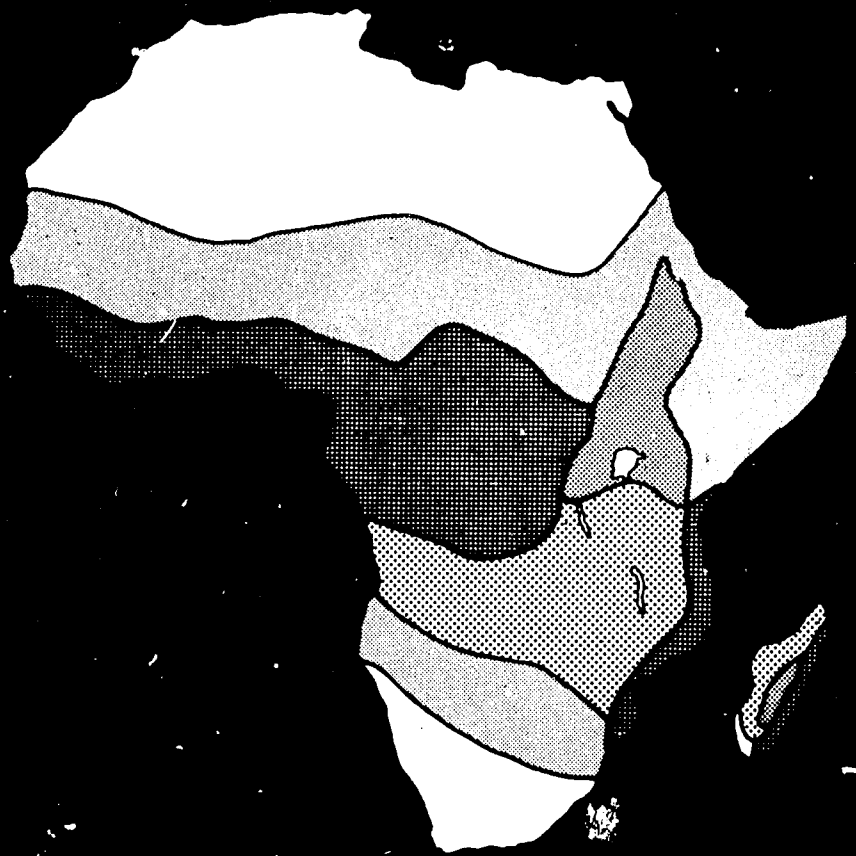
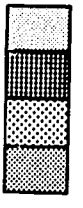


The map on the cover of this publication shows those parts of the four ecological zones to be included in the AFRENA Programme.

La carte sur la couverture de cette publication montre une partie des quatre zones écologiques devant relever du programme AFRENA.



semi-arid lowlands — Zone semi-aride de basse altitude

humid lowlands — Zone humide de basse altitude

unimodal (rainfall) plateau — Zone de plateau à régime pluviométrique unimodal

bimodal (rainfall) highlands — Zone de hautes terres à régime pluviométrique bimodal

GOVERNMENT OF UGANDA

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY

AFRENA PROJECT UGANDA PROGRESS REPORT FOR THE PERIOD SEPTEMBER 1988 TO FEBRUARY 1990

No. 28

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J. Okorio
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August 1990

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1. INTRODUCTION

At the end of 1986, ICRAF launched a collaborative agroforestry research programme in highlands of East and Central Africa. Funding was primarily provided by USAID. The countries participating in the research are Kenya, Uganda, Rwanda and Burundi, and are part of ICRAF's Agroforestry Research Network for Africa (AFRENA) programme, which encompasses three other ecological zones in Sub-Saharan Africa. The two main objectives of the AFRENA programme are:

- to develop appropriate agroforestry technologies for land-use systems within an ecological zone, and

- to develop the national and regional capabilities to plan, formulate and implement agroforestry research.

The establishment of a research network of nations within common agro- ecological zones was adopted because the member countries all face similar land-use constraints. The network facilitates complimentary research whereby scarce resources can be efficiently applied to priority zonal problems, and results derived therefrom can be shared for the benefit of all.

The East and Central Africa AFRENA highland zone (Table 1) was delineated primarily by altitude and rainfall. Altitude range was set from 1,000 to 2,500 m above sea level (ASL). The upper limit was chosen because frost becomes a common feature above this level affecting the choice of crops and trees. The lower limit of 1,000 m ASL was chosen to enable the inclusion of the major land areas having a high potential for agricultural production, especially Uganda. A lower limit of 1,000 mm annual rainfall was chosen to exclude low-potential areas. The zone is generally characterized by two rainy seasons each year. Table 1 shows the estimated land area and population (1987) in the E.A. AFRENA highland zone.

Table 1. Estimated land area and population (1987) E.A. AFRENA highland zone.

Country	Land area (km^2)	percent of area	Population (1987)	percent of pop.
Kenya	72,000	15	10.0	50
Uganda	96,000	40	8.0	63
Rwanda	16,000	62	3.4	73
Burundi	23,000	85	4.4	90
Region total	207,000	27*	25.8	61*

*weighted averages.

Network activities in East and Central Africa commenced in the beginning of 1987, with the identification of agroforestry potentials within the highland zone of each member country. Diagnostic and Design surveys were conducted to identify environmental and farm-level constraints which limit present and future agricultural production. Subsequent analyses led to the identification of agroforestry technologies that could alleviate these constraints. Each member country within the network was assigned and agreed to take primary responsibility for specific agroforestry technologies. The Uganda AFRENA programme was mandated to develop the boundary and upperstorey tree planting technologies for the zone as a whole. This involves:

- selecting and screening appropriate MPT's for boundary and upperstorey planting; and

- developing appropriate management practices for the upperstorey technology for the production of poles, timber, fuelwood, fodder, green mulch and fruits.

In addition to this zonal responsibility, the Uganda AFRENA programme selected the Kigezi Annual food-crop montane system in Kabale district as the land-use specific project. This agricultural system under high population pressure was chosen because it faces serious soil fertility problems and has severe shortages of poles, timber, fuelwood and fodder. This aspect of the programme emphasizes the testing of proven prototype technologies such as:

- alley cropping or hedge-row inter-cropping;

- shrub and grass strips on terrace bunds and risers;

- upperstorey trees on hedges, grass/shrub strips and plot boundaries; and

- fruit trees in crop-land.

2. THE PROJECT SITES (STATIONS)

The Uganda AFRENA programme has three stations (Kampala, Bushenyi, and Kabale) at which the programme activities are concentrated. The zonal emphasis on upperstorey trees covers all three. The choice of the sites was based primarily on altitude with the intent of including low, middle, and high elevations within the East and Central African highlands. Kampala is at the lowest site, Kabale is the highest, and Bushenyi lies in the middle (Table 2).

Table 2. Uganda AFRENA: General site information

SITE	KACHWEKANO	KABANYOLO	BUSHENYI
ALTITUDE (m)	2,000	1,250	1,610
LATITUDE	1°16'S	0°28'N	0°34'S
LONGITUDE	29°57'E	32°27'E	30°13'E
RAINFALL (mm)	1,040	1,440	1,200
TEMPERATURE mean annual mean maximum mean minimum	 14.0 23.5 10.9	 22.5 27.9 15.7	 21.0 25.6 13.3
SOILS soil type slope(s) angle	 Ferralsol 8-56%	 Ferralsol 5-10%	 Ferralsol 5-25%

The country or land-use specific component of the programme on the other hand is concentrated in Kabale District. A brief description of each of these sites follows:

2.1 Kampala site

Initial project activities at this site started at Makerere University Agricultural Research Institute, Kabanyolo, in October 1988, but due to shortage of land at this location, later project activities will be moved to Namalonge Research Station, in May 1990. Makerere University Farm, Kabanyolo, is located at latitude 0-28°N and longitude 32-27°E, lying at an altitude of 1,250 m above sea-level, and is situated about 14 km outside Kampala City. Rainfall is bimodal with the first rains falling between February and May, while the second rains are received from August to November. Mean annual rainfall is about 1,440 mm, while the mean annual temperature is about 22.5°C. Soils are ferralsols and are mainly red loams with pH varying from 5.0 to 6.9. The slope at the site varies from 5-10%. The site had been fallow for several years and the vegetation was mainly elephant grass (*Pennisetum purpureum*) with isolated *Spathodea nilotica* and *Albizia coriaria* trees.

As of January 1990, five experiments had been planted at this site. These include two screening trials, two management trials and one banana/tree association trial.

2.2 Bushenyi site

Government permission to use the Bushenyi District Farm Institute (DFI) was obtained in December, 1989. Land preparation began in March 1990 and the first experiment was planted in April 1990. The DFI is about 3 km outside Bushenyi town. The Institute was established in 1962 and has a total land area of about 148 acres (59 ha). The area that has been allocated to the project is about 5 ha and is located on the Eastern side of the farm. Bushenyi is located at latitude 0°, 34'S and longitude 30°, 13'E, lying at an altitude of about 1,610 m above sea-level. Rainfall is bimodal, with the first rains falling in February-May and the second from September-November. The longest dry season is June-August, while the December-January one is short. The mean annual rainfall is about 1,200 mm, while the mean annual temperature is about 21°C. Soils are ferralsols and are acidic, ranging in pH from 3.7-4.2 and they are deficient in humus, potash and phosphate. The slope varies from 5 to 25% at the experimental site. The site had been fallow for several years and the vegetation was mainly *Digitaria scalarum* grass with herbs and shrubs and a few isolated *Erythrina abyssinica* trees.

Since no experimental work was conducted in 1989, activities at this site will not be mentioned further in this annual report.

2.3 Kabale site

Project work at this site started in March 1989 at Kachwekano District Farm Institute, which is located about 8 km outside Kabale town. It is located at latitude 1°, 16'S and longitude 29°, 57'E, lying at an elevation of about 2,000 m above sea level. Rainfall is also bimodal, with the first rains being received from March-May and the second from September-November.

Mean annual rainfall is about 1,040 mm, while mean annual temperatures average about 14°C. Ferralsols are dominant on terraced slopes which range from 8 - 56% in the experimental plots. The site had also been fallow for a few years with the dominant vegetation being *Pennisetum clandestinum* with herbs and shrubs.

As of February 1990, three experiments had been planted at this site, that is one screening trial, one management trial and one prototype trial. Soil samples have been taken, but not yet analyzed.

3. UPPERSTOREY MULTIPURPOSE (MPT) SCREENING TRIALS

3.1 Objectives

A diagnosis of the farming systems in the highlands of East and Central Africa revealed a severe shortage of poles, fuelwood and timber at the farm level. Thus, it was found desirable to incorporate MPT's on farm or plot boundaries as upperstorey trees so as to provide these products without reducing crop productivity. The main purpose of the screening trials is to select suitable upperstorey MPTs for use within and along the boundaries of croplands. Subject to availability of seed, these trials have been and will continue to be established at three experimental sites.

The main objectives of these trials are:

- to select promising MPT's for upperstorey planting;
- to quantify the biomass (pole, fuelwood, small timber) production potentials of different MPT's planted as upperstorey trees;
- to assess the effect of the MPT's on the companion crop; and
- to make recommendation with respect to the selection of the most beneficial MPTs and the procedures by which they can be successfully incorporated into crop lands.

3.2 Observations

The following observations are being made in the screening trials:

- survival of the trees at the end of the first growing season;
- tree height, stem diameter (root collar) and crown development assessed after every three months;
- crop biomass and grain yields assessed every season;
- measurements of biomass from the trees (weight of pruned biomass and final product); and
- pests and disease incidence.

3.3 Methods

Randomized Complete Block Designs with three replications were used for the MPT screening trials at each site. A plot consists of a single row of trees planted along the contours with individuals spaced two metres apart. Plot widths were 6 m with 3 m on the upper part and 3 m on the lower side. Plot length is dependent on the number of trees

in the central row. One tree on each end of the row was considered as a guard tree. Measurements made on these guard trees will only be used if it can be shown that there is no significant difference between them and the remainder. Adjacent to the row of trees, on both sides, a crop is raised. Minor differences in the experimental details are summarized in Table 3, while Table 4 lists the species and provenances that have been included in the trials.

Management of the Tree Component. Tree seedlings were raised in the nursery and then planted out. Those that died within one month after planting were replaced, but subsequent failures were left. The trees are side-pruned from time to time, and a specific schedule for future years is being developed. Biomass of leaves, twigs, and wood is being measured. Only *Cordia abyssinica* (24-6-89) and *Melia azedarach* (28-6-89) in Experiment 1 (Kabanyolo) have been pruned so far and the data have yet to be analyzed.

Table 3. Experimental details for MPT screening trials at Kabanyolo and Kabale.

Experimental characteristics	Kampala		Kabale
	Exp.1	Exp.4	Exp.1
- Total number of trees in plot row	9	9	7
- Number of guard trees in row	2	2	2
- Length of plot (m)	16	16	12
- Width of plot	6	6	6
- Fertilizer (CAN) applied to each tree at time of planting (g)	20	0	0
- Watering of seedlings	yes	yes	no
- Date of establishment	5/11/88	2/06/89	7/04/89
- Number of treatments excluding control	9	9	9
- spacing of bean rows (cm)	60	60	45
- spacing of beans within row (cm)	10	10	10
- dates of planting beans	28/10/88 21/04/89 3/10/89	- 4/06/89 13/10/89	- 10/04/89 26/09/89

Table 4. Upperstorey MPTs currently planted in screening trials at two sites in Uganda.

Species	Kampala		Kabale
	Exp. 1	Exp. 4	Exp. 1
Alnus acuminata	+	-	+
Alnus nepalensis	-	+	+
Cassia siamea	-	+	-
Casuarina equisetifolia	+	+	+
Casuarina cunninghamiana (Kibuye)	-	-	+
Casuarina cunninghamiana (Ruhande)	-	-	+
Cordia abyssinica	+	-	-
Cupressus lusitanica	+	+	+
Erythrina abyssinica	-	+	+
Grevillea robusta (Kakamega)	-	-	+
Grevillea robusta (Kenya)	-	+	-
Grevillea robusta (India)	-	+	-
Jacaranda mimosifolia	-	+	-
Maesopsis eminii (Kakamega)	+	-	-
Maesopsis eminii (Wundanyi)	+	-	-
Maesopsis eminii (Mabira)	-	+	-
Markhamia lutea	+	-	-
Markhamia platycalyx	-	-	+
Melia azedarach	+	-	-
Control plot (no tree, but crop only)	+	+	+

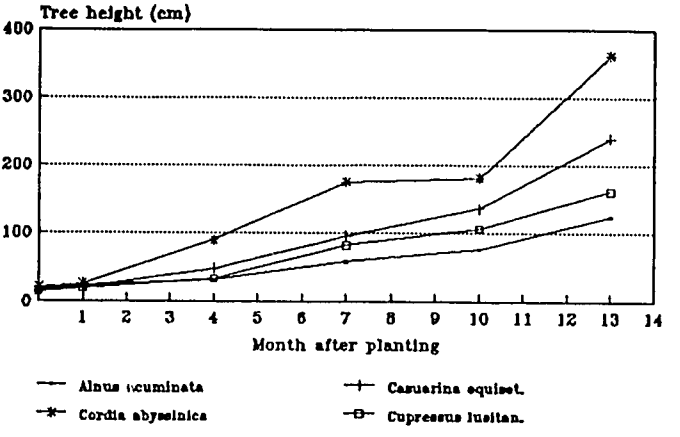
Note: "+" indicates MPTs that were planted at a particular site.

Management of the Crop. During the period covered in this report, the only crop planted in the three MPT screening trials was beans (*Phaseolus vulgaris*). Variety K20 was used in all experiments. No fertilizers or pesticides were used in any of the experiments. Details of the planting procedures and schedules are given in Table 3.

3.4 Results

Tree Survival. Tree survival (table 5) at the end of the first growing season was generally high with most varieties of MPTs having no mortality. The most notable exception was *Alnus nepalensis* in Experiment 4 at Kabanyolo where more than 60% were lost. Low levels of mortality were observed in *Cupressus lusitanica*, *Alnus acuminata*, *Maesopsis eminii*, *Cassia siamea*, and *Erythrina abyssinica*.

Figure 1. Growth (height) of trees in Expt. 1, Kabanyolo



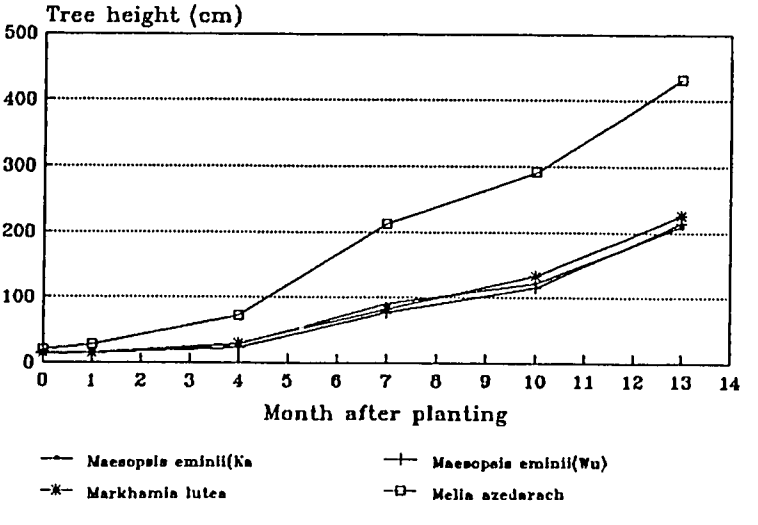
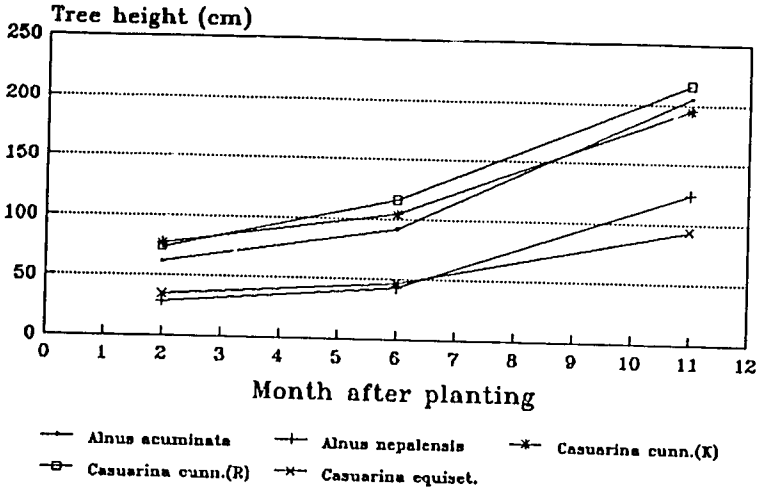


Figure 2. Growth (height) of trees in Exp. 1, Kachwekano



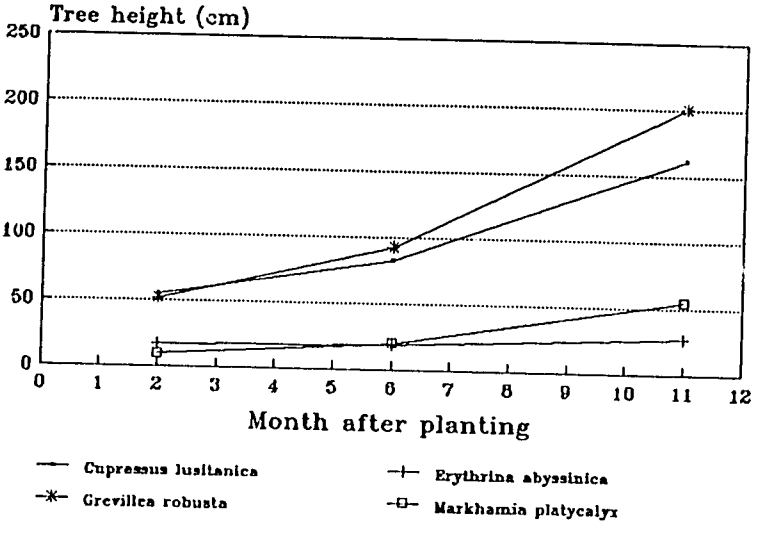


Table 5. Survival rates (%) of the upperstorey MPT's after one growing season in screening trials at Kabanyolo and Kabale Experiment 1, Kabale.

Species	Kampala		Kabale
	Exp. 1	Exp. 4	Exp. 1
Alnus acuminata	85	-	100
Alnus nepalensis	-	37	100
Casuarina cunninghamiana (Kibuye)	-	-	100
Casuarina cunninghamiana (Ruhande)	-	-	100
Casuarina equisetifolia	100	100	100
Cupressus lusitanica	100	96	100
Erythrina abyssinica	-	100	95
Grevillea robusta	-	-	100
Markhamia platycalyx	-	-	100
Cordia abyssinica	100	-	-
Maesopsis eminii (Mabira)	-	89	-
Maesopsis eminii (Kakamega)	96	-	-
Maesopsis eminii (Wundanyi)	100	-	-
Markhamia lutea	100	-	-
Melia azedarach	100	-	-
Cassia siamea	-	96	-
Jacaranda mimosifolia	-	100	-
Grevillea robusta (India)	-	100	-
Grevillea robusta (Kenya)	-	100	-

Tree Growth. The MPT screening trials started at different dates and were sampled over different time periods. Differences in germ plasm and various environmental factors make site-to-site comparisons difficult. However within each site, highly significant ($p < 0.01$) differences among MPTs were observed (Tables 6, 7, and 8, and Figures 1 and 2) with respect to heights, root collar diameters crown diameters, and crown depths.

In Experiment 1, Kampala, *Melia azedarach* was the fastest growing tree reaching an average height of more than 4 m over 13 months and having a root collar diameter of about 11 cm. *Cordia abyssinica* was the second highest tree after 13 months (362 cm), but its excessively spreading crown (diameter of 386 cm) appeared to be interfering with the adjacent crop. *Casuarina equisetifolia*, *Maesopsis eminii*, and *Markhamia lutea* were middle ranked with heights ranging from 209 to 240 cm. In relation to height attained, Markhamia was characterized by a small crown diameter of only 111 cm. *Alnus acuminata* and *Cupressus lusitanica* exhibited the lowest growth rates failing to reach 2 m over the 13 month period.

In Experiment 4, Kampala, *Erythrina abyssinica* attained the greatest height (213 cm) after 7 months, but it was severely attacked by insects, and it appears that it may not do well in the long run. *Cupressus lusitanica* showed very little initial growth reaching a height of only 31 cm. *Alnus nepalensis* had a high mortality rate (67%) with one replication loosing all individuals. Of the survivors, height was variable averaging 34 cm. *Cassia siamea*, *Jacaranda mimosifolia*, *Grevillea robusta*, *Maesopsis eminii* and *Casuarina equisetifolia* ranged from 193 cm to 121 cm in height after 7 months. During the first 7 months of MPT growth, root collar and crown development appeared to be generally related to tree height.

In Experiment 1, Kabale, *Casuarina cunninghamiana*, *Alnus acuminata* and *Grevillea robusta* reached similar heights ranging from 195 to 216 cm over the first 11 months. Lesser heights ranging from 162 to 55 cm were reached by *Cupressus lusitanica*, *Alnus nepalensis*, *Casuarina equisetifolia*, *Markhamia platycalyx* and *Erythrina abyssinica*. During the first 11 months of MPT growth, root collar diameters and crown depths and diameters appeared to be generally correlated with tree heights.

Table 6. Mean growth parameters (cm) for MPTs thirteen months after planting (December 1989) in the upperstorey screening trial (Experiment 1, Kampala).

Species	Height	Root collar diameter	Crown diameter	Crown depth
Alnus acuminata	124	3.2	97	120
Casuarina equisetifolia	240	3.8	158	234
Cordia abyssinica	362	9.3	386	354
Cupressus lusitanica	161	3.2	134	161
Maesopsis eminii (Kakamega)	209	5.3	222	181
Maesopsis eminii (Wundanyi)	215	5.4	220	196
Markhamia lutea	226	3.9	111	183
Melia azedarach	436	11.1	338	333
Grand mean	247	5.65	208	220
S.E. of difference of means	24.5	0.68	20.4	23.1
C.V. for plot means (%)	12.2	14.5	12.0	12.8

Table 7. Mean growth parameters (cm) for MPTs seven months after planting (January 1990) in the upperstorey screening trial (Experiment 4, Kampala)

Species	Height	Root collar diameter	Crown diameter	Crown depth
Erythrina abyssinica	213	6.1	144	189
Alnus nepalensis	34*	0.9*	29*	30*
Cassia siamea	193	4.6	221	184
Cupressus lusitanica	31	0.6	15	30
Jacaranda mimosifolia	178	4.0	128	143
Grevillea robusta (India)	153	3.4	136	141
Grevillea robusta (Kenya)	139	3.3	136	125
Maesopsis eminii	134	3.3	137	123
Casuarina equisetifolia	121	2.1	104	119
Grand mean	145	3.4	128	132
S.E. of difference of means	18.5	0.40	16.7	18.4
C.V. for plot means (%)	15.6	14.4	16.0	17.1

*67% of the Alnus trees died, and these results for the survivors were not included in the analyses of variance.

Table 8. Growth (cm) of MPTs eleven months after planting (December 1989) in Experiment 1, Kabale

Species	Mean height	Mean root collar diameter	Mean crown diameter	Mean crown depth
Alnus acuminata	205	4.9	188	208
Alnus nepalensis	124	2.9	112	125
Casuarina cunninghamiana (Kibuye)	195	2.7	101	182
Casuarina cunninghamiana (Ruhande)	216	3.0	119	206
Casuarina equisetifolia	94	1.2	48	93
Cupressus lusitanica	162	2.9	132	166
Erythrina abyssinica	27	1.5	39	32
Grevillea robusta	201	4.5	190	197
Markhamia platycalyx	55	2.1	61	58
Grand mean	142	2.85	110	141
S.E. of difference of means	28.9	0.55	22.6	29.9
C.V. for plot means (%)	24.6	23.5	25.2	26.0

Bean Yield. Early estimates of crop yields are not included herein because it is assumed that the impact of newly planted trees on adjacent crops is minimal. After 13 months (December, 1989), the upperstorey trees in Experiment 1, Kampala, were well established, and highly significant differences ($p < 0.01$) in bean yields were observed (Table 9) among treatments (MPT species). Yields of beans were greatest next to *Alnus acuminata* (41 g/m) and least adjacent to both *Melia azedarach* and *Cordia abyssinica* (13 g/m). Yields of beans ranged from 25 to 32 g/m for other 6 MPT species. Highly significant differences in bean yield were also observed among rows of beans within treatments. In general yields were lowest in rows nearest to the tree row and highest in rows farthest away. This effect was most apparent with Cordia. Melia was notable in having lower bean yields in all rows of beans, and there is an indication that bean rows next to Alnus were greater than those which are farther distant.

Experiment 4, Kabanyolo, is characterized by very stony soil and fertility seems low. Bean yields have been poor. Compared to Experiment 1 which had an overall average yield of 26 g/m, the average yield harvested in January 1990 in experiment 4 was only 2.4 g/m of bean row. There were no significant differences among treatments, and the crop was so poor that data were not recorded by row. Unless soil treatments are used in future,it is unlikely that this screening trial will provide meaningful results of tree-crop interactions.

Experiment 1, Kabale, is very steep, and although no soil analyses are yet available, soil fertility seems very low. Grain yields from 1989 are not high. Farm workers took it upon themselves to harvest the beans from one entire replicate and two treatments from another before any weight measurements could be made. Observations made during the year indicate that there is a very high degree of variability within individual benches of the terraced landscape of Kabale District. The analyses of variance for beans harvested in January, 1990, revealed no significant ($p < 0.05$) differences among treatments. Significant differences were observed among rows of beans. Noting that the trees were planted along the contour in the middle of the terrace benches, those rows located above the trees generally had higher bean yields than those on the lower side. Row to row variations was high. Because the MPTs are still young, and because of the high variation within and among plots, no meaningful conclusions with respect to tree-crop interactions are possible. In future it may be necessary to add fertilizer to homogenize the experimental area if useful results are to be obtained in future.

Table 9. Bean yield (g/m of row) by row in Experiment 1, Kabanyolo, 13 months after planting (December, 1989).

Species	Distance from MPT row (cm)					Plot average
	60	120	180	240	300	
Control plot	27	32	28	24	27	28
Alnus acuminata	42	45	45	38	37	41
Casuarina equisetifolia	28	25	29	28	28	28
Cordia abyssinica	1	5	14	19	25	13
Cupressus lusitanica	22	38	25	39	36	32
Maesopsis eminii (Kakamega)	23	24	34	29	27	27
Maesopsis eminii (Wundanyi)	19	22	26	25	33	25
Markhamia lutea	27	33	27	30	34	30
Melia azedarach	10	12	14	13	15	13
Mean	22	26	27	27	29	26
S.E. of difference of means	5.7	5.7	5.7	5.7	5.7	4.4
C.V. for row & plot means (%)	20	20	20	20	20	19

4. MANAGEMENT TRIALS

4.1 Objectives

While it is still too early to draw conclusions from the screening trials for upperstorey trees, enough information from elsewhere indicates that *Grevillea robusta* and *Casuarina spp.* can be integrated into cropland without significantly reducing crop production. Both of these tree species have potential for agroforestry in Uganda. However, very little is known about their management in an agricultural setting. Two critical issues require resolution. First, the optimal intra-row spacing of upperstorey trees must be determined. Second, it is necessary to determine the degree to which upperstorey trees can be interplanted with understorey species such as Napier grass and leguminous hedges such as *Calliandra calothyrsus*. This second issue is of great importance in sloping farmland where control of soil erosion is required and scattered upperstorey trees will not help. Interplanting upperstorey trees with understorey trees along the contours may serve multiple purposes including erosion control, production of timber, fuel wood, green mulch, fodder, and stakes for climbing beans. Three management trials addressing these issues were established at Kabanyolo (Kampala) and Kachwekano (Kabale).

The main objectives of the management trials are:

- to determine the production potential of the MPTs grown at different spacings and with different types of understorey;
- to determine the effect of the upperstorey trees and understorey vegetation on the associated crops; and
- to determine the effect of upperstorey trees on the understorey and vice-versa.

4.2 Observations

The following observations are being made on these trials:

- survival of the trees at the end of the first growing season recorded as a percent;
- height, diameter and crown growth of the MPTs recorded four times per year;
- crop yields;
- biomass of prunings and final product of upperstorey MPTs;
- growth and biomass production from the understories; and
- incidences of pests and disease.

4.3 Methods

Randomized Complete Block Designs with three replications were used for the management trials. A plot consists of either a control without upperstorey trees or a single row of trees spaced at 1, 3, or 5 m intervals. Plot lengths vary according to the number of trees in the row. Width of the plot is 6 m, with 3 m on the upper slope and 3 m on

the lower slope. Adjacent to the tree rows, on either side, a crop is raised. One guard tree is provided at each end of the plot. The understories, Napier grass (*Pennisetum purpureum*) and *Calliandra calothyrsus*, are planted along the contours in the same rows as the trees at intervals of 0.5 m. Site-specific details are given in tables 10 and 11.

Two trials, one with *Casuarina equisetifolia* (Experiment 2) and one with *Grevillea robusta* (Experiment 3) as upperstorey trees were established at Kabanyolo. At the Kabale site, one trial with *Grevillea robusta* was established. Treatments included in each experiment are described in Table 10, and experimental details are given in Table 11.

Table 10. Combinations of upperstorey tree spacing and type of understorey used in the management trials at Kabanyolo and Kabale.

Treatment in experiment		Kampala		Kabale
Upperstorey tree spacing (m)	Understorey type	Exp 2	Exp 3	Exp 2
no trees	none	+	+	+
no trees	Napier	-	+	+
no trees	Calliandra	-	+	+
1	none	+	+	+
1	Napier	+	-	-
1	Calliandra	+	-	-
3	none	+	+	+
3	Napier	+	+	+
3	Calliandra	+	+	+
5	none	+	+	+
5	Napier	+	+	+
5	Calliandra	+	+	+

"+" indicates those treatment combinations found in each given management trial.

Table 11. Experimental details for Management trials at Kabanyolo and Kabale.

Experimental details	Kampala		Kabale
	Exp 2	Exp 3	Exp 2
- Total number of upperstorey trees in plots with spacing of: - 1 m	6	11	16
- 3 m	6	6	6
- 5 m	6	6	6
- Total plot length (m) with intra-row spacing of trees of: - none	15	10?	15
- 1 m	5	10	15
- 3 m	15	15	15
- 5 m	25	25	25
- Number of guard trees	2	2	2
- Total plot width (m)	6	6	6
- Fertilizer (CAN) applied to each tree at time of planting (g)	20	0	0
- Date of establishment	9/11/88	20/05/89	8/04/89
- Watering of seedlings	yes	no	no
- Number of treatments including control	10	10	10
- Intra-row spacing of Napier (cm)	50	50	50
- Dates of planting Napier	6/05/89	6/05/89	09/89
- Intra-row spacing of Calliandra (cm)	50	50	50
- Dates of planting Calliandra	4/05/89	5/05/89	8/04/89
- Length (cm) of Napier cuttings planted	20-30	20-30	50
- Spacing of bean rows (cm)	60	60	45
- Spacing of beans within row (cm)	10	10	10
- Dates of planting beans	10/11/88	-	-
	28/04/89	17/05/89	13/04/89
	6/10/89	11/10/89	26/09/89

Management of the Tree Component. Tree seedlings that had been raised in the nursery were planted out in the trials. In Experiment 2, Kabanyolo, 20 g of Calcium ammonium nitrate (CAN) was applied to each seedling at the time of planting, and the seedlings were watered during the first dry season. No fertilizer was used and no water was given in the other two experiments. Tree seedlings that died within one month after planting were replaced. After one month, dead trees were not replaced. The trees are side pruned from time to time when shading of the adjacent crop is likely to be significant.

Management of the Understorey. *Calliandra calothyrsus* seedlings that had been raised in the nursery were planted on 4-5-89. Seedlings that failed one month after planting were replaced, but subsequent failures were left. The pruning of Calliandra is done at a height of 0.5 m. Pruning schedules are being developed and will vary from site to site.

Cuttings of Napier grass were planted on dates shown in Table 11, and those that failed to establish after one month were replaced, but subsequent failures were left. The napier grass is also cut back to a height of 0.5 m, and a schedule for this being developed for each site, and will depend on the growth rate of the grass and the cropping calendar.

Management of the Crop. During the period covered in this report,the only crop planted in the three management trials was beans (*Phaseolus vulgaris*). Variety K20 was used in all trials. No fertilizer or pesticides were used. Details are given Table 10.

4.4 Results

Tree Survival. Mortality of upperstorey trees was low. Over all three experiments, all Grevillea trees and all-but-one Casuarina survived.

Tree Growth. The management trials were established at different dates and were sampled over different time periods so that site-to-site comparisons are difficult to make. Initial results (Table 11) indicated that upperstorey trees intercropped with understorey develop less quickly than those which are grown without understorey. The effect of Napier appears to be greater than that of Calliandra in retarding tree growth.

Table 12. The growth (treatment means, cm) of **Casuarina equisetifolia** and **Grevillea robusta** planted as an upperstorey tree in association with understorey vegetation.

Tree spacing (m)	Understorey type	Kabanyolo (Kampala)								Kachwekano (Kabale)			
		Exp 2 Casuarina (12/89)				Exp 3 Grevillea (12/89)				Exp 2 Grevillea (02/90)			
		Hght	Root coll diam	Crwn diam	Crwn dpth	Hght	Root coll diam	Crwn diam	Crwn dpth	Hght	Root coll diam	Crwn diam	Crwn dpth
1	none	173	2.5	99	167	193#	3.8#	172#	163#	204#	4.2#	182#	201#
1	Napier	183	2.4	89	177	-	-	-	-	-	-	-	-
1	Calliandra	175	2.3	85	169	-	-	-	-	-	-	-	-
3	none	169	2.6	100	160	180	3.7	162	149	206	4.4	186	205
3	Napier	156	2.1	78	151	160	2.9	119	134	178	3.8	172	176
3	Calliandra	172	2.3	91	160	182	3.2	135	148	183	3.5	161	184
5	none	143	2.4	91	134	194	4.1	183	169	175	3.9	175	177
5	Napier	176	2.5	89	159	166	2.8	130	144	174	3.6	170	171
5	Calliandra	156	2.2	77	148	181	3.1	142	145	171	3.2	144	162
Grand mean		167	2.4	89	153	177	3.3	145	148	181	3.7	168	179
S.E. of difference:													
- spacing		8.6	0.14	4.9	9.2	4.6	.12	7.5	6.7	11	.27	8.5	11
- understory		8.6	0.14	4.9*	9.2	5.6*	.14*	9.2*	8.2	13	.34	11	13
- 2X interaction		15	0.24	16	16	7.9	.20	13	12	19	.47	15	19
C.V. Plot (%)		11	12	12	12	5.5	7.6	11	9.6	13	16	11	13

* indicates ANOVA with significant differences ($p < 0.05$)
# indicates plots that were not included in the ANOVAs.

Understorey Growth. The understorey species of Napier and Calliandra were planted at the three sites in April and May, 1989. In Kabale, no understorey harvests were made in 1989. At Kabanyolo, some data collected in 1989 were not analyzed in time for inclusion in this report. The only harvest for which data were available was Calliandra in Experiment 2, Kabanyolo. Since the Calliandra component of a management trial is only a small fraction ot the total number of plots, very few degrees of freedom were available for this analysis. Mean yields of Calliandra plants are given in Table 13. There is a slight indication that production of Calliandra is less in plots having a 1 m spacing of Casuarina compared to those with 3 and 5 m spacings. After seven months Calliandra reached an average height of 237 cm and there were no significant differences in height among the different plots containing this shrub.

Table 13. Mean dry weight yields (g) of Calliandra plants in Experiment 2, Kabanyolo over a 6 month period beginning with planting in May 1989.

Intra-row spacing Casuarina (m)	Leaves	Stems
1	135	87
3	196	133
5	193	157
Grand mean	175	126
S.E. Diff. of means	20	19
C.V. of plot means (%)	14	19

NB: ANOVA for stems was significant ($p < 0.05$).

Bean Yields. As with other measurements, the experiments are still too young for the full impact of the treatments to influence bean yield. However, at this early stage, there is some indication (Table 14) that bean yields are less in plots with Napier and greatest in plots without understorey vegetation. This was only true for the bean harvests made in January 1990 when the trees and understorey had had a chance to establish themselves. At Kabanyolo, bean yields ranged from a low of about 15 g/m of row to about 36 g/m. At Kachwekano, bean yields ranged from a low of 6.5 to a high of about 21.6 g/m of row.

The original objectives included estimation of the production of bean plant stover. This was subsequently dropped because dried bean plants are fragile, and measurements of their standing biomass at the time of harvest do not reflect the significant levels of leaf fall. The soils at Kachwekano are proving to be unsuitable for crop production, and future use of fertilizers may be necessary if tree- crop interactions are to be studied. As mentioned in the discussion of the upperstorey screening trials, there is a very high degree of

heterogeniety in the experimental area (among rows and among plots). Soil samples have been taken and are awaiting analysis.

Table 14. Bean yields (g/m of row) on a dry weight in two upperstorey/understorey management trials.

Tree spacing (m)	Understorey type	Kabanyolo (Kampala)				
		Exp 2 Casuarina			Exp 3 Grevillea	
		02/89	08/89	01/90	08/89	01/90
none	none	31.6#	24.3#	25.0#	12.0	21.6
none	Napier	-	-	-	11.0	6.5
none	Calliandra	-	-	-	11.0	10.3
1	none	26.6	31.0	23.8	11.1#	17.0#
1	Napier	30.6	25.7	22.6	-	-
1	Calliandra	31.2	27.3	19.4	-	-
3	none	31.7	24.0	26.7	12.3	16.7
3	Napier	34.7	28.3	19.5	12.3	8.7
3	Calliandra	31.8	29.0	24.0	10.0	9.6
5	none	36.7	24.0	28.7	12.0	21.3
5	Napier	30.2	23.0	14.9	14.3	9.6
5	Calliandra	35.9	34.0	33.1	13.0	11.2
Grand mean		32.1	27.9	23.6	12.0	12.8
S.E. difference:						
- spacing		2.5	2.1	2.9	.03	2.2
- understorey		2.5	2.1	2.9*	.03	2.2*
- 2X interaction		8.5	3.6	4.9	.04	3.8
C.V. plot (%)		16	16	27	44	36

# indicates treatments not included in the ANOVAs.
* indicates significant differences ($p < 0.05$).

5. TERRACE MANAGEMENT TRIAL (Experiment 3, Kabale)

The Diagnostic and Design Survey of the Kigezi Annual Montane Food Crop System noted the importance of terracing in managing the agricultural lands of south west Uganda. Terrace management is currently based on a set of by-laws which were established about forty years ago and which were based on much less intensive land use practices than those now common. In addition to satisfying demands for products such as fuel wood, fodder, green mulch and stakes for climbing beans, agroforestry technologies may be useful in stabilizing the terrace structures while contributing to better conservation of the soil.

In November 1989, a terrace management trial was established at the District Farm Institute, Kachwekano. The trial consists of various combinations of Napier grass, *Calliandra calothyrsus*, and mountain paw paw planted along the upper and lower edge of the terrace risers. While addressing issues related to terrace management, this trial emphasizes the need for fodder production in "near fields". "Near fields" are those located near settlements where it is feasible for farmers to cut fodder for livestock and return manure as a fertilizer. The terrace management trial has only just been established, and no data have yet been gathered.

6. NON-EXPERIMENTAL ACTIVITIES

6.1 Training Workshops

Project staff have participated in various workshops and conferences. Those held at ICRAF headquarters in Nairobi include:

- Mr. John Okorio, 6 month on-the-job training from September 1987 to March 1988.
- Dr. John Aluma and Mr. Steven Byenkya, three week course, Agroforestry for Development" in November and December 1987.
- Mr. D. Wafula, technicians' training course in September 1989.
- Dr. D. Peden, Agroforestry for Development Course and DATACHAIN workshop in May and December respectively.

In addition, project scientists have attended the Annual Zonal and Planning Meeting of the East Africa AFRENA Network held in Kampala from the 5th to 10th of June 1989.

6.2 Installation of a Weather Station at Kabale

The Uganda AFRENA Programme re-habilitated the weather station at the Kachwekano District Farm Institute (DFI). The instrument cage and Min-Max thermometer were repaired. The programme replaced the rain guage. DFI staff started recording weather data in January 1990.

6.3 Establishment of Kabale as a Focus for Agroforestry Research

The past year (1989) marks a major step in the development of the Ugandan component of the East Africa AFRENA. Much time and effort was spent in organizing the transfer of staff to Kabale and in obtaining housing, schools, and office space. Work was initiated to rehabilitate the Forest Department Tree Nursery, Bugongi. AFRENA expects to produce a minimum of 50,000 seedlings per growing season.

6.4 Visitors

Increasing numbers of visitors have inspected the experimental sites and offices in Kabale and Kampala. These have included government officers, researchers, students, representatives of non-governmental organizations, and professional staff from international organizations.

Appendix I: STAFFING

The project team composition is as follows:

Scientific staff
- Donald Peden, Agrologist, ICRAF Scientist (Team leader)
- John Okorio, Forester, (Team Leader, Ugandan Counterpart)
- Steven Byenkya, Animal Scientist
- Nelson Wajja-Musukwe, Agronomist
- John Francis Esegu, Tree Breeder

Support staff
- Joyce Muwanga (Mrs.), Project Administrator
- David Wafula, Forest Ranger, Technician
- Andrew Lumumba, Forest Ranger, Technician
- Posiano Nteziryayo, Agricultural Assistant, Technician
- Evelyn M. Tarushoke (Mrs.), Secretary
- David Sseguya, Driver
- Janet Sseguya (Mrs.), Office Worker

Labour
- Kampala (22)
- Bushenyi (10)
- Kabale (19)

Many individuals not mentioned in the foregoing list contributed to the technical and administrative progress of the Uganda AFRENA Programme. They include:

- Dr. John Aluma, Head, Department of Forestry, Makerere University
- Dr. James Roger, Statistician, ICRAF, Nairobi
- Dr. M.R. Rao, Agronomist, ICRAF, Nairobi
- Mr. Dirk Hoekstra, Economist, ICRAF, Nairobi
- Mr. Rik Thijssen, Agronomist, ICRAF, Nairobi
- Miss Claire Muniafu, Senior Bilingual Secretary, ICRAF, Nairobi
- District Administrator, Kabale District
- District Forest Officer, Kabale District
- District Agricultural Officer, Kabale District
- Members of the National Steering Committee