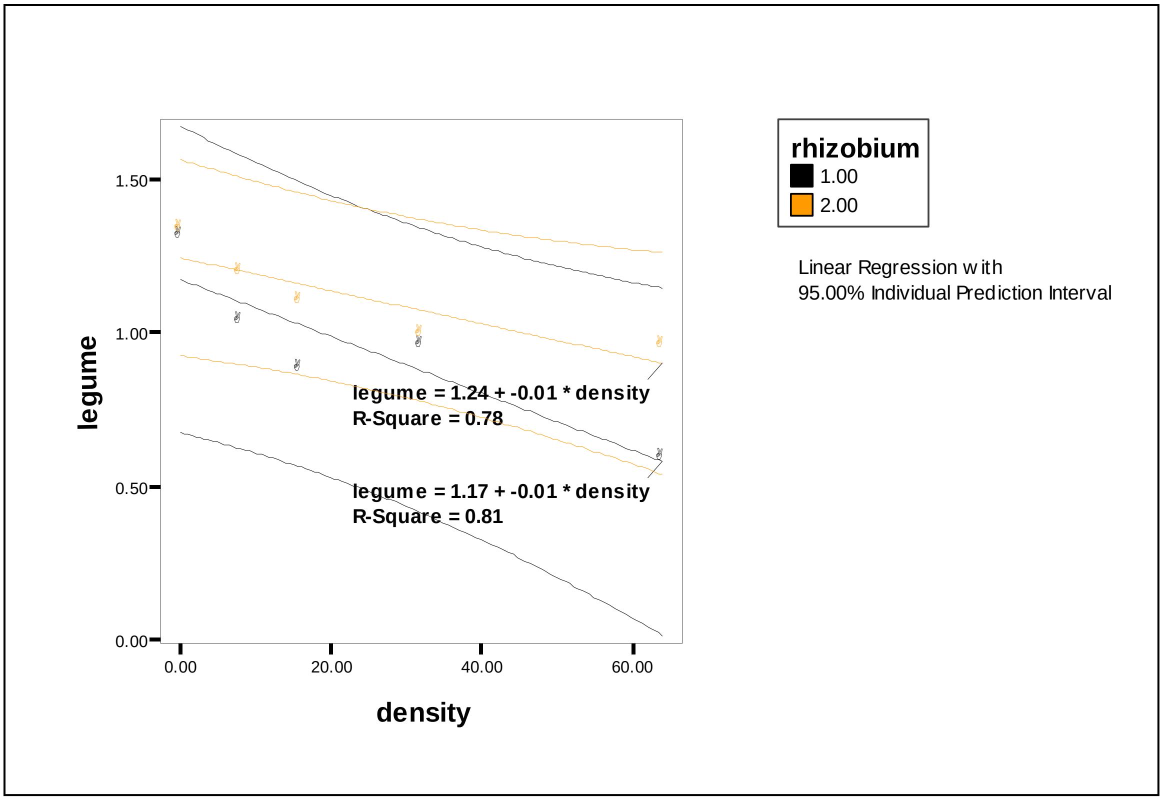

Figure 1: This graph plots the natural log of the weight of the legume (red clover) against the density of the competing plants (red fescue). In the key, 1 represents the treatment with *Rhizobium*, and 2 is without. The flatter the line, the less the clover is affected by the competition from fescue. The overlapping of the confidence intervals in this graph shows that there was no difference in clover's competitive ability in environments with or without *Rhizobium*.