HAITI PRODUCTIVE LAND USE SYSTEMS PROJECT

SOUTH-EAST CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

AND

AUBURN UNIVERSITY

November 1993

Evaluation of Tree Species Adaptation for Alley Cropping in Four Environments in Haiti. A. Establishment Phase

by

Dennis A. Shannon and Lionel Isaac

SECID/Auburn PLUS Report No. 6

This work was performed under USAID Contract No. 521-0217-C-0004-00. The views expressed herein are the views of the contractor and not necessarily those of the U.S. Agency for International Development.

FORWARD

This is the first of several reports on the progress of Agroforestry Trial 1. Because this is a long-term trial, considerably more information was included in the document than was needed to simply provide preliminary results to the PLUS project implementors. This was to insure that the data remains available for future users of the trial results. The supplemental information includes names of suppliers and seed lot numbers should the project wish to utilize seed of the same or similar provenance, field plot diagrams for anyone wishing to view the trials themselves, daily rainfall data and information useful to anyone wishing to analyze the data in greater depth. Some of this information will not be repeated in future reports.

Publication of these results was delayed because of the suspension of the project, the delay in reinstatement of the trials and the transfer of the first author to Auburn, which has made communication regarding data analysis difficult. On the other hand the suspension of project made possible a more thorough literature review than would have been possible otherwise.

Despite the preliminary nature of this first report, some conclusions of practical relevance to the project may already be drawn.

ACKNOWLEDGEMENTS

The authors are grateful to Steve Goodwin of SECID/Auburn and to Mike Bannister, of PADF, together with Gaspard Brice and other PADF staff for their assistance in the critical task of finding suitable sites for experimentation. Because of the rough terrain and the small size of most land holdings, finding suitable sites was not a simple task. To David and Judy Heady and Randy Nease of Global Outreach, the authors are grateful for making available land free of charge and facilitating collection of rainfall data and provision of labor. Their hospitality on visits to their hot, dry location is also appreciated. Dr. Greg Somers of the School of Forestry, Auburn University provided invaluable assistance in identifying an appropriate experimental design for the site at Ft. Jacques and for determining the method of data analysis by SAS. The devotion and hard work of Lionel Isaac, Patrick Condé and Rodney St. Juste was invaluable in establishing and maintaining the trials. During the embargo, Marilyn Louis played a key role in assuring the security of the sites and Lionel Isaac went far beyond the call of duty in an attempt to minimize the loss of data. Thanks are also due to Dr. Edzard van Santen and Dr. Jim Edwards of the Agronomy and Soils Department for sharing their computers.

The authors are grateful to USAID for funding this research and to PADF for their moral encouragement in ensuring that these trials would be carried through to completion.

Dennis A. Shannon

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CARE	CARE International, a project implementor
COHDEFOR	Corporación Hondurena de Desarollo Forestal
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
IITA	International Institute of Tropical Agriculture, Nigeria
ILCA	International Livestock Center for Africa
PADF	Pan American Development Foundation, a project implementor
PLUS	Productive Land Use Systems Project
SAS	Statistical Analysis Systems
SECID	South-East Consortium for International Development
USAID	United States Agency for International Development

Evaluation of Tree Species Adaptation for Alley Cropping in Four Environments in Haiti A. Establishment Phase

by

D.A. Shannon and L. Isaac

EXECUTIVE SUMMARY

Thirty-five tree species were planted in hedgerows in four environments in Haiti: high elevation (1150 m); low elevation, humid on calcareous soil; low elevation, humid on basaltic soil; and low elevation, semi-arid, with 16, 20, 16 and 18 species at the four sites respectively. *Leucaena leucocephala*, variety K 636, *L. diversifolia* variety K 156, *Casuarina cunninghamiana* and *Gliricidia sepium* variety HYB were included at all sites. Seed that failed to emerge were replaced with seedlings of the same age as those initially seeded, but this process was interrupted by the project suspension. Plant counts were taken at 6 weeks after planting and at 2-4 month intervals thereafter. Plant height was measured at monthly intervals.

Large differences in emergence, plant height and leaf numbers were recorded. Satisfactory stands were obtained with a number of species at all sites. Poor establishment with direct seeding was observed with *Casuarina cunninghamiana, Desmodium gyroides, Grevillea robusta, Piptadenia peregrina* and most of the *Acacia* species, with the exception of *A. angustissima*, which established satisfactorily except at basaltic site, and *A. colei*. Survival was

good for most species at high elevation except for *Acacia mearnsii, Mimosa scabrella,* and A. decurrens. *Erythrina poeppigiana* disappeared from the plots at the calcareous site, as did *A. tumida* at the semi-arid site. Severe stand losses were recorded for *Piptadenia peregrina, Albizia procera, Cassia siamea, Albizia guachapele,* and *Enterolobium cyclocarpum* at this site. Significant stand losses were also observed in *Acacia colei* and *A. ampliceps*. Good or satisfactory survival was recorded for most other species.

At two and a half months after planting, K 636, *Erythrina indica*, *Leucaena* hybrid KX3, *Gliricidia*, K 156 and *Erythrina poeppigiana* were tallest at the high elevation site; *Enterolobium cyclocarpum* was tallest at the calcareous site, followed by K 636, *L. salvadorensis* and *Erythrina indica*; *Enterolobium* was tallest at the basaltic site, followed by *L salvadorensis*, K 636 and *Gliricidia;* and *Enterolobium* and K 636 were tallest at the semi-arid site. At approximately 10 months to one year, K 636 was tallest at the high elevation site, followed by KX3, K 156 and *Acacia angustissima*; K 636 and KX3 were tallest at the calcareous site, followed by *L. shannonii;* K 636 and KX3 were tallest at the basaltic site, followed by *Calliandra, L. salvadorensis*, *L. shannonii* and K 156; and K 636 was tallest at the semi-arid site, followed by wild *Leucaena leucocephala* (Delin), *Enterolobium* and *Gliricidia*. Leaf numbers generally followed similar patterns except that most leaves were observed on *Casuarina*.

Many of the small seeded species appeared to be unsuitable for direct seeding in the field because of difficulty in obtaining satisfactory stands. This limits their usefulness as hedgerows for alley cropping. The dry conditions and irregular rainfall pattern at the semi-arid site are not conducive to direct seeding of trees.

Growth of hedgerows was excellent at the high elevation and calcareous sites and adequate at the basaltic site for the promotion of alley cropping, but poor at the semi-arid site. The major difference between the calcareous and basaltic sites appeared to be lower soil fertility at the basaltic site and a lower soil water retention capacity. At the semi-arid site, drought and high temperatures are so severe that growth of all but the most drought tolerant is greatly inhibited. Growth of K 636 to 1 m height in one year, more than double that of the next best species, is impressive under these conditions. Its superior performance under these extreme conditions confirms the suitability of this species in the less severe drought conditions that prevail in the agricultural areas of the Northwest.

Based upon establishment and first-year growth rates, several species appear promising for alley cropping under different agro-ecological conditions in Haiti. None grew better than *Leucaena leucocephala* variety K 636 at any of the sites. Promising species include, for high elevation, *Leucaena* hybrid KX3 and *Acacia angustissima*; for low elevation, humid sites, the *Leucaena* species and *Acacia angustissima*, with *Calliandra callothyrsus* at the wetter sites; for semi-arid conditions, *L. leucocephala* and *Gliricidia*. KX3, *L. salvadorensis* and *L. shannonii* also show potential.

These results should be regarded as preliminary. Final assessment will be based on biomass production under a pruning regime favorable to crop production.

REZIME KREYOL

Tran-senk espès bwa te plante sou ranp nan divès zòn nan péyi-a: 16 nan wotè (1150 m); 20 sou sòl kalkè nan ba altitid imid, 16 sou sòl bazaltik nan ba altitid imid; 18 nan ba altitid zòn sèk. Kèk espès tankou lesena K636 (*Leucaena leucocephala,* var K636), lesena ti fèy (*L. diversifolia*, var K156), pichpen (*Casuarina cunninghamiana*) ak piyon (*Gliricidia sepium*, var HYB) te simen nan tout sit yo. Semans ki pat leve te ranplase pa ti pyebwa ki gen menm laj ak sa ki te deja leve yo, men transplantasyon an te sispan-n akòz pwojè-a te kanpe. Nou te konte pyebwa ki nan ranp yo sou sis semen-n apre simen ak apeprè chak 2 a 4 mwa. Wotè pyebwa yo te mezire apeprè chak mwa.

Nou konstate gwo diferans nan jan yo te leve, nan wotè pyebwa ak kantite fèy pou divès espès yo. Plizyè espès te byen etabli nan tout sit yo. Kèk lòt espès tankou pichpen, desmodium, grevilya, pifò akasya yo sòf espès *colei* a ak *angustissima* ki té mal vini sèlman nan sit bazaltik la, te difisil pou etabli lè yo simen yo dirèkteman. Nou remaké ke plant yo te byen vini pou pifò espès ki te plante sou sit nan wotè (1150 m) sòf pou *Acacia mearnsii*, *Mimosa scrabella* ak *Acacia decurrens*. De espès te disparèt nan esè yo, imòtel (*E. poeppigiana*) nan sit kalkè-a, *A. tumida* nan sit ba altitid zòn sèk la. Nan sit sèk la tou, kèk espès tankou *Piptadenia peregrina*, *Albizia procera*, *cassia siamea*, *Albizia* *guachepele* ak *Enterolobium cyclocarpum* te pèdi anpil pye. Yon bon kantité tou te pèdi pou espès *A. colei* ak *A. ampliceps*. Nou te konstaté ke plant yo te byen vini pou pifò nan rès lòt espès yo.

Sou 2 mwa edmi apre yo te simen, lesena K636, imòtel (*E. indica*) lesena ibrid KX3, piyon, lesena ti fèy K156 ak imòtel(*E. poeppigiana*) te piwo sou sit ki nan wotè a; *E. cyclocarpum* te piwo nan sit kalkè-a, apre li, nou te jwenn lesena K636, lesena espès *salvadorensis* ak imòtel (*E. indica*); nan sit bazaltik la se *Enterolobium* ki te piwo, lòt espès tankou *L. salvadorensis*, lesena K636 ak piyon te swiv li; *Enterolobium* ak lesena K636 te piwo nan sit ba altitid zòn sèk la. Apeprè 10 mwa pou rive sou 1 nan, lesena K636 te piwo nan sit ki nan wotè-a. Apre li nou jwenn lesena ibrid KX3, lesena ti fèy K156 ak A. angustissima. Lesena K636 ak lesena ibrid KX3 piwo nan sit kalkè a, lesena espès *shannonii* swiv yo. Nan sit bazaltik la, se lesena K636 ak lesena ibrid KX3 ki piwo, aprè yo sé kalyandra, lesena espès *salvadorensis*, lesena espès *shannonii* ak lesena ti fèy K156 ki vini. Nan sit zòn sèk la, lesena K636 pran plis wotè, apré li nou jwenn delen, *Enterolobium* ak piyon. Kantite fèy pa espès te swiv preske men-m lòd la tou sòf nou te jwenn plis fèy sou pichpen.

Anpil nan espès ki gen grenn piti yo pa rekòmande pou simen dirèkteman nan jaden akòz pwoblèm pou yo jèmen. Sa limite enpòtans espès sa yo nan ranp pou kilti an koulwa. Kondisyon sèk ak fason lapli tonbe nan zòn ba altitid sèk la pa pèmèt pou simen dirèkteman.

Kwasans ranp yo te bon anpil nan sit yo ki nan wotè ak sou tè kalkè, nòmal nan sit bazaltik la pou ankouraje kilti an koulwa, men kwasans ranp yo te pòv nan sit sèk la. Pi gwo diferans ant tè kalkè-a ak tè bazaltik se tè ki pòv ki nan sòl bazaltik la e ki pa ka kenbé dlo. Nan sit zòn sèk la, lesèk ak gwo tanperati te sitèlman rèd, kwasans tout espès yo men-m sila yo ki ka reziste ak lesèk té ralanti. Kwasans lesena K636 ki yon mèt (1 m) apre 1 nan, 2 fwa plis kwasans espès ki vinn apre-a, ankourajan nan kondisyon sa-a. Siperyorite espès sa-a anba kondisyon difisil sit sèk la, pèmèt nou kwè ké varyete K636 la ap pi byen adapte nan kondisyon mwen sèk ke nou jwenn nan nòdwès.

Lè nou konsidere fason espès yo etabli ak kwasans yo sou premye lane-a, plizyè nan yo pwomèt pou fè kilti an koulwa anba divès kondisyon peyi dayiti. Pa gen espès ki grandi pi byen ke lesena K636 nan tout sit yo. Sou sit nan wotè-a, espès ki pwomèt se lesena ibrid KX3 ak *A. angustissima*; pou sit ba altitid imid yo, se espès lesena yo ak *A. angustissima*, avèk kalyandra sou sit ki jwenn plis lapli a; pou zòn sèk la, se lesena ak piyon ki pwomèt.

Rezilta sa yo pa definitif. Rezilta final kap pèmèt nou konpare espès yo ap chita sou diferans ki genyen ant yo nan pwodiksyon byomas dapre fason ke koup bwa yo te fèt.

INTRODUCTION

Population growth during the past thirty years in Haiti and the lack of fertile, agriculturally suitable lands have increased pressure on marginal lands, many of which have steep slopes and are susceptible to erosion (CRESDIP, 1990). Intensive exploitation of these marginal lands, combined with deforestation, gives rise to increasing rates of erosion, soil degradation, declining yields and jeopardize future productivity of these lands for annual crops (Pelleck, 1989; CRESDIP, 1990). As a means to stabilize yields and reduce soil loss from cropped fields, SECID/Auburn University is conducting research for the Productive Land Use Systems Project (PLUS) to adapt alley cropping to Haitian conditions.

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 where no crop is grown, the trees are allowed to grow freely.

BENEFITS OF ALLEY CROPPING

Alley cropping has shown much promise during the last decade as a technology suitable for small farmers in the Third World. It improves soil by improving fertility and moisture retention, recycling plant nutrients and reducing erosion (Kang *et al.*, 1984; Farmer *et al.*, 1989; Bannister and Nair, 1990). In addition, it can help reduce weeds and provide forage and fuelwood (Okigbo, 1989).

Higher maize (*Zea mays*) yields with alley cropping than with conventional cropping have been reported by Kang and Wilson (1987) in Nigeria, Shannon *et al*. (1990) in Zaire and Balasubramanian and Sekayange (1991) in Rwanda. Higher bean (*Phaseolus vulgaris*) and sorghum (*Sorghum bicolor*) yields with alley cropping were also recorded (Balasubramanian and Sekayange, 1991). Alley cropping without fertilizer increased yield of *paitsai (Brassica chinensis)* (Chen *et al*., 1989).

Continuous cropping without adding inputs to soil generally results in declining yields over time (Kang and Balasubramanian, 1990; Sanchez, 1976). The effect of alley cropping on preventing the decline in crop yields over time has been measured in Africa by Kang (1989) and by Shannon *et al*. (1990).

Enhancement of nutrient status of surface soils under alley cropping compared to conventional cropping was reported by Kang (1989). Balasubramanian and Sekayange (1991) reported increases in calcium and effective cation exchange capacity over time.

Alley Cropping in Haiti

In Haiti, only anecdotal evidence of improved yields with alley cropping is available. P. Welle (personal communication) reported that planting contour hedgerows permitted farmers in the Northwest to grow maize next to hedgerows in fields where they could previously only grow sorghum. Bannister and Nair (1990) reported that an enriched microsite could be delineated behind hedgerows extending up to about 3 m upslope from the hedgerows. They reported a "better physical appearance of the soil," "better growth of crops," and improved "soil moisture retention."

One might question whether the current practice of growing hedgerows in Haiti qualifies as alley cropping. Under current practice, hedgerow prunings are not generally applied to the alleys. Soil retention, rather than soil fertility improvement is the primary goal.

Chéry (1989) described the use by farmers in Western Haiti of clippings from grass rows in border plantings to enhance soil fertility in much the same way as the prunings from hedgerows are used in alley cropping. He attributed relatively high yields of beans, maize and yam (*Dioscorea alata*) to the beneficial effects of mulching with grass prunings.

While these reports are not questioned (soil buildup and better appearance of soil behind hedgerows can readily be observed), empirical evidence of improved crop yields due to alley cropping under Haitian conditions is lacking. Also lacking is information on hedgerow management requirements and on the most suitable hedgerow species for alley cropping in Haiti's diverse agro-ecologies. The issue of suitable species is addressed in this document.

HEDGEROW SPECIES AND AGRO-ECOLOGICAL CONDITIONS

The most widely-used hedgerow species in alley cropping research is leucaena (*Leucaena leucocephala*). This species grows rapidly, fixes N, and coppices and produces seed readily. The leaves are an excellent forage, the seed is edible and the wood an excellent source of fuel and poles for construction and stakes (BOSTID, 1984). However, leucaena is not suitable or the best choice for all environments. For example, leucaena does not grow well on acid soils (Naidu *et al.*, 1990; Kadiata and Molongoy, 1991) and has been badly affected in Asia and the Pacific by the psyllid, *Heteropsylla cubana* (Kang, 1989). Bannister and Nair (1990) observed psyllid insects in Haiti on *L. leucocephala*, especially at elevations greater than 500 m.

Climate, soil and tolerance to local pests and diseases must be considered when selecting suitable species for alley cropping. Species which have given good results in trials in humid, lowland tropics are *Leucaena leucocephala* and *Gliricidia sepium* (gliricidia) (Kang, 1989). *Cassia siamea* also showed potential, while *Cajanus cajan* required replanting. In Western Samoa, on a moderately acid soil, leucaena and *Calliandra callothyrus* (calliandra) survived well and produced the most biomass, while *Erythrina subramans* and *Sesbania sesbans* had poor survival and *Samanea saman* and *Erythrina* produced the least biomass (Kidd and Taogaga, 1984). Gliricidia was intermediate in both survival and productivity.

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 dry leaf 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, semi-arid conditions (1400 m, 836 mm annual rainfall) are leucaena, calliandra, *Cassia spectabilis*, and *Leucaena diversifolia* (Balasubramanian and Sekayange, 1991). *Sesbania sesbans* did not survive well.

Experience in Haiti

In Haiti, limited data is available on which to base choice of species for use as hedgerows in alley cropping. Information relative to the contribution of certain species to soil fertility improvement is not available. One must base selection of species on field observation, on reports from similar environments in other parts of the world and on forestry trials, which indicate trees which may grow well in a particular environment, but provide no information on biomass production and how the species will perform under regular prunings. Promising species must then be tested under management conditions similar to that used with alley cropping before final selections can be made.

Forestry Trials

Lantagne (1980) compared tree species for reforestation in the area of Jean Rabel and Mare Rouge, Northwest. This area may be classed as semi-arid. Among species classed as successful based on emergence, survival, height and diameter measurements over two years were *Acacia cyaniophylla, Albizia lebbeck, Azadiracta indica* (neem), *Delonix regia* (flamboyant or flame tree), leucaena variety K8 and *Pithecolobium saman*. *Acacia decurrens* was classed as unsuitable. Poor establishment was obtained in nursery with *Grevillea robusta*. *Acacia accuminata* and *A. melonoxylon* were not productive.

Hedgerow Trials

Trials were established at various locations in Haiti by SECID Agronomist P.M. Rosseau and Agroforester A.G. Hunter to evaluate tree species for alley cropping. These trials were established with collaborators and had to be abandoned due to inadequate protection or management. However, it was possible to observe abandoned trials at Barbe Pagnole, Northwest Department and Mirebalais, Plateau Central, together with hedgerows established in farmers' fields and at training centers. These observations enabled the elimination from the present trials, of certain species obviously unsuited for alley cropping under local conditions (see Appendix I).

A hedgerow species trial conducted by the Targeted Watershed Management Project (Cunard, 1991; Cunard and Jouissance, 1991) was completed at Camp Perrin (200 m elevation, 2390 mm rainfall) following the establishment of the present trials. Cunard reported that leucaena and calliandra yielded a 2-cut total of over 3000 kg/ha fresh biomass, while Gliricidia yielded 1700 kg biomass/ha. *Albizia lebbeck, Sesbania sesbans* and *Moringa oleifera* yielded less than 1000 kg/ha, the latter only yielding 300 kg/ha.

Initial attempts at introducing alley cropping 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 staff reported poor performance of leucaena on basaltic soil (G. Brice, personal communication) and lack of vigor at high elevation (J. Timyan, personal communication). In many areas, insufficient fodder led to browsing of hedgerows by livestock and poor development of leucaena. Under such conditions, use of a less palatable species might ensure better hedgerow growth and more successful alley cropping. Also, it is desirable to identify alternative species for different environments and management systems in Haiti in case some new disease or pest should render leucaena undesirable.

OBJECTIVES

The objectives of this trial were to identify tree species suitable for alley cropping in the environments where alley cropping would most likely be introduced, i.e. 1.) mid to high elevation (800-1200 m); 2.) low elevation, humid on calcarious soils; 3.) low elevation humid on basaltic soils and 4.) low elevation, semi-arid conditions. This paper covers the establishment and first 10 - 12 months of the trial. Specifically, we were interested in evaluating seedling establishment, growth rates and survival during this period.

MATERIALS AND METHODS

SITES

Four sites were selected for this trial (Figure 1). The high elevation site was at Ft. Jacques (18 ° 29 ′ N latitude, 1150 - 1200 m elevation) in the Commune of Kenscoff, Département de l'Ouest. Annual rainfall is estimated at approximately 1200 mm, distributed mainly between March through June, and September through November. Mean temperature is about 21 °C, with lows of 5 °C or lower expected in January. According to the Holdridge system for classification of ecological zones, this zone is classified as low elevation mountain humid forest (Organization of American States, 1972). The soil is probably a Mollisol (R.L. Guthrie, personal communication) of limestone origin, clay loam texture, with pH > 7. The site has

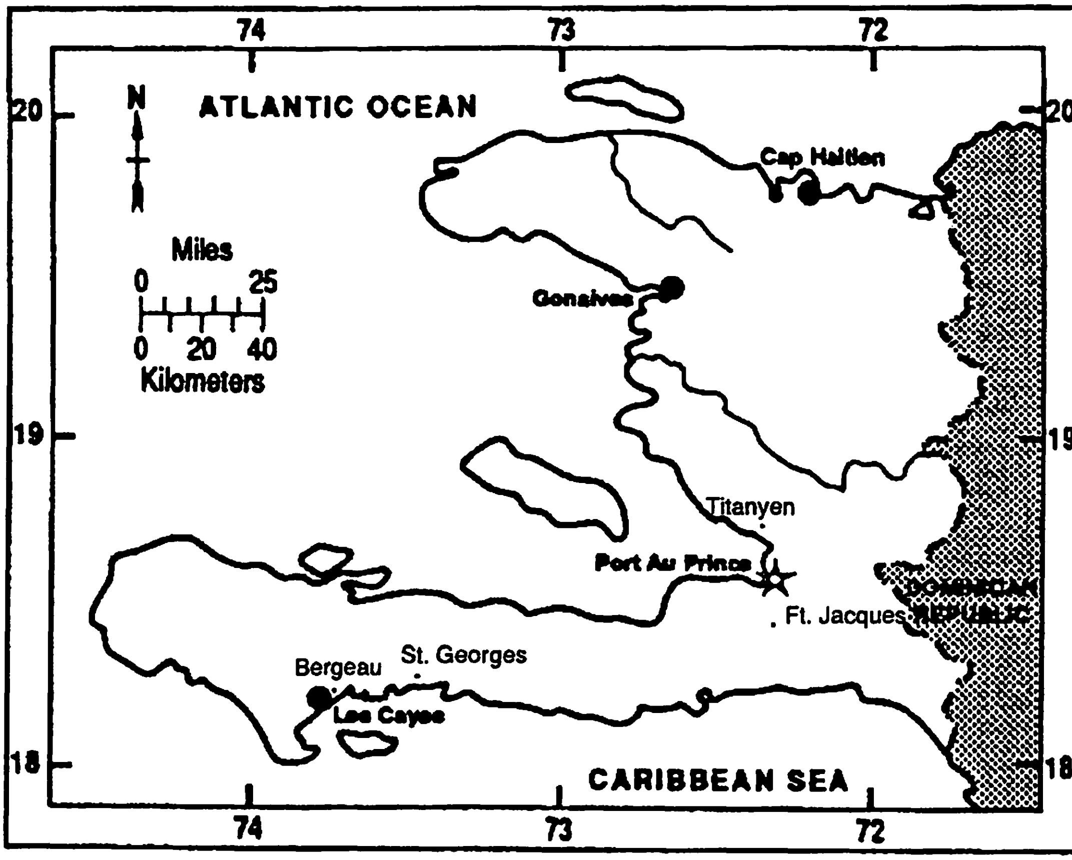


Figure 1. Location of trial sites in Haiti.

a steep north-facing slope (30-45 %) on which were stone dry walls, resulting in terraces with slopes varying from 15-25 %. In the previous year, beans, cassava and sweet potato had been planted in the first season, followed by vegetables in the cool second season.

The low elevation humid site on limestone parent material, hereby referred to as the calcareous site, was at Bergeau (18° 13′ N) in the District of Cayes, Département du Sud. Average temperature is 26.5 C and mean rainfall is 1800 mm, distributed as at Ft. Jacques. A soil profile at a nearby site was classified as a loamy, mixed, shallow (calcareous) isohyperthermic Typic Ustropept (Guthrie *et al.*, 1990). Surface soil pH was 8.3 and texture was loam in the surface and silt loam in the B horizon. The cation exchange capacity (CEC) was in excess of 26 meq/100 g soil. The research site is on an east-facing slope of 30 % at an elevation of about 50 m. Soil depth to bedrock is about 30-45 cm. The site was in unimproved pasture for the previous four or five years. Previous to that, sorghum was cultivated in rotation with maize and bean.

The low elevation site on basaltic soil, hereby referred to as the basaltic site, was at St. Georges (18° 15′ N latitude) at about 60 m elevation. Rainfall, distributed evenly between April and November, averages 1600 mm. Mean temperature is 26 C. The slope of 25 - 45 % faces north. The soil is a loam with abundant fine gravel. Soils of basalt parent material at other sites were classed as Lithic Ustropepts and Cumulic Haplustolls, with pH values of 7.6 and 7.2 (Guthrie *et al.*, 1990), and textures of loamy sand and sandy loam, respectively. The CEC's were in excess of 30-34 meq/100 g soil. 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. Elevation was approximately 87 m. Rainfall was estimated to average 780 mm with a highly erratic distribution pattern as is illustrated in the following records:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						mm						
1988						45	121	140	0	0	0	0
1989	0	0	0	0	130	25	70	273	147	132	89	0
1990	83	41	0	0	46	38	25	0	266	279	0	0
Mean	41	20	0	0	88	36	72	138	138	137	30	0

Mean temperature was estimated at 28.5 C. The soil was sandy and contained > 50 % cobbles and gravel. A slope of 5 - 8 % faces westward. The site had not been cultivated in recent history and contained a sparse cover of shrubs and grasses.

SPECIES

A total of 35 species of diverse origins were included in the trial. Most were legumes. Selections were based upon previous experience in Haiti, performance in other countries, recommendation of colleagues and a review of literature (Table 1 and Appendix I). The seed was obtained from seed banks in five countries, from four organizations within Haiti and seed harvested at three sites in Haiti (Table 2).

Environmental adaptation and coppicing ability were the main criteria for inclusion in the trial. Some species had been successfully grown in alley cropping; others were deemed to have

Table 1. Adaptation and appropriate agroforestry systems for species used in Agroforestry Trial 1.

SPECIES	CLIMATE Precip-itation[1]	Temp-erature[2]	SOIL Tex-ture[3]	pH[4]	USES[5]
	mm	°C			
Acacia ampliceps	250 - 700	>20	S-C	6.5- 7.5	AS-NF-SC
Acacia angustissima	>1000	>20	---	-	HR-NF-SC
Acacia colei	-------	---	---	-	NF-SC
Acacia decurrens	600->1200	>18	S	6.5- 7.5	AS-NF-SC
Acacia holosericea	300- 1100	>20	S-L	>7.5	AS-NF-SC
Acacia mearnsii	600->1200	>18	S-L	6.5- 7.5	AS-NF-SC
Acacia melanoxylon	>1200	>18	S	6.5- 7.5	AS-NF-SC
Acacia tumida	450- 1000	---	S-C	>7.5	NF-SC
Albizia guachapele	-------	---	---	-------	NF-SC
Albizia lebbeck	250->1000	>18	S-L	6.5->7.5	HR-NF-SC
Albizia procera	500->1000	>20	S-L	-------	HR-NF-SC
Calliandra calothyrsus	600->1500	>20	S	<6.5- 7.5	HR-NF-SC
Cassia emarginata	-------	---	---	-------	NF-SC
Cassia siamea	250->1200	>18	S-L	<6.5- 7.5	HR-NF-SC
Casuarina cunninghamiana	250->1200	>18	S-L	>7.5	AS-NF-SC
Delonix regia	-------	---	---	-------	AS-NF-SC
Desmodium gyroides	-------	---	---	-------	NF-SC
Enterolobium cyclocarpum	500->1000	>20	---	-------	HR-NF
Erythrina indica	-------	---	---	-------	HR-NF-SC
Erythrina poeppigiana	600- 1500	>20	S	>7.5	HR-NF-SC
Flemingia macrophylla	>1000	>20	---	-------	HR-NF
Gliricidia sepium	600->1200	>20	S-L-C	<6.5- 7.5	HR-NF-SC
Grevillea robusta	600->1200	>18	S	6.5- 7.5	AS
Inga vera	-------	---	---	-------	AS-NF
Leucaena diversifolia	>1000	>18	S-L	-------	HR-NF-SC
Leucaena leucocephala	300->1000	>20	S-L-C	6.5->7.5	HR-NF-SC
Leucaena hybrid	>1000	>18	S-L	-------	HR-NF-SC
Leucaena salvadorensis	>1000	>20	S-L	6.0	HR-NF-SC
Leucaena shannonii	>1000	>20	S-L	4.5- 5.0	HR-NF-SC
Mimosa scabrella	600->1500	>18	S	6.6->7.5	AS-NF-SC
Paraserianthes falcataria	>1200	>20	S	6.5- 7.5	HR-NF-SC
Piptadenia peregrina	500->1000	>20	S-L	-------	AS
Pseudoalbizia berteriana	500->1000	>20	S	-------	AS-NF
Tephrosia candida	---------	---	---	-------	AS-NF

[1] Range in annual rainfall.
[2] Mean annual temperature
[3] S = Sand; L = Loam ; C = Clay
[4] Range in soil pH
[5] AS = Agroforestry ; HR = Hedgerows / Alley Cropping
NF = Nitrogen Fixing ; SC = Soil Conservation

Compiled from: NFTA, 1989; Turnbull, 1986; Von Carlowitz, 1986

Table 2. Species planted at the different sites and seed source.

SPECIES	Variety	Sites[1] Ber	SG	FJ	TT	Sources[2]
Acacia ampliceps					+	CSIRO
Acacia angustissima		+	+	+		CATIE
Acacia colei					+	CSIRO
Acacia decurrens				+		CSIRO
Acacia holosericea					+	CSIRO
Acacia mearnsii				+		PADF/CSIRO
Acacia melanoxylon				+		PADF/CSIRO
Acacia tumida					+	CSIRO
Albizia guachapele		+			+	PADF
Albizia lebbeck		+			+	PADF
Albizia procera				+	+	PADF
Calliandra calothyrsus		+	+	+		ORE/Formont
Cassia emarginata			+		+	PADF
Cassia siamea		+	+		+	PADF
Casuarina cunninghamiana		+	+	+	+	Zimbabwe
Delonix regia		+	+		+	PADF
Desmodium gyroides		+	+			PST
Enterolobium cyclocarpum		+	+		+	PADF
Erythrina indica		+		+		PST/PADF
Erythrina poeppigiana		+		+		PADF
Flemingia macrophylla			+	+		IITA
Gliricidia sepium	HYB	+	+	+	+	IITA
Grevillea robusta			+	+		Baptist
Inga vera		+				Labod/Cayes
Leucaena diversifolia	K156	+	+	+	+	ODH
Leucaena leucocephala	K636	+	+	+	+	ODH
Leucaena leucocephala	Delin				+	Puits Blin
Leucaena hybrid	KX3	+	+	+		ODH
Leucaena salvadorensis		+	+			COHDEFOR
Leucaena shannonii		+	+			COHDEFOR
Mimosa scabrella				+		PADF
Paraserianthes falcataria		+				PADF
Piptadenia peregrina					+	Anana/ Lascahobas
Pseudoalbizia berteriana					+	Berthé
Tephrosia candida		+				IITA

[1] Ber = Bergeau; SG = St. Georges; FJ = Ft. Jacques; TT = Titanyen. "+" in column indicates presence of species at particular site.

[2] Supplier: CSIRO = Australia; CATIE = Costa Rica; PADF = Pan American Dévelopment Foundation, Haiti; PST = Targeted Watershed Project, Haiti, ORE = Organization for the Rehabilitation of the Environment, Haiti; IITA = International Institute of Tropical Agriculture, Nigeria; Baptist = Baptist Mission, Fermathe, Haiti; ODH = Operation Double Harvest, Roche Blanche, Haiti; COHDEFOR = Honduras; Remaining locations are harvest sites in Haiti unless otherwise indicated.

potential in alley cropping (Table 1). Less information was available on other species. At times, conflicting information was obtained regarding individual species. Further details regarding the decisions to include or exclude species are presented in Appendix I.

Leucaena leucocephala, variety K 636, was selected as the control at each site. Three other species, *L. diversifolia*, variety K 156; *Gliricidia sepium*, variety HYB; and *Casuarina cunninghamiana* were also planted at each site. The other species were distributed based upon expected adaptation and available space at each site (Table 2). A total of 16 species were planted at the high elevation and basaltic sites, 20 at the calcareous site and 18 at the semi-arid site.

ESTABLISHMENT

The trials were established during the first rainy season of 1991. Three weeks before planting, shrubs and weeds were removed with hand tools, without disturbing the soil, and the plant residues left on the soil surface. Soil preparation was begun two weeks later. The rows were marked out on a contour by means of an A-frame level or string level. The rows were 24 - 40 m in length and were spaced 3 m apart where possible. The soil was prepared to a depth of 20-30 cm in a 30 cm width along each row with a hoe or pick. At the high-elevation site, the walls were reconstructed at certain points to prevent soil loss. At the basaltic site, the rows were established mid-way between existing hedgerows of

Erythrina indica and leucaena, which were pruned low to minimize competition to the trees in our trials. At the semi-arid site, large stones were removed and a shallow trench was formed with a ridge on the down-slope side to serve as water catchment.

Plots consisted of single rows of 5 m (calcareous and basaltic sites) or 6 m (high elevation and semi-arid sites). Plants were spaced 10 cm apart within the row except at the semi-arid site where plants were spaced 20 cm. At the ends of rows, borders of 2 m length were planted with various leucaena varieties. Field Plans are presented in Appendix (Figures A1-A4).

A randomized complete block design with four replications was used at all but the high elevation site (Figure A1). 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).

Seed pretreatment varied with species (Table 3). Seeding was done on May 8, May 23, May 22 and May 13, for the high elevation, calcareous, basaltic and semi-arid sites, respectively. From 3-10 seeds were planted per hill depending upon laboratory germination test and seed size. Where emergence was poor, hills were reseeded approximately three weeks after the first seeding. Seedlings were thinned to one per hill at approximately four weeks after planting. Because of drought and the early onset of the dry season,

Table 3. Number of sites, seed weight, seed treatment and percent germination of species included in Agroforestry Trial 1.

Species	Variety	Sites	Seed/Kg	Treat-ment[1]	Germi-nation
		#			%
Acacia ampliceps		1	46,000	A	42.0
Acacia angustissima		3		A	86.0
Acacia colei		1	82,500	A	80.5
Acacia decurrens		1	60,600	A	27.5
Acacia holosericea		1		A	57.5
Acacia mearnsii		1	72,600	A	43.5
Acacia melanoxylon		1		A	22.0
Acacia tumida		1	19,500	A	55.5
Albizia guachapele		2	23,000	B	92.0
Albizia lebbeck		2		B	62.5
Albizia procera		2	25,000	B	91.0
Calliandra calothyrsus		3		B	91.5
Cassia emarginata		2		A	19.0
Cassia siamea		3	31,500	E	32.0
Casuarina cunninghamiana		4	1,297,400	E	61.0
Delonix regia		3	1,900	C	67.0
Desmodium gyroides		2		E	18.0
Enterolobium cyclocarpum		3	1,120	C	81.0
Erythrina indica		2	1,500	D	49.5
Erythrina poeppigiana		2	4,500	D	41.0
Flemingia macrophylla		2		E	67.0
Gliricidia sepium	HYB	4		E	71.0
Grevillea robusta		2	44,000	D	No Test
Inga vera		1		E	No Test
Leucaena diversifolia	K156	4	50,000	B	86.5
Leucaena leucocephala	K636	4		B	71.0
Leucaena leucocephala	Delin	1		B	87.0
Leucaena hybrid	KX3	3		B	84.0
Leucaena salvadorensis		2	11,411	B	97.5
Leucaena shannonii		2	37,965	B	91.0
Mimosa scabrella		1		D	35.0
Paraserianthes falcataria		1	41,000	B	63.0
Piptadenia peregrina		1	12,000	E	87.5
Pseudoalbizia berteriana		1	70,000	A	30.5
Tephrosia candida		1		E	26.5

[1] A: Seeds immersed in boiling water for 30 seconds.
B: Round end of seeds cut or scratched.
C: Round end of seeds cut or scratched and soaked in water for 12 hours.
D: Soaked in cold/tepid water for 12 hours.
E: No treatment.

irrigation was provided at approximately weekly interval at a rate of about 2.6 l per linear m of row. At the semi-arid site irrigations were twice weekly for the first three months. These were later reduced to once weekly. At the onset of the second rainy season, 60 day old seedlings of *Grevillea robusta, Casuarina cunninghamiana, Desmodium gyroides, Pseudoalbizia berteriana, Flemingia macrophylla, Mimosa scabrella* and *Erythrina poeppigiana* were transplanted to fill in gaps in rows. Transplanting of seedlings at the basaltic and semi-arid sites was interrupted by suspension of the project.

The first weeding took place three weeks after planting. Later weedings were done at 30-45 day intervals as long as we were able to maintain a watchman for the site. Between May and November 1992, when permission was finally granted to recommence the trials, plots remained unweeded.

Observations

Stand counts were made at approximately 1, 3, 6, 9 and 12 months. Plant height was measured from the base of the stem to the terminal node on 10 plants per plot (where available) at intervals of 30-45 days, except at the semi-arid site, where access was limited due to the political unrest. Leaf numbers were determined at the same time as plant height. Rainfall was recorded after each rain.

Soils samples were collected at the 0-20 cm depth from each plot and composite samples were pooled for each block. These were analyzed by the Soil Testing Laboratory at Auburn University. The Mississippi Extract (Lancaster, 1970), developed for high pH soils, was used for phosphorus (P) determination. Cations were extracted in 1N ammonium acetate, pH was determined in water and in KCl, total N was determined by the LECO CHN600 analyzer, organic C was determined by Walkley-Black and electrical conductivity was used to determine soluble salts. Particle sizes and water availability were also determined.

RESULTS

Soil Properties

Soils at the high elevation site were high in clay content, at the calcareous site were high in silt, and at the semi-arid and basaltic sites were high in silt and sand (Table 4). Moisture holding capacity followed texture, being highest at the high elevation site and lowest at the basaltic site. Not measured were the gravel and cobble content which probably approached 50 % at the semi-arid site, rendering it lower in moisture and nutrient holding capacity than the laboratory results might indicate.

Soil pH was neutral at the basaltic site and alkaline at the others (Table 4). Phosphorus and organic matter were very low at the basaltic site and high at the semi-arid site. The cation exchange capacity was high at all the sites. Calcium (Ca) content was very high. Magnesium (Mg) content was low at all except the basaltic site, potassium was low at all sites and sodium (Na) was relatively high at the basaltic site, as was the difference in pH

Table 4. Soil Properties at each site.

a. Chemical Properties

Site	pH	pH	Exchangeable P	Exchangeable Cations					Organic Matter	Total N	Soluble Salts
				Ca	Mg	K	Na	CEC			
	water	KCl	ppm	------ me/100 g -------					%	%	ppm
High elevation	8.1	7.0	10.4	43.5	0.9	0.4	0.1	44.8	4.4	0.48	249
Calcareous	8.0	7.5	11.1	24.5	0.9	0.1	0.1	25.7	4.3	0.43	427
Basaltic	7.1	5.2	2.9	27.4	11.1	0.1	0.3	38.8	2.1	0.21	182
Semi-arid	8.1	7.6	21.1	28.0	1.9	0.3	0.1	30.3	5.6	0.45	319

b.) Physical Properties

Site	Sand	Silt	Clay	Texture	Moisture Retention Properties	Electrical Conductivity
	%	%	%		cm/cm	mmhos/cm
High elevation	10.9	38.2	50.9	Clay	0.22	0.18
Calcareous	23.8	56.3	20.0	Silt Loam	0.19	0.31
Basaltic	43.4	34.1	22.5	Loam	0.14	0.13
Semi-arid	35.6	43.1	21.3	Loam	0.16	0.23

in water compared with the pH in KCl, also an indication of high salt content. Electrical conductivity was highest at the calcareous and semi-arid sites indicating higher soluble salts at these sites.

Rainfall

Rainfall gauges were installed only after establishment of the trials, so data is lacking concerning the first one to three weeks of the trial. However, rainfall was inadequate during this period at the high elevation and semi-arid sites and supplemental irrigation was required. Rainfall was generally erratic during the first months of the trial (Fig. 2-5) and irrigation was necessary during June and July, especially at the semi-arid and basaltic sites, but also at the other two sites. Total measured rainfall over the 10-month period, excluding the period before installation of the rain gauges, was 467 mm at the high elevation site, 918 mm at the calcareous site and 919 at the basaltic site (Tables A.1-A.3). At the high-elevation site, no rainfall measurements were taken during the first 24 days of the trial, while at the calcareous and basaltic sites rainfall data was not collected during the first nine and ten days of the trials, respectively. Rainfall data was available at the semi-arid site for only the last months of this reporting period (Table A.4).

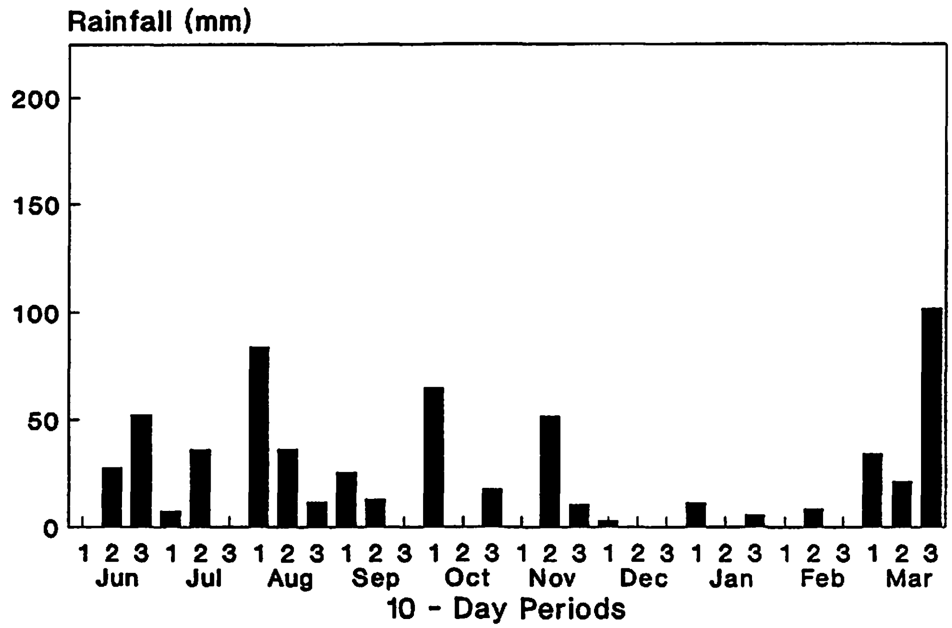


Fig. 2. Rainfall at High Elevation Site

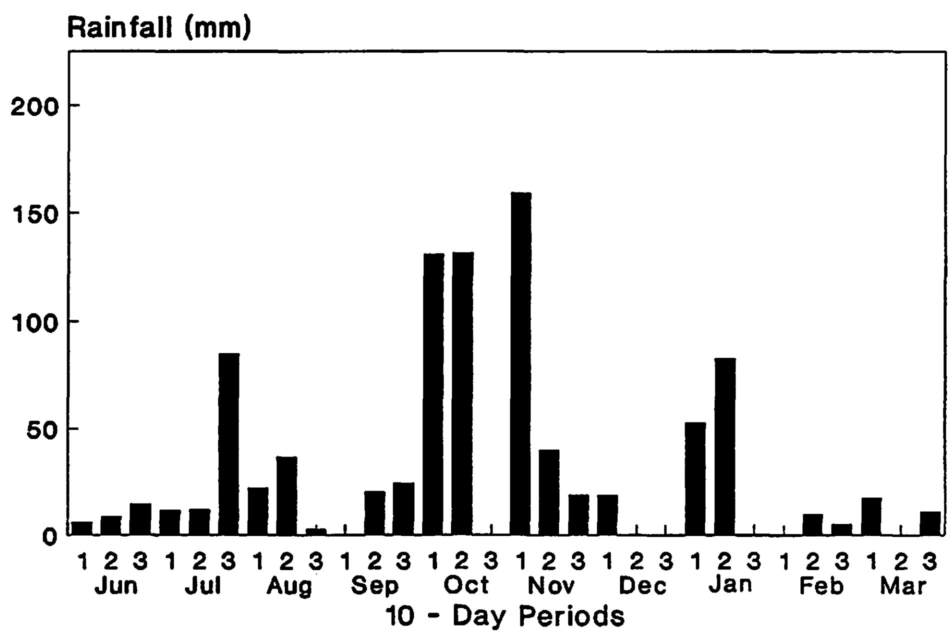


Fig. 3. Rainfall at Calcareous Site.

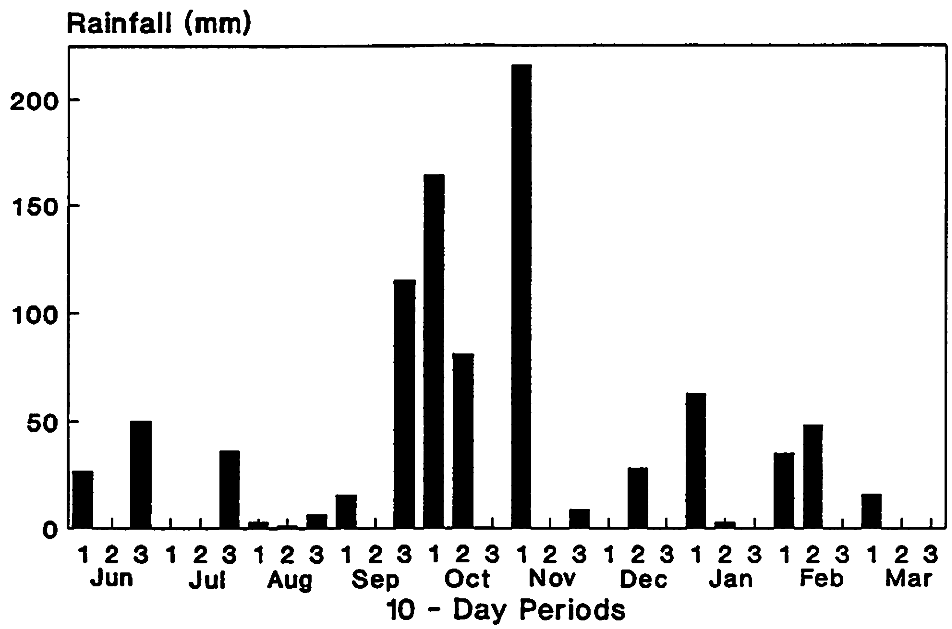


Fig. 4. Rainfall at Basaltic Site.

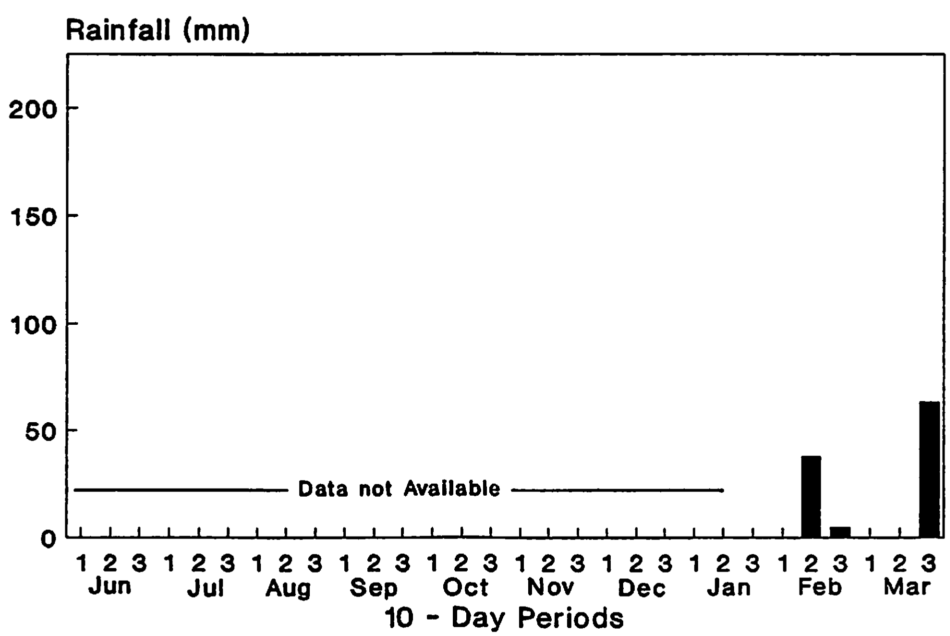


Fig. 5. Rainfall at Semi-arid Site.

Hedgerow Establishment

Emergence varied from excellent for some species to none for others (Tables 5-8), drought after planting being a major factor Figures 2-5). *Casuarina, Desmodium gyroides* and *Pseudoalbizia* did not emerge at the sites at which they were planted (Tables 5-8), *Grevillea* did not emerge at the basaltic site (Table 7) and only poorly at the high elevation site. Emergence was poor for all *Acacia* species except for *A. angustissima* at the high elevation site. At the high elevation site, *Mimosa, Erythrina poeppigiana, Albizia procera, Erythrina indica, Acacia mearnsii* and *Flemingia* had poor emergence.

Satisfactory emergence (≥ 75 % emergence) was obtained by four species at the calcareous site, and one species at the semi-arid site (Tables 5-8). No species emerged satisfactorily at the high elevation and basaltic sites. Satisfactory initial stands (≥ 90 %) were obtained with three species at the high elevation site, eight species at the calcareous site and two each at the basaltic and semi-arid sites. Soils at the latter two sites had poor water retention properties (Table 4). Fair initial stands (≥ 75 %) were obtained by an additional two, five, four and three species at the respective sites. The semi-arid site had a high percentage of cobbles and gravel, irregular rainfall, high temperatures and wind, all rendering it an extremely droughty site.

Higher stands for certain species at the 105 days after planting (DAP) or later reflect the additional plants obtained from reseeding and transplanting into the plots (Tables 5-8).

Table 5. Percent emergence and plant number as percent of hills planted, for hedgerow species at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Emergence 35 DAP[2]	Plants[1] 35 DAP	Plants[1] 114 DAP	Plants[1] 229 DAP	Plants[1] 348 DAP
		%	%	%	%	%
Leucaena leucocephala	K 636	60.5	91.5	97.1	97.3	96.6
Calliandra calothyrsus		66.8	94.7	97.7	100.5	94.2
Gliricidia sepium	HYB	57.7	86.8	93.0	85.1	92.7
Leucaena hybrid	KX3	46.3	94.3	98.2	89.9	90.8
Leucaena diversifolia	K 156	30.3	56.1	80.5	87.3	90.1
Casuarina cunninghamiana		0.0	3.0	6.5	91.2	84.8
Acacia angustissima		42.4	79.7	73.8	85.7	84.7
Flemingia macrophylla		24.2	41.3	56.7	82.6	84.7
Erythrina indica		22.6	66.4	87.5	74.7	52.4
Grevillea robusta		0.8	8.8	21.9	65.1	51.9
Albizia procera		12.3	41.5	61.0	42.8	43.8
Acacia melanoxylon		2.9	10.4	-1.2	40.8	36.6
Erythrina poeppigiana		13.5	28.1	28.6	27.9	25.2
Acacia mearnsii		22.1	59.5	43.3	23.9	16.8
Mimosa scabrella		9.4	31.1	28.8	26.7	16.4
Acacia decurrens		4.5	23.0	18.1	26.3	15.3
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		10.8	17.5	20.3	23.6	24.2
SE		3.8	4.3	5.0	5.8	6.0
CV %		29.0	21.2	22.5	22.3	24.5

1 Means adjusted for differences between blocks. [2] Days after planting.

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.

Table 6. Percent emergence and plant number as percent of hills planted for hedgerow species at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Emergence 40 DAP[1]	Plants 40 DAP	Plants 105 DAP	Plants 183 DAP	Plants 293 DAP
		%	%	%	%	%
Enterolobium cyclocarpum		71.8	98.5	99.0	97.0	99.0
Gliricidia sepium	HYB	80.4	96.9	98.0	97.0	98.0
Albizia lebbeck		23.0	71.9	71.9	95.0	96.4
Leucaena leucocephala	K 636	66.0	94.9	94.9	93.5	95.4
Erythrina indica		35.4	77.5	96.4	93.5	95.4
Albizia guachapele		73.5	97.4	96.9	93.0	94.9
Inga vera		100.0	96.4	96.9	91.5	93.4
Leucaena shannonii		76.6	93.9	89.3	89.0	90.8
Cassia siamea		36.7	84.7	94.4	88.5	90.3
Acacia angustissima		11.3	52.6	60.2	87.0	88.8
Leucaena hybrid	KX3	54.3	89.3	87.8	86.0	87.7
Delonix regia		31.1	78.6	86.2	86.0	87.7
Paraserianthes falcataria		21.5	61.2	49.5	84.5	86.2
Casuarina cunninghamiana		0.0	0.0	0.0	78.5	80.1
Leucaena diversifolia	K 156	41.8	79.1	77.0	68.0	69.4
Calliandra calothyrsus		74.9	94.9	87.8	67.0	68.4
Leucaena salvadorensis		71.8	95.4	90.3	56.5	57.6
Tephrosia candida		12.2	53.1	53.1	54.5	55.6
Desmodium gyroides		0.0	0.0	0.0	55.0	51.0
Erythrina poeppigiana		6.5	25.5	8.2	0.0	0.0
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		9.2	9.6	10.3	11.2	12.3
SE		3.3	3.4	3.6	4.0	4.3
CV %		14.7	9.4	10.1	10.1	10.9

[1] Days after planting.
*** = Significant at the 0.1 % level of probability.

Table 7. Percent emergence and plant number as a percentage of hills planted at the basaltic site at St Georges. Agroforestry Trial 1.

SPECIES	Variety	Emergence 41 DAP[1]	Plants 41 DAP	Plants 107 DAP	Plants 295 DAP
		%	%	%	%
Leucaena leucocephala	K636	69.0	91.8	89.8	91.8
Gliricidia sepium	HYB	62.3	88.8	87.2	86.7
Enterolobium cyclocarpum		61.5	90.3	87.2	85.7
Leucaena hybrid	KX3	41.7	89.8	87.8	74.0
Leucaena salvadorensis		64.0	87.8	76.0	72.4
Calliandra calothyrsus		39.0	72.9	68.9	63.3
Leucaena shannonii		52.4	76.5	65.8	61.2
Delonix regia		16.6	48.5	62.7	56.1
Leucaena diversifolia	K156	13.1	49.5	50.5	47.4
Cassia siamea		17.0	59.7	55.6	42.3
Flemingia macrophylla		8.5	27.0	20.9	16.8
Cassia emarginata		7.9	26.0	16.8	15.3
Acacia angustissima		1.8	7.1	11.2	9.7
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 $_{0.05}$		12.1	20.0	14.7	16.4
SE		4.3	7.0	5.2	5.8
CV %		30.0	27.6	21.2	25.5

[1]**Days after planting.**
***** = significant at the 0.1 % level of probability.**

Table 8. Percent emergence and plant number as a percentage of hills planted at the semi-arid site at TiTanyen. Agroforestry Trial 1.

SPECIES	Variety	Emergence 37 DAP[1]	Plants 45 DAP	Plants 108 DAP	Plants 366 DAP
		%	%	%	%
Leucaena leucocephala	K636	61.7	91.7	90.8	90.8
Leucaena leucocephala	Delin	70.0	86.7	89.2	90.8
Gliricidia sepium	HYB	53.8	83.3	78.3	78.3
Cassia emarginata		38.5	71.7	80.8	75.0
Acacia colei		63.5	73.3	79.2	59.2
Delonix regia		19.0	59.2	60.0	53.3
Albizia lebbeck		21.1	57.5	58.3	53.3
Leucaena diversifolia	K156	17.2	23.3	43.3	39.2
Acacia ampliceps		22.4	68.3	77.5	50.0
Enterolobium cyclocarpum		79.2	95.8	95.8	43.3
Albizia guachapele		43.5	69.2	56.7	31.7
Albizia procera		42.9	57.5	51.7	5.8
Acacia holosericea		40.5	68.3	50.8	18.3
Cassia siamea		23.8	64.2	60.0	8.3
Piptadenia peregrina		13.3	33.3	20.8	2.5
Acacia tumida		32.0	77.5	30.0	0.0
Casuarina cunninghamiana		0.0	0.0	0.0	0.0
Pseudoalbizia berteriana		0.0	0.0	0.0	0.0
Significance (F test)		***	***	***	***
$LSD_{0.05}$		15.2	20.9	27.0	24.3
SE		5.4	7.4	9.5	8.5
CV %		30.1	24.6	33.5	44.0

[1] Days after planting.
*** = Significant at the 0.1 % level of probability.

SURVIVAL

High elevation site

Survival after establishment was generally good (Table 5). The *Erythrina's* succumbed to a foliar disease that appeared at the beginning of the cool period following the second rainy season. Small grey spots first appeared on lower surfaces of leaves. These gradually spread to cover the entire leaf surface within 30 days. A whitish coating resembling fungal hyphae covered the leaves and upper stems. This was followed by desiccation and abscission of leaves, drying of the stems and finally death of the plants.

Acacia mearnsii, *Mimosa scabrella* and *A. decurrens*, which established poorly, also declined in population. After 11 months, stands were fair to good for half of the species in the trial.

Calcareous site

Erythrina poeppigiana completely died off within six months at this site (Table 6). A foliar disease with large brown spots was evident on the leaves. The spots, which covered half the leaf surfaces, were surrounded by yellow margins. The central veins became discolored shortly before premature abscission. This was followed by drying and death of the stems.

Early stand losses occurred in calliandra, *Paraserianthes*, *Leucaena salvadorensis* and *L. diversifolia*, but no further losses occurred between six and 10 months. Increased stands in other species resulted from seedling transplants. Final stands at about 10 months were acceptable for most species with the exceptions of

Desmodium gyroides, Tephrosia candida, and *L. salvadorensis.*

Basaltic site

Stand losses were recorded for KX3, *L. shannonii*, the two *Cassia's, Flemingia* and *A. angustissima* (Table 7). Final stands at 10 months were fair to satisfactory for K 636, gliricidia and *Enterolobium*. Stands were acceptable for KX3, *L. salvadorensis*, calliandra and *L. shannonii*. Stands were poor for the remaining species.

Semi-arid site

Between three months and one year, *Acacia tumida* completely disappeared from the plots (Table 8) and only a few plants remained of *Piptadenia, Albizia procera* and *Cassia siamea*. Large stand losses were also recorded for *Acacia holosericea, Albizia guachapele, Enterolobium, Acacia colei,* and *Acacia ampliceps*. Excellent survival was recorded for the two *L. leucocephala* varieties, gliricidia, *Cassia emarginata, Delonix,* and *Albizia lebbeck*. Final stands at 12 months were satisfactory for K 636 and Delin, and fair for gliricidia and *Cassia emarginata*. Stands of the remaining species were poor.

GROWTH

After emergence, larger seeded trees, such as *Enterolobium cyclocarpum, Delonix regia,* leucaena and *Erythrina* species (Table 3), produced taller seedlings (Tables 9, 11, 13, 15, A5), while small-seeded species like the acacias were short in stature and initially grew slowly. This was to a lesser extent also true of leaf number (Tables 10, 12, 14, 16, A6). Growth rates varied between species and between sites.

High Elevation Site

At the high elevation site, leucaena was tallest from the first measurement until the final measurement at ten months (Table 9, A1 and Figure 6). *Acacia angustissima*, which initially was among the shortest species, was second in height by 160 days, but did not increase in height between 191 and 301 DAP. It was surpassed in height by KX3 at 229 DAP. *L. diversifolia* ranked fourth. K 636 was significantly taller than all of the other varieties except KX3. There was no significant difference in height between KX3, *A. angustissima* and K 156.

Between 51 and 191 DAP, leucaena gained 8.0 mm/day, *A. angustissima* gained 5.6 mm/day, while the shortest tree, *Mimosa scabrella*, gained 1.9 mm/day (Table A1). Between 191 and 301 DAP, the same species gained 3.1, 0 and 0.2 mm/day.

Where leaf size of different species is similar, it provides some indication of relative growth. Where differences in leaf size are great, absolute leaf number is not a good means of comparison between species, but rate of increase remains a useful parameter.

Tree leaf number was generally highest for the tallest trees (Table 10), with the major exception of *Casuarina*, which had numerous small leaves but was among the shorter trees. More

Table 9. Tree height (adjusted[1]) at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	51	79	114	160	191	229	268	301
		Days after Planting							
		cm							
Leucaena leucocephala	K 636	7.1	15.0	34.3	73.1	110.8	112.1	128.3	143.7
Leucaena hybrid	KX3	5.6	10.7	19.8	46.3	80.1	88.5	104.7	115.2
Leucaena diversifolia	K 156	4.2	8.1	15.3	28.2	58.8	60.9	64.0	82.9
Acacia angustissima		2.0	5.5	17.3	47.6	83.2	80.0	84.3	78.8
Erythrina indica		6.8	11.0	17.7	32.2	46.8	45.8	50.9	55.9
Gliricidia sepium	HYB	5.0	9.1	14.2	25.3	33.6	31.9	30.8	32.4
Grevillea robusta		1.8	4.0	5.3	10.9	17.5	20.1	24.8	25.6
Albizia procera		2.7	3.9	7.5	12.2	18.3	18.5	20.6	24.7
Casuarina cunninghamiana		0.0	3.4	0.0	14.8	17.9	25.2	28.6	23.7
Acacia decurrens		0.7	2.5	4.8	15.9	19.0	18.6	20.7	-.[3]
Calliandra calothyrsus		3.2	4.7	7.4	11.5	14.8	20.1	17.7	20.2
Erythrina poeppigiana		5.0	7.2	9.8	16.0	17.2	18.4	18.6	19.9
Flemingia macrophylla		1.9	3.2	3.4	9.3	10.5	11.9	12.1	10.9
Acacia melanoxylon		-0.3	0.2	5.0	5.4	5.2	4.9	3.1	3.2
Acacia mearnsii		1.1	1.2	2.0	5.2	0.4	0.2	-0.5	-0.1
Mimosa scabrella		2.2	2.3	-0.2	-6.5	-10.1	-8.1	-10.9	-11.1
Significance (F test)		***	***	***	***	***	***	***	***
$LSD_{0.05}$		1.0	2.9	8.6	20.9	33.0	30.7	35.4	41.9
SE		0.2	0.7	2.1	5.1	8.0	7.5	8.6	12.8
CV %		14.4	30.0	46.0	55.7	56.3	49.6	52.1	56.3

[1] Means adjusted for differences between blocks. Actual means are presented in Table A9.
*** = significant at 0.1 % level of probability.

[2] Because of 3 missing plots, it was not possible to obtain a reliable estimate of adjusted height.

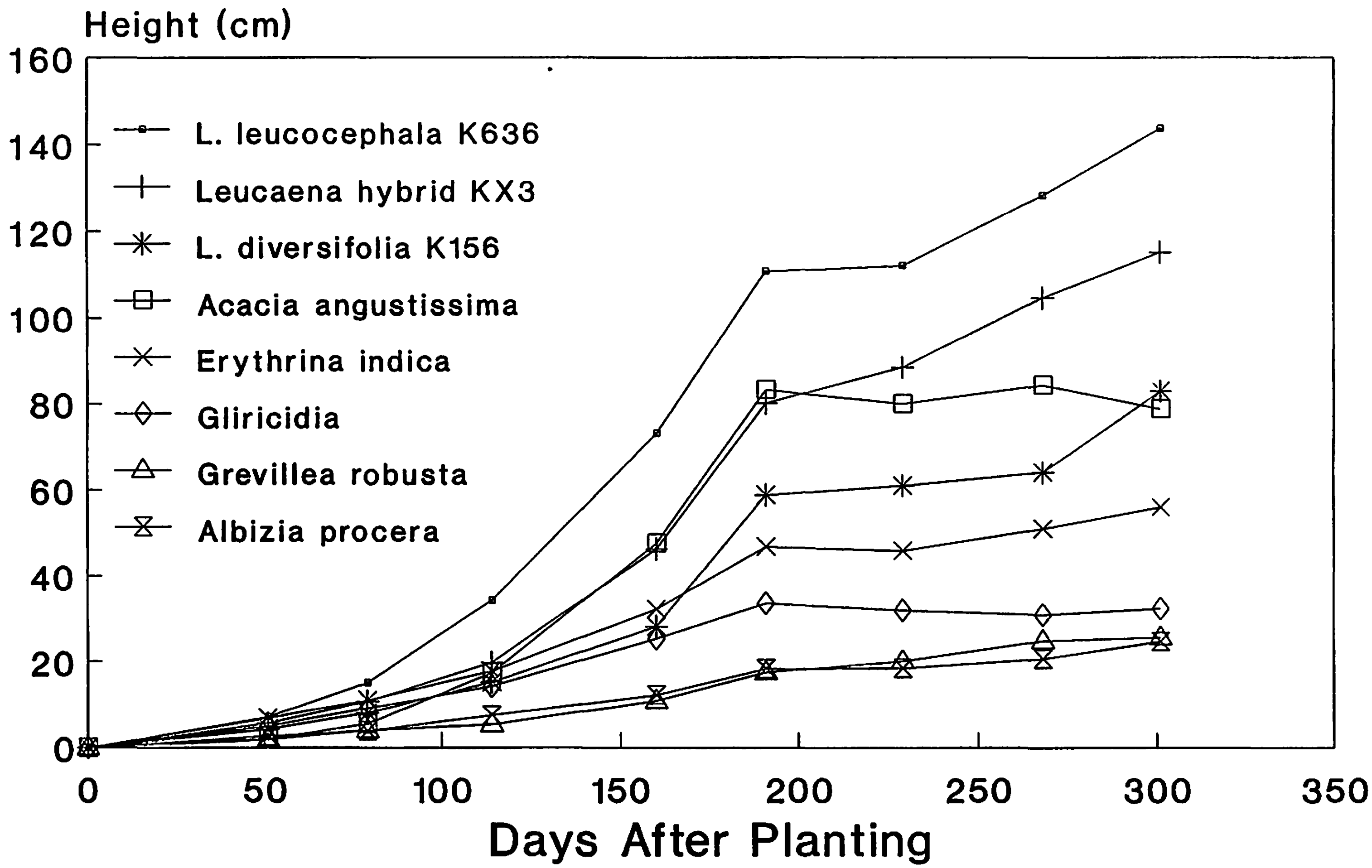


Figure 6. Growth of Trees at High
Elevation Site

Table 10. Leaf Number (adjusted[1]) at high elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting							
		51	79	114	160	191	229	268	301
Casuarina cunninghamiana		0.0	0.0	0.0	24.7	33.6	47.1	49.1	55.4
Leucaena leucocephala	K 636	6.3	9.9	14.2	21.4	25.5	26.0	29.3	33.5
Leucaena hybrid	KX3	7.0	10.0	12.4	18.7	22.6	22.3	20.2	24.9
Grevillea robusta		3.1	5.6	7.1	13.0	15.2	17.4	16.6	18.4
Acacia angustissima		5.4	7.9	11.5	19.5	29.6	26.6	20.5	14.5
Leucaena diversifolia	K 156	4.8	6.8	9.1	11.6	18.5	16.9	12.8	12.2
Albizia procera		5.9	7.7	8.7	10.8	11.3	8.1	6.1	7.5
Calliandra calothyrsus		5.6	8.2	7.9	8.8	8.7	7.9	6.1	5.0
Erythrina poeppigiana		4.3	5.2	5.7	7.1	6.7	3.7	1.9	2.0
Erythrina indica		6.6	7.9	10.5	11.6	12.5	6.7	5.5	4.6
Gliricidia sepium	HYB	7.2	11.0	14.4	19.2	23.4	17.7	6.9	4.2
Flemingia macrophylla		4.6	4.3	4.5	6.6	7.5	7.6	6.6	3.7
Mimosa scabrella		4.1	4.7	4.3	5.0	6.5	12.5	6.5	2.9
Acacia decurrens		2.8	4.0	4.3	6.6	5.7	5.7	5.1	-. [2]
Acacia mearnsii		3.7	4.8	4.8	5.9	4.4	2.2	2.2	0.1
Acacia melanoxylon		1.5	2.7	5.1	3.6	4.0	1.7	1.0	0.1
Significance (F test)		***	***	***	***	***	***	***	***
LSD $_{0.05}$		1.0	1.5	2.3	5.0	6.9	8.6	9.4	12.3
SE		0.3	0.4	0.6	1.2	1.7	2.1	2.3	3.0
CV %		9.6	13.4	16.5	24.2	26.8	34.7	41.8	52.9

[1] Means adjusted for differences between blocks

[2] Because of 3 missing plots, it was not possible to obtain a reliable estimate of adjusted leaf number.

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

importantly, the shortest trees added very few leaves during the 140 days between the first and fifth counts and several of the less adapted species had lost leaves by 301 DAP. These included *A. melanoxylon, A. mearnsii, Mimosa scabrella, Erythrina indica*, gliricidia, *Erythrina poeppigiana, Flemingia* and *Albizia procera*.

Calcareous site

Enterolobium was the tallest species following emergence but in less than 10 months, leucaena K 636 and KX3 were significantly taller than the other species (Table 11 and Figure 7). *L. shannonii* ranked third, followed by *L. diversifolia, Acacia angustissima* and *L. salvadorensis*. *Erythrina indica,* calliandra, and *Delonix* produced moderate growth. *Desmodium gyroides* failed to grow and *Erythrina poeppigiana* died out during the course of five months.

Initially, *Enterolobium* produced the most leaves, but growth was limited and in the end many leaves dropped (Table 12). After nearly 10 months, the most leaves were observed on *Casuarina*, followed by K 636, KX3, *Acacia angustissima*, and *Cassia*. Loss of leaves was recorded for most species, probably due to the effects of the dry season or the physiological cycle of the plants, but the loss appeared to be important for the *Albizia's, Paraserianthes, Inga vera, Enterolobium* and gliricidia. In the case of gliricidia, a severe attack by defoliating insects was responsible for much of the leaf loss and probably affected growth at this site.

Table 11. Tree height at calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting 40	70	105	152	183	217	250	293
		-----------	-----------	-----------	cm	-----------	-----------	-----------	-----------
Leucaena leucocephala	K 636	9.9	17.5	37.5	65.7	93.7	114.3	140.0	172.9
Leucaena hybrid	KX3	6.9	10.6	21.9	47.8	76.2	105.1	135.0	161.5
Leucaena shannonii		7.8	13.4	28.0	48.9	73.5	78.8	97.3	118.6
Leucaena diversifolia	K 156	4.1	7.0	11.5	27.0	47.6	73.1	81.6	86.5
Acacia angustissima		1.7	3.0	5.2	16.5	39.9	46.1	62.6	75.2
Leucaena salvadorensis		12.0	15.7	21.5	29.8	37.1	56.9	56.9	58.3
Erythrina indica		9.4	15.5	20.6	29.7	45.2	44.3	59.8	57.4
Calliandra calothyrsus		3.5	4.2	6.3	16.3	34.7	43.5	53.7	56.8
Delonix regia		8.1	9.5	18.5	34.2	43.9	45.5	62.2	55.1
Cassia siamea		4.4	7.7	12.2	23.2	33.9	37.3	50.4	50.8
Enterolobium cyclocarpum		17.9	22.3	29.9	42.0	44.9	46.4	52.3	46.6
Tephrosia candida		5.4	7.0	8.8	12.1	19.1	23.7	34.7	39.5
Albizia guachapele		8.4	10.6	14.4	22.1	28.7	27.8	36.3	37.9
Gliricidia sepium	HYB	8.9	12.8	18.1	31.6	35.7	37.5	39.6	35.8
Casuarina cunninghamiana++		.	.	.	13.5	21.0	23.0	31.4	30.5
Albizia lebbeck		6.5	9.1	12.5	19.7	23.6	26.8	28.2	27.7
Paraserianthes falcataria		1.6	1.8	2.7	5.7	9.0	14.0	23.0	25.4
Inga vera		9.6	10.7	12.9	15.1	17.1	19.6	23.5	23.7
Desmodium gyroides++		.	.	.	9.7	12.2	14.3	13.5	14.6
Erythrina poeppigiana++		4.8#	5.0	5.6	.	.	.	.	.
Significance (F test)		***	***	***	***	***	***	***	***
$LSD_{0.05}$		1.2	2.1	5.6	12.5	19.3	16.5	26.5	28.0
SE		0.4	0.7	2.0	4.4	6.8	5.8	9.3	9.9
CV %		11.3	14.4	24.6	32.9	35.1	25.2	32.8	32.0

*** = significant at 0.1 % level of probability.
++ "." indicates no plants. Not included in analysis.
# Mean of 2 plots, adjusted for missing plots.

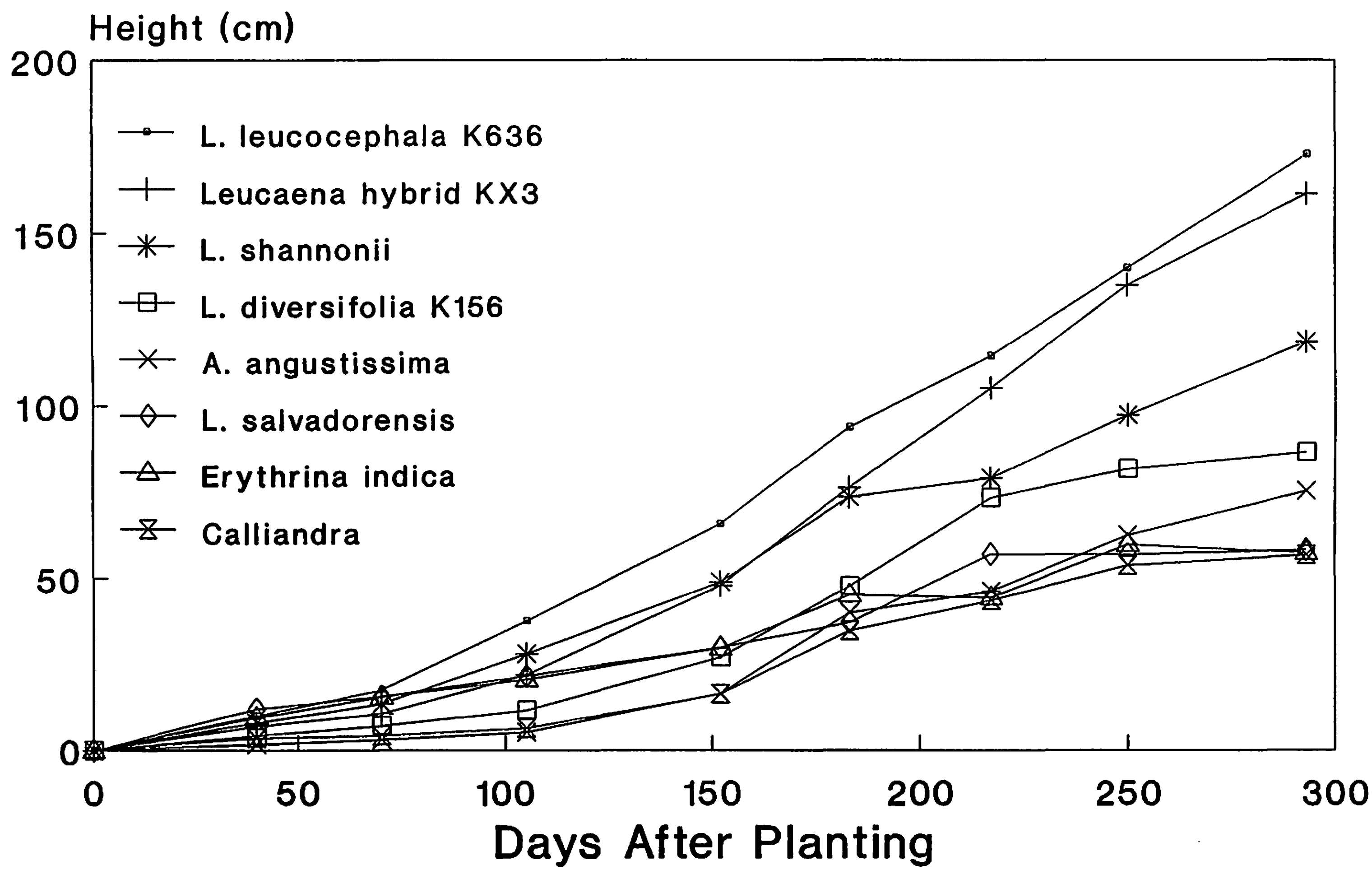


Figure 7. Growth of Trees at Low Elevation, Calcareous Site

Table 12. Leaf number at the calcareous site at Bergeau. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting 40	70	105	152	183	217	250	293
		#	#	#	#	#	#	#	#
Casuarina cunninghamiana++		.	.	.	20.8	28.7	33.2	35.1	63.9
Leucaena leucocephala	K 636	6.9	9.0	11.6	16.8	26.1	31.7	33.0	31.3
Leucaena hybrid	KX3	6.5	8.3	10.5	16.1	24.2	32.5	35.1	30.7
Acacia angustissima		5.7	5.2	7.3	14.1	23.6	25.3	31.0	28.3
Cassia siamea		6.9	8.6	13.5	20.5	27.6	27.2	33.8	27.3
Leucaena shannonii		6.3	7.5	10.0	15.0	20.6	25.3	27.1	22.7
Erythrina indica		7.6	11.1	13.1	18.0	24.2	20.8	26.2	21.3
Leucaena diversifolia	K 156	6.1	6.2	7.1	12.4	17.8	25.8	24.8	20.6
Leucaena salvadorensis		5.6	7.2	8.1	12.7	15.5	20.2	23.5	16.8
Desmodium gyroides++		.	.	.	20.9	24.0	25.6	21.0	16.5
Calliandra calothyrsus		5.9	6.2	7.3	11.6	16.7	22.0	25.6	15.6
Gliricidia sepium	HYB	7.3	9.3	11.5	20.3	22.6	24.0	22.2	12.9
Delonix regia		7.5	9.7	11.3	13.2	14.6	10.9	14.9	10.1
Tephrosia candida		6.4	4.9	5.2	6.4	9.8	10.1	14.4	10.1
Albizia guachapele		6.1	8.1	8.9	12.9	14.1	13.7	18.1	9.8
Enterolobium cyclocarpum		8.6	11.4	13.2	15.7	18.3	15.8	17.1	9.3
Inga vera		4.2	5.8	7.5	10.7	12.5	13.4	16.0	7.8
Paraserianthes falcataria		5.2	5.5	5.5	9.1	10.8	13.2	13.3	7.4
Albizia lebbeck		6.8	8.3	10.0	13.8	15.4	14.9	12.1	5.0
Erythrina poeppigiana++		4.6#	4.6	3.5	.	.	.	.	.
Significance (F test)		***	***	***	***	***	***	***	***
LSD $_{0.05}$		0.7	1.2	1.8	3.0	4.6	5.2	6.8	5.6
SE		0.2	0.4	0.6	1.0	1.6	1.8	2.4	2.0
CV %		7.4	10.7	14.1	14.1	16.9	17.2	20.5	20.3

*** = significant at the 0.1 % level of probability.
++ "." indicates no plants. Not included in analysis.
# Mean of two plots, adjusted for missing plots.

Basaltic site

Following emergence, *Enterolobium* was the tallest species, followed by *L. salvadorensis* (Table 13). At about 10 months after planting, leucaena K 636 and KX3 were tallest (Table 13 and Figure 8). These were followed by calliandra, the three remaining *Leucaena* species and *A. angustissima*.

Leaf numbers were initially highest on *Enterolobium*, gliricidia and K 636 (Table 14). At almost 10 months after planting, highest leaf numbers were observed on *Acacia angustissima* and the *Leucaena* species. Loss of leaves was only important on *Enterolobium*.

Semi-arid site

Following emergence, the tallest plants at the semi-arid site were *Enterolobium*, followed by leucaena K 636 (Table 15 and Figure 9). After three months, K 636 and *Enterolobium* were tallest. At one year, K 636 had twice the height of the next-ranked variety. There was no difference in height between the wild leucaena (Delin), *Enterolobium* and gliricidia. The *Acacia's* grew extremely slowly during the first three months. After one year, *A. ampliceps*, the tallest acacia, measured only 21 cm.

The most leaves were initially observed on *Enterolobium* and K 636 (Table 16). After one year, *Cassia emarginata*, leucaena variety Delin, *Acacia ampliceps* and K 636 had the most leaves, followed by gliricidia. *Enterolobium had the same number of leaves*

Table 13. Tree height at the basaltic site at St Georges. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting 42	72	107	186[†]	295
		----------------		cm		----------------
Leucaena leucocephala	K636	9.6	16.6	27.3	68.4	89.5
Leucaena hybrid	KX3	5.3	8.4	11.7	30.4	63.6
Calliandra calothyrsus		3.1	4.4	7.2	29.1	47.4
Leucaena salvadorensis		11.1	16.7	21.3	31.7[§]	47.0
Leucaena shannonii		5.7	10.5	15.5	24.4[§]	46.7
Leucaena diversifolia	K156	3.2[§]	4.6	6.6	4.0[¶]	45.2
Acacia angustissima[++]		1.4[§]	2.1[§]	3.7[§]	.	36.8
Gliricidia sepium	HYB	9.6	15.2	19.5	31.4	32.2
Enterolobium cyclocarpum		22.1	26.2	30.2	31.7	31.9
Flemingia macrophylla[++]		2.0[§]	3.4[§]	5.4[§]	.	19.4[§]
Cassia siamea		2.3	4.7	7.6	8.0[#]	16.2
Delonix regia		7.2	8.1	9.6	4.7[§]	10.5
Cassia emarginata		1.7	3.0	3.7	.	7.2
Casuarina cunninghamiana[++]		.	.	.	.	.
Desmodium gyroides[++]		.	.	.	.	.
Grevillea robusta[++]		.	.	.	.	.
Significance (F test)		***	***	***	**	***
$LSD_{0.05}$		1.4	3.2	6.2	23.8	29.0
SE		0.5	1.1	2.2	8.0	10.2
CV %		13.5	22.6	32.6	49.2	53.1

[++] "." indicates no plants. Not included in analysis.
, * = significant at the 1 % and 0.1 % levels of probability, respectively.

[†] Because of constraints caused by the embargo, it was not possible to measure all plots.

[§] Observations obtained from 3 plots. Mean adjusted for missing plot.
[#] Observations obtained from 2 plots. Mean adjusted for missing plots.
[¶] Observation obtained from 1 plot. Value adjusted for missing plots.

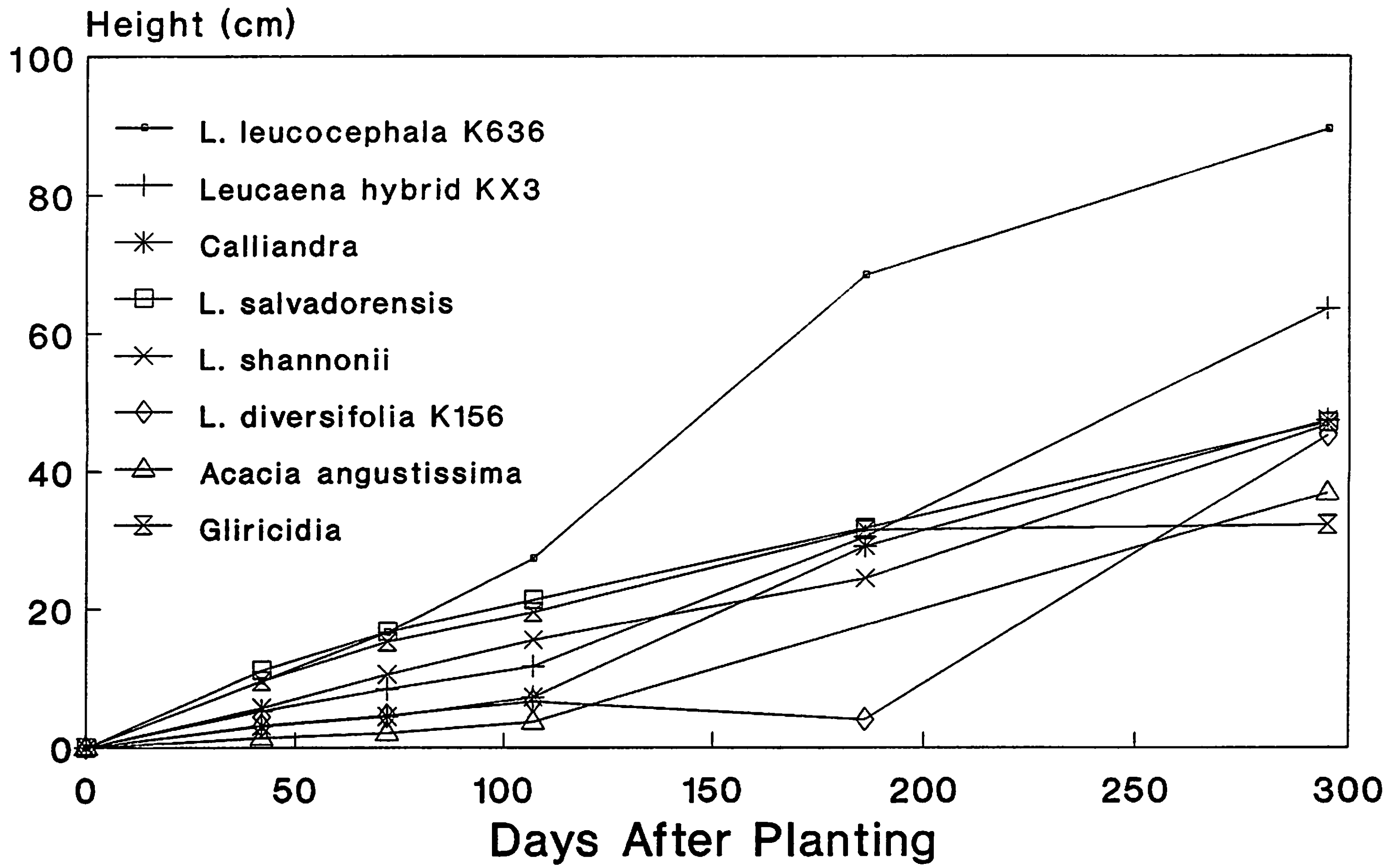


Figure 8. Growth of Trees at Low Elevation, Basaltic Site

Table 14. Leaf number at basaltic site at St. Georges. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting 42	72	107	186[†]	295
		#	#	#	#	#
Acacia angustissima[++]		4.8[§]	5.0[§]	5.1[§]	.	25.4[§]
Leucaena leucocephala	K636	7.3	7.9	9.4	17.7	21.1
Leucaena hybrid	KX3	6.7	6.2	6.8	15.0	20.7
Leucaena salvadorensis		5.4	6.8	8.2	12.5[§]	18.6
Leucaena shannonii		5.3	6.4	6.6	11.3[§]	16.9
Calliandra calothyrsus		5.4	6.8	7.8	15.4[§]	15.9
Cassia siamea		5.2	6.3	9.3	16.3[#]	15.8
Leucaena diversifolia	K156	6.3[§]	4.7	6.1	13.1[¶]	15.2
Gliricidia sepium	HYB	7.6	9.3	10.6	17.4	13.0
Cassia emarginata[++]		4.5	5.0	5.7	.	9.1[§]
Flemingia macrophylla[++]		5.2[§]	4.4[§]	4.4[§]	.	7.5[§]
Delonix regia		6.5	5.9	6.3	5.5[§]	5.9
Enterolobium cyclocarpum		8.1	9.6	8.0	7.7	4.6
Casuarina cunninghamiana[++]		.	.	.	.	.
Desmodium gyroides[++]		.	.	.	.	.
Grevillea robusta[++]		.	.	.	.	.
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		1.0	1.5	2.3	4.4	7.7
SE		0.3	0.5	0.8	1.5	2.7
CV %		11.0	15.3	21.5	21.9	35.7

++ "." indicates no plants. Not included in analysis.
*** = significant at the 0.1 % level of probability.

[†] Because of constraints caused by the embargo, it was not possible to measure all plots.

[§] Observations obtained from 3 plots. Mean adjusted for missing plot.
[#] Observations obtained from 2 plots. Mean adjusted for missing plots.
[¶] Observation obtained from 1 plot. Value adjusted for missing plots.

Table 15. Tree height at the semi-arid site at Titanyen. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting			
		45	72	108	366
		cm	cm	cm	cm
Leucaena leucocephala	K 636	11.6	20.2	28.5	106.1
Leucaena leucocephala	Delin	6.9	10.9	15.2	47.8
Enterolobium cyclocarpum		18.3	21.5	25.8	43.6
Gliricidia sepium	HYB	8.7	13.0	19.8	38.1
Leucaena diversifolia	K156	4.4	6.1[§]	8.2	32.7[§]
Cassia emarginata		4.6	7.5	12.4	26.5
Albizia lebbeck		7.6	10.3	11.6	23.5
Delonix regia		8.1	9.5	10.6	21.5
Acacia ampliceps		3.2	4.6	5.9	21.0
Cassia siamea		4.0	6.0	9.1	19.4[§]
Piptadenia peregrina		4.9	5.0	7.3[§]	19.4[¶]
Albizia guachapele		6.3	6.6	8.4	14.5
Albizia procera		4.5	4.9	6.4	13.2[¶]
Acacia colei		2.7	3.1	4.4	10.6
Acacia holosericea		2.3	2.2	3.1	7.5
Acacia tumida[++]		1.6	1.5	2.0	.
Casuarina cunninghamiana[++]		.	.	.	.
Pseudoalbizia berteriana[++]		.	.	.	.
Significance (F test)		***	***	***	***
$LSD_{0.05}$		1.0	2.4	4.4	13.9
SE		0.4	0.9	1.5	4.8
CV %		11.7	20.5	27.6	31.1

++ "." indicates no plants. Not included in analysis.
*** = significant at the 0.5% level of probability.

§ Observations obtained from 3 plots. Mean adjusted for missing plot.
# Observations obtained from 2 plots. Mean adjusted for missing plots.
¶ Observation obtained from 1 plot. Value adjusted for missing plots.

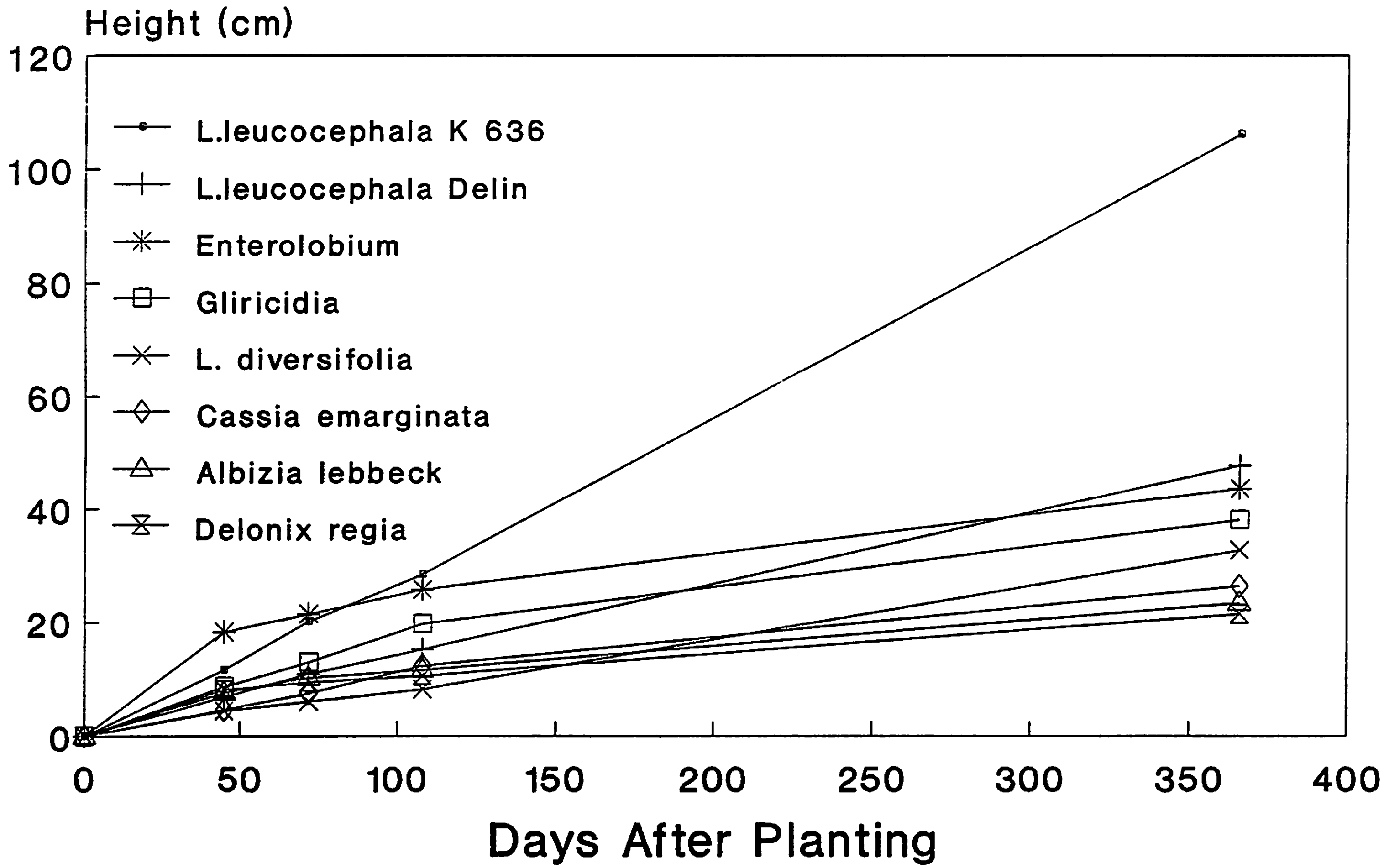


Figure 9. Growth of Trees at Low Elevation, Semi-Arid Site

Table 16. Leaf number at the semi-arid site at Titanyen. Agroforestry Trial 1.

SPECIES	Variety	Days after Planting 45	72	108	366
		#	#	#	#
Cassia emarginata		6.8	8.4	10.4	21.6
Leucaena leucocephala	Delin	8.1	9.6	10.2	18.9
Acacia ampliceps		4.8	6.7	6.9	18.4
Leucaena leucocephala	K 636	9.2	10.9	10.9	17.9
Gliricidia sepium	HYB	7.5	9.1	10.5	15.1
Leucaena leucocephala	K 156	5.7	7.3	6.6	10.9[§]
Enterolobium cyclocarpum		10.1	10.4	9.1	10.1
Cassia siamea		5.1	8.7	9.6	9.6[§]
Acacia colei		3.8	4.5	4.6	9.0
Delonix regia		7.4	6.9	5.9	7.4
Albizia lebbeck		7.0	8.4	7.9	7.3
Albizia procera		5.5	5.5	4.0	6.7[¶]
Acacia holosericea		3.6	4.2	3.8	6.6
Piptadenia peregrina		4.5	5.5	5.3[§]	5.8[¶]
Albizia guachapele		5.3	5.5	4.4	5.2
Acacia tumida[++]		3.8	3.0	2.6	.
Casuarina cunninghamiana[++]		.	.	.	.
Pseudoalbizia berteriana[++]		.	.	.	.
Significance (F test)		***	***	***	***
$LSD_{0.05}$		1.4	1.7	2.4	6.3
SE		0.5	0.6	0.9	2.2
CV %		16.1	17.0	24.1	36.9

++ "." indicates absence of plants. Not included in analysis.
*** = significant at the 0.5 % level of probability.

§ Observations obtained from 3 plots. Mean adjusted for missing plot.
# Observations obtained from 2 plots. Mean adjusted for missing plots.
¶ Observation obtained from 1 plot. Value adjusted for missing plots.

at one year as it did at 45 DAP. Little increase in leaf numbers was observed in the other *Acacia's*, *Albizia's* and *Piptadenia*.

DISCUSSION

ESTABLISHMENT

Suitability for direct seeding in the field is an important criterium in assessing the suitability of hedgerow species for alley cropping. Transplanting, though resulting in stronger, more vigorous seedlings, is impractical because it significantly increases the labor requirement and requires more sophisticated management. Reproduction by cuttings does not require much sophistication, but is more labor intensive than direct seeding and renders dissemination of the species costly and inefficient. Trees reproduced by cuttings also tend to have a more shallow root system.

Suitability of a species for direct seeding is more difficult to assess in a single trial, because emergence is affected by the age and condition of the seed, the management (e.g. seed treatment, seeding depth) and by the environmental conditions at the time of the trial. Nevertheless, some conclusions can be reached from this trial.

In general, greater problems occurred in obtaining satisfactory stands from direct seeding of small-seeded species as compared to larger-seeded species, despite efforts to place small seeds in shallow pockets. Shallow seeding exposed the seed more quickly to drought, which was experienced at all sites, and manual irrigation was not adequate to compensate for the rapid drying of the soil. *Casuarina* had particularly small seed, comparable in size to carrot, and was particularly susceptible to drying out of the soil surface and to removal by ants. Similarly, poor initial stands were achieved with the *Acacia* species with the exception of *Acacia angustissima* at the high elevation site and *A. colei* at the semi-arid site.

Grevillea germinated poorly or not at all (Tables 5-8), despite the use of refrigeration and sealed plastic bags to maintain seed viability. This species is unsuited to direct seeding.

Inga vera had the best emergence of any species (Table 6), but, as with *Grevillea*, the seed remains viable for only 1-2 months. The seed used in this trial was newly harvested. The short period of seed viability limits the period in which the farmer can establish the hedgerows. The need to collect, store and distribute the seed in a timely fashion would make it difficult for the PLUS Project to utilize this species on a large scale.

Because of late planting and early commencement of the dry season, establishment conditions were not ideal, making irrigation necessary in order to insure satisfactory stands. Without satisfactory stands, it is virtually impossible to distinguish between species for biomass production. Under normal conditions, the hedgerows would be planted with the crops at beginning of the rainy season, thus ensuring that the plants were taller and deeper rooted at the beginning of the dry season. Nevertheless, the tree seedlings must be able to withstand some drought during establishment due to the irregularity of rainfall at many locations in Haiti.

Given the extremely droughty conditions at the semi-arid site, direct seeding should not be recommended. While we did obtain acceptable stands of several species, this would have not been possible without irrigation. Because of the dry conditions, the population of *Rhizobium*, which is necessary for nitrogen fixation and good growth by leguminous trees, was probably at a low level in the surface soil.

For seedling establishment by direct seeding, the leucaena species, calliandra, gliricidia, *Enterolobium* and *Acacia colei* appeared to be among the best (Table 5-8).

SURVIVAL

Survival, together with data on growth, is an important indicator of adaptation to a given environment. Good to excellent survival of established stands was observed under the high elevation conditions of Ft. Jacques for most species (Table 5), except for the *Erythrina's*, *A. decurrens,* and *A. mearnsii*. Good to excellent survival was observed for most species at the high rainfall, calcareous site at Bergeau (Table 6) except for *Erythrina poeppigiana, L. salvadorensis* and calliandra. At the basaltic site at St. Georges (Table 7), K 636 and gliricidia survived well, whereas significant losses were recorded for *Cassia emarginata,* and *Flemingia*. K 636 and Delin had excellent survival at the semi-arid site at Titanyen (Table 8), whereas significant losses were recorded for *Acacia tumida, Cassia siamea, Piptadenia, A. holosericea,* the *Albizia's* and *Enterolobium.*

These assessments must be qualified by the knowledge that the seedlings experienced harsher conditions than would normally be the case under farmer conditions, where the hedgerows would probably be planted soon after the crop, perhaps at the time of first weeding.

GROWTH

Leucaena variety K 636 was unsurpassed for first-year growth at any of the sites (Tables 9-12), including the two at which it was least expected to excel, the high elevation site and the semi-arid site. The superior performance of leucaena under the cool winter temperatures of the high elevation site, the extremely droughty, hot conditions of the semi-arid site and the humid warm conditions of the calcareous and basaltic sites demonstrate the wide adaptation of this species.

<u>High Elevation Site</u>

Excellent growth was obtained with all of the *Leucaena's* as well as *Acacia angustissima* (Table 9). The *Erythrina's* grew satisfactorily initially but were affected by disease. Gliricidia appeared to grow satisfactorily during the warm part of the year, but was badly stunted during the cool winter months.

Calcareous Site

The leucaena species and *Acacia angustissima* clearly grew the best at this site (Table 11), while *Erythrina poeppigiana, Desmodium gyroides, Paraserianthes, Albizia lebbeck* and *Casuarina cunninghamiana* did not grow satisfactorily at this site. Lack of weeding during the period of project suspension may have played a role in the poor growth of some species at this site.

Basaltic Site

Leucaena varieties K 636 and KX3 clearly grew the best at this site (Table 13). Calliandra and the remaining *Leucaena* species also grew well. *The Cassia's*, *Delonix* and *Flemingia* did not grow well during this period, but were probably badly affected by dense growth of the surrounding grasses, due to the lack of weeding during the suspension of the project.

Semi-arid Site

At the semi-arid site, growth of leucaena was strikingly superior to all the other species (Figure 9). This demonstrates that leucaena is quite tolerant to drought. Vertical orientation of leaflets, evidence of drought stress, was particular apparent on *Enterolobium, Piptadenia* and the *Albizia's* by 9:00 AM. The fact that many species grew at all under the highly stressed conditions at Titanyen, with irrigations suspended before most tree species had attained suitable size and the lack of maintenance following September 1991, is in itself encouraging. Under the comparatively more favorable conditions of the Northwest, these species should survive better and grow much more vigorously.

Under the extreme conditions of Titanyen, alley cropping may not be a viable system under rainfed conditions. Transplanting may be necessary here, and competition with crops for scarce water might be a problem. Agroforestry systems involving wind breaks, partial shade and the use of trees which shed their leaves during the cropping season, such as *Acacia albida (Faidherbia albida)*, found in the Sahel of Africa (BOSTID, 1979), may be more appropriate.

COMPARISON OF SPECIES PERFORMANCE ACROSS SITES

Figures 10 - 19 compare growth of individual species across sites. Leucaena variety K 636 grew extremely well at the high elevation and calcareous sites (Figure 10), but less well at the basaltic and semi-arid sites. The same was observed with *Leucaena* hybrid KX3 (Figure 11) and *Acacia angustissima* (Figure 12), although they were not planted at the semi-arid site, and with *Leucaena diversifolia* K 156 (Figure 13). The poorer performance at the latter two sites may be attributed primarily to low soil fertility, especially of N and P, and drought, respectively (Table 4 and Figures 4 & 5), although both factors were limiting at each site. A combination of growth data, soil analyses and rainfall data suggest that the calcareous and high elevation sites have greater productive potential than the semi-arid and basaltic sites.

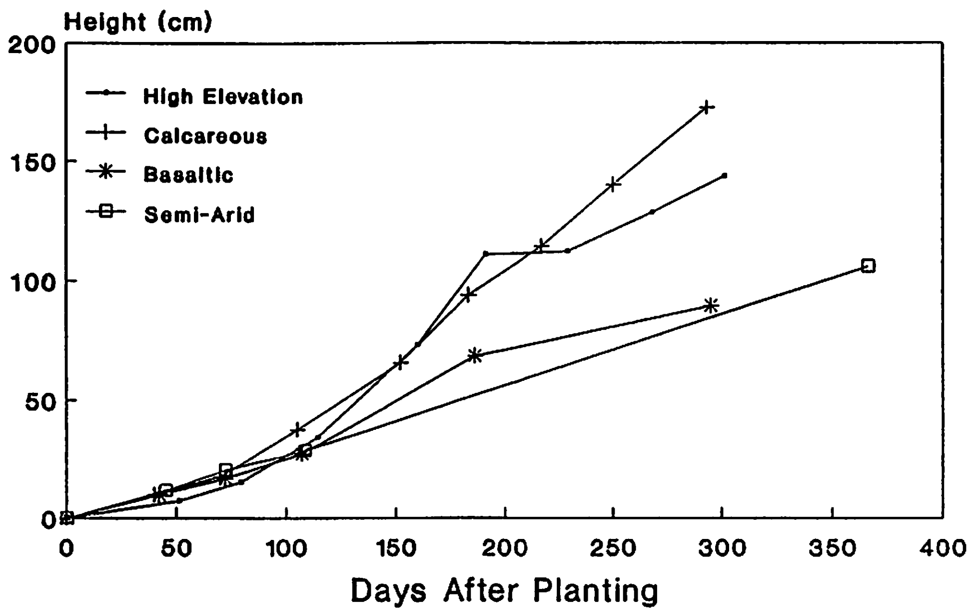


Figure 10. Growth of leucaena variety K 636 in four agro-ecological zones

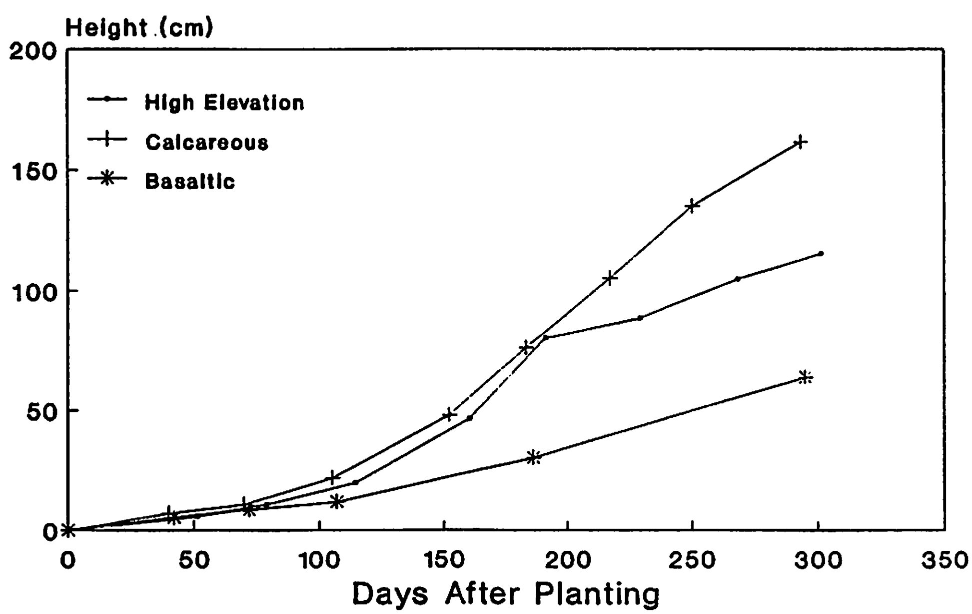


Figure 11. Growth of Leucaena hybrid KX3 in three agro-ecological zones.

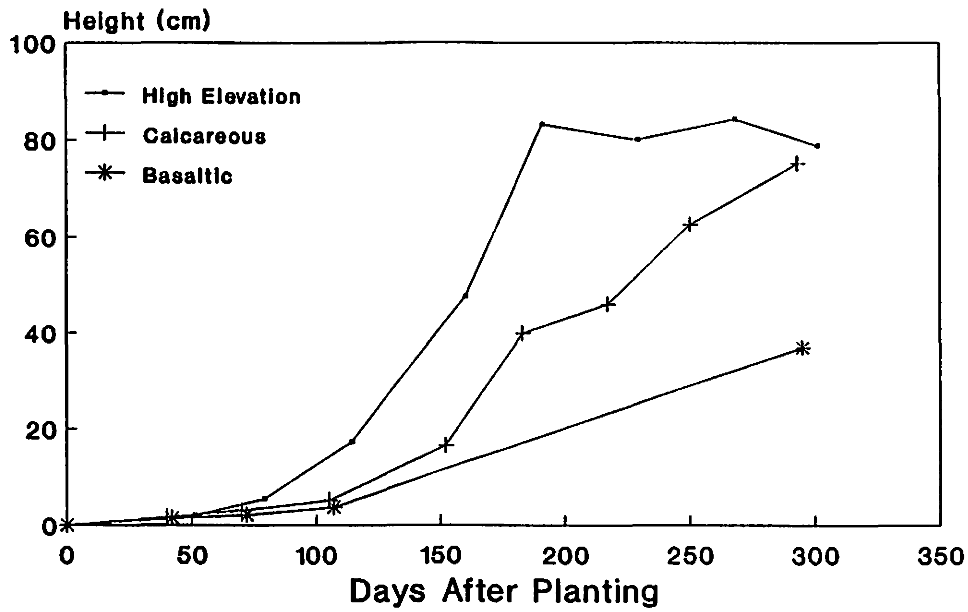


Figure 12. Growth of Acacia angustissima in three agro-ecological zones.

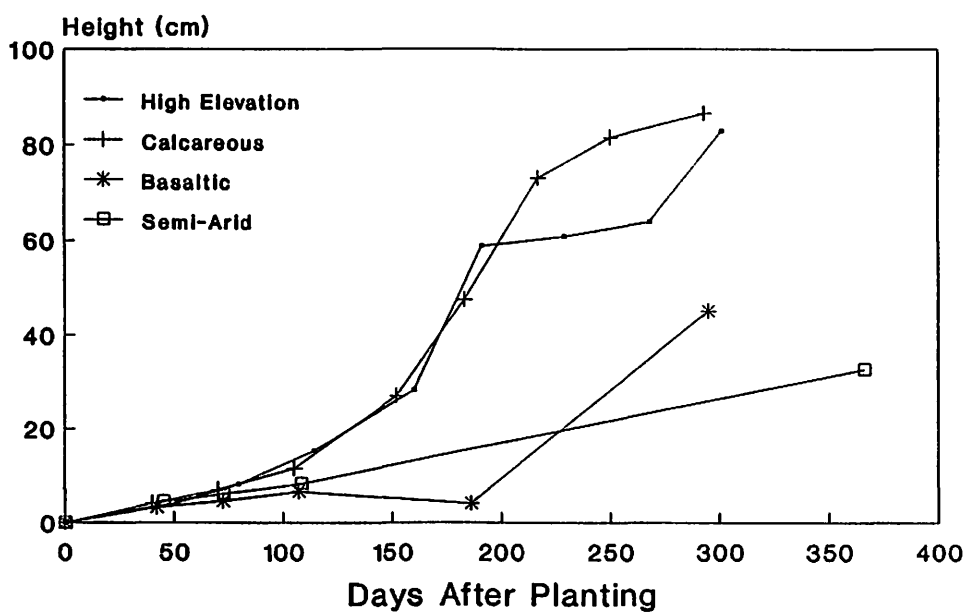


Figure 13. Growth of Leucaena Variety K 156 in Four Agro-ecological Zones

The least difference in performance across sites was with gliricidia (Figure 14). This may be attributed to the lack of cold tolerance, resulting in lack of growth during the winter months at the high elevation site and a susceptibility to foliar insect attack at the calcareous site, resulting in a cessation of growth during the winter dry season. Prior to the last measurement, it appeared that the best growth was occurring at the calcareous site.

At 10 months, growth of K 636, KX3, K 156 and calliandra appeared greater at the calcareous site than at the high elevation site (Figures 10, 11, 13, 15). Temperature and rainfall would appear to be more favorable at the calcareous site than at the high elevation site. The opposite was true for *Acacia angustissima* (Figure 12), which seemed to perform better at the high elevation site, at least during the first six months. One can only speculate as to the cause. The period during which this species did not grow at the high elevation site corresponds to the cool winter months.

Leucaena leucocephala grew equally well at both the basaltic and semi-arid sites, as did *Cassia siamea* (Figure 10 and 16). On the other hand, *L. diversifolia* performed poorer at the semi-arid site than at the basaltic site (Figure 13). This may indicate lower drought tolerance in *L. diversifolia*. Temperatures would also be more favorable at the basaltic site than at the semi-arid site.

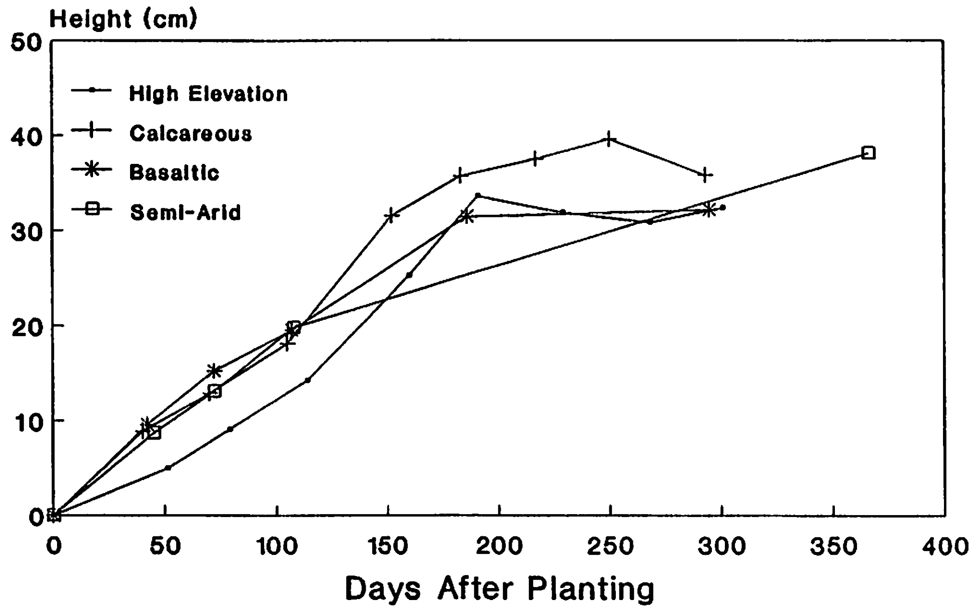


Figure 14. Growth of Gliricidia sepium in four agro-ecological zones

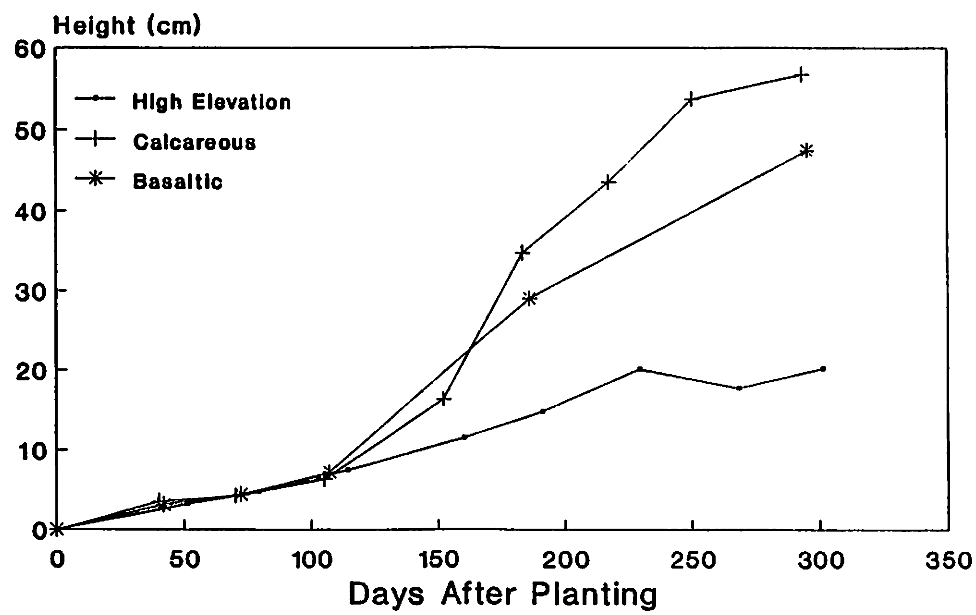


Figure 15. Growth of Calliandra callothyrsus in three agro-ecological zones.

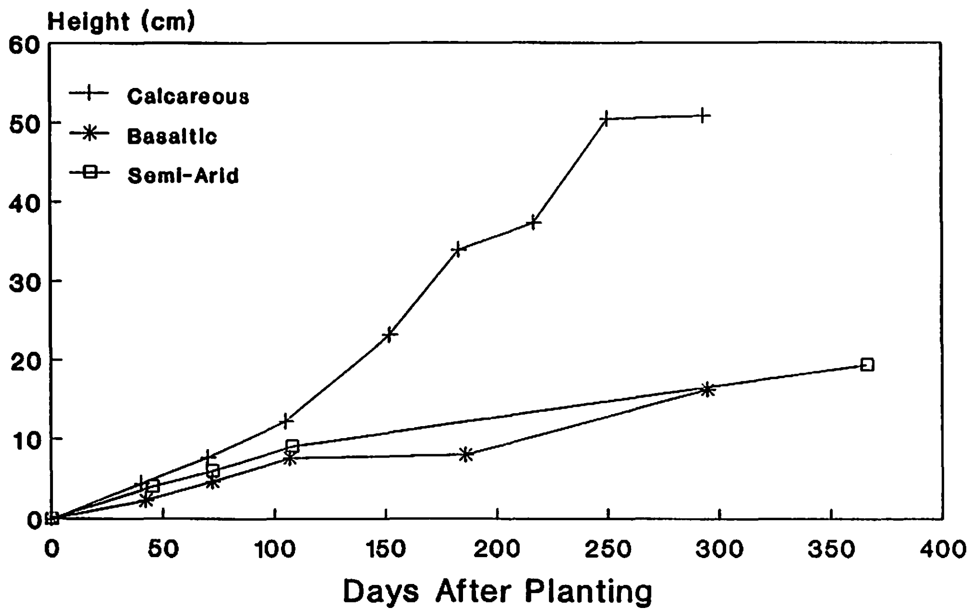


Figure 16. Growth of Cassia siamea
in three agro-ecological zones

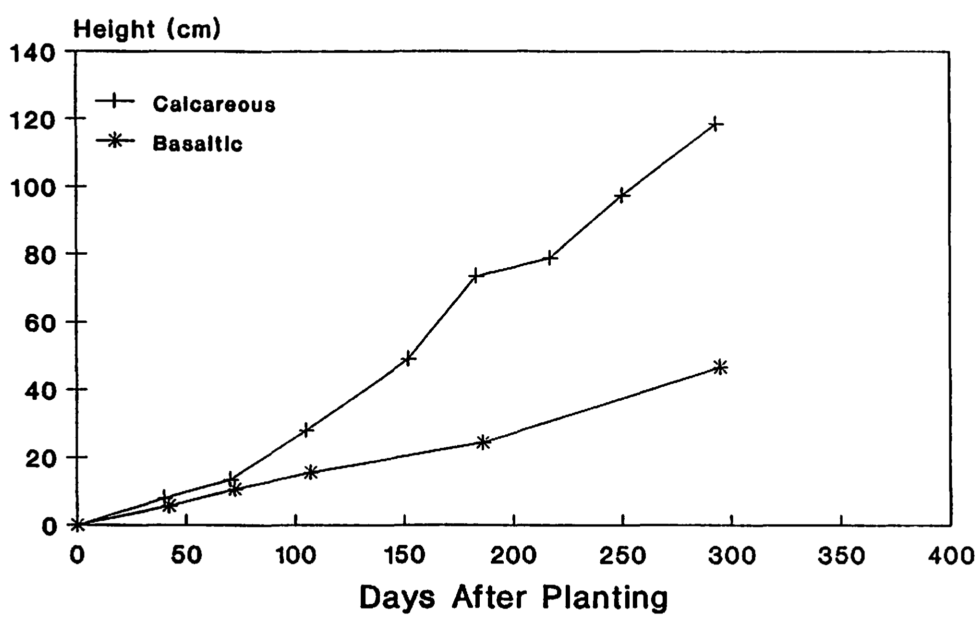


Figure 17. Growth of Leucaena shannonii
on Basaltic and Calcareous soils.

Calcareous v.s. Basaltic Soils

The reason for locating a trial at St. Georges was to test the hypothesis, put forth by some of our colleagues, that leucaena was not suited to basaltic soils, and that some other species more adapted to basaltic soils should be identified. With this report, it is possible to put to rest speculation that leucaena is not suited to this site. Leucaena grew tallest at this site and ranked second to *A. angustissima* in leaf number. Plots of individual species (Figures 10 - 19) consistently show higher yields at the calcareous site than at the basaltic site. This, together with the soil analysis data, confirms what has been known since the 18'th century (Street, 1960), that basaltic sites are less productive for agriculture.

PADF had begun planting hedgerows of *Erythrina indica* at this site. Because this species was already growing within the trial site and had few leaves and appeared to lack vigor, and because of limited space, it was excluded from the trial at the basaltic site. It was, however, included at the calcareous site, where its performance was mediocre. The lower 10 cm of stems of both *E. indica* and leucaena previously planted at the basaltic site were swollen. When cut open longitudinally, the xylem area was brown, indicating the presence of a pathogen.

Preliminary trial results suggest that leucaena is indeed the best species to plant on basaltic as well as calcareous soils, although the presence of disease at this site suggest caution in limiting oneself to a single species. Other species to consider

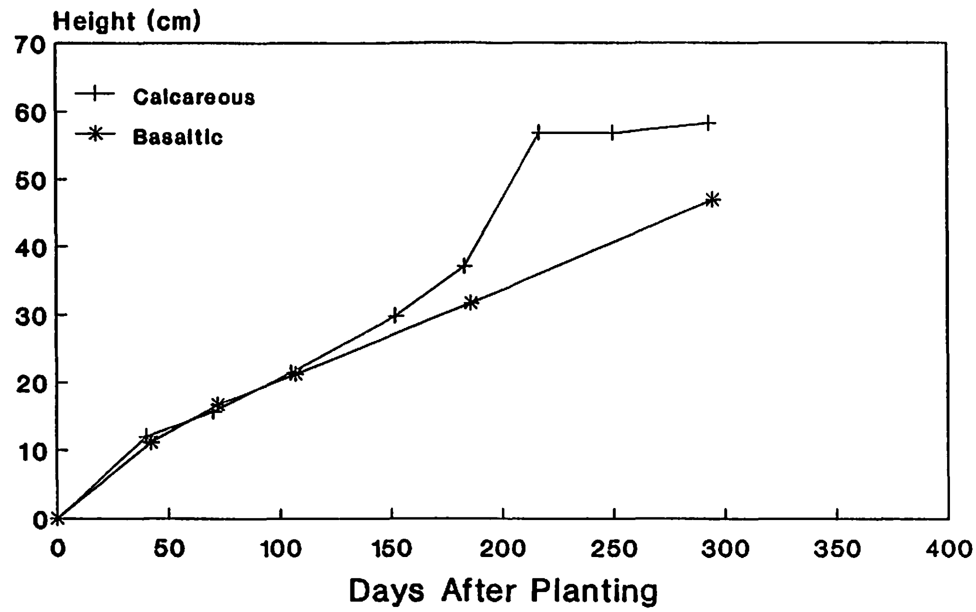


Figure 18. Growth of Leucaena salvador-
ensis on Basaltic and Calcareous soils.

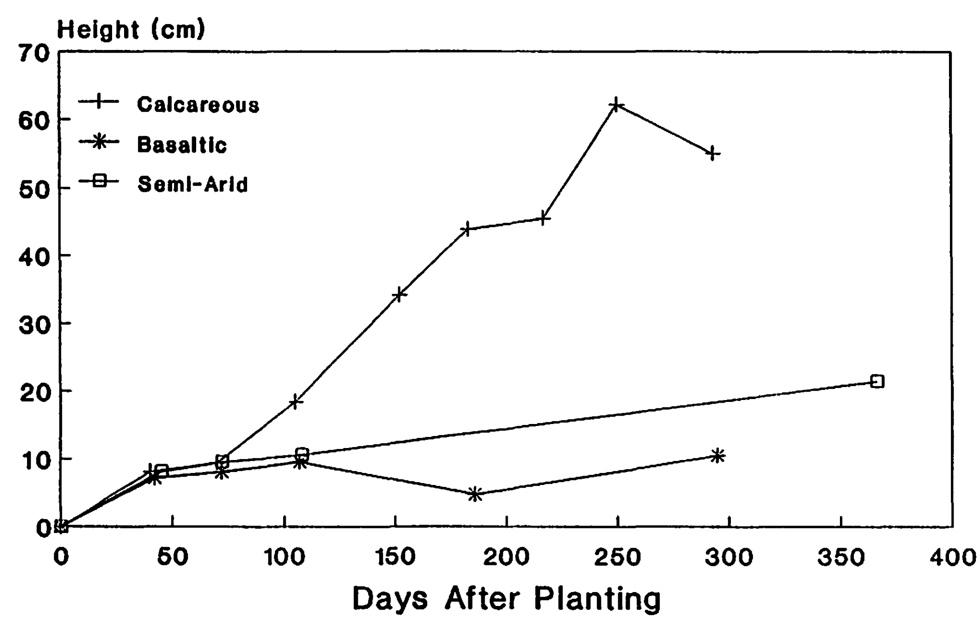


Figure 19. Growth of Delonix regia
in three agro-ecological zones

include the leucaena hybrid, KX3, calliandra, *Leucaena salvadorensis* and *L. shannonii*.

RAINFALL CONDITIONS AND HEDGEROW SPECIES

Because not all species were tested at each site and because the differences between sites were due to several factors, only one of which was rainfall, it is not possible to determine rainfall requirements or drought tolerance of individual species. It is possible to propose certain hypotheses based upon these results and what is already known about individual species. Calliandra performs very well at Formond, an altitude similar to that of Ft. Jacques, but calliandra did not perform well at Ft. Jacques. It performed much better at the calcareous and basaltic sites, where rainfall was higher. It is our hypothesis that this difference was due to the droughty conditions encountered at Ft. Jacques. Similarly *Erythrina indica* performed better at the calcareous site than at the high elevation site (Figure 19). The latter species has been highly promoted in Costa Rica, where rainfall is high. It is probable that these two species are better adapted to areas where annual rainfall is greater than 1500 mm.

At the semi-arid site, the *Albizia*'s and *Enterolobium* grew fairly tall, but the leaves of these species lack the physical adaptations to droughty conditions and regularly exhibited symptoms of drought stress. The *Acacia*'s on the other hand, have thick, waxy leaves, but growth was too slow to be encouraging for alley cropping. This may in part be due to the poor conditions experienced by seedlings at the site and the fact that small seeds have only limited nutrient reserves. The *Leucaena's*, gliricidia and *Cassia emarginata* appeared better at this site than the remaining species.

TEMPERATURE AND HEDGEROW SPECIES

Low night temperatures during the "winter" months are the principal constraint to tropical tree species at 1200 m elevation. Leucaena tolerates these temperatures well, as indicated by the 1.4 m of growth in only 10 months (Table 9). Gliricidia appeared to be severely affected by these temperatures, as evidenced by an rosetting of terminal shoots and lack of growth during this period (Figure 15). Growth of *Acacia angustissima* was also retarded during this period (Figure 12).

High temperatures were associated with the low rainfall conditions at Titanyen. It is not possible to distinguish between these two factors.

CONCLUSIONS AND RECOMMENDATIONS

These results are preliminary since no recommendations regarding optimum species for alley cropping can be made until the performance of these species is evaluated under a typical pruning regime. The results presented here permit the elimination from consideration of those species which establish difficultly, survive poorly or grow slowly. Secondly, they provide an indication of which species are less suitable for alley cropping because of the need to establish hedgerows by transplanting seedlings rather than by direct seeding. Together with information obtained elsewhere, it is possible to provide some guidance to those currently making choices of hedgerow species.

Our experience indicates that direct seeding may not be appropriate for many small seeded tree species, particularly if there is any chance of drought in the weeks directly following planting. Good seed viability may be especially important for small seeded species.

At the semi-arid site, better results might have been obtained with all species, but especially the *Acacia's* and *Casuarina* had three month seedlings been used instead of direct seeding. Without regular irrigations, none of the seedlings would have survived. As it was, only poor stands were obtained with small-seeded species despite known adaptation to semi-arid ecologies. The moisture and soil nutrient conditions were inadequate for even fair seedling growth.

The difficulty of establishing hedgerows by direct seeding at Titanyen raises the issue of whether alley cropping has any relevance to the extremely hot, dry coastal areas represented by Titanyen. It may not, at least not in the manner in which alley cropping is traditionally conceived. On the other hand, it may be possible to establish hedgerows by transplanting seedlings established naturally under selected mother trees, thus reducing the cost of growing seedlings. However, the more important question is what use can and should be made of these lands and what can be done to render these lands productive. With a water supply, perhaps obtained through water harvesting, and a high value crop, there may a be need for the organic matter, nitrogen and mulch which an adapted hedgerow species can supply. Additionally, there is a great need for windbreaks in this area, as well as barriers to surface erosion and forage for livestock. The information being gained on adaptation and growth of trees in this trial will be invaluable in the selection of tree species for these purposes.

While leucaena grew the best at all four sites during the first year, several other species also grew well. Alternative species to leucaena appear to exist for all the agro-ecological zones included in the trial. Species diversity provides some insurance against unanticipated disease or insect attacks, which usually tend to be species or even variety dependent.

Promising Species for PLUS

High Elevation

Several species grew vigorously at high elevation and appear capable of providing significant quantities of biomass for alley cropping in this zone. While *Leucaena leucocephala* performed best in the first year, data to be presented later indicate that it is unsuitable.

Acacia angustissima and *Leucaena* hybrid KX3 appear to be a promising alternatives to leucaena. Observations at Formond support the use of calliandra at high elevations where rainfall is more reliable than at Ft. Jacques. A test comparing *A. angustissima*, calliandra, and KX3 at Formond would be very informative.

Low Elevation Humid Sites

For low elevation sites, all the leucaena species and *A. angustissima* look promising. Calliandra appears promising in wetter environments. It is already being grown with success in the high rainfall areas of Camp Perrin and ranked high at the humid lowland sites in the present trial. It equaled leucaena in biomass production at Camp Perrin (Cunard, 1991). Cassia, *Delonix* and gliricidia did not appear outstanding but should not yet be ruled out for low elevation humid sites.

Semi-arid Areas

The good survival and moderate growth of some species at Titanyen are particularly encouraging for CARE's work in the Northwest, as well as other drier areas of the country. Our semi-arid site is much dryer and hotter than major CARE sites. The basaltic site, though receiving considerable rainfall, is actually a fairly droughty site because of the steep slope and low moisture retention properties of the soil (Table 4). Results from there are probably relevant to the Northwest.

Leucaena appears to be the best species for the Northwest. It is suggested that improved K 636 be used instead of K 8. Though not included at the semi-arid site, *Leucaena* hybrid KX3, *L. salvadorensis* and *L. shannonii* all merit consideration based upon their performance at St. Georges. Gliricidia ranked high at the semi-arid and basaltic sites and produced significant quantities of biomass in trials conducted by SECID/Auburn at Barbe Pagnole and Bombardopolis in the Northwest. It can also be recommended for semi-arid areas.

More time is needed to reach conclusions regarding other species.

LITERATURE CITED

Baggio, A. and J. Heuveldop. 1984. Initial performance of *Calliandra calothyrsus* Meissm. in live fences for the production of biomass. Agroforestry Systems 2: 19-29.

Balasubramanian, V. and L. Sekayange. 1991. Effects of tree legumes in hedgerows on soil fertility changes and crop performance in the semi-arid highlands of Rwanda. Biological Agriculture and Horticulture 8: 17-32.

Bannister, M. and P.K.R. Nair. 1990. Alley cropping as a sustainable agricultural technology for the hillsides of Haiti: Experience of an agroforestry outreach project. Am. J. Alternative Agric. 5 (2): 51-57.

BOSTID. 1979. *Tropical Legumes: Resource for the Future.* Report of an Ad Hoc Panel of the Advisory Board on Science and Technology for International Development (BOSTID), National Research Council. National Academy of Sciences, Washington, D.C. 331 pp.

BOSTID. 1984. *Leucaena: Promising Forage and Tree Crop for the Tropics.* Second Edition. Report of and Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development. National Academy Press, Washington. 93 pp.

Budelman, A. 1988a. Leaf dry matter productivity of three selected perennial leguminous species in humid tropical Ivory Coast. Agroforestry Systems 7:47-62.

Budelman, A. 1988b. The decomposition of the leaf mulches of *Leucaena leucocephala, Gliricidia sepium* and *Flemingia macrophylla* under humid tropical conditions. Agroforestry Systems 7: 33--45.

Chen, Y.S., B.T. Kang and F.E. Caviness. 1989. Alley cropping vegetable crops with *Leucaena* in Southern Nigeria. HortScience 24: 839-840.

Chéry, Y. 1990. Les haies vives et leur place dans la production agricole: Expérience du Projet Ouest Jacmel. Pages 18-22 in *Actes du Colloque sur les Haies Vives pour une Agriculture Continue et Soutenue*. Groupe de Recherches, d'Etudes et de Formation en Environnement, Secretariat Technique à l'Amenagement des Bassins Versants, (STABV/MARNDR and ADO/USAID). Proceedings of Conference held at Cap Haitien, 12-15 December 1989.

CRESDIP, 1990. *Haïti, Terre Délabrée. Ecologie et Dictature*. Centre de Recherches Sociales et de Diffusion Populaire (CRESDIP). Pétionville, Haïti. 95 pp.

Cunard, A.C. 1991. Measurement of biomass production by living hedgerow species at the Perrin site. Projè Sové Tè, USAID, Port-au-Prince, Haiti. 20 pp.

Cunard, A.C. and P.R. Jouissance. 1991. Height growth measurements on living hedgerow species established on slopes of four soil types. PST Report for USAID/Haiti. Projè Sové Tè, Camp Perrin, Haïti. 38 pp.

Farmer, D.B. and A.S.R. Juo. 1990. Impact des haies vives ou des systèmes de cultures en couloirs sur l'amélioration du sol. pp. 45-62 in *Actes du Colloque sur les Haies Vives pour un Agriculture Continue et Soutenue*. Groupe de Recherche, d'Etudes et de Formation en Environnement, Secrétariat Technique à l'Aménagement des Bassins Versants (STAB/MARNDR and ADO/USAID). Proceedings of a conference held at Cap Haitien, 12-15 December 1989.

Guthrie, R.L., P.M. Rosseau, G.A. Hunter and M.P. Enilorac. 1990. Soil profile description for selected sites in Haiti. SECID/Auburn Agroforestry Report No. 16. South-East Consortium for International Development and Auburn University, Petionville, Haiti.

Kadiata, B. and K. Mulongoy, 1991. Soil effects on early growth and nodulation of three leucaena species. Leucaena Research Reports 12: (11) 80-82.

Kang, B.T. 1989. Alley cropping/farming: Background and general research issues. Paper presented at the AFNETA Inaugural Meeting, International Institute of Tropical Agriculture, Ibadan, Nigeria. 1-3 August 1989.

Kang, B.T. and V. Balasubramanian. 1990. Long term fertilizer trials on Alfisols in West Africa. *Transactions, 14'th International Congress of Soil Science*, Kyoto, Japan. 4: 20-25.

Kang, B.T. and G.F. Wilson. 1987. The development of alley cropping as a promising technology. pp. 227-243 *in* Steppler, H.A. and P.K.R. Nair, eds., *Agroforestry: a decade of* *development*. International Council for Research in Agroforestry.

Kang, B.T., G.F. Wilson and T.L. Lawson. 1984. *Alley cropping: a stable alternative to shifting cultivation*. International Institute of Tropical Agriculture, Ibadan, Nigeria. 22 pp.

Kidd, T.J. and T. Taogaga. 1984. Survival and herbage yield of six nitrogen-fixing trees intercropped with taro in Western Samoa. Nitrogen Fixing Tree Research Report 2: 22-23.

Lancaster, J.D. 1970. Determination of phosphorus and potassium in soils. Mississippi Agricultural Experiment Station Mimeo.

Lantagne, D.O. 1980. Tree species selection for reforestation of the Jean Rabel area of Northwest Haiti. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Naidu, R., R.W. Tillman and J.K. Syers. 1990. Lime-aluminum-phosphorus and the growth of *Leucaena leucocephala*. I. Plant Growth Studies. Plant and Soil 126: 1-8.

NFTA. 1989. Establishment Guide: A Guide to Establishment of Research and Demonstration Plantings of Nitrogen Fixing Trees. Nitrogen Fixing Tree Association, Paia, Hawaii. 36 pp.

Okigbo, B.N. 1989. Welcoming Address. pp. 2-5 *in* Kang, B.T. and L. Reynolds, eds. *Alley farming in the humid and subhumid tropics*. Proc. International Workshop, Ibadan, Nigeria, 10-14 March 1986, International Development Research Centre, Ottawa, Canada.

Organization of American States. 1992. Ecologie, République d'Haiti. Map, 1:500,000. Washington, D.C.

Pelleck, R. 1990. Impact positif des haies vives en contour sur les relations plante/sol et le micro-environement. pp 23-43 in *Actes du Colloque sur les Haies Vives pour une Agriculture Continue et Soutenue*. Groupe de Recherches, d'Etudes et de Formation en Environnement, Secrétariat Technique à l'Aménagement des Bassins Versants (STABV/MARNDR and ADO/USAID). Proceedings of a workshop held at Cap Haïtien, 12-15 December 1989.

Sanchez, P.A. 1976. *Properties and Management of Soils in the Tropics*. John Wiley and Sons, New York. 618 pp.

Shannon, D.A., W.O. Vogel and K.N. Kabaluapa. 1990. The effects of alley cropping and fertilizer application on continuously-cropped maize. SECID/Auburn Agroforestry Report No. 30.

Street, J.M. 1960. *Historical and economic geography of the Southwest Peninsula of Haiti*. Department of Geography, University of California, Berkeley.

Turnbull, J.W. 1986. *Multipurpose Australian Trees and Shrubs: Lesser-known Species for Fuelwood and Agroforestry*. ACIAR Monograph No. 1. Canberra, Australia. 316 pp.

Von Carlowitz, P.G.. 1986. *Multipurpose Tree and Shrub Seed Directory*. ICRAF, Nairobi. 265 pp.

APPENDIX I

Basis for Selection or Exclusion of Species

Reasons for Inclusion

Species	Reason for Inclusion
Acacia ampliceps	- Adapted to hot, dry sub-tropics, with good coppicing, good growth (NFTA Highlights).
Acacia angustissima	- Recommended by NFTA Establishment Guide
Acacia colei	- Grows well in hot, semi-arid tropical zones with good coppicing. Resist insect attack (Harwood and House, CSIRO)
Acacia decurrens	- Recommended by Chris Harwood (CSIRO) for high elevation and 800-1500 mm annual rainfall.
Acacia holosericea	- Recommended by CSIRO. Drought tolerance, grows well in semi-arid (270-690mm) tropical zones, coppicing ability (Harwood and House, CSIRO)
Acacia mearnsii	- Performed well at Kenscoff (Wynne farm), recommended by Harwood (CSIRO) and Jane Wynne for high elevation.
Acacia melanoxylon	- Grows well at 1000-2000 m elevation, have some potential for hedgerows (Boukante Pawol, PADF)
Acacia tumida	- Adapted to hot, dry sub-tropics, varying coppicing ability
Albizia guachapele	- Adapted to semi-arid, subhumid tropical zones, grows on degraded soils, coppicing ability
Albizia lebbeck	- Adapted to semi-arid conditions as low as 400 mm/year, coppices readily (NFTA Highlights)
Albizia procera	- Adapted to the humid and subhumid tropics (1000-1750 mm), fast-growing tree, coppicing ability (Turnbull)

Calliandra calothyrsus	- Used successfully by the Organization for the Rehabilitation of the Environment at Formond
Cassia emarginata	- Fast growth even on very poor soils, potential hedgerow species, coppices vigorously (Boukante Pawol)
Cassia siamea	- Planted by PADF in Northern Haïti
Casuarina cunninghamiana	- (river she oak) - based on growth, wide adaptation and coppicing ability (NFTA reports, Turnbull)
Delonix regia	- Very good performance at abandoned trial at Bab Pagnole, Northwest. Survival dry season well. Not subject to browsing.
Desmodium gyroides	- Recommended by Dean Treadwell (PST)
Enterolobium cyclocarpum	- Adapted to semi-arid and subhumid conditions (650-2500 mm), coppicing ability, can be used in alley cropping systems (NFTA highlights)
Erythrina indica	- Planted by PADF in Southwest Haïti
Erythrina poeppigiana	- NFTA Guide.
Flemingia macrophylla	- Utilized in Alley Cropping Hedgerows in Indonesia and Nigeria.
Gliricidia sepium	- Performed well in variety trial at Barbe Pagnole. Variety HYB was one of top performance at Barbe Pagnole. It is a composite bulk of 4 varieties originating from CATIE, Costa Rica and selected at Ibadan Nigeria.
Grevillea robusta	- Grows vigorously from sea level up to 2300 m, acid to calcareous soils, tolerates poor and eroded soils. Used at Fermathe and Kenscoff areas.
Inga vera	- Utilized in Agroforestry systems in Haïti.
Leucaena diversifolia	- Adapted to higher elevation than *L. leucocephala*
Leucaena leucocephala	- Most widely used species for alley cropping in Haïti, Asia and Africa.

Variety K 636 is Hawaiian Giant type known for a high leaf/stem ratio. The variety was reselected at Roche Blanche for low seed set.

Leucaena leucocephala - Variety Delin, local wild type found in droughty areas.

Leucaena hybrid KX3 - A hybrid of *L. leucocephala* and *L.diversifolia*. It is known for its vigor.

Leucaena salvadorensis - Not previously tested. Recommended by J. Timyan, SECID Tree Germplasm Specialist.

Leucaena shannonii - Not previously tested. Recommended by Timyan

Mimosa scabrella - Performed well on Wynne Farm at Kenscoff

Paraserianthes falcataria- NFTA Guide

Piptadenia peregrina - Native Haitian species adapted to dry conditions. (Bois caïman, bois galle, bois l'écorce and oeuf de poule). Recommended by Timyan.

Pseudoalbizia berteriana- Indigenous species recommended by Timyan

Tephrosia candida - Grows well on acid soils for lowland and mid-altitude under high rainfall conditions (>1300 mm), IITA.

	Reason for Exclusion
Azadiracta indica	- Popular tree for planting. Coppices but seed not available at time of planting. This species was included with grasses trial which was planted later at Bergeau.
Cassia spectabilis	- Recommended by F. Owino (ICRAF) and by Atta-Krah (IITA/ILCA) for high elevation, but seed not available at time of planting.
Cajanus cajan	- Poor survival with pruning in Africa.
Moringa oleifera	- Popular species for hedgerows in Northwest but dies back after dry season in Barbe Pagnole, Mirebalais and North (observed in abandoned trials and in farmers' fields).

APPENDIX II

Descriptive Information on Varieties included in Trial

Species	Seed Lot Number SECID	Seed Lot Number Supplier	Information on Varieties
Acacia ampliceps	91-33	15741	Collected from 9 parent trees in Western Australia by CSIRO Division of Forest Research.
Acacia angustissima	91-50	-	Selected by Banco Latino-americano de Semillas Forestales (BLSF) in Costa Rica.
Acacia colei	91-38	15774	Collected from 15 parent trees in Western Australia by CSIRO, Division of Forest Research.
Acacia decurrens	91-34	15847	Collected from 20 parent trees in New South Wales by CSIRO, Division of Forest Research.
Acacia holosericea	91-37	16389	Collected from 12 parent trees in Northern Territory by CSIRO, Division of Forest Research.
Acacia mearnsii	91-35	16625	Collected from 10 parent trees at Nelligen by CSIRO, Division of Forest Research.
Acacia melanoxylon	91-32	16358	Collected from 10 parent trees in Queensland by CSIRO, Division of Forest Research.
Acacia tumida	91-36	17170	Collected from 50 parent trees in Western Australia by CSIRO, Division of Forest Research.
Albizia guachapele	91-03	B-6388	Collected in Honduras; received from PADF seed bank.
Albizia lebbeck	91-05	648	Collected at Bon Repos, Haïti by PADF

Albizia procera	91-07	925	Seed received from PADF seed bank and collected in Puerto Rico.
Calliandra calothyrsus	91-21	-	Seed collected at Formont, Haïti, by the Organization for the Rehabiltation of the Environment (ORE).
Cassia emarginata	91-28	-	Collected at Puits Blin, Haïti, by Joël Fleury.
Cassia siamea	91-09	710	Seed collected at Petit Goâve, Haïti by PADF.
Casuarina cunninghamiana	91-14	-	Selected by Forest Research Centre at Salisbury Station.
Delonix regia	91-19	467	Seed collected at Frecyneau, St Marc, Haïti, by PADF.
Desmodium gyroides	91-55	88/62	Collected in Trinidad, received from Dean Treadwell (PST), Camp Perrin, Haïti.
Enterolobium cyclocarpum	91-12	B11387	Collected in Honduras, received from PADF seed bank.
Erythrina indica	91-15	678	Seed collected in Cayes areas, Haïti by PADF.
Erythrina poeppigiana	91-06	4099	Selected in Costa Rica, received from PADF seed bank.
Flemingia macrophylla	91-39	-	Obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
Gliricidia sepium	91-41	-	Variety HYB is a composite bulk of 4 varieties originating from CATIE, Costa Rica and selected at Ibadan, Nigeria by ILCA.
Grevillea robusta	91-49	-	Selected at Kenscoff by Mission Baptiste, Fermathe, Haïti.

Inga vera	91-57	-	Collected from 5 parent trees at Laborde, Haïti, by Homère Fanfan.
Leucaena diversifolia	91-10	-	Collected from a F2 generation at Cazeau, Haïti, by Operation Double Harvest (ODH).
Leucaena leucocephala	91-54	-	Variety K 636 reselected by Joël Timyan at Roche Blanche, Haïti, for low seed set.
Leucaena leucocephala	91-27	-	Variety Delin, collected at Puits Blin, Haïti, by Joël Fleury.
Leucaena hybrid KX3	91-24	-	A hybrid of *L. leucocephala* and *L.diversifolia* from orchard at Operation Double Harvest, Roche Blanche.
Leucaena salvadorensis	91-30	-	Collected from an indigenous forest on isolated trees by ESNACIFOR-COHDEFOR, Honduras.
Leucaena shannonii	91-31	-	Collected from the best sources in Honduras (managed stand) by ESNACIFOR-COHDEFOR.
Mimosa scabrella	91-11	529	Selected in Brazil, received from PADF seed bank.
Paraserianthes falcataria	91-17	868	Obtained from SETROPA seed company in Holland; received from PADF seed bank.
Piptadenia peregrina	91-13	-	Collected at Ananas, Lascahobas, Haïti by Joël Timyan.
Pseudoalbizia berteriana	91-22	-	Collected at Barbe Pagnole, Haïti, by Joël Timyan.
Tephrosia candida	91-40	-	Obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Distance between plants : 10cm **Plot length : 6m**

Blocks of 4 Plots

Blocks

—6m— Border : K 397

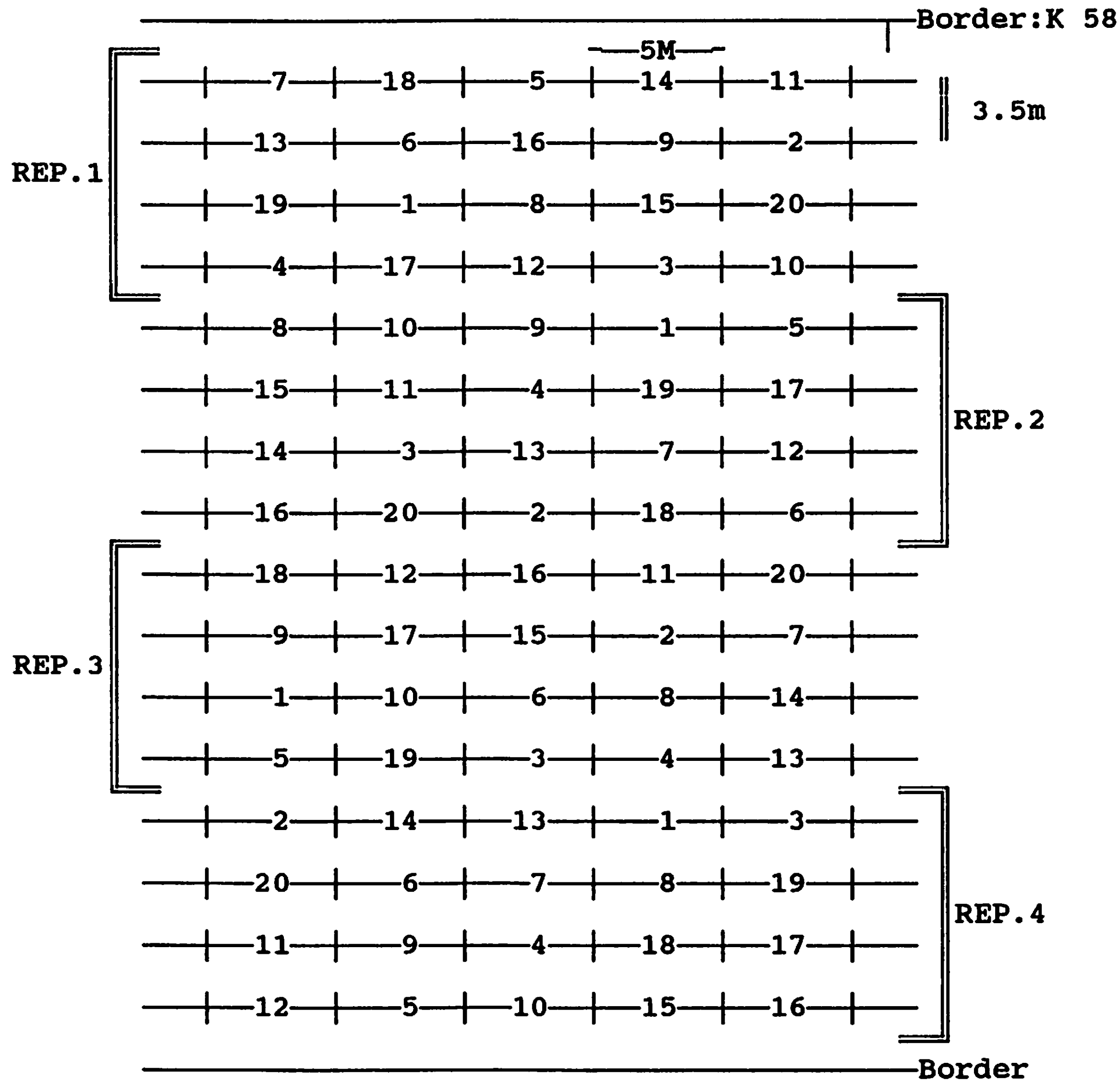
1.	—┼—5—┼—11—┼—2—┼—8—┼—
2.	—┼—4—┼—13—┼—10—┼—7—┼—
3.	—┼—15—┼—1—┼—14—┼—16—┼—
4.	—┼—6—┼—12—┼—9—┼—3—┼—
5.	—┼—7—┼—16—┼—2—┼—9—┼—
6.	—┼—4—┼—6—┼—5—┼—15—┼—
7.	—┼—3—┼—14—┼—13—┼—8—┼—
8.	—┼—12—┼—11—┼—1—┼—10—┼—
9.	—┼—8—┼—10—┼—9—┼—15—┼—
10.	—┼—7—┼—14—┼—12—┼—5—┼—
11.	—┼—6—┼—13—┼—16—┼—11—┼—
12.	—┼—2—┼—4—┼—1—┼—3—┼—
13.	—┼—11—┼—4—┼—9—┼—14—┼—
14.	—┼—7—┼—1—┼—6—┼—8—┼—
15.	—┼—3—┼—5—┼—16—┼—10—┼—
16.	—┼—15—┼—12—┼—2—┼—13—┼—

Species

1. *Acacia angustissima*
2. *Leucaena K 636*
3. *Casuarina cunninghamiana*
4. *Acacia melanoxylon*
5. *Albizia procera*
6. *Calliandra calothyrsus*
7. *Acacia mearnsii*
8. *Erythrina indica*
9. *Erythrina poeppigiana*
10. *Flemingia macrophylla*
11. *Acacia decurrens*
12. *Leucaena KX3*
13. *Mimosa scabrella*
14. *Grevillea robusta*
15. *Leucaena K 156*
16. *Gliricidia sepium*

Figure A1. Plot layout at high elevation site at Ft. Jacques, seeded 8 May 1991.

Distance between plants - 10cm Plot length: 5m



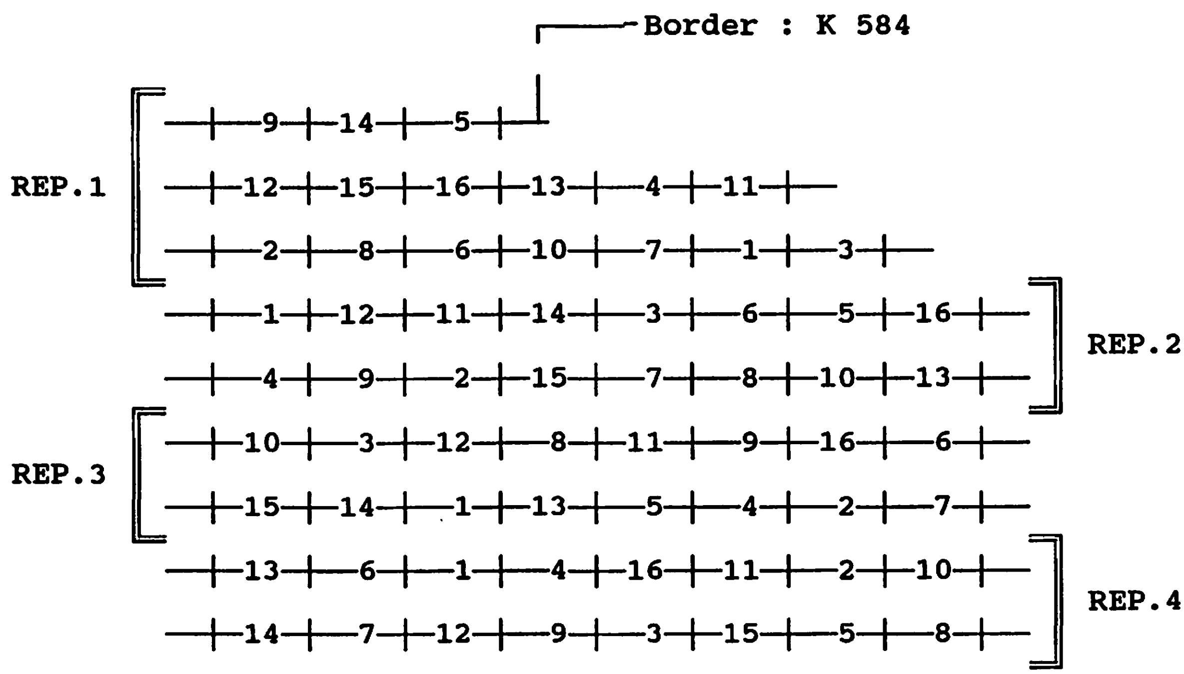
Species

1. *Acacia angustissima*
2. *Albizia guachapele*
3. *Calliandra calothyrsus*
4. *Cassia siamea*
5. *Casuarina cunninghamiana*
6. *Delonix regia*
7. *Enterolobium cyclocarpum*
8. *Erythrina indica*
9. *Erythrina poeppigiana*
10. *Gliricidia sepium*
11. *Inga vera*
12. *Leucaena* K 156
13. *Leucaena* K 636
14. *Leucaena salvadorensis*
15. *L. shannonii*
16. *Leucaena* KX3
17. *Albizia lebbeck*
18. *Desmodium gyroides*
19. *P. falcataria*
20. *Tephrosia candida*

Figure A2. Plot layout at calcareous site at Bergeau, seeded 23 May 1991.

Distance between plants : 10cm **Plot length : 5m**

Space between hedgerows : 1.5-2.5m



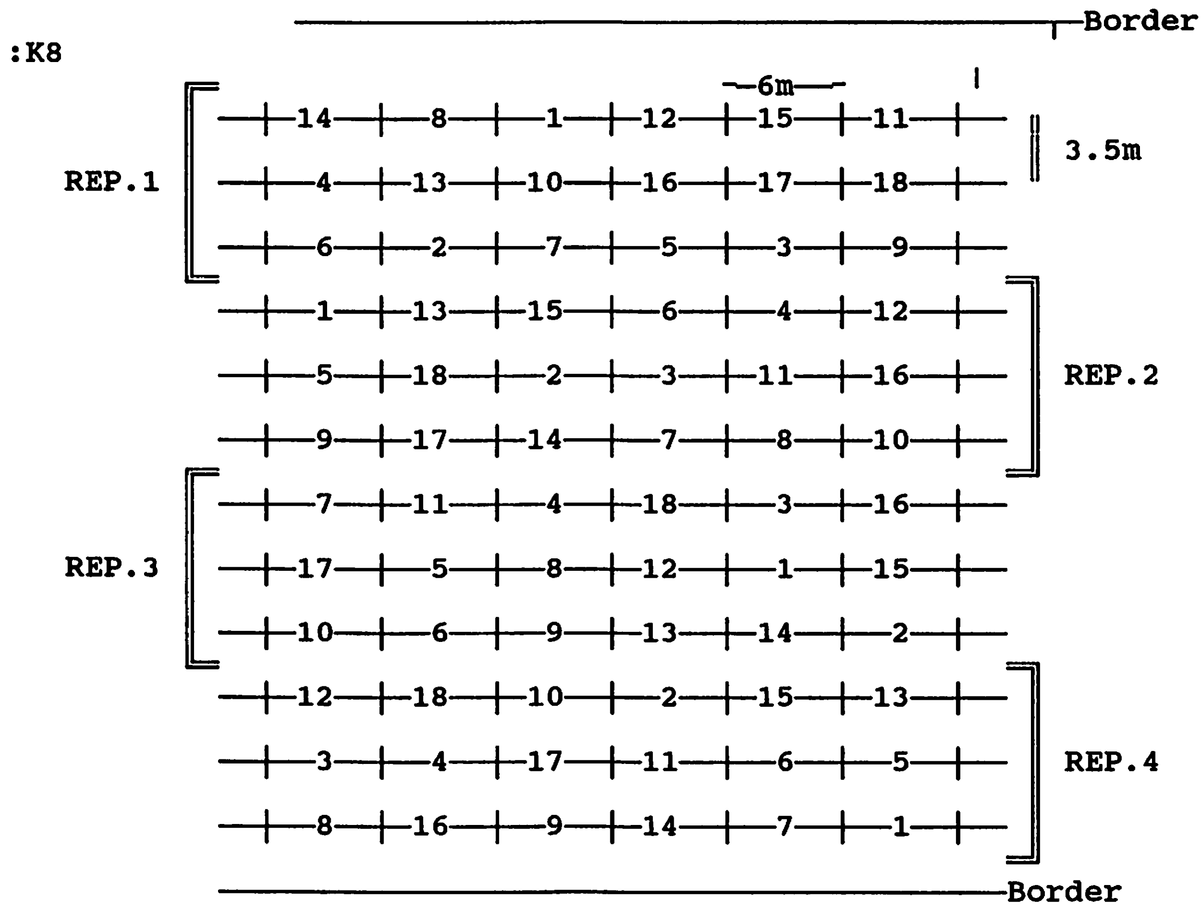
Species:

1. Acacia angustissima
2. Calliandra calothyrsus
3. Cassia emarginata
4. Cassia siamea
5. Casuarina cunninghamiana
6. Delonix regia
7. E. cyclocarpum
8. Gliricidia sepium
9. Leucaena K 156
10. Leucaena K 636
11. Leucaena salvadorensis
12. L. shannonii
13. Leucaena KX3
14. Grevillea robusta
15. Desmodium gyroides
16. Flemingia macrophylla

Figure A3. Plot layout at Basaltic site at St. George, seeded 22 May 1991.

Distance between plants : 20cm **Plot length : 6m**

Space between hedgerows : 3-3.5m



Species

1. *Acacia ampliceps*
2. *Acacia colei*
3. *Acacia holosericea*
4. *Acacia tumida*
5. *Albizia lebbeck*
6. *Albizia procera*
7. *Cassia emarginata*
8. *Cassia siamea*
9. *Delonix regia*
10. *Gliricidia sepium*
11. *Leucaena* K 636
12. *Leucaena* K 156
13. *Piptadenia peregrina*
14. *Pseudoalbizia berteriana*
15. *Casuarina cunninghamiana*
16. *Enterolobium cyclocarpum*
17. *L. leucocephala* Delin
18. *Albizia guachapele*

Figure A4. Plot layout at semi-arid site at Titanyen, seeded 13 May 1991.

Table A1. Daily rainfall from June 1991 through May 1992 for the high elevation site at Ft. Jacques. Agroforestry Trial 1.

Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Year
1												28.0	
2					25.4							13.2	
3					29.4								
4			59.4						0.8				
5			24.5										
6					10.0								
7		7.6		25.4					14.2				
8								7.8		8.6	3.4	7.6	
9								3.6		8.2			
10							3.2			2.6	15.6		
11			2.4			25.4		8.8					
12						24.6						39.0	
13										4.2		4.6	
14						1.8				8.2	49.2		
15			34.0							6.4	2.0		
16		7.0		12.8						2.8	8.4		
17											14.2		
18		29.0									30.0	29.6	
19											22.0		
20	27.4										41.4	13.8	
21												5.6	
22	0.4				4.6			5.6				22.0	
23	9.6				4.8					2.6		3.8	
24													
25					3.6	10.4							
26					3.2					85.2		18.0	
27			1.0							12.6		12.6	
28	23.6			1.4							4.0		
29	18.6		10.8								13.0		
30										1.6	10.6		
31													
Total:	79.6	43.6	132.1	38.2	82.4	62.2	3.2	17.0	8.8	158.0	213.8	197.8	1036.7

Table A2. Daily rainfall from June 1991 through May 1992 for the calcareous site at Bergeau. Agroforestry Trial 1.

Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Year
1	0.4		0.8										
2	1.6				10.2							16.4	
3											2.6		
4					4.2			8.0		14.6			
5			8.0		15.6	56.8	10.4	31.0				18.4	
6	4.0	11.6	13.4			66.6							
7						36.0							
8					67.2			13.8			24.4		
9													
10					33.6		8.2			2.6	1.6		
11					82.6						2.4		
12					24.4			57.4					
13									1.4				
14											16.2		
15													
16					24.4	18.4		8.2	8.6			32.6	
17			15.6					8.6					
18	8.6		17.2	16.0							10.6		
19		12.0	3.8	4.2		21.6		8.4				21.0	
20											18.2		
21			2.8	4.6		18.8							
22										6.8			
23		18.0		9.4								18.0	
24		3.6		2.0							16.4		
25													
26										0.8	23.4		
27				4.4							1.6	11.0	
28	2.4			4.2					5.2	3.4			
29	12.4	20.0											
30		3.0									6.4		
31		40.2											
Total	29.4	108.4	61.6	44.8	262.2	218.2	18.6	135.4	15.2	28.2	123.8	117.4	1163.2

Table A3. Daily rainfall from June 1991 through May 1992 for the Basaltic site at St. Georges. Agroforestry Trial 1.

Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
1													
2	3.0		3.0	8.0	76.2								
3					57.6			5.0					
4										8.6			
5	8.6					68.4				7.6			
6	15.2					48.4							
7				8.0				58.0					
8					30.2	79.2							
9									35.4				
10						19.6							
11					48.8				33.6				
12													
13			1.2										
14								3.0					
15													
16					32.2								
17													
18									15.0				
19							28.2						
20													
21													
22				10.4									
23													
24													
25				50.8									
26													
27	30.2					9.0							
28	4.5												
29	12.8			53.8									
30	2.4	36.2	6.6										
31													
Total	76.7	36.2	10.8	131.0	245.0	224.6	28.2	66.0	84.0	16.2	0.0	0.0	918.7

Table A4. Daily rainfall from June 1991 through May 1992 for the Semi-arid site at Titanyen. Agroforestry Trial 1.

Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1												15.2
2												
3												
4												
5												
6												
7												
8												
9												
10												
11									38.1			12.7
12												
13												
14											38.1	
15												7.6
16												
17											7.6	15.2
18											7.6	
19											12.7	
20											10.2	
21									5.1			
22												7.6
23												
24												
25												5.1
26										27.9		
27										35.6		
28												
29											10.2	
30											10.2	5.1
31												
Total		Data Not Available						0.0	43.2	63.5	96.6	68.5

Table A5. Percent emergence and plants (unadjusted) as percent of hills planted at high-elevation site at Fort Jacques. Agroforestry Trial 1.

SPECIES	Variety	Emergence 35 DAP[1]	Plants 35 DAP	Plants 114 DAP	Plants 229 DAP	Plants 348 DAP
		%	%	%	%	%
Leucaena leucocephala	K 636	60.5	95.0	98.0	97.1	96.8
Calliandra calothyrsus		66.8	88.8	97.1	97.1	93.4
Gliricidia sepium	HYB	57.7	90.0	94.7	82.8	91.4
Leucaena diversifolia	K 156	30.3	59.6	87.7	89.8	90.2
Leucaena hybrid	KX3	46.3	89.2	93.0	88.1	88.5
Casuarina cunninghamiana		0.0	0.0	0.0	93.4	87.7
Flemingia macrophylla		24.2	48.3	60.7	89.8	86.1
Acacia angustissima		42.4	80.0	79.5	80.7	79.9
Acacia melanoxylon		2.9	8.3	1.0	72.1	67.2
Erythrina indica		22.6	70.4	88.9	83.6	59.0
Grevillea robusta		0.8	5.6	23.5	61.5	51.2
Albizia procera		12.3	37.5	53.3	49.6	48.4
Acacia decurrens		4.5	25.4	13.1	32.8	31.2
Acacia mearnsii		22.1	56.7	47.5	38.8	28.4
Erythrina poeppigiana		13.5	29.2	28.3	30.1	24.6
Mimosa scabrella		9.4	33.8	31.1	30.3	23.4
Significance (F test)		***	***	***	***	***
$LSD_{0.05}$		10.8	17.4	19.9	23.5	22.1
SE		3.8	6.1	7.0	8.3	7.8
CV %		29.0	23.9	25.1	25.2	25.4

[1] Days after planting.
*** = significant at 0.5 % level of probability.

Table A6. Tree height (unadjusted) at high-elevation site at Ft. Jacques.

Species	Variety	Days after Planting							
		51	79	114	160	191	229	268	301
		cm	cm	cm	cm	cm	cm	cm	cm
Leucaena leucocephala	K 636	7.5[§]	16.4	36.8	79.6	120.7	124.2	140.2	154.8
Leucaena hybrid	KX3	5.7[§]	12.2	23.5	55.4	92.6	104.4	119.6	133.1
Acacia angustissima		2.5[§]	5.1	16.7	43.8	80.7	73.9	79.3	80.0
Leucaena leucocephala	K 156	4.0[§]	9.2	17.7	36.8	68.4	73.8	79.3	97.2
Erythrina indica		6.4[§]	9.8	16.3	27.9	41.2	39.8	44.7	45.8
Acacia decurrens		0.6[§]	0.8	1.0[§]	3.0[#]	3.2[#]	4.1[#]	4.1[#]	5.3[¶]
Gliricidia sepium	HYB	4.9[§]	8.5	12.0	20.5	25.5	24.6	24.2	24.7
Grevillea robusta		1.5[#]	2.8[§]	3.1[§]	6.1	5.9	7.2	8.0	7.7
Albizia procera		2.5[§]	3.3	4.5	6.3	6.4	7.2	7.6	6.9
Casuarina cunninghamiana[++]		.	0.3[¶]	.	16.7	21.2	24.6	27.2	25.3
Calliandra calothyrsus		3.1[§]	4.2	6.3	10.9	15.3	18.8	19.2	20.2
Erythrina poeppigiana		4.9[§]	7.0	8.6	10.9	14.2[§]	15.7[§]	17.5[§]	17.1[§]
Flemingia macrophylla		1.9[§]	3.2	4.3	8.5	11.6	14.0	15.6	17.7
Acacia melanoxylon		1.0[¶]	1.1[§]	2.4[¶]	7.9[#]	9.3[#]	9.2[#]	9.9[#]	8.6[#]
Acacia mearnsii		1.0[§]	1.3	1.8	3.4	4.2[§]	4.9[§]	5.9[§]	5.4[§]
Mimosa scabrella		2.0[§]	3.6	4.6	8.1	9.5	15.0	12.8	12.7

[++] "." indicate no plants.

[§] Mean of 3 plots
[#] Mean of 2 plots
[¶] Value from 1 plot.

Table A7. Leaf number (unadjusted) at the high elevations site at Fort Jacques.

SPECIES	Variety	Days after Planting 51	79	114	160	191	229	268	301
		#	#	#	#	#	#	#	#
Casuarina cunninghamiana[++]		.	.	.	24.8	34.2	46.8	47.9	54.0
Leucaena leucocephala	K 636	6.5[§]	10.4	14.5	22.6	27.9	24.4[§]	30.4	34.3
Leucaena hybrid	KX3	6.7[§]	9.8	12.5	19.9	25.0	22.1[§]	24.2	31.5
Leucaena diversifolia	K 156	5.2[§]	7.8	9.8	13.6	20.0	16.4[§]	16.1	17.4
Acacia angustissima		6.0[§]	8.0	11.3	18.4	28.8	25.7	19.0	15.1
Grevillea robusta		3.6[#]	6.0[§]	7.2[§]	11.7[§]	12.5	13.6	12.0	12.6
Mimosa scabrella		3.8[§]	5.3	5.3	7.7	8.9	13.5	8.9	8.4
Calliandra calothyrsus		5.7[§]	7.6	7.6	8.6	8.5	8.1	7.6	7.0
Flemingia macrophylla		4.3[§]	4.5	4.9	7.1	8.0	9.9	8.6	6.7
Acacia mearnsii		3.2[§]	4.3	4.8	6.0	5.4[§]	5.1[§]	4.5[§]	3.5[§]
Erythrina poeppigiana		4.4[§]	5.3	5.8	6.5	6.6	4.8[§]	4.0[§]	3.4[§]
Gliricidia sepium	HYB	7.4[§]	10.8	14.4	18.7	21.5	18.2	7.2	3.4
Albizia procera		5.6[§]	7.0	7.8	9.9	10.1	8.7	5.4	3.2
Acacia decurrens		2.4[§]	3.3	3.4[§]	3.7[#]	3.7[#]	3.6[#]	2.8[#]	3.2[¶]
Acacia melanoxylon		2.5[¶]	3.1[§]	4.5[¶]	5.4[#]	5.7[#]	4.2[#]	3.3[#]	3.0[#]
Erythrina indica		6.3[§]	7.9	10.3	10.5	11.1	5.0	3.2	1.8

[++] "." indicates no plants or missing value.

[§] Mean of 3 plots
[#] Mean of 2 plots
[¶] Value from 1 plot.

Table A8. Average number of observations per plot for tree height and leaf number at high-elevation site at Ft. Jacques.

Species	Variety	Days after Planting 51	79	114	160	191	229	268	301
Leucaena leucocephala	K 636	10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Acacia angustissima		10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena hybrid	KX3	10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena diversifolia	K 156	10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Erythrina indica		10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Gliricidia sepium	HYB	10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Acacia decurrens		8.0[§]	8.3	4.7[§]	9.5[#]	7.5[#]	7.0[#]	7.0[#]	10.0[¶]
Albizia procera		9.7[§]	10.0	9.3	10.0	10.0	9.5	9.0	10.0
Casuarina cunninghamiana		0.0	1.0[¶]	0.0	10.0	10.0	10.0	10.0	10.0
Grevillea robusta		3.5[#]	4.3[§]	4.7[§]	7.0[§]	8.3	9.0	9.8	9.8
Erythrina poeppigiana		8.0[§]	7.8	7.5	7.5	8.3[§]	8.7[§]	8.0[§]	10.0[§]
Calliandra calothyrsus		10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Flemingia macrophylla		10.0[§]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Acacia melanoxylon		10.0[¶]	3.3[§]	2.0[¶]	10.0[#]	10.0[#]	10.0[#]	10.0[#]	10.0[#]
Acacia mearnsii		9.7[§]	9.8	8.8	8.0	10.0[§]	9.3[§]	8.0[§]	10.0[§]
Mimosa scabrella		9.7[§]	9.8	8.0	9.3	8.3	6.8	7.1	7.6

[§] Mean of 3 plots.
[#] Mean of 2 plots.
[¶] Observations from 1 plot.

Table A9. Average number of observations per plot for tree height and leaf number at the calcareous site at Bergeau.

SPECIES	Variety	Days after Planting 40	70	105	152	183	217	250	293
Leucaena leucocephala	K 636	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena hybrid	KX3	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena shannonii		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena diversifolia	K 156	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Acacia angustissima		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Leucaena salvadorensis		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Erythrina indica		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Calliandra calothyrsus		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Delonix regia		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Cassia siamea		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Enterolobium cyclocarpum		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Tephrosia candida		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Albizia guachapele		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Gliricidia sepium	HYB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Casuarina cunninghamiana		0.0	0.0	0.0	10.0	10.0	10.0	10.0	10.0
Albizia lebbeck		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Paraserianthes falcataria		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Inga vera		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Desmodium gyroides		0.0	0.0	0.0	10.0	10.0	10.0	10.0	9.3
Erythrina poeppigiana		6.0#	8.8	3.3	0.0	0.0	0.0	0.0	0.0

Mean of 2 plots.

Table A10. Average number of observations per plot for tree height and leaf number at the basaltic site at St. Georges.

SPECIES	Variety	Days after Planting 42	72	107	186	295
Leucaena leucocephala	K636	10.0	10.0	10.0	10.0	100
Leucaena hybrid	KX3	10.0	10.0	10.0	8.0	100
Calliandra calothyrsus		10.0	10.0	10.0	10.0[§]	98
Leucaena salvadorensis		10.0	10.0	10.0	10.0[§]	100
Leucaena shannonii		10.0	10.0	10.0	10.0[§]	98
Leucaena diversifolia	K156	10.0[§]	10.0	9.0	10.0[¶]	95
Acacia angustissima		5.3[§]	5.3[§]	4.0[§]	0.0	38
Gliricidia sepium	HYB	10.0	10.0	10.0	10.0	100
Enterolobium cyclocarpum		10.0	10.0	10.0	10.0	100
Flemingia macrophylla		8.3[§]	8.0[§]	6.7[§]	0.0	63
Cassia siamea		10.0	10.0	10.0	10.0[#]	88
Delonix regia		10.0	10.0	9.5	10.0[§]	90
Cassia emarginata		8.8	8.3	5.3	0.0	53
Casuarina cunninghamiana		0.0	0.0	0.0	0.0	00
Desmodium gyroides		0.0	0.0	0.0	0.0	0.0
Grevillea robusta		0.0	0.0	0.0	0.0	00

[§] Mean of 3 plots.
[#] Mean of 2 plots.
[¶] Mean of 1 plot.

Table A11. Average number of observations per plot for tree height and leaf number at the semi-arid site at Titanyen.

SPECIES	Variety	Days after Planting 45	72	108	366
Leucaena leucocephala	K 636	10.0	10.0	10.0	5.3
Leucaena leucocephala	Delin	10.0	10.0	10.0	5.3
Enterolobium cyclocarpum		10.0	10.0	10.0	5.0
Gliricidia sepium	HYB	10.0	10.0	10.0	5.8
Leucaena diversifolia	K156	6.8	8.0[§]	6.5	5.3[§]
Cassia emarginata		9.5	10.0	10.0	5.5
Albizia lebbeck		9.8	9.5	9.5	5.0
Delonix regia		9.8	10.0	9.5	5.5
Acacia ampliceps		10.0	10.0	10.0	5.0
Cassia siamea		8.8	9.3	8.8	3.3[§]
Piptadenia peregrina		7.5	7.5	8.0[§]	3.0[¶]
Albizia guachapele		10.0	9.8	8.3	4.3
Acacia colei		10.0	10.0	10.0	4.8
Albizia procera		8.8	9.0	8.0	4.0[¶]
Acacia holosericea		9.3	8.5	8.0	3.0
Acacia tumida		10.0	9.5	6.8	0.0
Casuarina cunninghamiana		0.0	0.0	0.0	0.0
Pseudoalbizia berteriana		0.0	0.0	0.0	0.0

[§] Mean of 3 plots.
[#] Mean of 2 plots.
[¶] Mean of 1 plot.