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Evaluation of Tree Species Adaptation for Alley Cropping in Four Environments in Haiti. B. First Year of Pruning

by

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FORWARD

This report is the second in a series of reports on Agroforestry Trial 1, conducted by SECID/Auburn University for the PLUS Project. This trial was designed to identify tree species suitable as hedgerows for alley cropping in different agroecological zones in Haiti. It is part of a larger agroforestry research program designed to provide information to be used by the extension programs of CARE International and the Pan American Development Foundation to conserve soil, and to sustain and increase crop production and farmer income. These researcher implemented trials are a vital component of a technology development and testing strategy for Haiti. PLUS will increasingly emphasize on-farm research to determine adaptability and adoptability of new technologies and to fine-tune technology to farmer conditions. Agroforestry Trial 1 and other researcher implemented trials will continue to provide the information needed to design on-farm trials and to provide information that cannot be readily obtained in the less controlled conditions of farmers' fields. We believe that this report of trial results is a small but important step in the process of fulfilling the goal and purpose of the PLUS Project, i.e., sustainable increases in on-farm income and productivity through sustainable land-use interventions.

ACKNOWLEDGEMENTS

This report would not have been possible without the dedication of Lionel Isaac and Patrick Condé in ensuring the security and continuation of these trials during the project suspension. Marilyn Louis, SECID/Auburn Administrative Officer, also played a key role in ensuring the continuation of these trials.

Thanks are due to Arlen Hunsburger and Mike Bannister of PADF and Greg Brady of CARE, as well as Michelet Fontaine and Dr. Abdul Wahab of USAID for supporting the continuance of the Agroforestry trials in PLUS. We hope that with this and subsequent reports, they will see their expectations fulfilled.

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EXECUTIVE SUMMARY

Tree species were evaluated for their suitability as hedgerows for alley cropping in Haiti. Major criteria discussed in this report are total and leaf biomass production, leaf/stem ratio, regrowth following pruning, and survival. The trial was planted at four sites in Haiti, each representing an important agro-ecological environment: high elevation (1150 m); low elevation, humid on calcareous soil; low elevation, humid on basaltic soil, and low elevation, semi-arid environment. At the low elevation, semi-arid site, the trees had not attained sufficient height for pruning during the period covered by this report. The semi-arid site is not discussed in this report.

Sixteen tree species were planted in hedgerows at the high elevation and basaltic sites and 20 species at the calcareous site. *Leucaena leucocephala*, variety K 636, *Leucaena* hybrid variety KX3, *L. diversifolia*, variety K 156, *Acacia angustissima*, *Calliandra calothyrsus*, *Casuarina cunninghamiana* and *Gliricidia sepium* variety HYB were included at all three sites. Between April 92 and May 93, biomass was harvested three times at the high elevation and calcareous sites and twice at the basaltic site. Only species that had reached more than 50 cm after one year of establishment were pruned. Large differences in annual biomass production were

recorded among the species across the sites.

The most biomass at the high elevation site was produced by *Acacia angustissima* followed by three species of *Leucaena*, *Leucaena* hybrid KX3 (*L. leucocephala* X *L. diversifolia*), *L. leucocephala* and *L. diversifolia*. Leaf and stem production was also greatest in these species. At the calcareous site, total biomass was greatest for *L. leucocephala* and KX3, followed by *L. shannonii* and *L. diversifolia*. *Cassia siamea* produced a similar amount of leaf biomass as *L. shannonii* and *L. diversifolia*. At the basaltic site, the most biomass was produced by *L. leucocephala* and KX3, followed by *L. salvadorensis* and *Calliandra calothyrsus*. Highest biomass overall was obtained by *Leucaena leucocephala* and *Leucaena* hybrid KX3 at the calcareous site, followed by *Acacia angustissima* at the high elevation site.

Those species which produced the most biomass also produced significant regrowth. Several species at each site failed to grow sufficiently to be harvested for biomass.

Survival of the high yielding species was excellent. Mortality was observed in many of the less productive species, most notably *Desmodium gyroides*, which completely died off, the *Erythrina* species, *Acacia melanoxylon*, *A. mearnsii*, *Mimosa scabrella* and *Cassia emarginata*, as well as *Acacia angustissima* and *Casuarina* at the low elevation sites and *Delonix* and *Flemingia* at the basaltic site.

Based upon the various factors considered, especially leaf

biomass production, the best performing species at each site may be classed as follows:

High Elevation:	**Excellent -**	*Acacia angustissima*
	Good -	*Leucaena* hybrid KX3, *L. leucocephala, L. diversifolia*
Calcareous site:	**Excellent -**	*L. leucocephala, Leucaena* hybrid KX3
	Good -	*L. shannonii, L. diversifolia, Cassia siamea*
Basaltic site:	**Good -**	*L. leucocephala, Leucaena* hybrid KX3

These trials need to be continued and additional observations taken. The importance of observing species performance over time is illustrated by the biomass yields at the high elevation site. Initially the most biomass was produced by *Leucaena leucocephala*, variety K 636. At subsequent prunings it dropped to fourth position, yielding significantly less biomass than did *Acacia angustissima*. *Flemingia macrophylla*, on the other hand, yielded little biomass during the first two harvests, but ranked third at the third harvest. Only further measurements will determine whether this species should be seriously considered for alley cropping at high elevation.

Rezime Kreyol

Nou te évalye espès bwa pou ranp vivan nan divès zòn nan peyi Dayiti. Sa ki pi diskite nan rapò sa-a se kantite fèy bwa yo bay, relasyon ant fèy ak branch tij, fason bwa yo repouse apre koup la, ak tan yo viv. Travay sa-a te realize nan kat (4) zòn diferan nan peyi-a: sou wotè (1150); sou sòl kalkè nan ba altitid imid, sou sòl bazaltik nan ba altitid imid, ak nan yon zòn sèk. Nan zòn sèk la, bwa yo pat gen wotè ase ki ta pèmèt nou koupe yo pandan peryod sa-a. Sa ki fè zòn sèk la pa antre na rapò sa-a.

Sèz (16) espès bwa te plante sou ranp nan zòn sou wotè ak sou tè bazaltik, 20 sou sòl kalkè. Kèk espès tankou lesena K636 (*Leucaena leucocephala*, var K636), lesena KX3 (*L. leucocephala X L. diversifolia*), lesena ti fèy (*L. diversifolia*, var. K156), akasya (*Acacia angustissima*) kalyandra (*Calliandra calothyrsus*), pichpen (*Casuarina cunninghamiana*) ak piyon (*Gliricidia sepium*, var. HYB) te simen nan tout sit yo. Ant mwa Avril 92 ak Me 93, nou te rékolté bwa yo twa (3) fwa nan zòn sou wotè ak nan zòn tè kalkè-a e de (2) fwa nan zòn tè bazaltik la. Sèl espès ki te grandi plis pase 50 cm nan peryod sa-a te rekolte. Nou konstate gwo diferans nan pwodiksyon byomas ant espès yo nan tout sit yo.

Nan sit sou wotè-a, se akasya (*A. angustissima*) ki te bay plis randman. Apre li, nou te jwenn twa (3) espès lesena yo: lesena ibrid KX3, lesena K636 ak lesena K156. Espès sa yo te bay plis fèy

ak branch tou. Sou sit tè kalkè-a espès ki te pwodwi plis byomas se lesena K636 ak lesena KX3; de (2) lòt espès lesena (*L. shannonii* ak *L. diversifolia*, K156) te swiv yo. Kaysa (*Cassia siamea*) pwodwi nan menm kantite fèy ak *L. shannonii* et *L. diversifolia*, K156. Nan sit sòl bazaltik la, se lesena K636 ak lesena KX3 ki te bay pi gwo randman. De (2) lòt espès tankou *L. salvadorensis* ak *C. calothyrsus* te vini apre yo. Lè nou konsidéré tout espès yo nan twa sit yo, se lesena K636 ak lesena KX3 ki sou sit kalkè-a ki te pwodwi plis byomas. Apre yo nou jwenn *A. angustissima* ki nan sit sou wotè-a.

Plizyè espès pat grandi ase pou nou te rekolte yo. Nou konstate tou ke espès yo ki te bay plis randman te pi byen repouse.

Nou pat remake pye bwa nan mitan ranp espès ki te pwodwi plis byomas yo. Kèk pye te mouri nan ranp espès ki pat bay bon jan randman tankou espès eritrina yo (*E. indica* ak *E. poeppigiana*), kèk akasya (*A. melanoxylon* ak *A. mearnsii*), *Mimosa scrabella* ak *Cassia emarginata*. Espès desmodiòm nan (*Desmodium gyroides*) té disparèt nèt nan tou de sit li te plante-a. Nou te remake tou angustissima ak pichpen-an (*C.cunninghamiana*) pat vini byen nan tou de sit ba altitid yo; *Delonix regia* ak *Flemingia macrophylla* te pèdi anpil pye nan sit basaltik-la.

Lè nou gade faktè nou té konsidere yo, espesyalman pwodiksyon fèy, nou ka klase pi bon espès nan chak sit yo konsa:

Sit nan wòtè:	Bon anpil	- *Acacia angustissima*
	Bon	- *Leucaena* hybrid KX3, *L. leucocephala, L.diversifolia*
Sit sòl kalkè:	Bon anpil	- *L. leucocephala, Leucaena* hybrid KX3
	Bon	- *L. shannonii, L. diversifolia, Cassia siamea*
Sit sòl bazaltik:	Bon	- *L. leucocephala, Leucaena* hybrid KX3

Li nesesè pou travay sa-a kontinye. Sa ka pèmèt nou jwenn plis enfòmasyon toujou sou espès yo. Li enpòtan pou nou fè remake ke nan sit sou wotè-a L. Leucocephala var. K636 te pwodwi plis nan premye koup la. Nan lòt rékot ki vin'n fèt, espès sa-a te desann an katryèm pozisyon apre A. angustissima ki vin-n bay plis randman. Se menm jan tou, F. macrophylla te bay you randman fèb nan de premye rekòt yo, men li vin-n pase an twazyèm pozisyon sou twazyèm koup la.

INTRODUCTION

Continuous cropping on fragile land without appropriate soil conservation measures can give rise to increasing rates of erosion, soil degradation and decreased yield of annual crops. Experience in some countries of the Third World has demonstrated that the use of contour hedgerows in alley cropping can be a viable means of sustaining production in farmers' fields in hillside agriculture systems. Alley cropping is a system whereby annual crops are planted between rows of trees, which are pruned during the cropping season and the prunings applied to the soil as a mulch or green manure (Kang et al., 1984). During periods when no crops are grown, the trees are allowed to grow freely. The benefits of this system were reviewed in SECID/Auburn PLUS Report No. 6 (Shannon and Isaac, 1993). SECID/Auburn University is conducting research for the Productive Land Use Systems Project (PLUS) to adapt alley cropping to Haitian conditions as a means to stabilize yields and reduce soil loss from cropped land.

ALLEY CROPPING AND CONSERVATION BARRIERS

It is important to point out that "alley cropping" is only rarely practiced in Haiti, although the use of hedgerows as a means of soil conservation is growing, thanks largely to the efforts of the Productive Land Use Systems Project and its predecessor, Agroforestry II, as well as other projects, such as the Targeted Watershed Management Project and the GTZ project in Northwest

Haiti. The distinction is that in alley cropping, the hedgerows are used primarily to maintain soil fertility through the application of prunings to the soil. In Haiti, most farmers plant the hedgerows to retain soil on cropped land. One also finds hedgerows planted on degraded land in long-term fallow (Lea *et al.*, 1993). In either case, the leaves and young stems are commonly browsed by livestock (Swanson *et al.*, 1993a) or cut and carried as fodder rather than being applied to the soil, and branches may be laid at the base of the hedgerows to retain soil (Bannister and Nair, 1990). An exception was reported by Swanson *et al.* (1993b), where an extension agent uses prunings of leucaena to fertilize tomato.

Because hedgerows have been promoted in Haiti primarily as a barrier to erosion, little documentation is available on alley cropping under Haitian conditions. Thus research on alley cropping is important so that extension workers and farmers can have an idea of the benefits which may accrue from adoption of this system. Nevertheless, the research results reported here are relevant whether the hedgerows are used in an alley cropping system or simply as a barrier to erosion. For alley cropping, we need to know the amount of leaf and stem material available for application to the soil. Where alley cropping is not practiced, it is still valuable to know the production of secondary products, such as fodder, fuelwood and stakes. In either case, a species is desired which will grow rapidly, survive frequent pruning or browsing by livestock and produce an economic return to the farmer.

CHOICE OF SPECIES

In a recent review, Dr. B.T. Kang (1993), the "father" of alley cropping, stated that "the success of the alley cropping system depends upon: (1) the right choice of woody species, (2) successful hedgerow establishment, and (3) proper hedgerow and crop husbandry. SECID/Auburn University is addressing points (1) and (2) in Agroforestry Trial 1, discussed here, and (3) in Agroforestry Trial 2.

Important factors in choosing hedgerow species are adaptation to environmental conditions, coppicing ability and tolerance to repeated pruning. Species which have given good results in trials in humid, lowland tropics are *Leucaena leucocephala* (leucaena) and *Gliricidia sepium* (gliricidia) (Kang, 1989). *Cassia siamea* also showed potential, while *Cajanus cajan* required replanting. *Erythrina poeppigiana* gave good results in hedgerows in a high rainfall area of Costa Rica (Kass *et al.*, 1992, cited in Kang, 1993). On a moderately acid soil in Western Samoa, leucaena and *Calliandra calothyrsus* (calliandra) survived well and produced the most biomass. *Erythrina subramans* and *Sesbania sesbans* had poor survival. *Samanea saman* and *Erythrina* produced the least biomass (Kidd and Taogaga, 1984). Gliricidia was intermediate in both survival and productivity.

In south central Zaire (7° S latitude, 780 m elevation) *Cassia floribunda*[1] produced more biomass than did *L. leucocephala*, but the

[1]There was some confusion as to whether the genus name was *Cassia* or *Acacia*. The tree closely resembles *Cassia siamea*, with very similar brilliant yellow clusters of flowers and waxy light green leaves and similar tree form. The main

effects on maize yield were similar (anonymous, 1987).

Cassia siamea performed well on highly acid soils (Kang, 1989). *Flemingia macrophylla* (flemingia) and *Tephrosia candida* were reported to have good potential. Calliandra grew and survived well on an acid soil in a high-rainfall area of Costa Rica at 650 m elevation (Baggio and Heuveldop, 1984). In Côte d'Ivoire, on a soil of pH 4.7 (H_2O), leucaena produced more leaf dry matter than either gliricidia or flemingia (Budelman, 1988a), as well as more potassium, but flemingia produced the mulch most resistant to decomposition (Budelman, 1988b).

Species which gave good results in high elevation (1400 m), semi-arid conditions (836 mm annual rainfall) were leucaena, calliandra, *Cassia spectabilis*, and *Leucaena diversifolia* (Balasubramanian and Sekayange, 1991). *Sesbania sesbans* did not survive well.

Initial attempts to introduce hedgerows in Haiti were made with hedgerows of *L. leucocephala*. However, because of Haiti's heterogeneous climate and soils, it was assumed that one species would not be best throughout. Project extension workers complained of poor performance of *leucaena* on basaltic soil and lack of vigor at high elevation. Various other species have been attempted in Haiti, including gliricidia, *Cassia siamea*, *Erythrina indica*, *E. poeppigiana*, *Calliandra calothyrsus* and *Moringa oleifera*. However, few of these species have been assessed in a systematic fashion.

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distinguishing features are a more lanceolate leaflet and longer pods on *floribunda*.

Cunard (1991) reported that leucaena and calliandra yielded a 2-cut total of over 3 t ha^{-1} fresh biomass, while gliricidia yielded 1.7 t ha^{-1}. *Albizia lebbeck, Sesbania sesbans* and *Moringa oleifera* yielded less than 1 t ha^{-1}, the latter only yielding 300 kg ha^{-1}.

OBJECTIVES

The research reported here is focused on identifying species suitable for hedgerows for alley cropping in some of the most important agro-ecological environments in Haiti. In this report, we compare the biomass production of hedgerow species during the first year of pruning in order to identify tree species suitable for alley cropping in the following agro-ecological conditions: 1.) mid to high elevation (1150 m); 2.) low elevation, humid on calcareous soil and 3.) low elevation, humid on basaltic soil. The evaluation of the hedgerow species for seedling establishment, growth rate and survival during the first year of the trial was discussed in SECID/Auburn PLUS Report No. 6 (Shannon and Isaac, 1993).

MATERIAL AND METHODS

Details of the trial design, species selection and trial establishment are described in SECID/Auburn PLUS Report No. 6 (Shannon and Isaac, 1993). The information essential to evaluation of the present data are presented herein.

SITES

Four sites, representing four distinct environments were selected for this trial (Figure 1). The high elevation site is at Fort Jacques (18° 29′ N latitude, 1150-1200 m elevation) in the Commune of Kenscoff, Department de l'Ouest. This zone is classified by the Holdridge Life Zones (Organization of American States, 1972) as humid forest of low elevation mountain. Annual rainfall, based upon data gathered between June 1991 and December 1993 averages 1031 mm, with a bimodal distribution pattern (Figure 2). The total rainfall recorded between the first and third pruning was 1276.5 mm, distributed mainly between March through May, and August through November. The site had a steep north-facing slope (40-50 %) on which were stone dry walls, resulting in terraces with slopes varying from 15-25 %.

The low elevation humid site on limestone parent material, hereby referred to as the calcareous site, is at Bergeau (18°13′ N latitude) in the District of Cayes, Department du Sud. The Holdridge Life Zone is Sub-tropical Humid Forest (Organization of American States, 1972. Annual rainfall, based upon data collected between June 1991 and May 1992 and between the third decade of January 1992 and first decade of February 1993, averages 1546 mm with a strongly bimodal pattern (Figure 3). The site is on an east-facing slope of approximately 35% at an elevation of about 55 m.

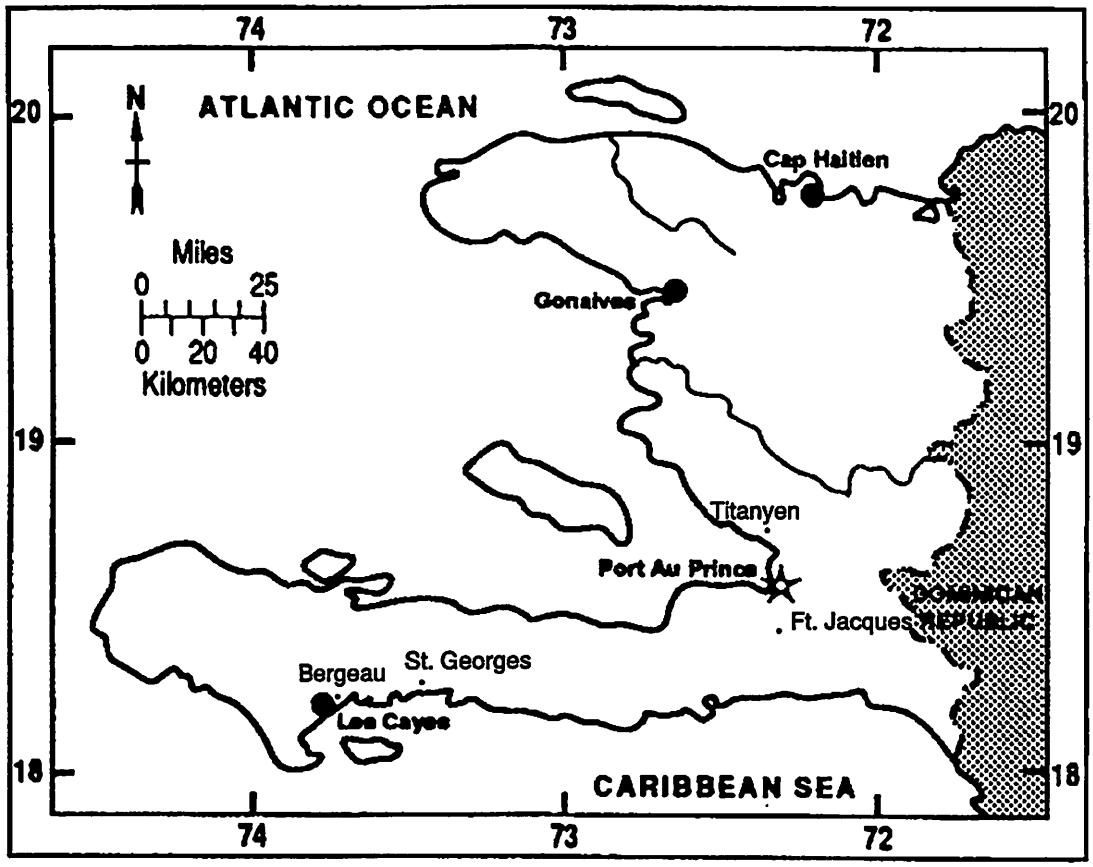

Figure 1. Location of trial sites in Haiti.

The low elevation site on basaltic soil, hereby referred to as the basaltic site, is at St. Georges (18°15′ N latitude) at about 70 m elevation. It is also in the Sub-tropical Humid Forest Zone (Organization of American States, 1972). Annual rainfall, based upon data collected between June 1991 and the first decade of March 1992 and between the third decade of January 1993 and March 1994 was estimated at 1316 mm with a bimodal, but somewhat more erratic pattern (Figure 4). Soils of basalt parent material at other sites were classed as Lithic Ustropepts and Cumulic Haplustolls (Guthrie *et al.*, 1990), with textures of loamy sand and sandy loam,

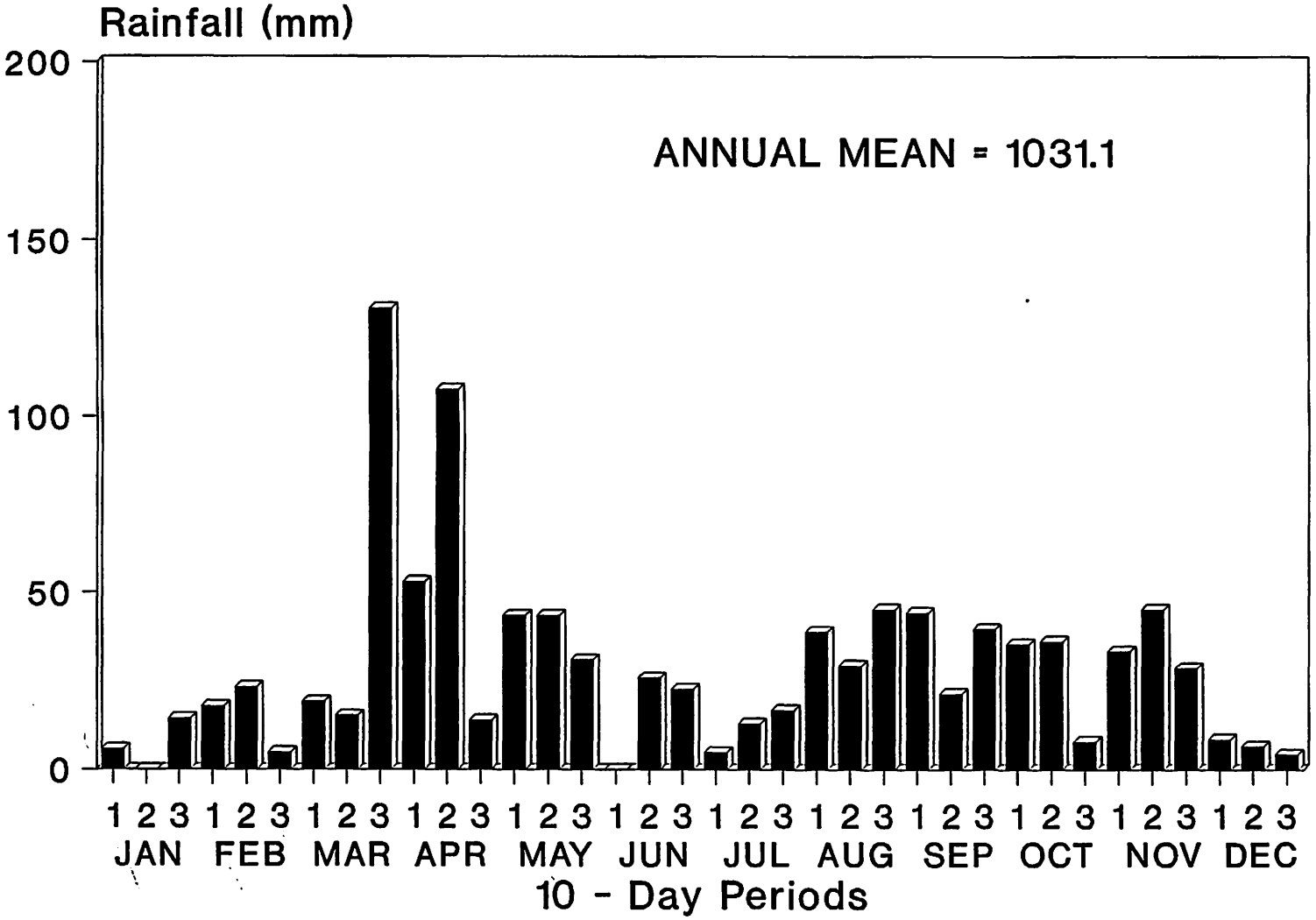

Fig. 2. Rainfall at high elevation site

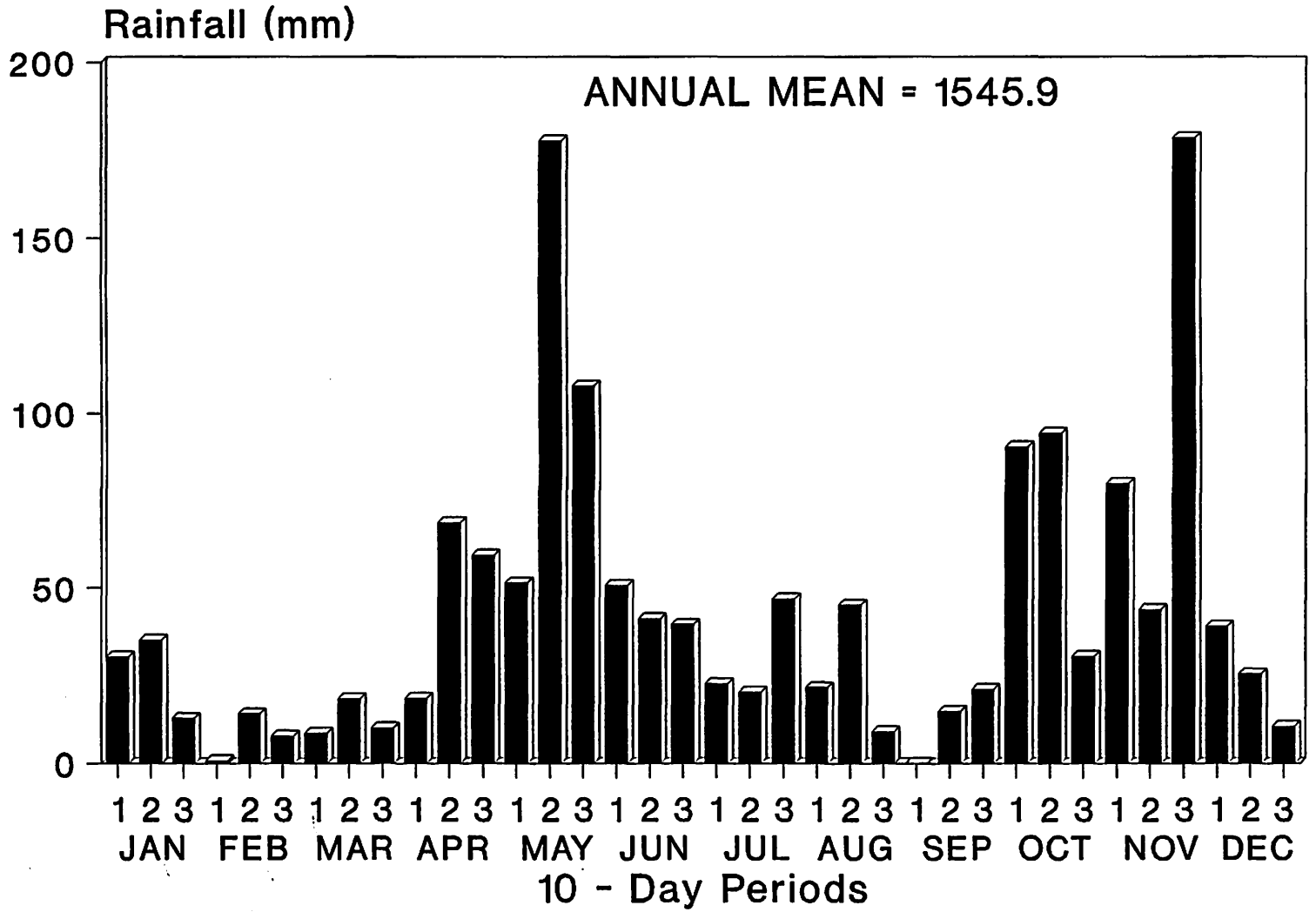

Fig. 3. Rainfall at calcareous site.

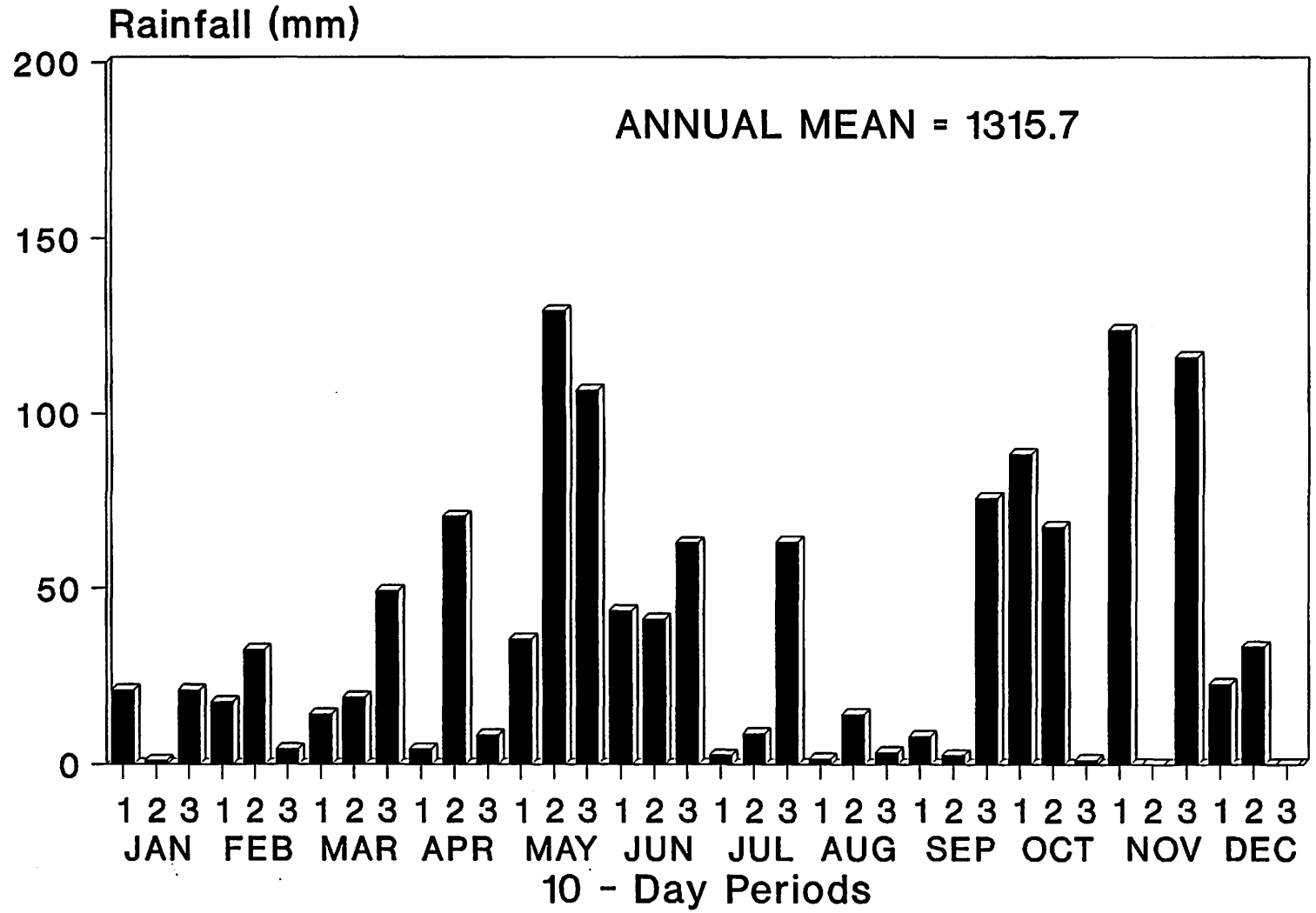

Fig. 4. Rainfall at basaltic site.

respectively. The site had previously been in pasture and had a grass cover into which had been planted hedgerows of *Erythrina indica* and *L. leucocephala* spaced 2.5 - 3.5 m apart.

The semi-arid site was located at Titanyen (18°41' N latitude) in the District of Port-au-Prince, Department de l'Ouest, on colluvium at the foot of a small mountain range. The Holdridge Life Zone is Sub-tropical Dry Forest (Organization of American States, 1972). The elevation was approximately 90 m. However, because only one species was above 50 cm after the first year of establishment, this site was not harvested. For this reason, the semi-arid site is not included in this report.

Data on chemical and physical properties of soils obtained at the four sites were reported in SECID/Auburn PLUS Report No. 6 (Shannon and Isaac, 1993). Field diagrams are also contained in that report for anyone wishing to observe the plots.

SPECIES

A total of 28 species of diverse origins were planted at the three sites. Most were legumes. Selections were based upon previous experience in Haiti, performance in other countries, recommendation of colleagues and a review of literature (Shannon and Isaac, 1993). Environmental adaptation and coppicing ability were the main criteria for inclusion in the trial.

Sixteen species were planted at the high elevation and basaltic sites and 20 at the calcareous site. *Leucaena leucocephala*, variety K636, was selected as the control at each site. Six other species, i.e. *Leucaena* hybrid KX3, *L. diversifolia*, variety K156, *Gliricidia sepium*, variety HYB, *Acacia angustissima*, *Calliandra calothyrsus* and *Casuarina cunninghamiana* were also planted at each site. The other species were distributed based upon expected adaptation and space at the site.

TRIAL DESIGN

Statistical Design

A randomized complete block design with four replications was used at all but the high elevation site. There, variability in soil depth induced by terracing mandated the use of incomplete blocks of four plots each. These were nested within four complete replications. Randomization was based on design SR 40 of Bose *et al.* (1954). Analysis of variance was calculated by the Statistical Analysis System (SAS) and average least significant difference (LSD) values calculated according to Bose *et al.* (1954).

For biomass estimates, not all plots were harvested. At Fort Jacques, this led to a lack of balance in the data because of the incomplete blocks. In this case, species which were not harvested in any of the plots were dropped and the data was analyzed as a randomized complete block design.

At all three sites, the presence of unharvested plots led to non-normal distribution patterns for biomass, thus violating the

assumptions upon which Analysis of Variance is based and resulting in high Coefficients of Variation (CV's). In practical terms, this means that the statistical tests lacked sufficient precision to distinguish differences among all but the best performing species. The data were again analyzed, this time using square root transformations of the data. This transformation resulted in a nearly normal distribution and acceptable levels of precision in most cases.

Field Design

Plots consisted of single rows of hedgerows, 5 m long at the calcareous and basaltic sites and 6 m at the high elevation site. The plots were arranged end to end in rows laid on the contour. The usual spacing between rows was 3 m, but this varied somewhat due to the need to follow the contour, and occasionally because of obstructions. The distance generally did not surpass 3.5 m.

ESTABLISHMENT

The trees were planted on May 8, May 23 and May 22, 1991 at the high elevation, calcareous and basaltic sites, respectively, in hills spaced 10 cm apart. The trees were thinned to one per hill and reseeding and later transplanting was used to obtain uniform stands where seed failed to germinate (Shannon and Isaac, 1993).

SAMPLING METHODS

The first biomass harvests were made at approximately 10, 11

and 17 months after planting, respectively at the calcareous, high elevation and basaltic sites. Two additional cuts were made at the calcareous and the high elevation sites at approximately 7 and 12 months after the first pruning. One additional cut was made at the basaltic site approximately 6 months after the first cut. The high elevation site was harvested on 21-23 April 1992, 23-25 November 1992 and 5-7 May 1993; the calcareous site on 25-28 March 1992, 9-12 November 1992 and 22-26 April 1993; the basaltic site on 6-8 November 1992 and 26-27 April 1993.

At each harvest, hedgerows were pruned to 50 cm height above the ground. The first harvest was made from those plots in which the hedgerows had reached a mean height of more than 75 cm. For those plots in which mean height was less than 75 cm, but more than 50 cm, the hedgerows were pruned if it appeared that the plant form was such that it could tolerate pruning. At subsequent harvests, regrowth was cut back to 50 cm regardless of height. The sample was collected from the central 3 m of plots at the calcareous and basaltic sites and central 4 m at the high elevation site. The trees were pruned with pruning shears and cut one by one to the 50 cm height.

At each cut, the pruning from the sampling areas of the plots were separated into a.) leaves, b.) branches and stems < 1 cm in diameter, c.) branches and stems 1-5 cm in diameter, d.) pods. Fresh weights of each component were determined in the field and subsamples of approximately 200 g taken for dry weight

determination. Stems and branches were sectioned to accelerate the drying. The samples were placed in paper bags, air dried and transported to a drying facility where leaves and stems were dried in an electric oven at 160°F (71.1°C) for 52 and 72 hours, respectively. Due to power outages, drying was not continuous, but consisted of 8-12 hours per day.

RESULTS AND DISCUSSION

BIOMASS PRODUCTION

High Elevation

Highest total, leaf and stem dry weight was produced by *Acacia angustissima* and *Leucaena* hybrid KX3, followed by the remaining species of *Leucaena* (Figure 5 and Table 1[2]). Analysis of transformed data allowed a greater precision in the test (Appendix Table A1). There were no significant differences among the last five species harvested for total, leaf and small stem biomass.

Leaf Biomass

Leaf production is the most important consideration for alley cropping, because the leaves decompose most rapidly and the nutrients they contain are most readily available to the crop. *A. angustissima* produced significantly more leaf biomass than any other species (Table A1). The three leucaena species ranked

[2]Note on Interpreting data: A significant F test indicates that there are differences among species. *** = significant at 0.1 % level of probability (less than 1:1000 chance that there are no differences). $LSD_{0.05}$ = least significant difference at 95 % level of certainty. If two species differ by greater than the $LSD_{0.05}$, it is assumed that the difference between species is not due to chance. SE and CV % are standard error of the mean and coefficient of variation, respectively, statistics useful in evaluating the data set.

ACAN: Acacia angustissima
KX3: Leucaena hybrid
K636: Leucaena leucocephala
K156: Leucaena diversifolia
FLMA: Flemingia macrophylla
CACA: Calliandra calothyrsus
ERPO: Erythrina poeppigiana

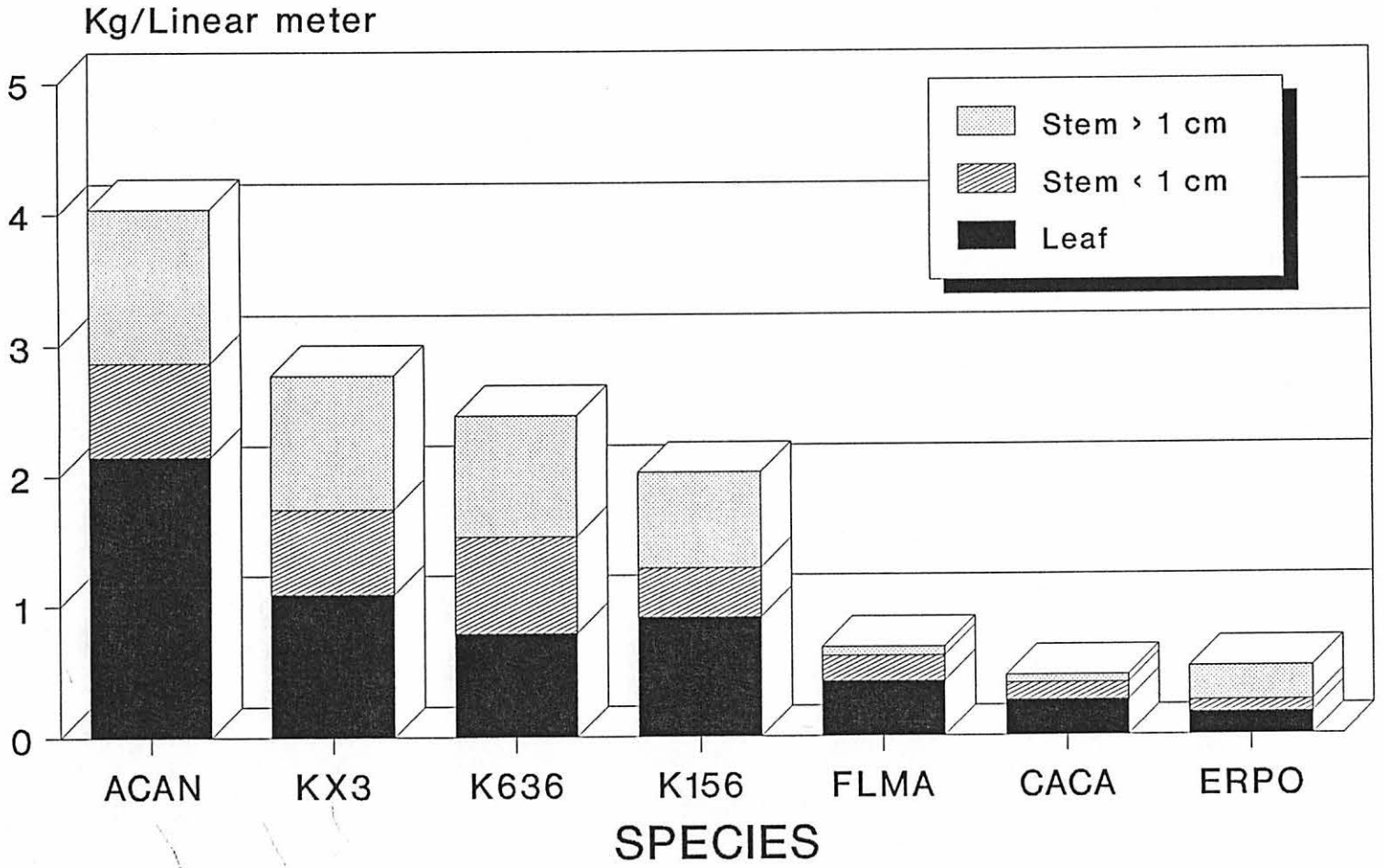

Figure 5. Dry weight biomass totaled over 3 harvests at high elevation site.

Table 1. Tree dry weight production totaled over the first three harvests (at 11, 18 and 24 months after planting) at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods	Leaf/Stem Ratio
		----------Kg / Linear meter---------					
Acacia angustissima		4.04	2.15	0.72	1.17	.	1.31
Leucaena hybrid	KX3	2.95	1.09	0.65	1.03	0.177	0.81
Leucaena leucocephala	K636	2.48	0.79	0.74	0.93	0.032	1.15
Leucaena diversifolia	K156	2.04	0.91	0.38	0.73	0.030	1.09
Flemingia macrophylla‡		0.71	0.42	0.19	0.07	0.032	1.88
Erythrina poeppigiana†		0.47¶	0.17¶	0.09¶	0.26¶	.	1.21
Calliandra calothyrsus‡		0.47	0.27	0.13	0.06	0.010	1.82
Gliricidia sepium	HYB‡	0.09	0.06	0.03	0.003	.	1.57
Casuarina cunninghamiana†		0.07	0.05	0.02	.	.	3.96
Grevillea robusta†		0.01	0.01	0.002	.	.	4.64
Erythrina indica§		0.01	0.002	0.004	0.002	.	0.62
Acacia melanoxylon		.	.	.	.	.	.
Albizia procera		.	.	.	.	.	.
Acacia decurrens		.	.	.	.	.	.
Acacia mearnsii		.	.	.	.	.	.
Mimosa scabrella		.	.	.	.	.	.
Significance (F test)		***	***	***	**	***	**
$LSD_{0.05}$		1.55	0.58	0.30	0.77	0.063	1.22
SE		0.54	0.20	0.10	0.26	0.021	0.41
CV %		89.0	74.6	78.0	115.6	73.4	52.6

, * Significant at 1 % and 0.1 % levels of probability, respectively.
†One cut at 24 months after planting; ‡Sum of two cuts (at 18 and 24 months after planting);
§Sum of two cuts (at 11 and 24 months after planting);
¶Mean adjusted upward because of missing plot in rep 4.

Note: "." means species not harvested. Not included in analysis.

second, with no significant differences among them, although KX3 ranked highest. *Flemingea macrophylla* produced statistically similar amounts of leaf biomass as K 636 and K 156. *Calliandra* produced significantly less leaf biomass than the *Leucaena* spp., but not significantly less than *Flemingia*.

Stems

Small stems or twigs applied to the soil also contribute to the nutritional needs of crops, but decomposition occurs at slower rates. Large stems are less useful in nutrient supply, because they only decompose slowly and because of a high C/N ratio, may even tie up nitrogen which might otherwise be used by the crop. Large stems are useful as fuel or stakes. With respect to stem biomass, the top four species and the remaining species formed two distinct groups (Tables 1 and A1), with no differences among them. KX3 produced more pods than the remaining four species.

Leaf/Stem Ratio

Leaf/stem ratio varied greatly, from 0.6 for *E. indica*, which has a fleshy stem to 4.6 for *Grevillea*, which was harvested only once. Most of the stem of this species and *Casuarina* was located below the 50 cm pruning height due to the slow development of these species.

Dry Matter Content

The dry matter content varied greatly among species and also varied among plant parts. These are presented in Appendix Table A2 for future reference. Fresh weights are presented in Table A3.

Time Trends

While biomass totaled over the three harvests provides a useful overview of species productivity, an examination of the trend over time is necessary to assess the long-term utility of the various species. A species which yields a great deal of biomass in the first year, but is not productive in later harvests would not be acceptable in an alley cropping system.

Figure 6 shows biomass production over time for the most productive hedgerow species at Fort Jacques. At the first harvest, greatest total and leaf biomass were produced by K 636, followed by KX3. At the second harvest, K 636 was surpassed in biomass yield by *A. angustissima* and KX3. This trend continued into the third harvest. The decline in biomass yield in the third harvest is of little consequence, since the second harvest took place in second season, whereas the first and third harvests took place in the first rainy season following the cool winter dry season. The important trend is upward, since the third harvest was greater than the first.

Another trend, not apparent in the biomass totals is the increasing productivity of *Flemingia macrophylla*, which was not harvested at 11 months and ranked sixth out of seven species harvested at the second harvest at 18 months. While the other species yielded less at the third harvest than at the second, *Flemingia* yielded more (Figure 6). At 24 months after planting *Flemingia* ranked third in biomass production and did not differ significantly from KX3.

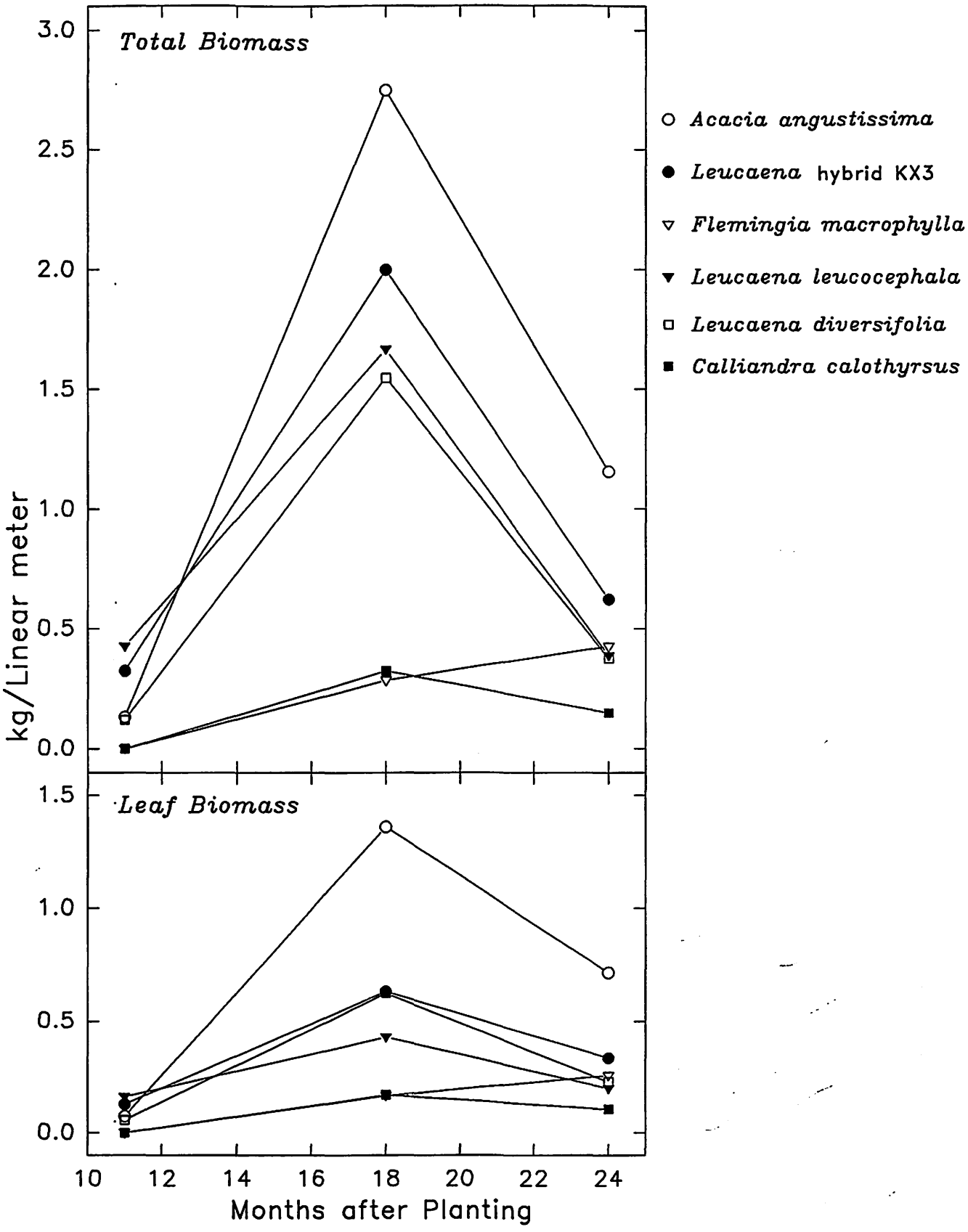

Figure 6. Total and leaf dry matter production of selected hedgerow species by harvest at the high elevation site at Fort Jacques.

Calcareous Site

Highest total, leaf, and stem biomass were produced by K 636 and KX3 (Figure 7 and Table 2). These two species produced significantly more biomass than the remaining species (Appendix Table A4). *L. shannonii, L. diversifolia* and *Cassia siamea* followed with no significant differences in leaf production among them, although *Cassia* produced significantly less large stem and total biomass than did the other two. *Gliricidia* produced similar leaf biomass as did *L. shannonii* and *L. diversifolia,* but did not produce significantly more than did *Calliandra* and *Delonix*.

Leaf:stem ratio varied from a low of 0.46 for *L. shannonii* and a high of 3.5 for *Cassia*. This parameter does not seem to be useful at this time due to the varied plant canopy forms and the method of harvest.

Dry matter content and fresh weight biomass production are presented in Appendix Tables A.5. and A.6. for future reference. Significant differences were observed among species. Differences among plant parts are also evident.

Time Trends

Some interesting trends in biomass production are evident at the calcareous site (Figure 8). The *Leucaena* species K 636 and KX3 were consistently superior to other species in total and leaf biomass production at each harvest and *L. shannonii* and *L. diversifolia* ranked third and fourth, respectively, for total biomass production at each harvest. However, *Gliricidia* ranked

K636: L. leucocephala, var K636
KX3: Leucaena hybrid
LESH: L. shannonii
K156: L. diversifolia
CASI: Cassia siamea
GLSE: G. sepium, var HYB
CACA: Calliandra calothyrsus
DERE: Delonix regia
ALLE: Albizia lebbeck

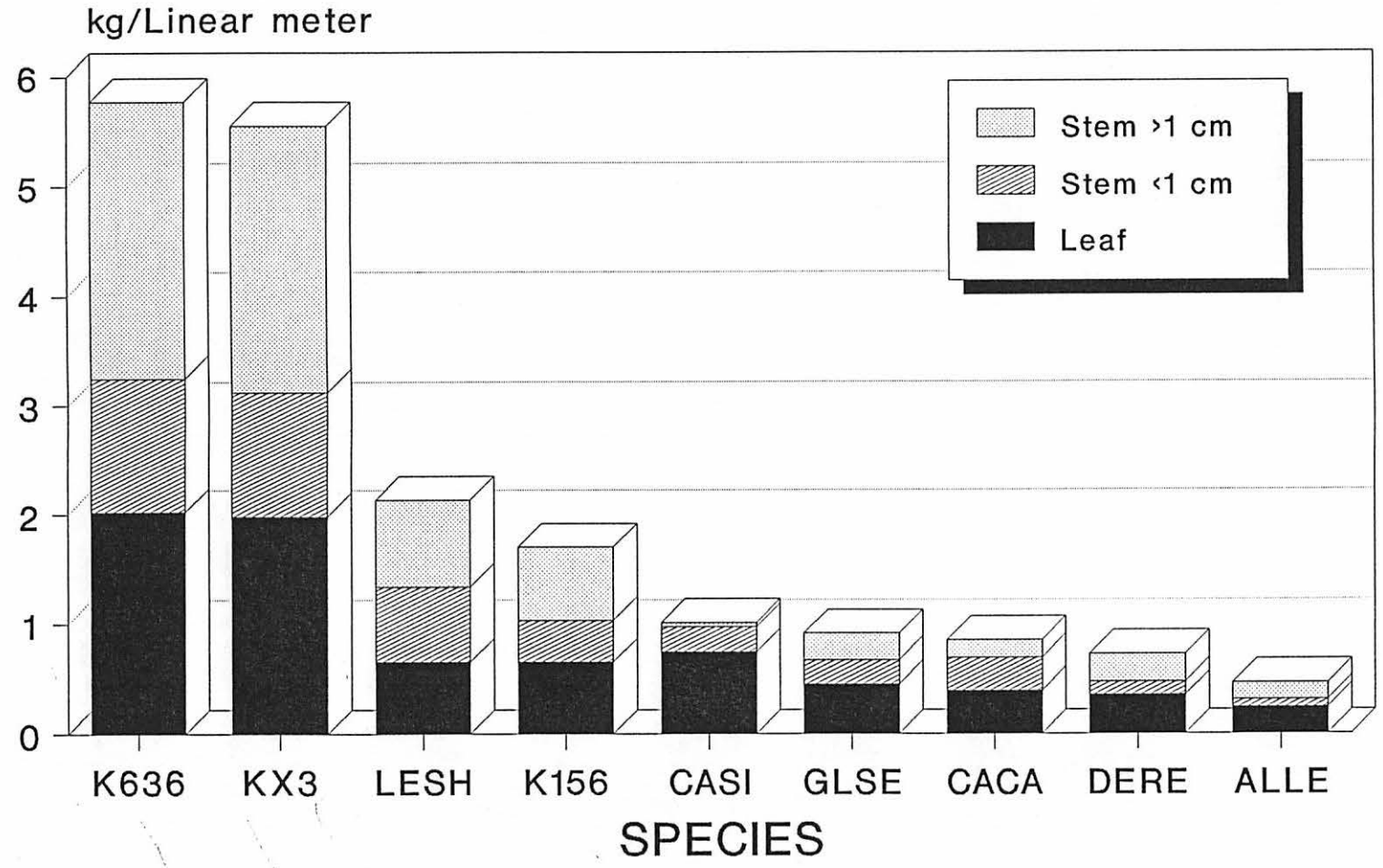

Figure 7. Dry weight biomass totaled over 3 harvests at the calcareous site.

Table 2. Tree dry weight production totaled over the first three harvests (at 10, 17 and 23 months after planting) at the calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods	Leaf/Stem Ratio
		---------- Kg / Linear m ----------					
Leucaena leucocephala	K636	5.85	2.02	1.23	2.54	0.058	0.54
Leucaena hybrid	KX3	5.60	1.98	1.14	2.43	0.045	0.56
Leucaena shannonii		2.13	0.65	0.69	0.79	0.002	0.46
Leucaena diversifolia	K156	1.79	0.65	0.38	0.67	0.087	0.62
Cassia siamea		1.02	0.74	0.23	0.04	.	3.48
Gliricidia sepium	HYB†	0.91	0.45	0.22	0.24	.	1.17
Calliandra calothyrsus		0.85	0.39	0.30	0.16	0.001	0.94
Delonix regia		0.72	0.35	0.12	0.25	.	1.02
Albizia lebbeck†		0.46	0.24	0.07	0.15	.	1.99
Leucaena salvadorensis		0.25	0.09	0.10	0.06	.	0.56
Acacia angustissima‡		0.22	0.12	0.10	0.01	0.002	1.19
Erythrina indica		0.19	0.09	0.05	0.05	.	0.81
Albizia guachapele		0.17	0.11	0.05	0.01	.	2.22
Enterolobium cyclocarpum		0.09	0.05	0.04	.	.	1.25
Tephrosia candida‡		0.05	0.01	0.02	.	0.011	0.75
Paraserianthes falcataria§		0.02	0.01	0.004	0.004	.	1.59
Inga vera		.	.	.	.	.	.
Casuarina cunninghamiana		.	.	.	.	.	.
Erythrina poeppigiana		A	A	A	A	A	A
Desmodium gyroides		A	A	A	A	A	A
Significance (F test)		***	***	***	***	*	***
$LSD_{0.05}$		0.75	0.26	0.17	0.38	0.055	0.91
SE		0.28	0.09	0.06	0.14	0.019	0.32
CV %		41.5	36.9	40.8	51.5	125.8	53.8

*, *** = significant at 5 % and 0.1 % levels of probability, respectively.

†Sum of two cuts (at 17 and 23 months after planting); ‡Sum of two cuts (at 10 and 17 months after planting); §One cut at 17 months after planting.

Note: "." indicates not harvested. Not included in analysis. "A" indicates species did not emerge or died.

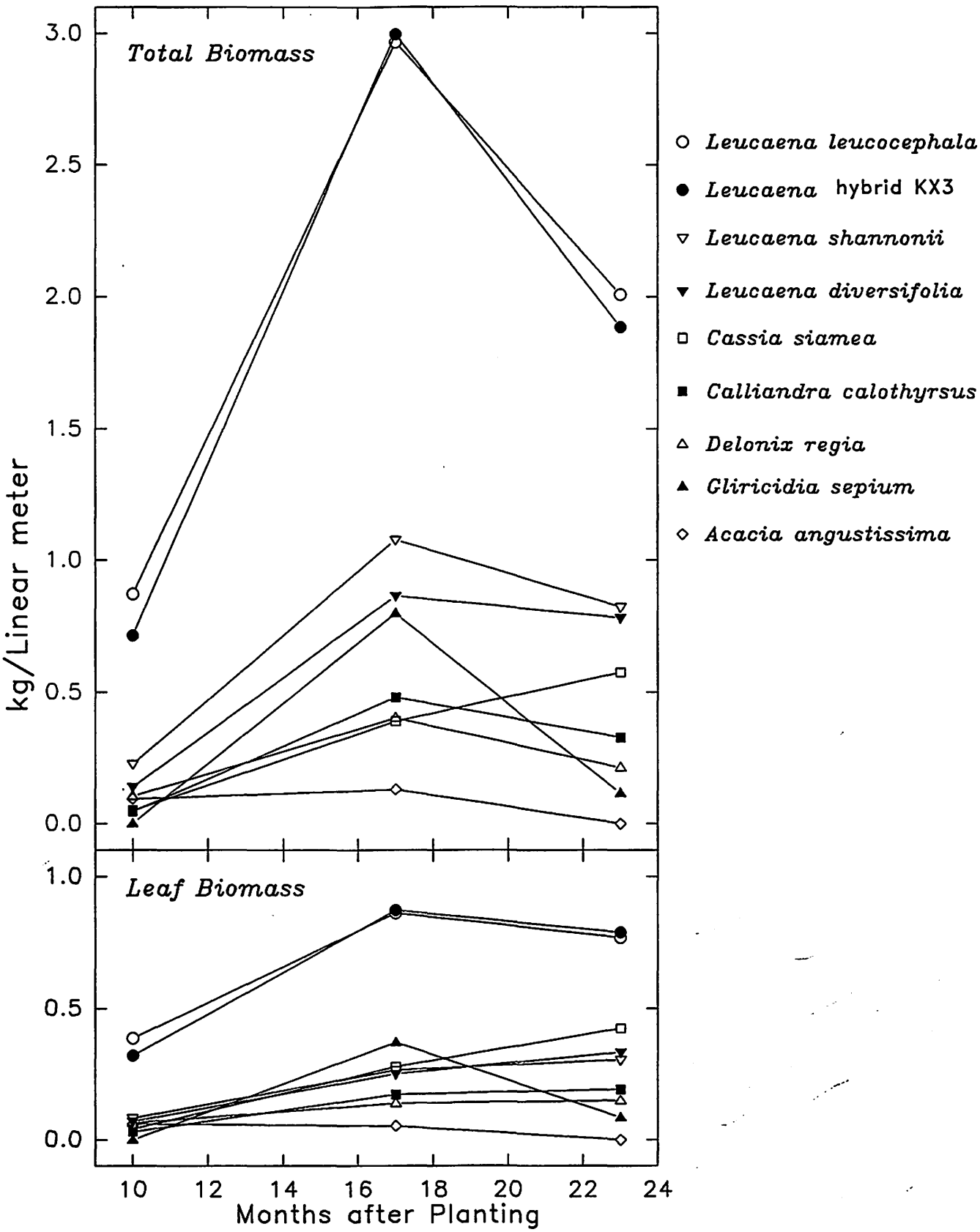

Figure 8. Total and leaf dry matter production of selected hedgerow species by harvest at the calcareous site at Bergeau.

third in leaf biomass at the second harvest and fifth in total biomass. This species was not harvested at the first harvest and yielded only one seventeenth of the highest yielding species at the third harvest. It is unclear at this point whether the apparently erratic performance of *Gliricidia* at this site is primarily related to insect damage observed during the winter dry season or if it also represents some physiological response to the seasons.

Another species of interest is *Acacia angustissima*, which ranked fifth in total biomass and sixth in leaf biomass at the first harvest, ranked tenth at the second harvest and was not harvested at the third harvest (Figure 8). The decline in production was contrary to that of the more productive species and suggests that *Acacia angustissima* was not adapted to this site.

While the total biomass production declined between the second and third harvests for many of the species, in most cases, leaf biomass remained the same or increased slightly (Figure 8). This is encouraging, because it suggests that biomass will be plentiful for soil application in both seasons of the year.

Basaltic Site

As at the Calcareous site, K 636 and KX3 gave highest yields of total, leaf, and stem biomass (Figure 9 and Table 3). There was no significant difference between these two species, but K 636 produced significantly more total and leaf biomass than any of the remaining species (Appendix Table A7). There were no significant differences in leaf biomass for KX3, *L. salvadorensis* and

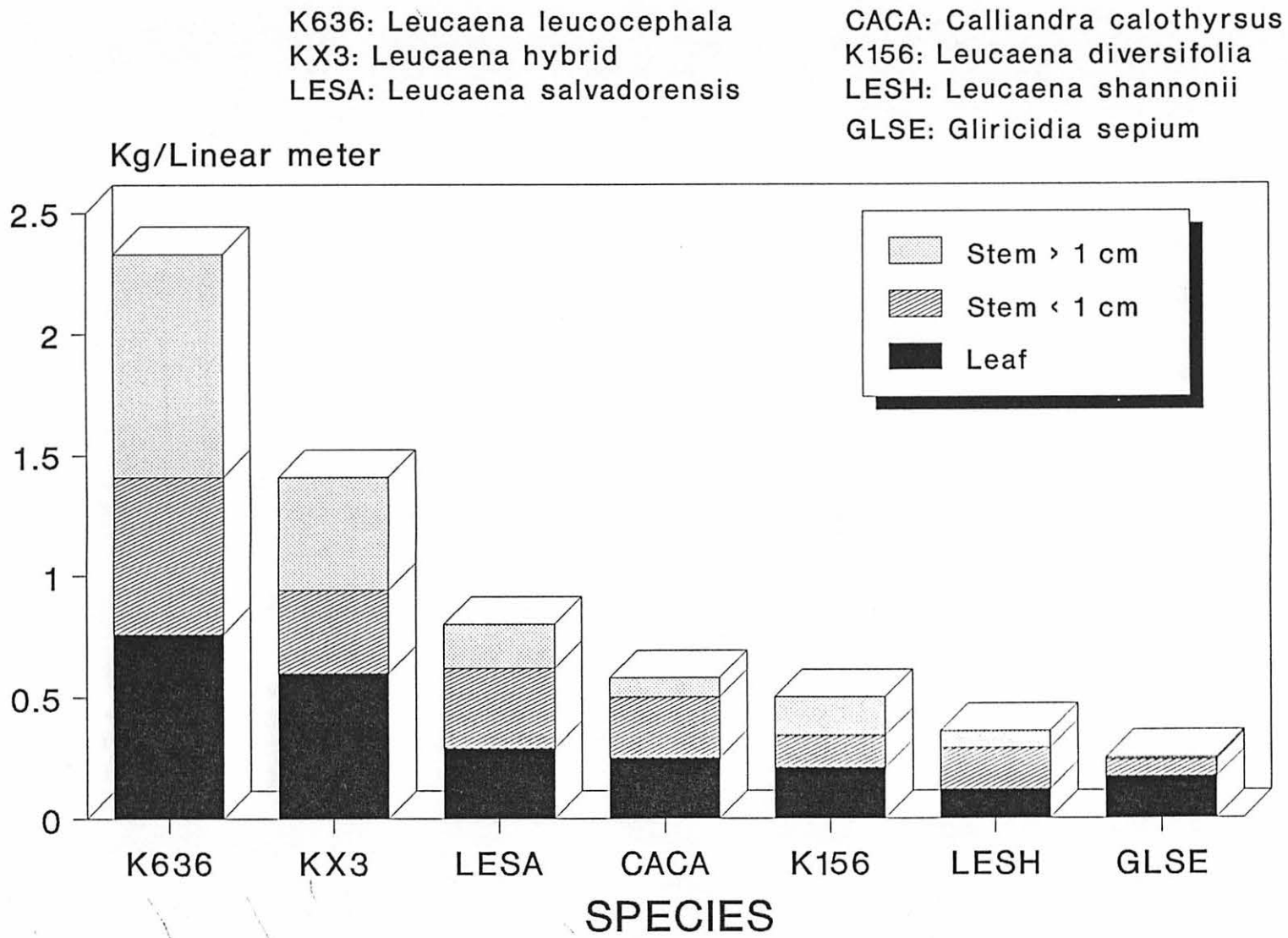

Figure 9. Dry weight biomass totaled over two harvests at the basaltic site.

Table 3. Tree dry weight production totaled over the first two harvests (at 17 and 23 months after planting) at the basaltic site at St. Georges. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1	Stem >1	Pods	Leaf/Stem Ratio
		---------- Kg / Linear m ----------					
Leucaena leucocephala	K636	2.33	0.76	0.65	0.92	0.005	0.68
Leucaena hybrid	KX3	1.42	0.60	0.34	0.47	0.013	0.83
Leucaena salvadorensis		0.81	0.29	0.33	0.18	.	0.61
Calliandra calothyrsus		0.58	0.25	0.25	0.08	.	0.82
Leucaena diversifolia	K156	0.50	0.21	0.13	0.16	0.003	0.94
Leucaena shannonii		0.35	0.12	0.17	0.07	.	0.49
Gliricidia sepium	HYB	0.26	0.17	0.07	0.01	.	2.06
Enterolobium cyclocarpum†		0.01	0.01	0.003	.	.	1.79
Acacia angustissima		.	.	.	.	.	.
Cassia emarginata		.	.	.	.	.	.
Cassia siamea		.	.	.	.	.	.
Flemingia macrophylla		.	.	.	.	.	.
Delonix regia		.	.	.	.	.	.
Casuarina cunninghamiana		A	A	A	A	A	A
Desmodium gyroides		A	A	A	A	A	A
Grevillea robusta		A	A	A	A	A	A
Significance (F test)		**	**	**	*	ns	***
$LSD_{0.05}$		1.17	0.38	0.31	0.54	0.03	0.45
SE		0.40	0.13	0.10	0.18	0.009	0.15
CV %		101.7	85.6	86.0	134.9	257.5	30.7

ns, *, **, *** = not significant, significant at the 5 %, 1 % and 0.1 % levels of probability, respectively.

† One cut at 23 months after planting.

Note: "." indicates no plots harvested. Not included in analysis. "A" indicates species failed to emerge or died off.

Calliandra, or between these three and K 156 and *L shannonii* for stems greater than 1 cm diameter.

Dry matter content varied by plant part and by species (Table A8). Fresh weight production is given in Table A9 for reference.

Time Trends

Only two harvests were made during the period covered by this report, so it is difficult to establish trends. It must be noted that the two harvests occurred in different times of the year. The first harvest at this site took place during the second rainy season following a year and a half of growth. The second harvest took place during the first rainy season of the following year, after the winter dry season, when temperatures were cool. Total biomass production declined for *Leucaena leucocephala* (Figure 10). The decline in total biomass may be explained by the lack of sufficient time to replace the wood harvested at the first pruning. The decreased total biomass is of little consequence for alley cropping since leaf biomass appeared to increase slightly. A similar trend is also evident with *Calliandra*. Total biomass production appeared to increase in *Leucaena diversifolia*.

As at the calcareous site, leaf biomass was consistent or increased slightly between the two harvests.

TREE HEIGHT

High Elevation

Prior to the first pruning, the tallest plants at the high

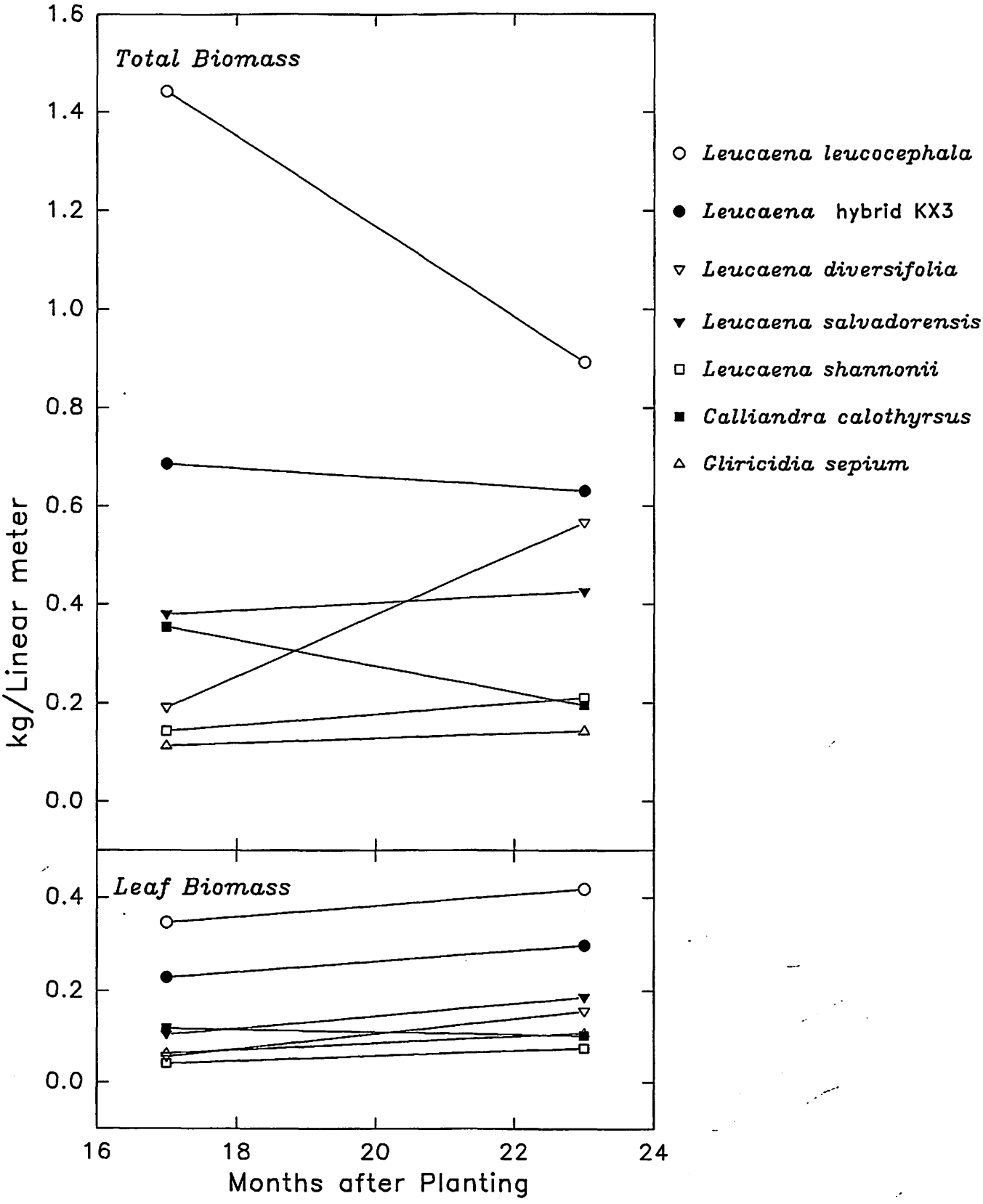

Figure 10. Total and leaf dry matter production of selected hedgerow species by harvest at the basaltic site at Saint Georges.

elevation site were the leucaena species, with *L. leucocephala* being significantly taller than the remaining species (Table 4). Following pruning, tallest regrowth was observed in *Acacia angustissima*. Significant regrowth was also observed with the *Leucaena* species, flemingia and calliandra. Several species failed to attain pruning height after nearly two years growth.

Calcareous Site

Prior to pruning, the tallest species at the calcareous site were *L. leucocephala* and KX3, followed by *L. shannonii* (Table 5). With regrowth following pruning, the same species were again tallest. Several species failed to attain pruning height after nearly two years' growth.

Basaltic Site

At the basaltic site, the tallest species prior to pruning were *L. leucocephala*, KX3, *L. salvadorensis* and *L. shannonii* (Table 6). The same species were again tallest following regrowth after the first cut.

SURVIVAL

Plant survival during the pruning period is associated with tolerance to pruning and adaptation to the environmental conditions. Plant counts conducted prior to each pruning, expressed as percent of hills planted, are presented in Tables 7-9. Plant counts following emergence and following transplanting are

Table 4. Tree height (adjusted)[1] prior to pruning and plots harvested at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	1'st cut (348 DAP†) Height	1'st cut (348 DAP†) Harvested Plots‡	2'nd Cut (564 DAP) Height	2'nd Cut (564 DAP) Harvested Plots‡	3'rd Cut (727 DAP) Height
		cm		cm		cm
Acacia angustissima		127.1	4/4	252.3	4/4	173.7
Flemingia macrophylla		29.2	0/4	110.3	4/4	132.4
Leucaena hybrid	KX3	125.2	4/4	196.8	4/4	118.5
Leucaena leucocephala	K636	148.2	4/4	208.2	4/4	114.0
Leucaena diversifolia	K156	82.4	3/4	224.7	4/4	108.8
Calliandra calothyrsus		34.4	0/4	105.6	4/4	74.5
Casuarina cunninghamiana		34.3	0/4	69.7	0/4	68.5
Erythrina indica		55.0	2/4	41.2	0/4	52.3
Gliricidia sepium	HYB	28.7	0/4	54.7	1/4	51.3
Erythrina poeppigiana		19.1	0/3	39.0	0/3	48.4
Grevillea robusta		31.3	0/4	51.7	0/4	45.9
Acacia melanoxylon		7.6	0/2	21.3	0/2	29.6
Albizia procera		28.9	0/4	36.2	0/4	25.0
Mimosa scabrella		-17.0	0/4	-11.1	0/4	17.2
Acacia decurrens		30.9	0/2	26.2	0/2	2.8
Acacia mearnsii		-1.5	0/3	-8.6	0/3	-2.0
Significance (F test)		***		***		***
$LSD_{0.05}$		43.7		61.9		40.5
SE		10.6		15.1		9.9
CV %		50.6		38.4		33.7

*** significant at the 0.1 % level of probability.
[1] Means adjusted for differences between blocks.
† Days after planting.
‡ Denominator indicates number of plots having plants.

Table 5. Tree height prior to pruning and plots harvested at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	1'st cut (308 DAP)† Height	1'st cut (308 DAP)† Harvested Plots‡	2'nd Cut (573 DAP) Height	2'nd Cut (573 DAP) Harvested Plots‡	3'rd Cut (705 DAP) Height
		cm		cm		cm
Leucaena leucocephala	K636	174.1	4/4	281.6	4/4	245.5
Leucaena hybrid	KX3	161.5	4/4	294.2	4/4	239.7
Leucaena shannonii		118.6	4/4	241.4	4/4	209.0
Leucaena diversifolia	K156	87.6	3/4	179.5	4/4	185.6
Cassia siamea		51.6	2/4	103.5	4/4	125.9
Calliandra calothyrsus		58.1	3/4	159.3	4/4	107.9
Leucaena salvadorensis		60.2	3/4	137.9	3/4	95.0
Delonix regia		55.9	2/4	98.9	4/4	84.1
Albizia lebbeck		30.4	0/4	91.9	4/4	80.3
Albizia guachapele		52.4	1/4	74.0	4/4	67.9
Gliricidia sepium	HYB	37.1	0/4	151.1	4/4	65.6
Erythrina indica		60.9	3/4	77.0	3/4	63.1
Enterolobium cyclocarpum		51.5	2/4	76.8	2/4	55.5
Paraserianthes falcataria		25.8	0/4	65.4	1/4	51.6
Casuarina cunninghamiana		33.5	0/4	50.5	0/4	47.5
Tephrosia candida		41.2	1/4	75.9	2/4	45.1
Acacia angustissima		77.5	3/4	93.3	4/4	43.1
Inga vera		24.2	0/4	44.2	0/4	42.7
Erythrina poeppigiana		A	0/0	A	0/0	A
Desmodium gyroides		14.4	0/4	A	0/0	A
Significance (F test)		***		***		***
LSD $_{0.05}$		27.5		35.8		28.3
SE		9.7		12.6		10.0
CV %		30.0		19.8		19.3

*** significant at the 0.1 % level of probability.
† Days after planting. ‡ Denominator indicates number of plots having plants.
Note: "A" indicates no plants. Not included in analysis.

Table 6. Tree height prior to pruning and plots harvested at basaltic site at St. Georges. Agroforestry Trial 1.

SPECIES	Variety	1'st cut (533 DAP†) Height	1'st cut (533 DAP†) Harvested Plots‡	2'nd Cut (707 DAP) Height
		cm		cm
Leucaena hybrid	KX3	153.3	3/4	205.8
Leucaena leucocephala	K636	184.7	3/4	202.5
Leucaena salvadorensis		162.0	3/4	192.2
Leucaena shannonii		144.4	3/4	171.4
Leucaena diversifolia	K156	108.2	2/4	152.5
Acacia angustissima		104.1	0/3	138.6
Calliandra calothyrsus		138.6	3/4	119.6
Gliricidia sepium	HYB	87.9	3/4	98.4
Flemingia macrophylla		49.2	0/3	90.3
Enterolobium cyclocarpum		52.9	0/4	54.2
Cassia siamea		39.8	0/3	45.8
Cassia emarginata		26.5	0/2	23.6
Delonix regia		17.6	0/4	17.0
Casuarina cunninghamiana		A	0/0	A
Desmodium gyroides		A	0/0	A
Grevillea robusta		A	0/0	A
Significance (F test)		***		***
LSD $_{0.05}$		61.4		48.7
SE		21.2		16.9
CV %		41.3		27.7

*** Significant at the 0.1 % level of probability.

† Days after planting.

‡ Denominator indicates number of plots having plants.

Note: "A" indicates species did not germinate or died out.

also presented for comparison purposes. Survival during a pruning cycle may be calculated based upon the plant count prior to pruning and the plant count prior to a subsequent pruning.

High Elevation Site

Survival during the period of pruning was good for most species (Table 7). It should be noted that stands of some species were already low prior to pruning because of poor emergence or poor survival during the first year of growth. There was a 70 % loss of existing plants for *Erythrina indica*, 61 % for *Acacia melanoxylon*, 57 % for *Mimosa scabrella*, 31 % for *A. mearnsii* and 25 % for *E. poeppigiana*. Of these, only the *Erythrina* spp. had been harvested, so that plant mortality was associated with other factors. Disease was probably a factor with the *Erythrina* spp. Among the highest yielding species, there was little loss in stands.

Calcareous Site

Plant loss following pruning at the calcareous site was 100 % for *Desmodium gyroides*, 80% for *Acacia angustissima*, 55 % for *Tephrosia candida*, 38 % for *Parserianthes*, 22 % for *Casuarina cunninghamiana*, 18 % for *Inga vera*, 9 % for *Leucaena salvadorensis*, 8 % for *Enterolobium cyclocarpum* (Table 8). *Desmodium*, *Casuarina* and *Inga* were not harvested. Plant loss following pruning was low for the remaining species.

Table 7. Plant number (adjusted)[1] as percentage of hills planted for hedgerow species at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	After Thinning 35 DAP[†]	After Transplant 229 DAP	Before 1'st Cut 348 DAP	Before 2'nd Cut 564 DAP	Before 3'rd Cut 727 DAP
		%	%	%	%	%
Leucaena leucocephala	K636	91.5	97.3	96.6	97.3	96.6
Calliandra calothyrsus		94.7	100.5	94.2	91.1	91.3
Leucaena diversifolia	K156	56.1	87.3	90.1	86.1	88.6
Leucaena hybrid	KX3	94.3	89.9	90.8	90.2	88.4
Flemingia macrophylla		41.3	82.6	84.7	85.0	85.9
Acacia angustissima		79.7	85.7	84.7	85.8	83.6
Gliricidia sepium	HYB	86.8	85.1	92.7	85.3	81.6
Casuarina cunninghamiana		3.0	91.2	84.8	80.0	77.2
Grevillea robusta		8.8	65.1	51.9	47.0	47.4
Albizia procera		41.5	42.8	43.8	45.7	40.5
Erythrina poeppigiana		28.1	27.9	25.2	20.1	18.8
Erythrina indica		66.4	74.7	52.4	24.5	15.7
Acacia decurrens		23.0	26.3	15.3	16.3	15.1
Acacia melanoxylon		10.4	40.8	36.6	19.9	14.3
Acacia mearnsii		59.5	23.9	16.8	13.5	11.6
Mimosa scabrella		31.1	26.7	16.4	4.7	7.1
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		17.5	23.6	24.2	24.1	20.8
SE		4.3	5.8	6.0	5.9	5.1
CV %		21.2	22.3	24.5	26.8	23.9

*** = significant at 0.1 % level of probability.

[1] Means adjusted for differences between blocks.

[†] Days after planting.

Table 8. Plant number as percentage of hills planted for hedgerow species at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	After Thinning 40 DAP†	After Transplant 183 DAP	Before 1'st Cut 293 DAP	Before 2'nd Cut 537 DAP	Before 3'rd Cut 705 DAP
Gliricidia sepium	HYB	96.9	97.0	98.0	96.5	96.5
Albizia lebbeck		71.9	95.0	96.4	94.0	93.0
Leucaena leucocephala	K636	94.9	93.5	95.4	93.0	93.0
Albizia guachapele		97.4	93.0	94.9	93.0	93.0
Enterolobium cyclocarpum		98.5	97.0	99.0	97.5	91.5
Leucaena shannonii		93.9	89.0	90.8	88.5	88.5
Cassia siamea		84.7	88.5	90.3	88.5	87.5
Erythrina indica		77.5	93.5	95.4	90.0	86.0
Leucaena hybrid	KX3	89.3	86.0	87.7	84.5	84.5
Delonix regia		78.6	86.0	87.7	83.0	82.5
Inga vera		96.4	91.5	93.4	80.5	76.5
Leucaena diversifolia	K156	79.1	68.0	69.4	68.5	68.0
Casuarina cunninghamiana		0.0	78.5	80.1	64.0	62.5
Calliandra calothyrsus		94.9	67.0	68.4	58.5	53.0
Leucaena salvadorensis		95.4	56.5	57.6	53.0	52.5
Paraserianthes falcataria		61.2	84.5	86.2	56.5	50.0
Tephrosia candida		53.1	54.5	55.6	33.0	25.0
Acacia angustissima		52.6	87.0	88.8	48.0	18.0
Desmodium gyroides		0.0	55.0	51.0	0.0	0.0
Erythrina poeppigiana		25.5	0.0	0.0	0.0	0.0
Significance (F test)		***	***	***	***	***
LSD $_{0.05}$		9.6	11.2	12.3	14.4	14.4
SE		3.4	4.0	4.3	5.1	5.1
CV %		9.4	10.1	10.9	14.8	15.6

*** = significant at 0.1 % level of probability.

† Days after planting.

Basaltic Site

At the basaltic site, some plant loss was recorded for all species following the first cut (Table 9). Most notable losses were 71 % for *Cassia emarginata*, 64 % for *Acacia angustissima*, 38 % for *Delonix regia* and *Flemingia macrophylla*, 31 % for *Cassia siamea*, 18 % for *Enterolobium*, 17 % for *Leucaena diversifolia*, 15 % for calliandra, 10 % for KX3 and 9 % for *L. shannonii*. Of these, the first five species mentioned were not harvested.

Diseased trees were found on this field prior to planting (Shannon and Isaac, 1993). It is likely that disease may have been a factor in the mortality of trees at this site. Poor vigor, associated with the low fertility of the soil at this site would increase susceptibility to disease.

COMPARISON WITH BIOMASS PRODUCTION IN THE LITERATURE

Because of small variations in spacing between the hedgerows to accommodate changes in slope, the biomass yields have been presented in terms of kg m^{-1}. At their center, hedgerows were generally spaced 3 m apart, but these often widened to about 3.25 or 3.5 m at the ends of rows. By using an average distance of about 3.25 m, it is possible to estimate hedgerow production in kg ha^{-1}. *A. angustissima* yielded approximately 12.4 metric tons total dry matter ha^{-1} (Table 1) or 35 tons fresh weight at the high elevation site (Table A3), K 636 yielded 18 tons dry matter (Table 2) and 46 tons fresh weight (Table A6) at the calcareous site and 7.2 tons dry weight (Table 3) and 17.5 tons fresh weight (Table A9)

Table 9. Plant number as a percentage of hills planted for hedgerow species at the basaltic site at Saint Georges. Agroforestry Trial 1.

SPECIES	Variety	After Thinning 41 DAP†	At 295 DAP	Before 1'st Cut 533 DAP	Before 2'nd Cut 707 DAP
		%	%	%	%
Leucaena leucocephala	K636	91.8	91.8	86.5	86.0
Gliricidia sepium	HYB	88.8	86.7	84.5	83.5
Enterolobium cyclocarpum		90.3	85.7	76.5	70.0
Leucaena salvadorensis		87.8	72.4	69.0	67.0
Leucaena hybrid	KX3	89.8	74.0	68.5	66.5
Leucaena shannonii		76.5	61.2	57.0	55.5
Calliandra calothyrsus		72.9	63.3	54.5	53.5
Leucaena diversifolia	K156	49.5	47.4	40.0	39.5
Delonix regia		48.5	56.1	45.0	35.0
Cassia siamea		59.7	42.3	31.0	29.0
Flemingia macrophylla		27.0	16.8	12.0	10.5
Cassia emarginata		26.0	15.3	6.0	4.5
Acacia angustissima		7.1	9.7	5.0	3.5
Casuarina cunninghamiana		0.0	0.0	0.0	0.0
Desmodium gyroides		0.0	0.0	0.0	0.0
Grevillea robusta		0.0	0.0	0.0	0.0
Significance (F test)		***	***	***	***
$LSD_{0.05}$		20.0	16.4	18.4	18.8
SE		7.0	5.8	6.5	6.6
CV %		27.6	25.5	32.6	34.9

*** = significant at 0.1 % level of probability.

†Days after planting.

at the basaltic site. This amounts to 6.2 t $ha^{-1}y^{-1}$ dry and 18 t $ha^{-1}y^{-1}$ fresh weight for *A. angustissima* at high elevation and 9 t $ha^{-1}y^{-1}$ dry weight and 23 t $ha^{-1}y^{-1}$ fresh for K 636 at the calcareous site.

These results are comparable with those found in the literature. Duguma *et al.* (1988) reported leaf and twig biomass of around 12 t ha^{-1} for prunings at 50 cm height at 6-month intervals, but only 2 t ha^{-1} when pruned at monthly intervals. This compares to about 5 t ha^{-1} leaves and twigs for the highest yielding treatment in our trial, K 636 at the calcareous site. However, the higher biomass yields reported by Duguma can be in part explained by the fact that Duguma spaced his hedgerows at 2 m apart. Kang *et al.* (1984) reported a 67 % increase in maize yields through application of 10 t ha^{-1} of leucaena biomass. Shannon *et al.* (1990) reported fresh biomass yields of 11 t ha^{-1} in the first year of pruning and increasing to 25 t fresh weight ha^{-1} in the third year of pruning. Application of the leaf and small stem component of this biomass resulted in significant increases in maize yield, with a doubling of maize yields over a 4 year period.

The superior performance of *Leucaena leucocephala* is also consistent with the results reported by Cunard (1991) at the high rainfall site of Camp Perrin in Haiti (200 m elevation, 2390 mm rainfall). The intermediate performance of gliricidia and mediocre performance of *Albizia lebbeck* is also consistent with the present trials. The poor performance of *Moringa oleifera* is consistent with observations in farmers fields. However, at Camp Perrin, the

yield of *Calliandra calothyrsus* did not differ statistically from leucaena and was superior to that of other species in the trial. This is not consistent with our own observations and is probably attributable to the higher rainfall regime at Camp Perrin relative to the sites in the present trial.

CONCLUSIONS

This research has reached a crucial first stage, where it is possible to classify tree species as to biomass production. Based upon these initial results, with primary emphasis on leaf biomass, it is possible to class the species as indicated in Table 10. These classifications may be altered somewhat based upon future results. However they provide a much more clear indication of what species should be promoted for alley cropping in Haiti than was previously available.

Of major importance is the identification of *Acacia angustissima* as the most promising alley cropping species for high elevation in Haiti. To our knowledge, this species has not been previously tested in Haiti as a hedgerow and its superior performance at Fort Jacques provides a greater potential for alley cropping at high elevation sites, where leucaena is less satisfactory.

The data presented here also confirm our conclusions that leucaena is suitable for hedgerows on basaltic soils and that the two *Erythrina* species tested are not acceptable substitutes for leucaena, at least in the environments in which they were tested.

Table 10. Preliminary assessment of tree species suitability for alley cropping based on initial biomass production, survival and regrowth at three sites in Haiti.

Class	High Elevation	Calcareous	Basaltic
Excellent	*Acacia angustissima*	*Leucaena leucocephala* *Leucaena* hybrid KX3	
Good	*Leucaena* hybrid KX3 *Leucaena leucocephala* *Leucaena diversifolia*	*Leucaena shannonii* *Leucaena diversifolia* *Cassia siamea*	*Leucaena leucocephala* *Leucaena* hybrid KX3
Fair	*Flemingia macrophylla* *Calliandra calothyrsus*	*Gliricidia sepium* *Calliandra calothyrsus* *Delonix regia*	*Leucaena salvadorensis* *Calliandra calothyrsus*
Poor	*Erythrina poeppigiana* *Gliricidia sepium* *Casuarina cunninghamiana* *Grevillea robusta* *Erythrina indica*	*Albizia lebbeck* *Leucaena salvadorensis* *Acacia angustissima* *Erythrina indica* *Albizia guachapele* *Enterolobium cyclocarpum* *Tephrosia candida* *Paraserianthes falcataria*	*Leucaena diversifolia* *Leucaena shannonii* *Gliricidia sepium* *Enterolobium cyclocarpum*
Not Harvested	*Acacia melanoxylon* *Albizia procera* *Acacia decurrens* *Acacia mearnsii* *Mimosa scabrella*	*Inga vera* *Casuarina cunninghamiana* *Erythrina poeppigiana* *Desmodium gyroides*†	*Acacia angustissima* *Cassia emarginata* *Cassia siamea* *Flemingia macrophylla* *Delonix regia* *Casuarina cunninghamiana*† *Desmodium gyroides*† *Grevillea robusta*†

† Did not emerge

FUTURE RESEARCH

The present trial should be continued for at least another two years to determine if the top species continue to perform well over time. Alley cropping is a technology for sustainable production and the hedgerow species must be capable of sustained biomass production over an extended period.

Additional observations were included in the protocols which must now be implemented. These include analysis of the top performing species to determine nutrient content of leaves and stems to determine potential contribution of nutrients by various species. Soil samples taken at the start of the trial and soil samples taken later should be analyzed to determine the effect of mulching on soil chemical properties. These analyses can be performed at Auburn University.

Decomposition rates are crucial when hedgerow prunings are applied to the soil to improve crop nutrition. Tree species vary greatly in their decomposition rates (Budelman, 1988b). This would provide an excellent topic for graduate student research and could be addressed both in the field and in the laboratory, with soils taken from the experimental sites.

Additional Trials

It turns out that the high elevation site near Fort Jacques is a relatively dry site, despite its close proximity to Fermathe and Kenscoff, with much higher rainfall. The suitability of *Acacia angustissima* must be confirmed at high elevation sites that have

higher rainfall. The range in elevation at which this species performs well must also be determined. Small trials could be established in the Fermathe/Thomasaint area, Kenscoff and, in collaboration with ORE, at Formond. *A. angustissima* should be tested with KX3, K 636, K 156, *Calliandra calothyrsus* and any other species that may be identified with potential for high-elevation.

One of the major constraints to alley cropping in Haiti is the free grazing of fallow areas by goats, cattle and other ruminants, thus destroying young hedgerows or limiting the availability of biomass for soil application. This can mitigated in part by judicious attention to the crop rotation when establishing hedgerows, so that the hedgerows are protected from grazing during the first two years of development. Once hedgerows are productive in an alley cropping system, it will be possible to reduce or eliminate fallow periods, so that livestock are kept out of the fields to a much greater extent.

Another approach, already used by at least one farmer in Haiti, is the use of a non-palatable species, in this case, *Delonix regia* (Lea *et al.*, 1993). Unfortunately, all of the top performing species in our trials are palatable to ruminants. There are two strategies which can be followed to address this objective. The first is to identify and test other species which are non-palatable but produce high amounts of biomass. One such species, *Cassia floribunda*, compared favorably with *Leucaena leucocephala* in Zaire and might be expected to perform well in Haiti as well. Plots in the current trial which contain species which have not been

productive could be utilized to superimpose a second trial of new species within the sites of the present trials.

A second approach is suggested by the enormous range in biomass production observed with different provenances and varieties of *Gliricidia sepium* in tree improvement trials in the Northwest (Timyan, 1993). This would consist of testing a range of provenances or progeny for biomass production as was done in the case of gliricidia. Tree species which classed good or fair in the present trials would be excellent candidates for such trials. *Cassia siamea* and *Delonix regia* are non-palatable species which would fall into this category.

Before a tree species not yet utilized for alley cropping in Haiti can be promoted for alley cropping, it must be tested with crops. Whether this testing should begin with researcher-implemented trials or could be conducted directly with farmers is a subject for future study. The decision on a particular strategy should be based in large measure on how much is already known about the tree species.

Much progress is being made in identifying suitable species for alley cropping in different environments in Haiti. Further research is needed to capitalize on these gains and to make further progress in soil conservation and sustainable increases in crop productivity and farmer income.

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Table A1. Square root of tree dry weight production totaled over first three harvests (at 11, 18 and 24 months after planting) at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		√Kg / Linear meter				
Acacia angustissima		1.937	1.428	0.837	0.983	.
Leucaena hybrid	KX3	1.640	1.016	0.781	0.903	0.413
Leucaena leucocephala	K636	1.404	0.810	0.768	0.801	0.142
Leucaena diversifolia	K156	1.338	0.915	0.585	0.747	0.164
Flemingia macrophylla‡		0.810	0.628	0.423	0.180	0.151
Calliandra calothyrsus‡		0.620	0.484	0.324	0.204	0.070
Erythrina poeppigiana†		0.349¶	0.226¶	0.155¶	0.243¶	.
Gliricidia sepium	HYB‡	0.185	0.145	0.107	0.028	.
Casuarina cunninghamiana†		0.155	0.135	0.076	.	.
Grevillea robusta†		0.059	0.054	0.023	.	.
Erythrina indica§		0.058	0.032	0.038	0.028	.
Acacia melanoxylon		.	.	.	.	.
Albizia procera		.	.	.	.	.
Acacia decurrens		.	.	.	.	.
Acacia mearnsii		.	.	.	.	.
Mimosa scabrella		.	.	.	.	.
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		0.529	0.311	0.251	0.399	0.130
SE		0.183	0.108	0.087	0.137	0.042
CV %		47.0	40.2	46.2	60.4	44.9

*** Significant at 0.1 % level of probability.

†One cut at 24 months after planting;

‡Sum of two cuts (at 18 and 24 months after planting);

§Sum of two cuts (at 11 and 24 months after planting);

¶Mean adjusted upward because of missing plot in rep 4.

Note: "." means not harvested. Not included in analysis.

Table A2. Percent dry matter of hedgerow species at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		%	%	%	%	%
Casuarina cunninghamiana		45.6	45.4	47.8	.	.
Grevillea robusta		40.5	40.5	39.9	.	.
Calliandra calothyrsus		36.1	36.7	39.5	41.0	38.4
Acacia angustissima		36.0	33.0	36.2	45.2	.
Leucaena diversifolia	K156	35.2	33.5	32.9	41.1	22.1
Flemingia macrophylla		33.4	32.8	33.2	38.5	38.9
Leucaena hybrid	KX3	32.4	29.2	32.9	39.8	23.4
Leucaena leucocephala	K636	29.7	25.0	33.9	37.1	11.0
Gliricidia sepium	HYB	25.7	21.6	31.0	36.6	.
Erythrina poeppigiana		23.2	20.2	14.3	24.6	.
Erythrina indica		15.7	16.9	13.2	16.8	.
Mimosa scabrella		.	.	.	.	.
Acacia decurrens		.	.	.	.	.
Acacia melanoxylon		.	.	.	.	.
Albizia procera		.	.	.	.	.
Acacia mearnsii		.	.	.	.	.
Significance (F test)		***	***	***	***	**
$LSD_{0.05}$		3.7	4.2	3.7	6.0	10.4
SE		1.3	1.4	1.3	2.0	3.2
CV %		7.8	9.2	7.7	10.7	25.1

, * = significant at 1 % and 0.1 levels of probability, respectively.

Note: "." indicates not harvested. Not included in analysis.

Table A3. Tree fresh weight production totaled over the first three harvests at high elevation site at Fort Jacques. Agroforestry trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		---------- Kg/ Linear m ---------				
Acacia angustissima		11.28	6.59	2.05	2.64	.
Leucaena hybrid	KX3	9.54	4.00	2.07	2.74	0.789
Leucaena leucocephala	K636	8.70	3.31	2.26	2.75	0.378
Leucaena diversifolia	K156	6.07	2.85	1.16	1.91	0.140
Flemingia macrophylla		2.13	1.29	0.58	0.19	0.081
Erythrina poeppigiana		1.66¶	0.70¶	0.39¶	0.76¶	.
Calliandra calothyrsus		1.28	0.76	0.33	0.16	0.035
Gliricidia sepium	HYB	0.35	0.25	0.09	0.01	.
Casuarina cunninghamiana		0.15	0.11	0.04	.	.
Erythrina indica		0.05	0.01	0.03	0.01	.
Grevillea robusta		0.03	0.03	0.006	.	.
Albizia procera		.	.	.	.	.
Acacia decurrens		.	.	.	.	.
Acacia melanoxylon		.	.	.	.	.
Acacia mearnsii		.	.	.	.	.
Mimosa scabrella		.	.	.	.	.
Significance		***	***	***	*	**
LSD.05		5.07	2.07	1.01	2.12	0.418
SE		1.75	0.72	0.35	0.73	0.136
CV %		94.7	79.8	86.2	121.2	184.4

, * = significant at the 1 % and 0.1 % levels of probability, respectively.

¶ Mean adjusted because of missing plot in rep 4.

Note: "." indicates not harvested. Not included in analysis.

Table A4. Square root of tree dry weight production totaled over first three harvests (at 10, 17 and 23 months after planting) at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		--------√Kg / Linear meter---------				
Leucaena leucocephala	K636	2.40	1.41	1.10	1.58	0.190
Leucaena hybrid	KX3	2.36	1.41	1.06	1.56	0.174
Leucaena shannonii		1.43	0.79	0.82	0.85	0.030
Leucaena diversifolia	K156	1.33	0.80	0.61	0.81	0.282
Cassia siamea		0.98	0.84	0.46	0.16	.
Gliricidia sepium	HYB[†]	0.95	0.67	0.46	0.46	.
Calliandra calothyrsus		0.90	0.62	0.54	0.36	0.013
Delonix regia		0.80	0.56	0.32	0.47	.
Albizia lebbeck[†]		0.63	0.47	0.25	0.29	.
Acacia angustissima[‡]		0.46	0.33	0.30	0.05	0.034
Leucaena salvadorensis		0.43	0.26	0.28	0.17	.
Albizia guachapele		0.41	0.33	0.21	0.08	.
Erythrina indica		0.39	0.26	0.20	0.18	.
Enterolobium cyclocarpum		0.30	0.22	0.20	.	.
Tephrosia candida[‡]		0.16	0.08	0.11	.	0.074
Paraserianthes falcataria[§]		0.07	0.06	0.03	0.03	.
Inga vera		.	.	.	.	.
Casuarina cunninghamiana		.	.	.	.	.
Erythrina poeppigiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		0.27	0.17	0.13	0.23	0.138
SE		0.09	0.06	0.05	0.08	0.047
CV %		21.5	20.7	20.8	32.4	81.7

*** Significant at the 0.1 % levels of probability.

[†]Sum of two cuts (at 17 and 23 months after planting);
[‡]Sum of two cuts (at 10 and 23 months after planting);
[§]One cut at 17 months after planting.

Note "." indicates not harvested; "A" indicates that species did not germinate or died off.

Table A5. Percent dry matter of hedgerow species at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		%	%	%	%	%
Leucaena shannonii		40.4	31.3	43.8	50.1	26.6
Leucaena diversifolia	K156	40.4	32.2	41.9	49.3	43.4
Acacia angustissima		40.4	36.3	43.9	53.2	52.5
Leucaena salvadorensis		40.2	33.2	44.1	48.8	.
Leucaena hybrid	KX3	39.2	31.4	40.7	48.1	44.6
Calliandra calothyrsus		38.9	34.6	42.2	49.3	34.3
Leucaena leucocephala	K636	38.7	30.3	39.8	48.7	48.7
Tephrosia candida		38.5	33.7	42.2	.	37.2
Delonix regia		37.8	32.6	39.3	47.5	.
Paraserianthes falcataria		36.4	33.7	43.2	41.9	.
Cassia siamea		35.4	34.8	36.8	45.6	.
Albizia guachapele		34.7	31.9	37.0	51.0	.
Enterolobium cyclocarpum		34.6	31.4	39.5	.	.
Albizia lebbeck		32.1	28.5	35.6	47.0	.
Gliricidia sepium	HYB	31.2	26.8	33.7	42.4	.
Erythrina indica		24.2	21.5	24.3	31.8	.
Inga vera		.	.	.	.	.
Casuarina cunninghamiana		.	.	.	.	.
Erythrina poeppigiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Significance (F test)		***	***	***	***	ns
$LSD_{0.05}$		2.5	1.9	4.5	4.3	18.9
SE		0.9	0.7	1.6	1.5	5.6
CV %		4.7	4.3	8.1	6.3	26.1

ns, *** = not significant and significant at 0.1 % level of probability, respectively.

Note: "." indicates not harvested. Not included in analysis. "A" indicates that species did not germinate or died off.

Table A6. Tree fresh weight production from the first three harvests at the calcareous site at Bergeau. Agroforestry trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		----------Kg/ Linear m./Yr.-------				
Leucaena leucocephala	K636	15.11	6.67	3.10	5.23	0.109
Leucaena hybrid	KX3	14.24	6.33	2.79	5.05	0.092
Leucaena shannonii		5.21	2.06	1.57	1.57	0.008
Leucaena diversifolia	K156	4.43	1.97	0.91	1.36	0.193
Gliricidia sepium	HYB	2.92	1.71	0.64	0.57	.
Cassia siamea		2.83	2.12	0.61	0.10	.
Calliandra calothyrsus		2.18	1.13	0.72	0.32	0.002
Delonix regia		1.91	1.07	0.30	0.54	.
Albizia lebbeck		1.33	0.81	0.19	0.33	.
Erythrina indica		0.76	0.40	0.19	0.17	.
Leucaena salvadorensis		0.61	0.26	0.22	0.13	.
Acacia angustissima		0.55	0.31	0.22	0.02	0.004
Albizia guachapele		0.50	0.34	0.13	0.03	.
Enterolobium cyclocarpum		0.26	0.16	0.10	.	.
Tephrosia candida		0.12	0.04	0.06	.	0.028
Paraserianthes falcataria		0.05	0.04	0.01	0.01	.
Inga vera		.	.	.	.	.
Casuarina cunninghamiana		.	.	.	.	.
Erythrina poeppigiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Significance		***	***	***	***	**
LSD.05		1.91	0.83	0.41	0.82	0.099
SE		0.67	0.29	0.15	0.29	0.033
CV %		40.5	36.8	39.5	52.1	106.9

, * Significant at the 1 % and 0.1 % levels of probability, respectively.

Note: "." indicates not harvested. Not included in analysis. "A" indicates that species did not emerge or died off.

Table A7. Square root of tree dry weight production totaled over first two harvests (at 17 and 23 months after planting) at Basaltic site at St. Georges. Agroforestry Trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		√Kg / Linear meter				
Leucaena leucocephala	K636	1.40	0.82	0.75	0.81	0.036
Leucaena hybrid	KX3	1.12	0.74	0.56	0.62	0.058
Leucaena salvadorensis		0.82	0.50	0.54	0.35	.
Calliandra calothyrsus		0.72	0.48	0.48	0.23	.
Leucaena diversifolia	K156	0.63	0.41	0.32	0.34	0.027
Gliricidia sepium	HYB	0.50	0.41	0.27	0.07	.
Leucaena shannonii		0.59	0.33	0.40	0.27	.
Enterolobium cyclocarpum†		0.08	0.06	0.05	.	.
Acacia angustissima		.	.	.	.	.
Cassia siamea		.	.	.	.	.
Flemingia macrophylla		.	.	.	.	.
Cassia emarginata		.	.	.	.	.
Delonix regia		.	.	.	.	.
Casuarina cunninghamiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Grevillea robusta		A	A	A	A	A
Significance (F test)		**	**	***	*	ns
$LSD_{0.05}$		0.55	0.31	0.27	0.45	0.165
SE		0.19	0.10	0.09	0.15	0.048
CV %		51.0	44.5	43.7	79.2	238.1

ns, *, **, *** Not significant, significant at 5 %, 1 % and 0.1 % levels of probability, respectively.

†One cut at 23 months after planting.
Note: "." indicates not harvested, not included in analysis.

Table A8. Percent dry matter of hedgerow species at the basaltic site at St Georges. Agroforestry Trial 1.

SPECIES	Variety	Total†	Leaf	Stem <1 cm	Stem >1 cm	Pods
		%	%	%	%	%
Leucaena salvadorensis		42.1	35.8	45.4	51.5	.
Leucaena shannonii		42.1	32.8	48.8	49.1	.
Calliandra calothyrsus		41.8	36.0	47.1	52.9	.
Leucaena leucocephala	K636	40.2	32.3	44.0	50.4	83.9
Leucaena hybrid	KX3	38.9	32.7	45.7	46.8	27.4
Leucaena diversifolia	K156	38.3	33.4	42.0	50.3	27.5
Enterolobium cyclocarpum		29.8	28.2	33.5	.	.
Gliricidia sepium	HYB	24.7	22.3	30.6	38.7	.
Flemingia macrophylla		.	.	.	.	.
Cassia siamea		.	.	.	.	.
Cassia emarginata		.	.	.	.	.
Delonix regia		.	.	.	.	.
Acacia angustissima		.	.	.	.	.
Casuarina cunninghamiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Grevillea robusta		A	A	A	A	A
Significance (F test)		***	***	***	***	ns
$LSD_{0.05}$		3.7	2.3	5.8	3.5	.
SE		1.3	0.8	2.0	1.1	.
CV %		6.7	5.0	9.3	4.6	.

ns, *** = Not significant, significant at 0.1 % level of probability.

Note: "." indicates not harvested, not included in analysis. "A" indicates that species did not emerge or died out.

Table A9. Tree fresh weight production totaled over the first three harvests at the basaltic site at St. Georges. Agroforestry trial 1.

SPECIES	Variety	Total	Leaf	Stem <1 cm	Stem >1 cm	Pods
		---------Kg/ Linear m./Yr.---------				
Leucaena leucocephala	K636	5.70	2.44	1.46	1.80	0.006
Leucaena hybrid	KX3	3.68	1.87	0.74	1.02	0.050
Leucaena salvadorensis		1.96	0.83	0.76	0.37	.
Calliandra calothyrsus		1.38	0.70	0.54	0.14	.
Leucaena diversifolia	K156	1.22	0.61	0.29	0.31	0.010
Gliricidia sepium	HYB	1.04	0.76	0.24	0.03	.
Leucaena shannonii		0.85	0.36	0.34	0.15	.
Enterolobium cyclocarpum		0.03	0.02	0.01	.	.
Acacia angustissima		.	.	.	.	.
Cassia siamea		.	.	.	.	.
Flemingia macrophylla		.	.	.	.	.
Cassia emarginata		.	.	.	.	.
Delonix regia		.	.	.	.	.
Casuarina cunninghamiana		A	A	A	A	A
Desmodium gyroides		A	A	A	A	A
Grevillea robusta		A	A	A	A	A
Significance (F test)		**	**	**	*	ns
$LSD_{0.05}$		2.89	1.19	0.70	1.10	0.106
SE		0.98	0.41	0.24	0.37	0.030
CV %		99.1	85.7	87.2	135.0	280.1

ns, *, **,*** Not significant, significant at the 5 %, 1 % and 0.1 % levels of probability respectively.

Note: "." indicates no plots harvested. Not included in analysis. "A" indicates species did not germinate or died out.

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[1]Limited distribution only.

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