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 observations, ferns do not seem to affect the bean productivity in the experimental plots, and we might suggest that farmers need not concern themselves with bracken growth. Further studies should concentrate on other factors that do limit bean yield and the mechanisms of possible competition between bean crops and weeds.

THE PERFORMANCE OF FIVE POTENTIAL TERRACE TREE SPECIES IN CANTON COTO BRUS, COSTA RICA

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Abstract. We gathered baseline data on the performance of five potential terrace tree species in the Coto Brus area, Costa Rica. We measured percent survival, height, diameter, and percent leaf loss due to herbivory of 208 transplanted seedlings of 5 species: *Flemingia macrophylla, Erythrina poeppigiana, Inga edulis, Calliandra calothyrsus*, and *Acacia mangium*. Most seedlings were performing well by these measures after one year of growth. (TCB)

INTRODUCTION (JLB)

Tropical agricultural practices tend to alter the growing environment by depleting the soil of nutrients and initiating erosion. Terrace farming is designed to alleviate the problem of erosion. The planting of trees on these terraces helps to stabilize the soil and provides shade which is necessary for the growth of crop plants that are damaged by excessive sunlight (e.g., coffee).

Five tree species (*Flemingia macrophylla, Erythrina poeppigiana, Inga edulis, Calliandra calothyrsus*, and *Acacia mangium*), expected to grow well under local conditions, were planted from seedlings at the Cole Farm near Las Cruces, to determine suitability as terrace trees. All five were nitrogen-fixing and were recommended for tropical plantations. Baseline information on survivorship, growth, and intensity of herbivory for these species will be important for further comparative studies of their performance in this area.

METHODS (ALG)

All of the trees in our study were transplanted onto the terrace within two days of each other. Upon transplanting, the tops of all individuals were pruned.

Our census was made on 2 February 1992. The trees were located in experimental plots on the south slope of a field on Loma Linda farm, Valle de Coto Brus, Costa Rica. The plots consisted of 4 monospecific rows of each species; each row contained 9-12 plants spaced 0.5m apart.

We measured each tree's height, and its diameter at 3cm above the ground. We also estimated the percent leaf loss due to herbivory for two leaves: (i) the leaf at the second node (counting from the base), and (ii) the youngest full-sized leaf. Herbivory was classified as 0-1%, 2-5%, 5-10%, 10-25%, 25-50% or greater than 50%. For analysis, we assigned each leaf the midpoint of the range of its herbivory class.

RESULTS (TCB)

We examined 208 trees of the 5 species. Of these, 7 individuals were dead: 5 *Acacia mangium*, 1 *Erythrina poeppigiana*, and 1 *Inga edulis*.

The seedlings varied between species in height and diameter (Table 1). *Flemingia macrophylla* was shorter and smaller in diameter than any other species (Table 2). *E. poeppigiana* was the next tallest species. *I. edulis*, *C. calothyrsus* and *A. mangium* were of similar height (Table 2). *A. mangium*,

though tall, was thinner than all but *F. macrophylla*. *E. poeppigiana*, *I. edulis* and *C. calothyrsus* were similar in diameter.

The trees also showed variation in the amount of herbivore damage (Table 1). *I. edulis* was the most damaged, followed by *A. mangium* and *C. calothyrusus* (Table 2). *F. macrophylla* and *E. poeppigiana* showed the least damage.

Only *C. calothyrus* and *I. edulis* showed a significant difference in herbivore damage between old and new leaves (Table 3). In both species, old leaves were damaged more than new ones.

Discussion (ALG)

Our results provide baseline data for a long term study. However, there were already some differences among the species after only one year's growth.

F. macrophylla was the shortest and had the smallest stem diameter, possibly because it invests in multiple stems, rather than in vertical growth of a single stem. It is resistant to both dry spells and water-logged soil (Nitrogen Fixing Tree Association, NFTA 89-04 1989). A potential drawback to this species is that the leaves are resistant to decay, reducing the rate of nutrient cycling.

E. poeppigiana appeared the most vigorous. It was tall, had moderately high stem diameter and two to five relatively herbivory-free leaves. An additional advantage to this species is that the flowers and seeds can be sold for supplemental income (Nitrogen Fixing Tree Association, NFTA 86-02, 1986). *E. poeppigiana* also sprouts well vegetatively.

C. calothyrsus is good for terracing in high, dry areas (Nitrogen Fixing Tree Association, NFTA 88-02, 1988). However, most individuals of this species were severely defoliated. The upper leaves were brown and abscising, possibly from sun exposure.

I. edulis, one of the shorter plants, was severely damaged by herbivory, apparently by leaf-cutter ants.

A. mangium thrives in moist soils (Nitrogen Fixing Tree Association, NFTA 87-04, 1987). Possibly because of the seasonally dry soil conditions in the Coto Brus area, *A. mangium* had the highest mortality of the five species. An additional drawback to the acacia is that its seeds require mechanical scarring or immersion in boiling water to germinate.

Many more data are necessary to determine which species is most appropriate for terrace farming in the Coto Brus area. At present, we argue that all species are potential candidates except perhaps *A. mangium*.

Table 1. Summary of Terrace Tree Baseline Data.

Species	Height(m)	Diameter(cm)	% herbivory	
			New Leaves	Old Leaves
F. macrophylla	0.178±0.036	0.275±0.044	6.34±14.13	7.95±13.84
E. poeppigiana	0.342±0.087	0.546±0.139	5.57±11.53	5.84±14.88
C. calothyrsus	0.437±0.126	0.579±0.184	14.03±23.04	32.53±33.59
I. edulis	0.394±0.091	0.604±0.178	27.46±27.50	59.29±20.45
A. mangium	0.427±0.111	0.388±0.098	15.38±23.11	30.50±63.22

Table 2. Results of T-Test Pairwise Comparisons.

Pair	Height	Diameter	% herbivory	
			New Leaves	Old Leaves
Flemingia vs. *Erythrina*	t=11.15**	t=11.9**	t=0.27	t=0.665
Flemingia vs. *Calliandra*	t=12.7**	t=10.31**	t=32.06**	t=4.73**
Flemingia vs. *Inga*	t=14.0**	t=11.44**	t=4.31**	t=13.03**
Flemingia vs. *Acacia*	t=13.6**	t=6.68**	t=2.10*	t=2.23*
Erythrina vs. *Calliandra*	t=4.03**	t=0.931	t=2.12*	t=4.69**
Erythrina vs. *Inga*	t=2.56*	t=1.60	t=4.65**	t=23.02**
Erythrina vs. *Acacia*	t=3.78**	t=5.74**	t=2.37*	t=2.45*
Calliandra vs. *Inga*	t=1.72*	t=0.616	t=18.02**	t=4.198**
Calliandra vs. *Acacia*	t=0.377	t=5.60**	t=0.24	t=0.186
Inga vs. *Acacia*	t=0.72	t=6.60**	t-2.03*	t=2.60*

*p<0.05, **p<0.001

Table 3. Summary of t-test results of herbivory on old versus new leaves.

Species	t-value, p-value
F. macrophylla	0.520, p<0.9
E. poeppigana	0.092, p>0.9
C. calothyrsus	3.047, p<0.01
I. edulis	5.57, p<0.001
A. mangium	1.367, p<0.2

Literature Cited

Nitrogen Fixing Tree Association, NFT Highlights, NFTA 86-02, Jan. 1986.

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