areas was significantly greater than those adjacent to low mulch in both treatments (Figure 1, $t=2.52$, $p<0.02$; Figure 2, $t=2.14$, $p<0.02$). However, after conversion of pods to bean biomass, a significant difference in biomass was not found between rows adjacent to high and low mulch levels in either treatment (unfertilized: $t=1.00$, $p<0.4$; fertilized: $t=0.16$, $p<0.5$).

Discussion (JLD)

We found that plants on the edges of *espequeado* plots had greater production than those plants nearer the center. This was true whether the plot was fertilized or not (Figures 1 and 2). Regression analysis indicated that all rows except the outermost produce at a similar level, and t-tests showed their production to be significantly less than the outer row. These analyses were done with the numbers of bean pods and may therefore be inaccurate assessments of biomass. Based on the work of Shabel, et al. (this volume), we were able to compare bean biomass of plants in the outer most row with those nearer the center (Table 3). This further supported our hypothesis of greater production in the edge area.

Our second hypothesis, that the difference between edge and center would be greater in unfertilized plots than in fertilized plots was also upheld by our data. We found that both treatments had approximately 28 pods per plant at the edge. However, fertilized plots had significantly greater production (~14 pods per plant) than unfertilized plots (~8 pods per plant). This suggests without mulch, fertilizer increases bean production. Yet if a supply of mulch is nearby, fertilizer has minimal effect on production. This was further supported by the fact that the biomass in the center of the fertilized plot was greater than in the unfertilized plot, while there was no significant difference between the biomass of beans per plant of the two treatments. Production was greater in edges near high mulch than in edges near low mulch. When numbers of pods were converted to biomass, the same comparison was not significant. This indicates that either (i) our range of mulch was too small to detect a bean biomass difference, or (ii) that edge mulch provides nutrients that are directly related to the production of multiple pods, or (iii) that the correlation between number of bean pods and biomass is not as all-encompassing as we thought.

Literature Cited

Shabel, Alan, Sheryl Soucy and John J. Stachowicz. 1992. Bean biomass per pod. This volume.

EFFECTS OF BRACKEN FERN ABUNDANCE ON BEAN YIELDS

Janis M. Hall, Kimberly A. Isaacs, Jack V. Ko, Catherine N. O'Neill and Jon A. Rettmann

Abstract. We examined competition between beans (*Phaseolus vulgaris*) and bracken ferns (*Pteridium aquilinum*) in both the *frijol tapado* and the *espequeado* systems of bean cultivation in Coto Brus, Costa Rica. Locally high abundances of bracken ferns were expected to be associated with decreased bean yields. We found, however, no significant correlation between the two, suggesting that either substantial competition between the two species does not take place, or our methods were not sufficiently sensitive to detect it. We also attempted to determine the causes of the variation in bracken fern abundance, but neither the cultivation system nor the amount of applied fertilizer was found to significantly affect abundance. (JAR)

Introduction (JMH)

An ongoing study by Martha Rosenmeyer in Coto Brus, Costa Rica, is comparing the productivity of bean plants (*Phaseolus vulgaris*) cultivated by the *frijol tapado* method and the *espequeado* method under various fertilizer treatments. In the *frijol tapado* system, beans are broadcast over a vegetated area and the vegetation is then cut and left as mulch. The *espequeado* system requires clearing the land of vegetation, planting beans below the soil surface, and fertilizing. The Costa Rican Ministry of Agriculture recommends the latter method, with 30cm x 50cm plant spacing and 325kg fertilizer per hectare. In Rosenmeyer's experimental plots, there are some uncontrolled factors of the experimental design, the effects of which are not well-understood, including competition with weed species (Rosenmeyer, pers. comm.).

A common weed at the study site is the bracken fern, *Pteridium aquilinum*, which occurs in varying densities throughout the bean plots. We expected that there would be more bracken in areas with less fertilizer, as was found by an OTS study on these plots. We predicted that more branches would be found in plots which were closer to the forest and therefore more shaded.

We also predicted that the presence of bracken would decrease bean yield. The plots we studied for this were those planted using the most common combinations of techniques used by local farmers: *frijol tapado* with no fertilizer, and *espequeado* with the recommended fertilizer application.

Methods (JVK)

Data for this experiment were collected at El Naciente, Finca Loma Linda de Coto Brus, Canas Gorelas, Costa Rica. We analyzed the effects of various agricultural treatments on bracken density as well as density change with distance from forest edge. Six replicate plots of the following eight treatments were examined:

1) *frijol tapado* with no fertilizer
2) *frijol tapado* with 108kg/ha 10-30-10 fertilizer
3) *frijol tapado* with 216kg/ha
4) *frijol tapado* with 325kg/ha

5)*espequeado* with no fertilizer and 30cm x 30cm plant spacing
6)*espequeado* with 325kg/ha and 30cm x 30cm spacing
7)*espequeado* with 325kg/ha and 30cm x 50cm spacing
8)*frijol tapado* with foliar and 108kg/ha fertilizer

The total number of brackens by size class were counted in the center 2m x 2m area of each 4m x 4m plot to eliminate any possible edge effect from outside factors (observations indicated differences up to 50cm from edge). We then measured the shortest distance from each plot to the edge of the forest canopy.

Ten ferns of each size class (visually defined as small, medium and large) were randomly selected and weighed to get an average mass per fern for each class. We then calculated total bracken biomass per plot. Above ground bracken biomass was assumed to be correlated with below ground biomass and thus a measure of both root and shoot competition with bean plants for resources.

We also compared the effect of bracken density on bean yield within two treatment types, *frijol tapado* plots without any fertilizer and *espequeado* plots with 325kg/ha 10-30-10 NPK ratio fertilizer and 30cm x 50cm plant spacing. Again, the center 2m x 2m of each plot was selected for observations in order to eliminate edge effect. Any plant stems directly on the dividing line were considered outside the plot. This 2m x 2m area was subdivided into four 1m x 1m quadrats. Six replicate plots (total of 24 quadrats) were used per treatment type. In each quadrat we recorded total number of bean pods and the number of bracken

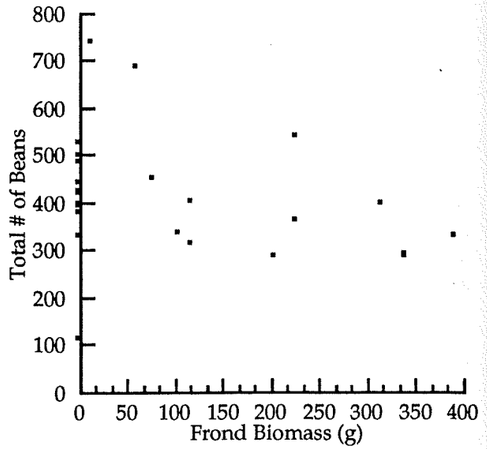

Figure 1. Scatter plot of *Tapado* bean yield vs fern frond biomass.

plants by size class. If the bean or fern plant stem was within the quadrat boundaries, we included the whole plant in our analysis. We then counted the number of beans per pod from ten randomly selected pods in each quadrat to get an average number of beans per pod per quadrat. By multiplying this average with the number of pods per quadrat, we calculated total number of beans per quadrat.

Results (KAI)

Both systems of cultivating *P. vulgaris* were examined, and fern biomass was not significantly correlated with bean production (#beans/m^2) in either the *frijol tapado* system ($r=-0.02$, $t=0.96$, $0.10>p>0.04$; Figure 1) or the *espequeado* system ($r=0.003$, $p > 0.05$; Figure 2).

An ANOVA indicated that (i) treatment of plot did not have a significant effect on bracken fern biomass ($F=1.04$, $p>0.05$) and (ii) blocking effects

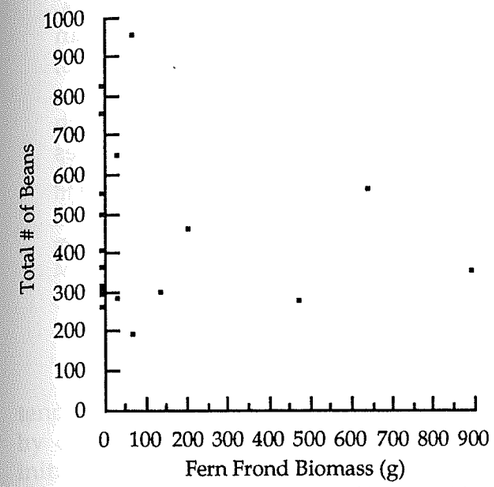

Figure 2. Scatterplot of *Espequead* bean yield versus fern frond biomass.

(i.e., spatial location of plot) did not have a significant effect on bracken fern biomass ($F=1.00$, $p>0.05$; Figure 3). We also found that distance from the forest canopy was not correlated with bracken fern abundance ($r=0.13$, $t=0.89$, $p>0.4$).

Discussion (CNO)

Bracken Distribution and Abundance. Our analysis showed that neither cultivation system, fertilizer input, nor distance from the forest accounted for any variation in the bracken biomass. However, the time that each area is shaded during the day may better reflect the influence of the forest, rather than the canopy proximity that we measured. Although beans are shade tolerant (Rosenmeyer, pers. comm.), more studies on the extent of shading by both the forest and the ferns may help to explain variances in bean yield, as well as bracken distributions. We did not differentiate between healthy and diseased pods in this study, but we noticed that those in the shade showed a greater frequency of pod damage than did those in the sunlight, thus reducing the number of healthy beans in a harvest.

Competition. In the *espequeado* plots (325 kg/ha-1 NPK), the bean yield (measured as #beans/m^2) was not correlated with the bracken frond mass in each plot. The *frijol tapado* plots (no fertilizer) showed only a slight and insignificant inverse correlation. It appears that other factors are influencing the bean yield more than the presence of brackens. The ferns may actually increase bean yield by acting as a trellis for the bean plants, allowing them support to grow towards the sunlight. In the *frijol tapado* system the brackens eventually become mulch in their second year. The mechanisms of bracken-bean interactions/should be explored by looking at root and shoot

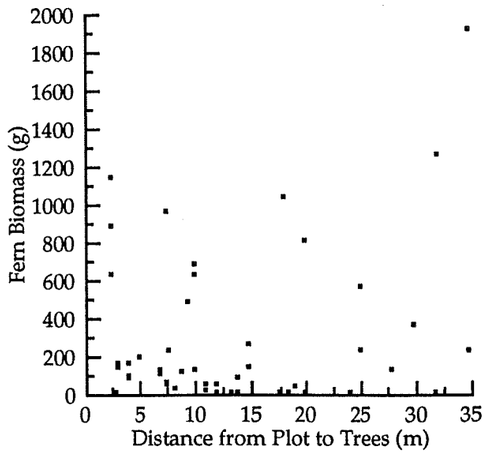

Figure 3. Scatterplot of bracken fern biomass in relation to the distance from the plot to th forest.

competition. Since several bracken fronds emerge from a single branching root system, perhaps the beans are being affected by roots of brackens outside the study plots, a possibility which was not accounted for in this experiment. Also, the roots might grow at different depths in the soil, resulting in little underground competition between the two species.

Based on our observation ferns do not seem to affect the bea productivity in the experimental plot and we might suggest that farmer need not concern themselves wit bracken growth. Further studie should concentrate on other factor that do limit bean yield and the mech anisms of possible competition be tween bean crops and weeds.