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Nitrogen Fixing Trees Suitable for Diversified Soils on Guam

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Abstract—Plant development of eight nitrogen fixing trees (NFTs) as potential hedgerow plants were evaluated on three soil regimes on Guam. Test plants included *Acacia angustissima* (Mill.) Kuntze, *Cajanus cajan* (L.) Millsp., *Calliandra calothyrsus* Meissner, *Desmodium rensonii*, *Flemingia macrophylla* (Willd.) Merr., *Gliricidia sepium* (Jacq.) Kunth ex Walp., *Leucaena leucocephala* (Lam.) de Wit cv. K636, and *Sesbania sesban* (L.) Merr. cv. Nubica. NFTs other than *F. macrophylla* and *C. calothyrsus* yielded more than 11 t ha^{-1} of biomass in the soil of Udic Haplustalfs at Barrigada, in central Guam. *L. leucocephala* cv. K636 produced the greatest biomass of 26.1 t ha^{-1} in the trial, followed by *S. sesban* cv. Nubica with 19.9 t ha^{-1}. The average biomass of eight NFTs was 3.63 t ha^{-1} in very shallow Yigo soil classified as Lithic Ustorthents. *L. leucocephala,* yielding 12.3 t ha^{-1}, was the only promising NFT in this location. In the acidic Oxic Haplustalfs soil in Ija, in southern Guam, *F. macrophylla, S. sesban, G. sepium,* and *D. rensonii* produced about the same amount of biomass, ranging from 6.6 to 4.8 t ha^{-1} while *L. leucocephala, A. angustissima,* and *C. calothyrsus* grew very poorly.

Introduction

Nitrogen fixing trees (NFTs) are plants that capture nitrogenous gas from air via symbiotic relationships with microorganisms. The nitrogenous compounds are then utilized in production of major organic compounds such as proteins. Hedgerow intercropping with NFTs have several advantages in farm management. NFTs can increase farm self-sufficiency by reducing use of fertilizers. Soil productivity can be improved by NFTs by their ability to conserve water and to enrich productivity through microbial activity when plant litter is used as mulch. NFTs can also serve as windbreaks and help prevent soil erosion. Several NFTs are recommended as hedgerow plants or multipurpose trees in the tropics (Giller & Wilson 1991, Elevitch & Wilkinson 2000).

Guam, an island of 549 km^2, has soil types ranging from highly alkaline to very acidic, and shallow to deep (Young 1988). The natural vegetation displays adaptation to varied soil types. Since plant development depends not only on the atmospheric environment but also on the soil environment, studies on plant adaptation to different soil regimes on Guam is needed to identify suitable NFTs for a particular locale. This paper reports the differential biomass production of selected tropical NFTs in response to three different soil regimes on Guam that have potential for use as hedgerow plants.

Materials and Methods

Eight species of nitrogen fixing trees were tested, namely acacia, *Acacia angustissima* (Mill.) Kuntze, pigeon pea, *Cajanus cajan* (L.) Millsp., calliandra, *Calliandra calothyrsus* Meissner, desmodium, *Desmodium rensonii,* flemingia, *Flemingia macrophylla* (Willd.) Merr., gliricidia, *Gliricidia sepium* (Jacq.) Kunth ex Walp., tangan-tangan, *Leucaena leucocephala* (Lam.) de Wit cv. K636, and sesbania, *Sesbania sesban* (L.) Merr. cv. Nubica. Seeds were sown in dibble tubes and seedlings were grown for approximately three months in the nursery.

Seedlings were transplanted to each of three experimental fields in July 2000. The Yigo experimental site in the northern part of the island is characterized as Lithic Ustorthents, clayey, gibbsitic, nonacid, isohyperthermic with pH of 6.4–7.5. It is very shallow soil laying on a limestone bed. The Barrigada experimental site in the central part of the island is characterized as shallow Udic Haplustalfs, clayey, montmorillonitic, isohyperthermic with pH of 6.0–7.5. Lastly, the Ija experimental site located in the south of the island, is characterized as Oxic Haplustalfs, very fine, kaolonitic, isohyperthermic soil with pH 4.5–6.2. The experiment at each location was conducted in a randomized complete block design (RCB) with three replications. The size of the basic experimental unit was 2 m x 2 m. Four seedlings of each species were planted in a row for each plot with 0.5 m between plants.

NFTs were examined once a month from November 2000 to July 2001 to evaluate plant biomass production. On the observation day, the top canopy of each plant was cut 76 cm above the ground. Stems, leaves and reproductive tissues of all plants from each plot were combined and weighed. Wet biomass data were analyzed by analysis of variance for each experimental site, and a combined analysis of variance over sites to determine adaptability of NFT at each locality by SuperANOVA (Abacus Concept Inc. 1997).

Results and Discussion

Growing location and plant species affected biomass production of NFTs. Analysis of variance for each locale indicated that the biomass production was influenced by the type of NFTs (Table 1). In a combined analysis, both location and NFT affected biomass production, and location x NFT was also observed (Table 2).

For each site, the total fresh biomass of each NFT harvested from November 2000 to July 2001 was summarized in Table 3. The biomass production of all plants at Barrigada was greater than that of Yigo and Ija (Table 3). At Barrigada,

Table 1. Analysis of variance for fresh biomass production of nitrogen fixing trees (NFTs) at each location from November 2000 to July 2001.

Source of variation	df	Significance		
		Barrigada	Yigo	Ija
Rep	3	NS	NS	NS
NFT	7	***	***	***
Residual	20			

NS, Nonsignificant at 0.05 level; * and ***, significant at 0.05 and 0.001 levels, respectively.

Table 2. The combined analysis of variance for fresh biomass production of nitrogen fixing trees (NFTs) over three locations from November 2000 to July 2001.

Source of variation	df	Significance
Location	2	***
Reps within location	9	
NFT	7	***
NFT x Location	14	***
Residual	60	

***Significant at the 0.001 probability level.

Table 3. Fresh biomass production of eight nitrogen fixing trees (NFTs) grown in three locations on Guam from November 2000 to July 2001.

	Location			
NFT	Barrigada	Yigo	Ija	NFT Mean
	– – – – – – – – – – – – – – t ha^{-1}– – – – – – – – – – – – – –			
Leucaena leucocephala K636	26.1a*	12.3a	0.4c	12.93
Sesbania sesban cv. Nubica	19.9b	2.2c	5.6a	9.23
Gliricidia sepium	15.3c	5.5b	5.3a	8.70
Desmodium rensonii	14.9c	1.5c	4.8a	7.07
Cajanus cajan	11.2c	2.0c	2.7b	5.30
Acacia angustissima	11.0c	4.4b	0.5c	5.30
Flemingia macrophylla	6.3d	0.6c	6.6a	4.50
Calliandra calothyrsus	1.9d	0.5c	0.1c	.083
Location Mean	13.33	3.63	3.25	6.73
CV(%)	21.1	39.8	36.1	

*Numbers in each column followed by same letters are not significantly different according to Fisher's protected LSD($P \leq 0.05$).

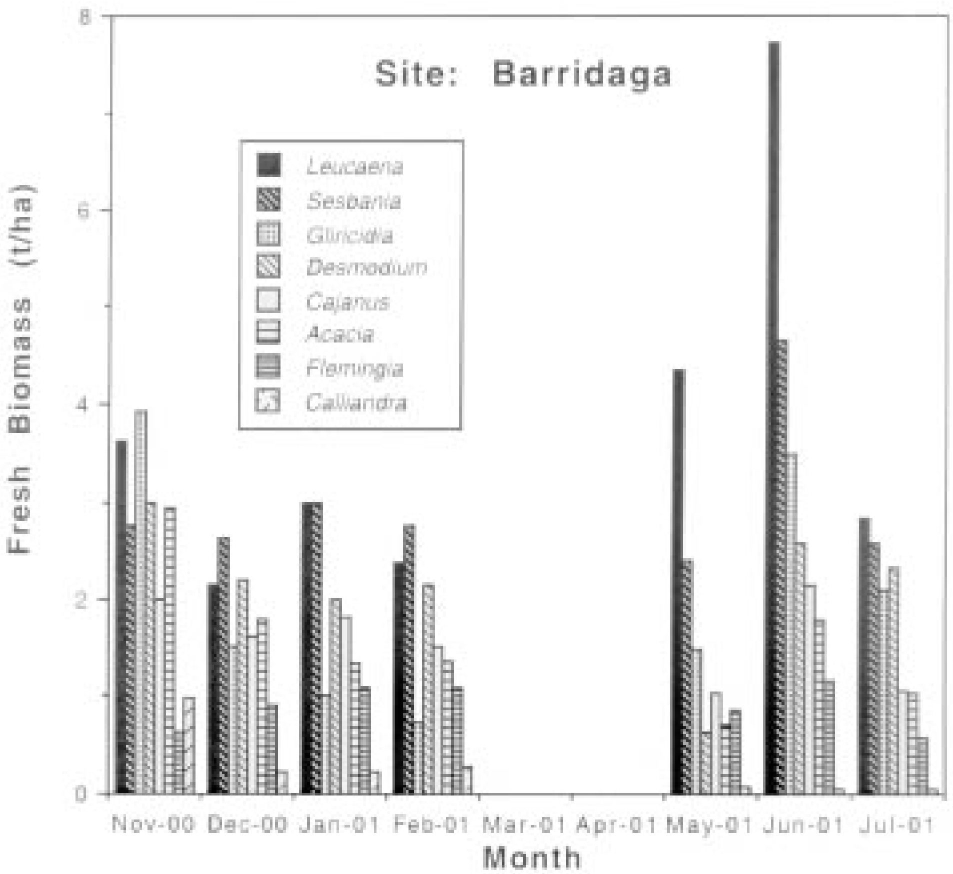

Figure 1. Monthly biomass production of NFTs at Barrigada from November 2000 to July 2001. There were no harvests during the driest months of March and April because canopy regrowth was very slow.

L. leucocephala cv. K636 had the highest yield of 26.1 t ha^{-1}, followed by *S. sesban*, cv. Nubica, *G. sepium*, *D. rensonii*, *C. cajan*, *A. angustissima*, *F. macrophylla* (6.3 t ha^{-1}), and *C. calothyrsus*, which was the poorest producer with 1.9 t ha^{-1}. In Yigo, *L. leucocephala* cv. K636 produced the highest biomass at 12.3 t ha^{-1}, while other NFTs produced much less, ranging from 0.5 to 5.5 t ha^{-1}. In Ija, *S. sesban* cv. Nubica, *G. sepium*, *D. rensonii*, and *F. macrophylla* produced about the same biomass with a range of 4.8 to 6.6 t ha^{-1}. *L. leucocephala* cv. K636 had very poor growth in the acidic soil of Ija. The result was comparable with other reports suggest that *L. leucocephala* is more adapted to alkaline soils (MacDicken 1994). In addition, indigenous nitrogen fixing rhizobia, *Rhizobium* spp. associated with *L. leucocephala* were found on Guam predominately in cobby clay soil (Lithic Ustorthents) in Yigo (Marutani & Manalastas 2000). The symbiotic rela-

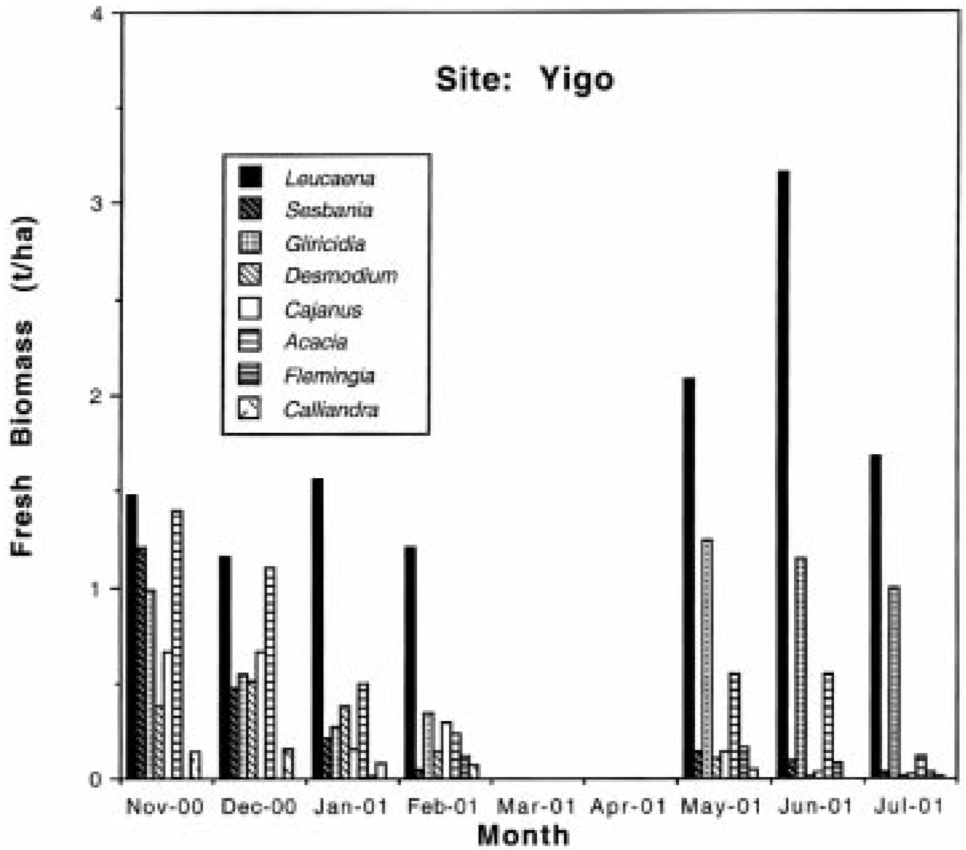

Figure 2. Monthly biomass production of NFTs at Yigo from November 2000 to July 2001. There were no harvests during the driest months of March and April because canopy regrowth was very slow.

tionship of indigenous *Rhizobium* spp. and *L. leucocephala* might have contributed to plant development in this species,

The biomass production of NFTs varied with season (Figs. 1, 2 and 3). A general decline in vegetative growth was observed from November to February. During the driest months of March and April there were no harvests because canopy regrowth was very slow. As precipitation started to increase in April through May and June, biomass production also increased. However, some species never recovered from drought stress. In Barrigada and Yigo, the highest biomass production was observed in *L. leucocephala* cv. K636 in June.

As the experiment proceeded, it became apparent that the decline of vegetative growth was due not only to abiotic environmental factors, but also to insect damage. The main insect pests observed were stem borers, leafminers, mealybugs, aphids, and grasshoppers. Ants associated with mealybugs and aphids were

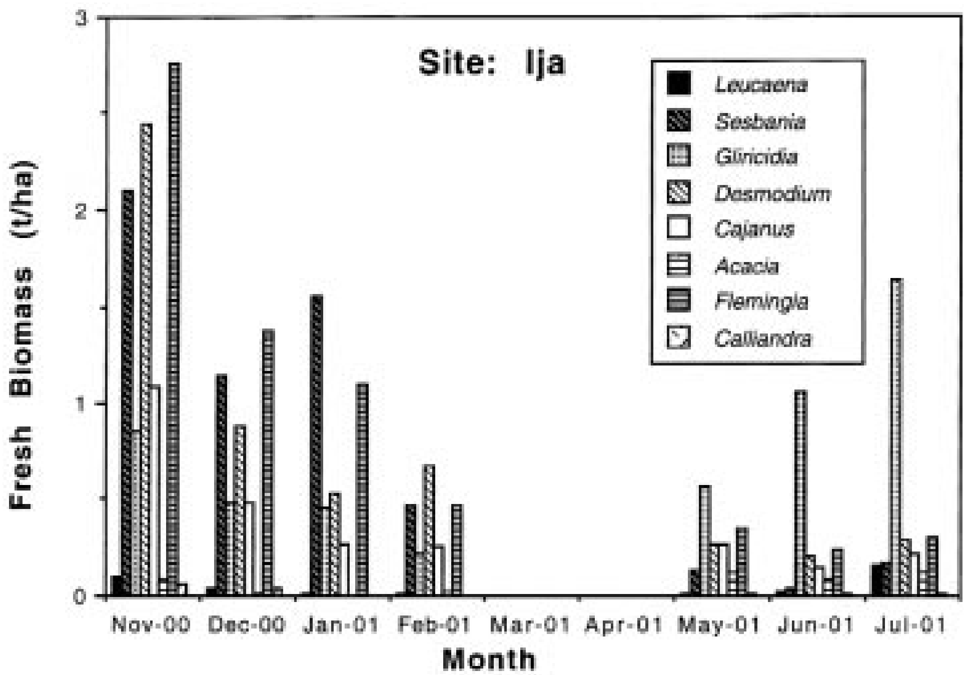

Figure 3. Monthly biomass production of NFTs at Ija from November 2000 to July 2001. There were no harvests during the driest months of March and April because canopy regrowth was very slow.

also observed on foliage veins and on the stems of NFTs. These pests are currently being collected for identification.

The soil structure and chemical properties of the planting site affected the growth of NFTs. Soils in Barrigada (Udic Haplustalfs) were the best farming soils of the three sites tested in this experiment. Similar results were also found in a trial of four leguminous green manure crops (Marutani & Simpson 1994). For the acidic Oxic Haplustalfs of Ija, soil amendment by liming would likely improve the field performance of NFTs as observed in the earlier study on legumes (Marutani & Simpson 1994). These results suggest that further evaluation of different germplasm of *Leucaena* spp. in very shallow Guam cobbly clay soil (Lithic Ustorthents) in Yigo is warranted.

Pruning methods should also be considered for as a factor to influence the biomass production of NFTs. The decline of *S. sesban* cv. Nubica at Ija and Yigo sites seemed to have accelerated with monthly pruning and drought conditions during the dry season. *S. sesban* cv. Nubica and *G. sepium* are recommended for areas with waterlogged soils (Elevitch & Wilkinson 2000).

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