PN-ABC-638

ICRAF FIELD STATION

MACHAKOS, KENYA

STATUS REPORT: MARCH, 1986

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ICRAF

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Several ICRAF colleagues who are involved in various activities on the Field Station have provided their inputs in the preparation of this report, for which, thanks are extended to all of them.

The names of the professionals who are responsible for the different activities and trials are indicated against the respective items. However, the day-to-day work related to all these activities is carried out by Mr. Peter Wambugu Kurira, the Farm Manager, and his staff (see p. 11); therefore, their names are not mentioned repeatedly in the report. Similarly, Mr. Dennis Wambuguh, Research Assistant, is also involved in carrying out a number of activities mentioned in this report.

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1. BACKGROUND AND JUSTIFICATION

ICRAF is an international research council that is neither mandated, nor equipped to undertake research of its own aimed at generating location-specific technology and/or understanding basic phenomena.

However, the newness of agroforestry as a scientific activity and the unique position of ICRAF as the sole international agency that has been set up exclusively for agroforestry research, raise expectation among people about our capacity to fill the vacuum that exists today on agroforestry know-how. There is also a considerable amount of interest among the international donor community in ICRAF being able to demonstrate on the ground the role of agroforestry in tackling some of the land management problems and providing the basic needs under local situations. Morevoer, in the process of methodology development, which has been the main thrust of ICRAF's field activities during the early phase of the Council's existence, it was felt essential to undertake some trials on a limited scale to yield quick results to solve some of the problems and technology constraints that were likely to be identified during land use systems evaluation and diagnosis. After careful consideration all the relevant issues, ICRAF's Board of Trustees decided in March 1981 that ICRAF should have a small field station of its own, which could play the support (service) role for other field programmes, and be used for demonstration and training purposes.

2. SITE DESCRIPTION

2.1. Location

The idea of establishing such a Station was discussed with the appropriate agencies of the Government of Kenya, with a view to obtaining a suitable site from the Government. ICRAF desired to have the Station to be located

within about one hour drive from Nairobi in view of the logistical aspects and coordination with other field research activities of ICRAF in Kenya. With the active support and cooperation of the Kenyan Government officials, such a suitable area was identified in Machakos District.

The site is located about 70 km south-east of Nairobi, and 7 km south of Machakos town. It is about 40 ha in area and irregular in shape. It is bordered by the Maruba (Manza) river on one side and the farm road on the other; the other two sides are bordered by the fields of Farmers' Training Centre at one end and of the National Dryland Farming Research Station, Katumani, at the other, both being Kenya Government (Ministry of Agriculture) institutions.

The site can be reached through a direct all weather route from Machakos Municipality through the Machakos FTC. However, for the 6 km non-tarmac portion of the route, the use of a four-wheel drive vehicle is desirable during the rainy seasons.

2.2. Land allotment

Following ICRAF's formal application for allotment of the identified site for establishing the Field Station and subsequent negotiations with the Government, the land was alloted free of cost to ICRAF, initially for a period of 10 years effective from 1st July 1981, with provisions for extention of the term with mutual agreement, according to the terms and conditions laid out in a Memorandum of Understanding that was signed between the Government and ICRAF on 14th August 1981.

Other major terms and conditions of the Memorandum include the following:

- the Government shall permit free and easy access to the site to ICRAF staff, their trainees and visitors;
- the Government will assist ICRAF in the provision of services

such as water, electricity and telephone to the Station site;

- ICRAF will assume full financial responsibility for the establishment of the Field Station including fencing, building, provision of service and security;
- ICRAF will reimburse to Government at mutually agreed rates for any services provided to it by the Government or one of its agencies, for example, hiring of machinery;
- ICRAF will undertake to observe all government regulations affecting importation and movement of plant materials, pest controls, etc. and, further, will undertake not to engage in research which is deemed harmful to surrounding land use practices;
- within the above mentioned limits, ICRAF will have full freedom to develop the Station.

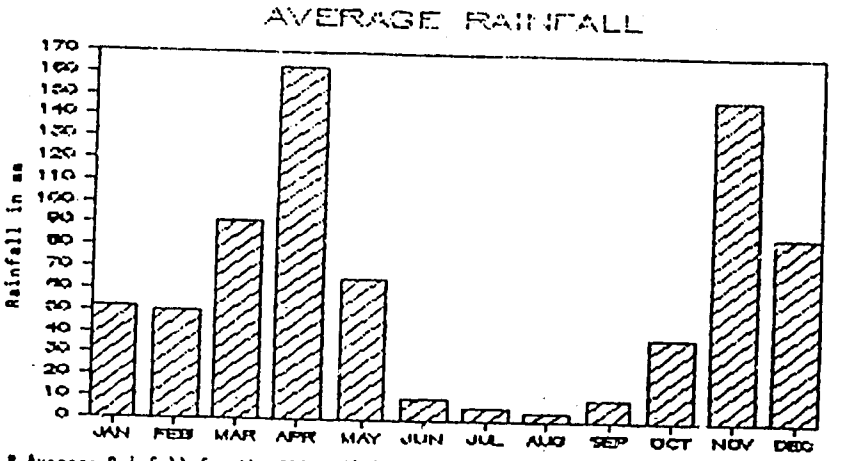
ICRAF has also obtained the required specific research permit in May 1981 from the office of the President of the Republic of Kenya authorizing ICRAF to undertake research in Kenya.

2.3. Ecology

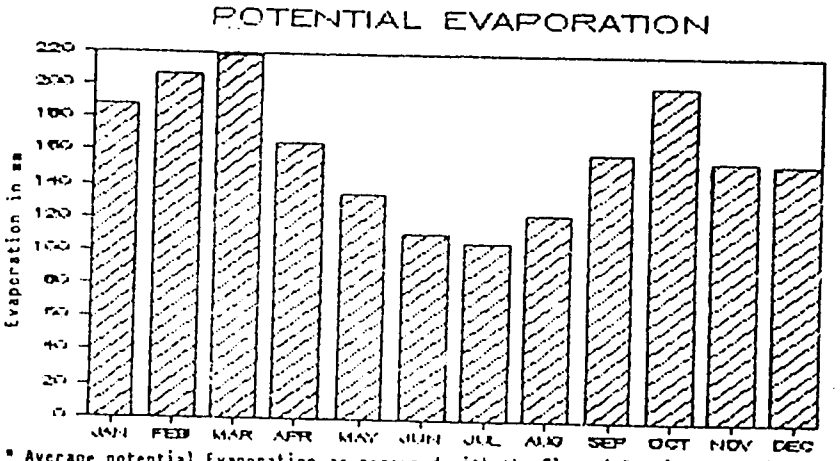
A detailed soil and vegetation survey of the site was conducted by the Kenya Soil Survey in March 1981 and a detailed report has been produced. Salient characteristics of the site are given below:

2.3.1. Climate

The area lies between 1° 30' and 1° 35' S latitudes and 37° 10' and 37° 15' E longitudes at an altitude of 1560 m above MSL in the sub-humid to semi-arid zone with an average annual rainfall of about 700 mm and an average evapotranspiration of about 1800 mm per year. Fig. 1 shows the average climatic pattern of the Station. See section 5.1 for detailed climatic information.



* Average Rainfall for the ICRAF Fieldstation calculated from KATUMANI and MACHAKOS DAM Rainfall data.



* Average potential Evaporation as measured with the Class A Pan in Katumani and adjusted by dividing by 0,93

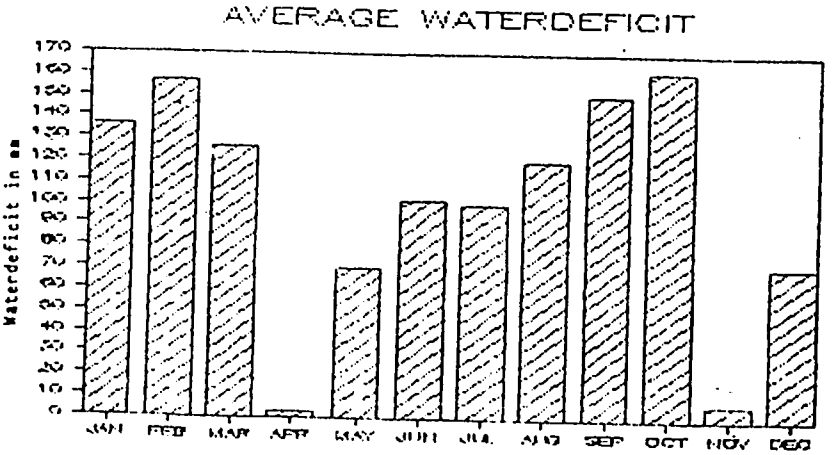


Fig. 1. Mean monthly rainfall, evaporation and water deficit at the ICRAF Field Station, Machakos.

2.3.2. Geology and Physiography

The area is underlain by rocks of the Precambrian Basement System; the predominant rocks are biotite gneisses and banded gneisses. Along the stream channels, narrow band of recent alluvial deposits also occur.

Physiographically the area belongs to the 'uplands'. It consists of a ridge with a convex upper part (slopes 0-5%) and straight sideslopes of 7-22%. Towards the stream the sideslopes grade into narrow stretches of nearly flat river terraces of less than 2% slope.

2.3.3. Soils

The predominant soil type is a well-drained, dark reddish brown sandy clay, derived from Basement Complex gneisses. It is friable, with a well-developed blocky structure and clay skins. The profile is deep to moderately deep on the convex upper slope, and also the meander core, becoming shallow on the steeper slopes. Nodular laterite concretions ('murram') occur in the base of the profile on the crest and mid-slope. There is a narrow belt of alluvial soils along parts of the valley floor.

The soils are weakly to moderately leached, with a weakly acid reaction (pH 6.0 - 6.5), a medium base saturation (50 - 80%) and moderate levels of organic matter (topsoil organic carbon (1.0 - 1.5%). Nutrient levels are medium.

On both the FAO and Kenya Soil Survey classification systems, most of the Station area belongs to the class of luvisols, including the pisoferric and lithic phases. The shallower profiles are lithosols, whilst small areas on the ridge crest, where the reaction approaches neutrality, are classed by the Kenya Soil Survey as phaeozems. On the US soil taxonomy the soils belong to the order alfisols, suborder ustalfs, including typic and lithic subgroups.

The deeper profiles have good physical properties, including root penetration and moisture-holding capacity, and a moderate level of natural fertility. They are suitable for annual crops with a short growing season, as well as for a range of multipurpose trees. On the gentle slopes, the main land use problem is drought. On the moderate to steep slopes there is a substantial erosion hazard, particularly important to control owing to the shallowness of the soils.

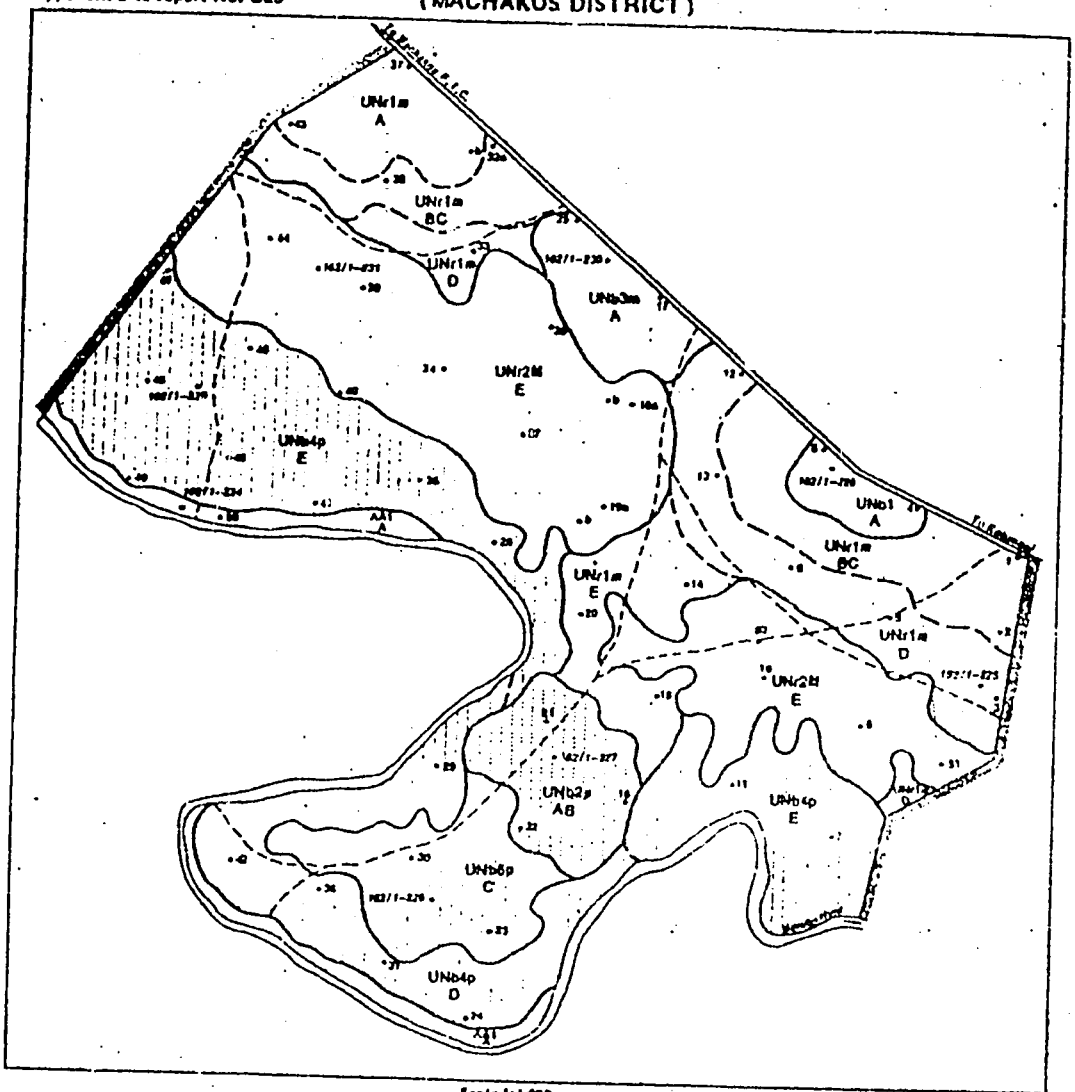
Fig. 2 shows the detailed soil map of the site and Table 1 gives the summary of chemical analysis data for different soil units, both taken from the detailed soil survey report prepared by the Kenya Soil Survey. Based on a detailed topographic map of the site (1:1000 scale with 1 m contour marking) got prepared by a Nairobi-based professional firm, a few distinct land units can be identified on the site as indicated in Fig. 3.

2.3.4. Vegetation

The natural vegetation of the site consists of bushlands, dense bushlands and bush thickets. The dominant shrubs and/or trees are: *Commiphora africana, Acacia tortilis, Acacia hockii, Lannea rivae, Acacia brevispica, Acalypha fruticosa, Acacia seyal, Dyschoriste depressa, Ocimum basilicum, Solanum incanum, Acacia elatior* and *Ficus* species. The dominant grasses are: *Eragrostic superba, Themeda triandra, Michrocloa kunthii, Panicum infestum, Pennisetum mezianum, Sporobolus marginatus, Eragrostis cilinensis, Chloris pyonothrix, Cynodon dactylon* and *Cyperus* spp. The tall and dwarf shrub dominate with cover ranges from 2-20% and 10-45% respectively. The physiognomy ranges from bushland to bushland thicket. Bushland thicket occur as cluster in some places. The vegetation map of the site is given as Fig. 4.

FIG. 3:- DETAILED SOIL MAP OF THE I.C.R.A.F EXPERIMENTAL FARM (MACHAKOS DISTRICT)

Appendix 2 to report No. D23



Scale 1:4,000

Prepared and drawn by Kenya Soil Survey, October 1981.

U UPLANDS (slopes 0–25%)

UNb Soils developed on basaltic gneisses and banded gneisses

UNb1r — well drained, very deep, dark reddish brown to dark brown, friable to firm (compact), clay (some PHAEOZEMS)

UNr1m — well drained, deep to very deep, dark red to dark reddish brown, friable clay over pseudomorphic material (murram) (domain LUVISOLS and some LUVISOLS, pseudomic phase)

UNb2p — well drained, deep to very deep, dark brown, friable to firm (compact), clay, in places rocky and stony (some PHAEOZEMS)

UNb3m — well drained, moderately deep to deep, dark reddish brown to dark grey, friable, sandy clay loam over pseudomorphic (murram) (domain LUVISOLS, pseudomic phase)

UNb4p — well drained, moderately deep to deep, dark reddish brown to dark yellowish brown, friable, sandy clay to clay, in places rocky and stony (some LUVISOLS)

UNb6p — well drained, moderately deep to deep, dark reddish brown to dark yellowish brown, friable to firm (compact), sandy clay loam to clay (some LUVISOLS)

UNr2M — well drained, very shallow to shallow, reddish brown to dark reddish brown, rocky and stony, friable to friable, gravelly, sandy clay to clay, over pseudomorphic (murram) and rock (some RHODOSOLS and LITHOSOLS)

A RIVER TERRACES (slopes 0–3%)

AB Soils developed on fluvial alluvial deposits

AA1 — imperfectly drained, very deep, dark brown to dark yellowish brown, mottled, friable, silty clay to clay (some FLUVISOLS)

KEY TO SLOPE CLASSES

Slope %	Slope class symbol	Name of the landform
0–2	A	flat to very gently undulating
2–5	B	gently undulating
5–8	C	undulating
8–16	D	rolling
16–30	E	hilly

KEY TO DEPTH CLASSES

Hardness	Symbol*		Name
Soil in cm	over rock	over murram	
0–25		AB	very shallow
25–50			shallow
50–80	D	m	moderately deep
80–120	D	m	deep
more than 120			very deep

* If a complex of depth classes occurs within one unit, the symbol of the shallowest depth class is underlined.

KEY

- soil mapping symbol
- UNb6p — depth class symbol
- AB — slope class symbol
- soil boundary
- slope class boundary
- 33 — observation, with reference number
- M27/1-330 — profile pit, with reference number
- farm and boundary of the surveyed area
- foot path
- dirt road
- 0.04 ha

Drawing No. 1 of 6

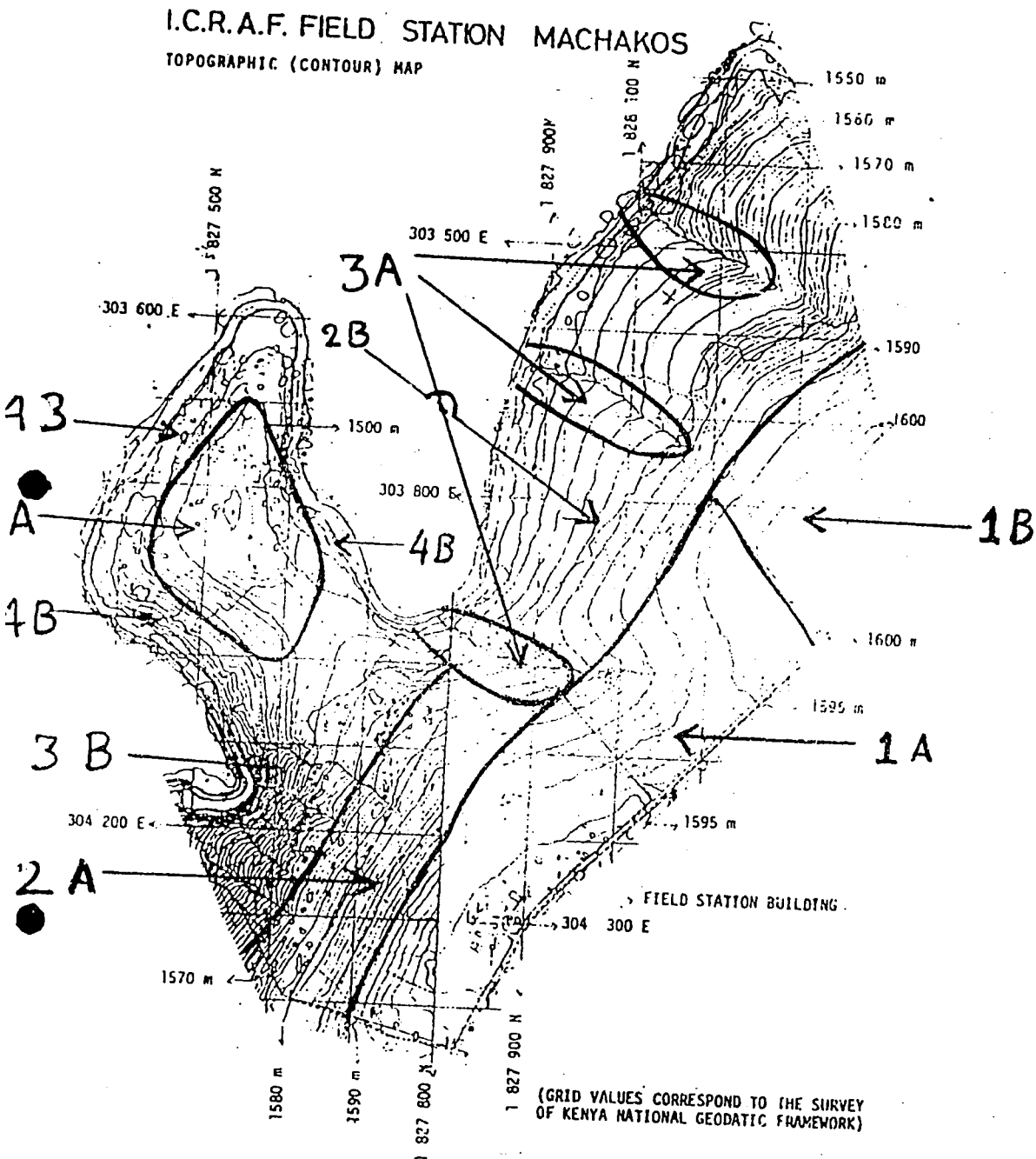
Table 1. Summary of soil chemical analysis data for the Field Station site (Date of sampling: April 1981)*

(see Fig. 3 for description of mapping units)

Mapping unit	Element							
	Na	K	Ca	Mg	Mn	P	Org.C	Total N
	(.....me/100g					)	(ppm)	(%)	(%)
UNb_1	0.2	0.6	6.0	2.0	0.4	55	1.2	0.2
UNr1m	0.1	0.6	3.2	2.8	0.4	16	0.8	0.2
UNb2p	0.1	0.5	7.2	2.2	0.6	228	1.0	0.2
UNb3p	0.1	0.5	2.0	1.3	0.5	6	1.5	0.1
UNb4p	0.1	0.4	6.1	3.2	0.3	570	1.5	0.1
UNb5p	0.1	0.3	2.9	1.8	0.3	50	0.5	0.1
UNr2M	0.1	0.6	5.2	2.3	0.4	216	0.9	0.1
AA1	0.1	0.6	7.2	2.4	0.6	162	0.1	0.2

*Source: Kibe, J.M., H. Ochung' and P.N. Macharia (1982). Soil and Vegetation of the ICRAF Experimental Farm, Machakos District. Detailed Soil Survey Report No. D23, 1981; Kenya Soil Survey, National Agricultural Laboratory, Nairobi. 68 p (mimeo.)

Fig. 3. A SIMPLIFIED DEMARCATION PATTERN OF LAND UNITS ON ICRAF FIELD STATION, MACHAKOS



1. Prime land
2. Steep land
3. Gullies
4. Meander core

1 A Already under trials and demonstrations
1 B Trials planned for 1984-85

2 A Demonstration of AF for soil conservation
2 B Not yet developed

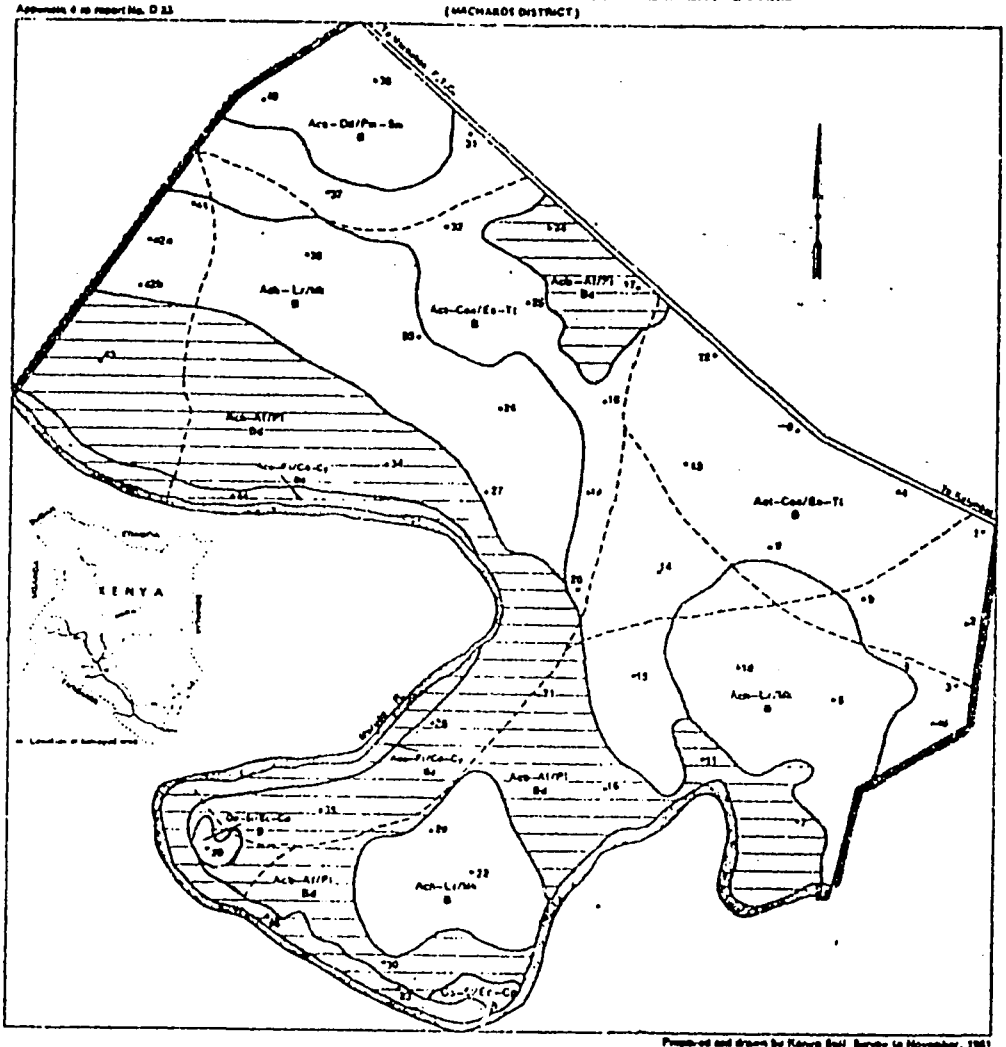
3 A Main gullies
3 B Dissected meander bluff

4 A Gentle to moderate slopes
4 B Steep slopes

FIG. 4: DETAILED VEGETATION MAP OF THE I.C.R.A.F. EXPERIMENTAL FARM

(MACHAKOS DISTRICT)

Appendix 4 to report No. D 23



Prepared and drawn by Kenya Soil Survey in November, 1981

Scale 1:4,000

0 40 80 120 160 200 240 280 Metres

LEGEND

Acc-Cas/Ea-Ti — Acacia tortilis – Camaphora africana / Eragrostis superba – Themeda triandra bushland with isolated dense bushland

Acb-Li/Na — Acacia seyal – Lannea rivae / Thunbergia lucens bushland

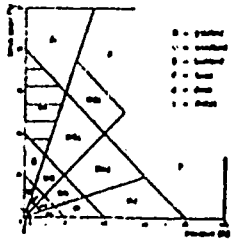
Acb-Al/Pl — Acacia brevispica – Acalypha fruticosa / Pennisetum latifolium dense bushland

Acc-Ol/Pu-Sa — Acacia seyal – Dyschoriste depressa / Pennisetum setiflorum – Sporobolus marginatus bushland

Ou-Ir/Ex-Cy — Ocimum basilicum – Ipomoea lacunosa / Eragrostis cilianensis – Cotonis pycnostachya bushland

Acc-Fl/Ca-Cy — Acacia drepanolobium – Flueggea virosa / Cynodon dactylon – Cyperus spectoni dense bushland

KEY TO PHYSIOGNOMIC CLASSES



Example: 8% tree cover and 27% grass cover = Bushland (B)

KEY

- trees and/or shrubs
- vegetation mapping unit (code(s))
- vegetation boundary
- vegetation observation point with number
- road
- foot path
- river
- farm and boundary of survey area

Drawing No. 81946

3. STATION DEVELOPMENT

3.1. Objectives

The general objective of establishing an ICRAF Field Station is to serve as a trial-cum-demonstration service to the other main technical programmes of the Council. Trials shall be undertaken primarily to assist in developing methodology for agroforestry research, and *inter alia,* to evolve some technologies for solving specific management problems and technology constraints, and for testing and screening limited components of agroforestry technology and management for facilitating adoption of agroforestry practices.

The demonstration and training activities at the Station shall be of value to both Kenyan and international communities. The likely benefit that will be derived to Kenyan institutions in this regard has been identified as one of the major outcomes of direct practical value to Kenya, based on which expectation the site has been alloted to establish the Station. The proximity of the Station to the Farmers' Training Centre and the NDFRS imparts it adequate prominence in demonstration and training activities. The demonstration activities on the Station will focus on demonstrating through a series of field trials the role and value of different agroforestry approaches to solving specific land management problems and providing the basic needs of food, fodder, fuel, etc

3.2. Personnel

Name	Position	Date of joining	Qualifications
Mr. P.N.W. Kurira	Farm Manager	August 1981	Dipl. Hort.; previously Farm Manager in Kenya's Agric. Dev. Corp.
Mr. D. Wambuguh	Research Assistant	December 1982	B.Sc, (Agric.); previously Res. Officer, Hort. Res. Station, Thika, Kenya.
Mr. G. Mwasambu	Field Assistant	December 1982	Certificate in agriculture: some previous experience
Mr. G. Kilonzo	Skilled Worker	August 1981	Primary education

In addition, there are also nine permanent labourers on the Station.

3.3. Field Station Advisory Committee

This ICRAF Committee was constituted in early 1984 to advice the Director on the issues relating to the development and management of the Station. The 1986 committee consists of Drs. T. Darnhofer, P. von Carlowitz and A. Young and Ir. D. Hoekstra in addition to Dr. Nair.

3.4. Physical Development (as of March 1986)

- Land clearing has continued at a slow pace of 5-8 ha per year starting from late 1981, in accordance with requirement of site for trials and demonstrations and with the overall development of the site in view. As of March 1986, nearly half of the total area has been cleared and properly fenced. Further clearing will be according to a "Medium-Term Plan for the Maintenance and a Development of the Field Station" that has been prepared in 1984 as an aid for proper development of the whole Station. Salient aspects of physical development so far are:
  - A semi-perment building was constructed on the site and the Station was formally inaugurated in March 1982 by the then Minister for Environment and Natural Resources of the Republic of Kenya; plans have been prepared in late 1985 to add an extension to this building in order to provide more facilities; construction of the extension part will be undertaken in 1986 (subject to availability of funds);

    Electricity, telephone and water (for irrigation and drinking) are available on the site;

    Limited facilities for irrigation are available and irrigation water is shared with the adjacently-situated NDFRS, Katumani on the basis of mutual understanding;
  - In order to facilitate proper planning for development of the site, a detailed topographic map of the site at 1:1000 scale with 1 m contour marking has been got prepared by a Nairobi-based professional firm; the map and a large aerial photograph are now available;

- An 80 H.P. tractor with the essential accessories has been purchased (March 1983);
- A small field laboratory has been set up with some essential items such as precision balance, air-oven, refrigerator, etc. (1983);
- An automatic weather recording unit has been set up in May 1983 and regular meteorological data recorded since then (see section 5.1)

1981 - ICRAF decided to have a Field Station (April);
- Got the land from the Government of Kenya (August);
- Undertook the soil and vegetation survey (March);
- Recruited the Farm Manager (August);
- Cleared a small portion of land and planted a few multipurpose trees (November).

1982 - The Field Station building was constructed and the Station was formally inaugurated (March);
- Physical development continued;
- Plans finalized for establishing demonstration plots.

1983 - Set up demonstration plots (soil conservation);
- Initiated other trials;
- Established the meteorology unit (May);
- Undertook systematic soil sampling (August);
- Set up a small field laboratory (December).

1984 - A Field Station Committee was constituted (January);
- Prepared a medium-term "Master Plan" for Station Development (June);
- General progress hampered by the severe draught of the first 9 months of the year;
- Initiated more trials and demonstrations (October).

1985 - Continuation of existing trials

- Initiation of new trials
  - sub-irrigation trial
  - tree-crop interface studies
  - phenology studies
  - improvements to the nursery
  - pigeon pea trials
- Preparation of plans for extension of FS building

1986 - Continuation of trials, demonstrations and other planned activities

- Construction of the extension phase of the FS building

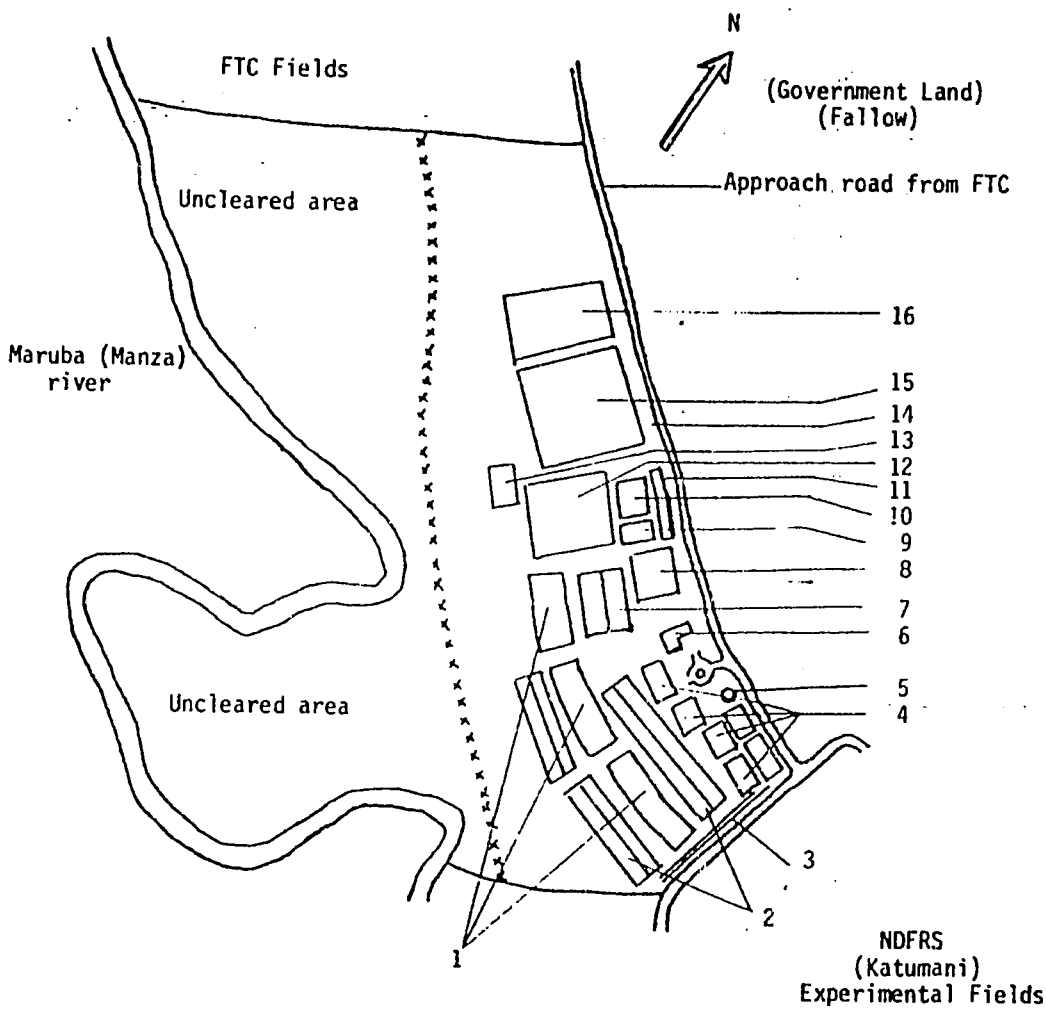
A site utilization plan of the Station as of March 1986 is give in Fig. 5.

Fig. 5

FIELD STATION, MACHAKOS

Site Utilization Plan (March 1986)

Scale: 1 cm equals approx. 50 m.



1. Soil conservation technologies
2. Multipurpose trees - Microplots
3. Shelterbelt/Windbreak
4. Multipurpose trees - Macroplots/Intercropping
5. Water tank
6. Farm building
7. Nursery
8. Meteorology Unit
9. Guava pruning trial
10. Sunken planting trial
11. South American germ plasm
12. Systematic designs, Tree-crop interface trials.
13. Sub-irrigation trial
14. Live hedges
15. Hedgerow intercropping (Alley cropping)
16. Pigeon pea germ plasm screening

4. DEMONSTRATIONS AND TRIALS

4.1. Multipurpose Trees (MPTs) and Shrubs for Agroforestry

(P.K.R. Nair and D. Wambuguh)

The project was initiated in 1981, soon after obtaining the land, by assembling a range of potentially useful woody species. More species were added to the collection in course of time. A list of species that have been planted so far is given in Table 2.

The species are among those likely to be useful in farming systems in the semi-arid agro-ecological zones. Moreover, they represent a range of different growth habits and plant architecture so that they could be useful in evolving a methodology for evaluating such agroforestry species. Short descriptions of some of the species are included as Annexure I.

Plants were collected and arranged in two sets of plots: seven species in relatively large numbers (100 or more per species) in "macro" plots of 5 - 8 rows at progressively varying distances between the rows. *Acacia albida, Atriplex nummularia, Leucaena leucocephala* (Peru), *L. leucocephala,* (K-8) and *Prosopis juliflora* (planted in 1981) and *Balanitis aegyptiaca* and *Sesbania grandiflora* (planted in 1982), are the species so planted in macro plots. The leucaena varieties have variable spacings of 2, 3 and 4 m in between plants on the same row; other species are at uniform espacement along the rows. All the other species listed in Table 2 are in "micro" plots of 12-15 plants each per species at 4 x 5 m espacement. More species are continuously being added to this group as and when they become available.

Table 2. List of Multipurpose Trees Assembled at ICRAF Field Station (as of March 1986)

Species	Date of planting
Acacia albida ...	28 October 1981
A. allophanta ...	04 January 1984
A. cyanophylla...	09 November 1981
A. deamii...	02 November 1984
A. farnesiana ...	02 November 1984
A. holosericea...	26 April 1982
A. mellifera ...	03 December 1983
A nilotica. ...	03 January 1984
A. pennatula ...	02 November 1984
A. saligna.. ...	18 May 1984
A. tortilis. ...	09 November 1981
A. victoriae ...	26 April 1982
A. xanthophloea.. ...	09 November 1984
Adansonia digitata ...	29 October 1984
Albizia allophanta ...	04 January 1984
Albizia longependata..	06 November 1984
Atriplex nummularia...	30 October 1981
Azadirachta indica ...	29 November 1983
Balanites aegyptiaca..	19 April 1982
Calliandra calothyrsus	10 May 1982
Cassia elata ...	14 November 1981
C. siamea...	07 December 1981
C. sturtii..	07 December 1983
Casuarina equisetifolia ...	05 April 1982
Cedrella odorata.	29 June 1984
Citrus sinensis..	02 February 1982
Colosphospermum mopane	02 November 1984
Cordeauxia edulis ...	29 June 1982
Croton megalocarpus...	29 October 1984
Erythrina abyssinica..	11 December 1982
Eucalyptus camaldulensis...	24 October 1984
E. cladocalyx ...	17 May 1984
Gliricidia sepium ...	21 December 1983
Grevillea robusta ...	23 December 1982
Leucaena diversifolia (K.195)...	13 June 1984
L. glauca...	09 November 1984
L. leucocephala..	
(Cunningham, K 8, K 67, Peru).	09-12 November 1984
(K 4, K 4, K29, K 156, K 500, K 636) ...	17 December 1983
Melia azedarach..	22 November 1983
Moringa oleifera.	23 April 1982
Parkinsonia aculeata..	29 October 1981
Persea americana.	11 December 1981
Prosopis alba ...	22 November 1983
Prosopis chilensis ...	22 April 1982
P. juliflora ...	27 October 1981
P. nigra ...	23 April 1983
P. pallida..	29 October 1981
P. tamarugo.	22 November 1983
P. velutina.	09 November 1984
Robinia pseudoacacia	22 May 1984
Samanea saman ...	01 July 1982
Sesbania grandiflora..	19 April 1983
S. sesban...	22 November 1983
Simmondsia chilensis..	14 November 1981
Tamarindus indica ...	26 April 1982
Terminalia brownii ...	29 October 1984
Zizyphus mauritania...	23 April 1982

Most species have established fairly well. They were given "life-saving" watering during the first year of their establishment as necessary. Regular observations on their survival and growth characteristics are recorded and maintained (see Table 3). Some of the trees have also been chosen for more regular phenology studies (ref. 4.8, Phenology Studies).

Some of the L. leucocephala plants in the macroplots were pruned in March 1983 by removing all weak branches up to 1 m height, leaving 3-5 main branches intact. On an average, a plant gave 5.02 ± 1.70 kg fresh loppings (16 months' growth). Additional management measures (cutting at 50 cm and 100 cm heights, pruning) were undertaken on these plants in March 1985, leaving some plants unpruned for comparative purposes. Summary of the March '85 prunings results are given in Table 4.

Subsequently when the trees regenerated, they were again pruned periodically at two cutting heights: 50 cm and 100 cm, and the fresh prunings incorported to the soil before cropping (see 4.11, Intercropping). A complete record of all the yields and other observations is being maintained. From the observations on regrowth it seems that one of the appropriate ways of managing Leucaena in Machakos conditions is by periodic cutting and pruning so that the problem of profuse seed formation that is found in trees that are not pruned can be overcome; a cutting height of 50 cm from the ground seems better than one metre in terms of regeneration and foliage yield.

A photographic record of the plants is maintained by assembling photos taken at various stages and a complete account of all operations and outputs recorded.

The multipurpose trees provide one of the major attractions for various visitors to the Station.

TABLE 3. Early growth characteristics of a few multipurpose leguminous woody perennials at ICRAF's Field Station, Machakos, Kenya

SPECIES	DATE OF PLANTING	NUMBER OF PLANTS MEASURED		1 HEIGHT (m)		2 CROWN DIAMETER (m)		3. STEM DIAMETER (cm)			
								AT BASE		1 m above ground	
		1983	1985	1983	1985	1983	1985	1983	1985	1983	1985
Acacia albida	28.10.81	45	39	1.77	2.29	1.24	2.36	4.09	5.21	2.12	4.50
Acacia cyanophylla/saligna	09.11.81	12	12	3.00	3.43	2.39	3.19	8.61	11.27	3.99	6.73
Acacia nilotica/seyal	09.11.81	12	9	1.66	2.18	2.57	3.63	6.46	10.87	1.37	-
Atriplex nummularia	30.10.81	104	92	1.95	2.32	1.22	1.60	-	-	-	-
Cassia alata	14.11.81	8	3	1.74	3.19	1.62	2.03	3.82	9.10	2.17	5.20
Cassia siamea	07.12.81	12	12	2.28	3.39	2.05	2.24	7.23	11.33	2.25	7.37
Casuarina equisetifolia	05.04.82	6	10	1.52	2.04	0.66	0.69	1.94	3.53	0.61	1.40
Erthryna abyssinica	11.12.82	12	11	0.82	1.45	1.09	1.40	4.36	7.52	-	2.97
Leucaena leucocephala (Cunn)	09.11.81	12	11	2.40	2.93	2.03	2.83	6.78	9.92	2.93	6.11
Leucaena leucocephala (KB)	12.11.81	66	88	3.02	3.80	2.29	2.59	6.95	9.74	4.70	6.91
Leucaena leucocephala (Peru)	13.11.81	36	48	2.55	3.44	2.02	2.48	6.09	7.32	3.86	5.20
Parkinson aculeata	29.10.81	11	11	1.74	2.57	2.51	2.65	5.12	7.86	2.19	5.61
Prosopis juliflora	27.10.81	59	50	2.29	3.36	1.92	3.02	4.98	8.13	1.74	5.53
Prosopis pallida	29.10.81	9	11	2.00	2.72	1.77	2.11	3.45	5.22	1.49	3.91
Sesbania grandiflora	19.04.82	42	28	2.40	4.75	1.61	2.35	10.15	16.42	3.83	9.42

Dates of measurement: July, 1983 and August 1985.

1. Height was measured with a heightpole and/or metre ruler
2. Crown diameter was measured using a measuring tape. At least two measurements at right angles to one another were taken and an average obtained.
3. Stem diameter was measured using vernier calipers. Two readings at right angles to one another were averaged. For multi-stemmed trees the average diameter of each stem was converted to basal area. The basal area of all the stems were summed and the corresponding diameter calculated.

Table 4.

YIELD OF LEUCAENA PRUNING

Date of planting: November 1981; Date of pruning: March 1985

Cutting height (cm)	Biomass	Mean biomass yield (kg/plant-fresh weight)						Estimated Yield (kg/ha) fresh weight					
		Rows 3 m apart			5 m rows			3 m rows			5 m rows		
		Within-row (plant-to-plant) distances						Within-row (Plant-to-plant) distances					
		2	3	4	2	3	4	2	3	4	2	3	4
50	Leaf mulch	7.3	7.0	9.4	16.1	10.5	22.3	12,000	7,700	7,750	16,000	7,000	11,100
	Firewood	7.4	7.5	8.5	15.5	16.4	14.3	12,200	8,300	7,000	15,500	10,800	7,100
	Total	14.7	14.5	17.9	31.6	26.9	36.6	24,200	16,000	14,750	31,500	17,800	18,200
100	Leaf mulch	4.6	8.3	9.5	8.8	14.9	13.5	7,600	9,100	7,800	8,800	9,800	6,750
	Firewood	4.4	5.9	5.8	6.4	8.9	6.1	7,250	6,500	4,900	6,400	5,800	3,050
	Total	9.0	14.2	15.3	15.2	23.8	19.6	14,850	15,600	14,700	15,200	15,600	9,800

4.2. Soil Conservation Technologies (P.K.R. Nair and D. Wambuguh)

With the help of the funds made available by the Swedish International Development Authority (SIDA) since 1982, and in collaboration with the Soil Conservation Unit of Kenya's Ministry of Agriculture, four sets of plots have been established on the Station to demonstrate the role of agroforestry in soil conservation. Most plots of the trial were severely affected by the 1983 & 1984 droughts; therefore the plots were re-planted altogether in October 1984. The plots are:

1. Trees and grasses in contour rows across the slope, so that the interspaces could be used for growing agricultural crops. Trees are at 2 m distances along the rows and the rows are at roughly 7 m distances, on a piece of land with about 10 percent slope. Eight tree species have been planted:

   Acacia albida

   Balanites aegyptiaca

   Cassia siamea

   Grevillea robusta

   Leucaena leucocephala

   Melia azedarach

   Prosopis alba

   Sesbania grandiflora

   Two species of grasses have been used: *Pannicum maximum* and *Panicum coloratum*. The grasses are along the rows in between the trees so that by the time they are established, they are expected to provide a natural barrier against erosion and facilitate formation of ridges in due course. They are periodically cut and their yields recorded (being excellent fodder grasses). Maize was planted as the first intercrop in

the interspaces in October 1985.

2. Contour bench terraces across the slope, the benches being stabilized by perennial grasses and woody species. The terraces were prepared in April 1983 with the cooperation of a soil conservation expert (Ms. Merete Styczen) of the Katumani Research Station (NDFRS). Grass *(Panicum coloratum)* was planted in May 1983 and three species of trees *(Cassia siamea, Leucaena leucocephala* and *Sesbania grandiflora)* were planted in November, 1983. The "benches" are being cropped with maize and beans in rotation, every cropping season since October 1983.

3. "Fanya-Juu" terraces along the contour, set up with the help of Dr. Lill Lundgren of SIDA (attached to the Soil Conservation Unit of the Ministry of Agriculture). Here again, perennial grass *(Panicum coloratum)* has been planted for bund stabilization. Fruit trees (avocado, citrus, guava and mango) have been planted in the trenches in 1985 (for economic products and for stabilizing the bunds).

4. Contour hedgerow planting of *Leucaena leucocephala* at 25 cm distance along the rows across a 10-15 percent slope; leucaena will be cut and the foliage added to the plot; the plot will be managed in an alley cropping scheme. Earlier plantings of leucaena were severely affected by the 1984 drought, they were re-planted in October 1984.

Soon after the plots of bench terraces, "fanya-juu" and hedgerow planting were set up in April, 1983, one set of profile measurements was made to follow the development of terraces. Such measurements are repeated periodically after major rainy seasons.

4.3. Tree Establishment Trials

(P.G. von Carlowitz)

During 1982-84, a "tree shelter trial" was conducted on the Station with a view to devising cheap, effective and adoptable practices to protect tree seedlings against early browsing and facilitate their efficient establishemnt. The trial, repeated during the wet and dry season plantings using five tree species (*Melia azedarach, Casuarina montana, Prosopis juliflora, Acacia albida* and *Balanites aegyptiaca*: the first four planted in the wet season and the last one in the dry season), indicated that seedlings of all species (except Casuarina) planted in pits (sunken planting) had the best rates of survival and vigour. *Balanites aegyptiaca* seedlings showed a remarkable ability to withstand early, post-planting drought and recover from browsing by small game (dik-dik and hare), whereas *Melia azedarach* could not survive the severe dry conditions just after planting and *Casuarina montana* succumbed to termite attack within the first 6 weeks after planting.

As a follow-up of this trial, a "sunken planting" trial was initiated in April 1984 with two tree species: *Acacia mellifera* and *Prosopis alba*. In this trial, the performance of seedlings planted in 60 cm-deep pits that are left open up to 50 cm depth after planting is being compared with those planted in the usual way (pits filled up fully after planting). Initial indications are that sunken planting is much better than the usual method in terms of tree establishment and height increment. During the first 10 months after planting, *Prosopis alba* plants of the sunken planting method grew almost twice as much taller as comapared to the same species planted in the conventional way (41.3 cm and 22.3 cm height respectively). The response of *Acacia mellifera*

plants to sunken planting in terms of plant heights was even more (51.1 cm for sunken planting vs 18.5 cm for conventional planting). Microclimatic variations in the pits are now being monitored with the help of appropriate probes connected to the agri-met monitoring unit (T. Darnhofer).

4.4. Windbreak Demonstration

(P.G. von Carlowitz and T. Darnhofer)

Following a detailed analysis of the pattern of wind speed and direction, action was initiated in 1984 to establish a windbreak for demonstration along the eastern border of the Station, roughly in north-south direction (generally, the winds are from the north-eastern side). The general concept is to achieve a curved cross-sectional shape for the windbreak canopy, so as to force the wind-ward direction upwards and avoid leeward turbulences after the wind has passed over the windbreak. In consideration of the desired attributes of the species to fulfill their windbreak function and at the same time their adaptability to local environmental conditions, *Acacia saligna* was chosen to form the single line on the wind-ward side (it generally does not exceed 4 m height, tends to spread sideways and usually forms a roundish, low, dense canopy). *Casuarina equisetifolia* will form the middle two rows, as they tend to grow tall, and at the chosen in-row spacing of 4 m, they will form a "comb"-like guard against wind. The single leeward line of trees is composed of *Prosopis juliflora*, which being shorter than *Casuarina* will complete the curved cross-sectional shape of the windbreak. All these species are evergreen, and they coppice well.

The middle rows *(Casuarina equisetifolia)* were planted in April 1984, and they have established well. The other two species will be planted

in 1986 according to the plan given in Fig. 6.

After about 10 years, these four rows of trees will be interplanted at regular espacements, with seedlings of the same (or other appropriate) species. Since the then 10 year-old trees planted initially should have formed a rather closed canopy, they might need to be pruned to allow the newly planted seedlings to grow. After another 10 years, the then 20 year-old trees will be harvested, and replaced with seedlings planted afresh in their places.

4.5. Tree-Crop Interface Studies

(P.A. Huxley, T. Darnhofer, Dennis Wambuguh, E. Akunda and D. Gatama)

A demonstration trial of a geometric design to investigate tree/crop interface effects was initiated in May 1984 by planting *Cassia siamea* according to the plan given in Fig. 7. The objectives are:

i) to demonstrate a geometric design suitable for the study of tree/crop interface where tree orientation is taken into consideration;

ii) to allow investigations on the most cost-effective ways of measuring plant and environmental parameters in the tree/crop interface area.

The layout (Fig. 7) consists of a 120^{0} row-orientation design laid out 0^{0} N, each area consisting of trees planted in 9 rows of 12 trees at 1.5 x 1.5 m, staggered between rows. Seedlings of *Cassia siamea* (25-30 cm tall) were planted out in April 1984, and watered during the dry months. Trees were kept free of weeds by soil surface scraping, and the surrounding area slashed as necessary. Trees were pruned in February 1985 to even-up growth. Maize was planted in the area around the tree stand in October 1985.

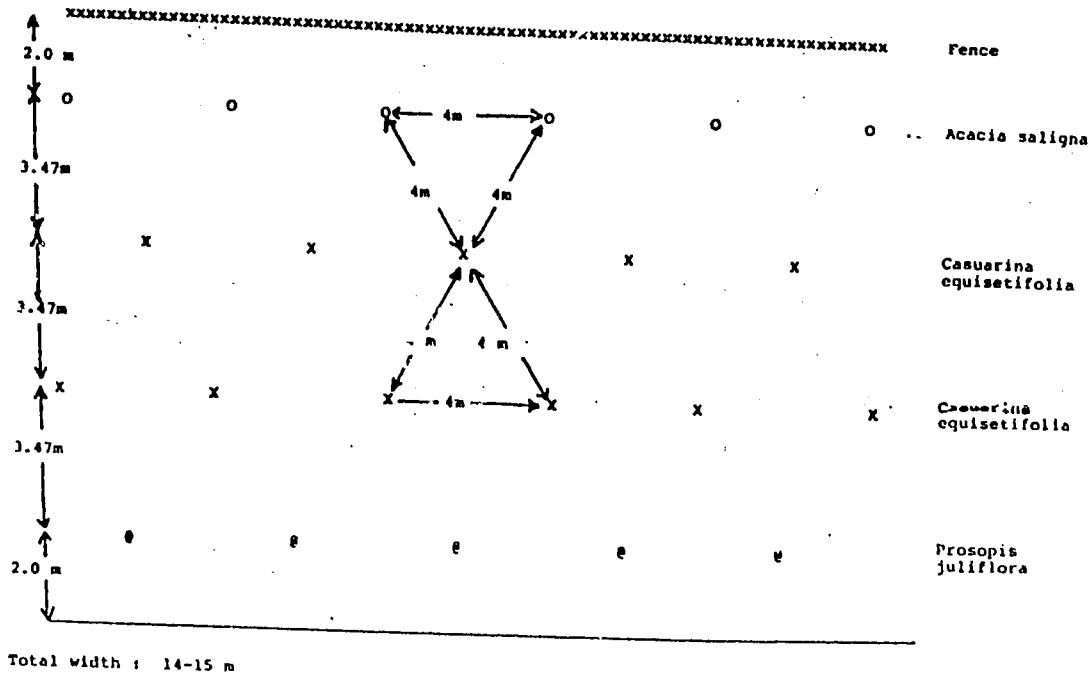


Fig. 6 PLANTING PATTERN FOR ESTABLISHING A WINDBREAK AT THE MACHAKOS FIELD STATION (Year 1-10)

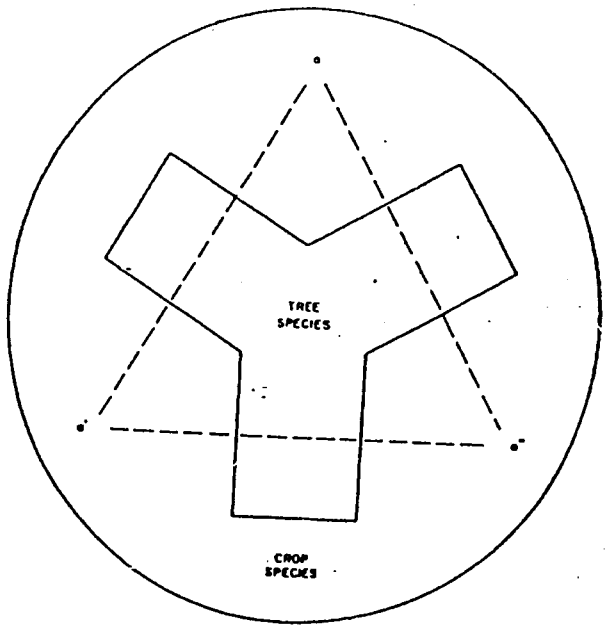


Fig. 7 LAYOUT OF THE GEOMETRIC DESIGN TO INVESTIGATE TREE/CROP INTERFACE EFFECTS

It is planned to undertake detailed measurements of a number of micro-climate parameters in and around the plant stand as well as monitor changes in plant characteristics, in order to obtain information on tree/tree, tree/crop and crop/crop associations. The outcome, after 3 or 4 seasons of intensive testing, is expected to be a set of practical recommendations extrapolable to other such experiments involving different species on the most cost-effective way of measuring plant and environmental characteristics for tree/crop interface investigations.

In another trial, *Cassia siamea* was planted as a test plant in April 1985 in single rows at 30 cm in-row spacing in a 120° orientation geometric design in association with annual castor (c. KC7) at 30 cm rows parallel to the hedges and with 30 cm in-row spacing. The closest rows of crop are removed along the design in three steps so as to give a systematic change in crop density pressure on hedgerow.

In one of these trials, *Cassia siamea* was replanted (replaced) with guava *(Psidium guajava)* as the hedgerow species.

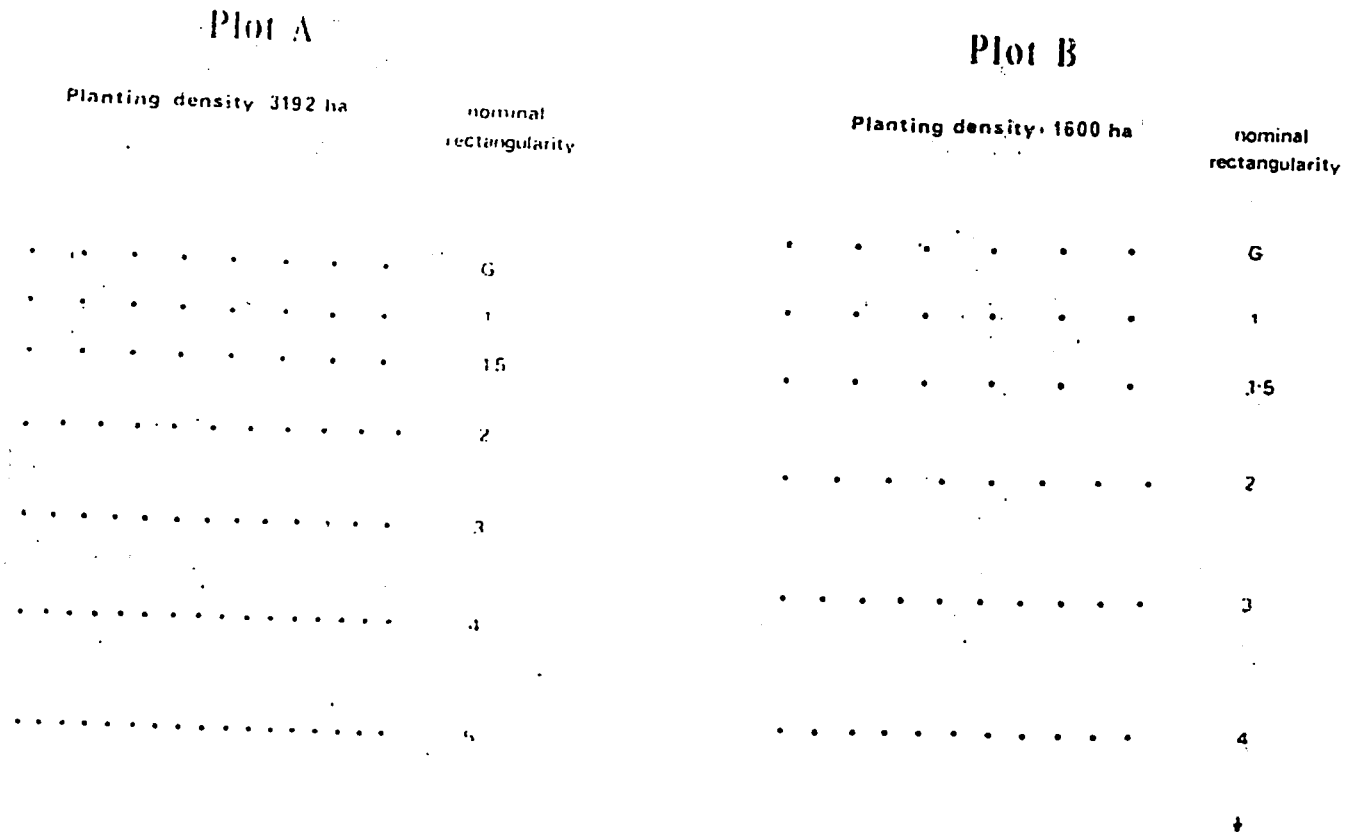
4.6. Systematic Tree Arrangements

(P.A. Huxley, E. Akunda and D. Wambuguh)

The objective of this trial is to demonstrate a systematic field layout suitable for testing changes in plant rectangularity at different total planting densities and to show the nature of the design. Two examples have been planted as shown in Fig. 8.

A. rectangularity changing from 1.5 to 8.5 steps; all rows with in-row spacing to represent 3192 plants ha^{-1};

Fig. 8. Parallel-row layout for testing the effects of plant rectangularities over two different plant densities.



B. rectangularity changing from 1.5 to 8.5 in 6 steps; all rows with in-row spacing to represent 1600 plants ha^{-1}.

Grevillea robusta seedlings, approx. 40 cm tall, were planted out in October 1984. Height and girth measurements are being recorded. The plots were side-pruned and row-planted to a mixture of sunflower and cowpea in order to have a three-storeyed canopy for observation. The plants will be left for as long as it is useful to demonstrate the layout and the responses of plants to the imposed rectangularities and planting densities.

In another demonstration, guava *(Psidium guajava)* was planted using a parallel-row systematic design to demonstrate pruning management in relation to between-row spacing.

4.7. Sub-Irrigation Trials

(A. Repollo/P.A. Huxley)

In order to test the effects of the application of small quantities of water below ground on the growth of newly planted seedlings, a trial with *Casuarina equisetifolia* was laid out as a systematic design in an area of approx. 120 m^2 in April 1985. Water is applied at the rate of 1 l/week through 2.5 cm diameter, vertically-placed, rigid plastic pipes, at 25, 50 and 75 cm depths, for 1, 2 and 3 months after the end of rainy season at frequencies of twice a week, once a week and once a fortnight. Based on the preliminary results obtained, another trial has been initiated in January 1986 by planting three tree species *(Casuarina, Grevillea* and *Mangifera)* in a split-split plot layout to test irrigation duration and quantity: the three species in whole plots, irrigation intervals in sub-plots and quantity of irrigation in sub-sub plots.

4.8. Phenology Studies

(P.A. Huxley, A. Repollo and D. Wambuguh)

These studies were initiated in May 1985 in order to demonstrate the value of simple phenological observations in the selection of MPT species and to decide the type of management best suited to them. Three trees each of nine MPT species, mostly from the MPT collection (Section 4.1) were selected; two branches on each were marked as control (to obtain natural seasonal phenology) and on three other branches, the apical portions were removed at different times of the season (middle and end of the dry season as well as middle and end of the wet season) and were observed for branch growth/flowering/fruiting characteristics at approximately one-month intervals. The study is in progress.

4.9. Alley Cropping

(P.K.R. Nair and D. Wambuguh)

In consideration of the view that the Field Station is expected to demonstrate the value of viable AF technologies as potential land use options, this trial initiated in October 1984 will be run in such a way that the constraints of moisture and nutrient availability will be minimized by "realistic levels" of irrigation and fertilizer application. Three tree species *(Cassia siamea, Gliricidia sepium,* and *Leucaena leucocephala)* are planted at between-row spacings of 3, 4, 5 and 6 m to provide 4 alleys for each spacing. Trees will be cut at 30, 60, and 90 cm heights at variable frequencies (intervals) the alleys being 10 m long for each cutting height, and the prunings incorporated into the alleys where agricultural crops are grown. A complete record is kept of all activities concerned with the trial indicating the input of resources (labour, manure, water, etc.) and output (yield) details and also the dynamics of soil changes.

These records will thus serve as an example of recording and maintaining data from AF experiments.

Cowpea was planted as the first agricultural crop in both the rainy seasons of 1985 (March and October). The first crop planted in the last week of March was harvested in the first week of August; the yield data from the three different tree-hedgerow plots are given in Table 5.

The prunings obtained from periodic harvesting of the hedgerows are incorporated into the soil; the 1985 results are given in Table 6.

4.10. Central American Hardwood Germ Plasm Trial
(P. Wood and D. Wambuguh)

This trial was planted in November 1984 with the objective of demonstrating the uses of a replicated randomized complete block design in the trial of some Central American Hardwood species and provenances in the introduction/elimination phase; simple indications on tree/crop compatibility are also expected. It consists of 18 species, planted out at 2 x 2 m spacing in a randomized complete block design using 6 trees/plot. Details of the species are given in Table 7. Early indications have already been obtained of species priorities for future research as well as variability within the population. Maize has been sown in November 1985 for observations in tree/crop interface.

4.11. Intercropping (P.K.R. Nair and D. Wambuguh)

Since the establishment of the MPT macroplots (Section 4.1), they have been intercropped with maize and beans in regular rotation.

Table 5.

Mean yields (± s.e.) in (*kg/ha) of **cowpea grain (March - October 1985) in the Alley Cropping Trial

Spacing (m) between tree rows	*C. siamea*		*L. leucocephala*		*G. sepium*	
3	715.29	(101.79)	878.61	(47.43)	572.59	(40.41)
4	829.70	(87.08)	982.57	(38.66)	733.60	(19.16)
5	993.75	(42.23)	999.51	(38.40)	876.97	(22.61)
6	685.34	(154.90)	991.94	(23.06)	1036.45	(44.43)

*refers to gross area, including the area occupied by the tree hedgerows.

**The crop was planted in the last week of March and harvested in the first week of August, 1985. The tree hedgerows were established in November 1984.

Table 6. Alley Cropping Trials: Mean Yield of Tree Hedgerow Prunings during the first year* after planting

Hedgerow			Fresh wt. (kg)				Dry wt (kg)			
Species	Management		per m row length			Per ha (total)	per m row length			Per ha (total)
	Row spacings (m)	Cutting height (cm)	1st cut	2nd cut	Total		1st cut	2nd cut	Total	
Leucaena leucocephala	3	30	1.05	0.95	2.00	6666	0.33	0.40	0.73	2433
		60	1.05	0.65	1.70	5666	0.33	0.26	0.59	1966
		90	1.05	0.62	1.67	5566	0.33	0.27	0.60	1999
	4	30	0.98	1.06	2.04	5100	0.34	0.38	0.72	1800
		60	0.98	0.94	1.92	4800	0.34	0.37	0.71	1775
		90	0.98	0.86	1.84	4600	0.34	0.34	0.68	1700
	5	30	1.66	1.33	2.99	5980	0.53	0.53	1.06	2120
		60	1.66	0.93	2.59	5180	0.53	0.36	0.89	1780
		90	1.66	0.75	2.41	4820	0.53	0.29	0.82	1640
	6	30	2.16	2.29	4.45	7413	0.59	0.80	1.39	2315
		60	2.16	1.55	3.71	6180	0.59	0.64	1.23	2049
		90	2.16	1.69	3.85	6414	0.59	0.60	1.19	1982
Cassia siamea	3	30	1.00	0.79	1.79	5966	0.26	0.24	0.50	1666
	4	30	1.20	1.03	2.23	5575	0.32	0.31	0.63	1575
	5	30	1.13	1.25	2.38	4760	0.31	0.37	0.68	1360
	6	30	1.39	1.20	2.59	4314	0.39	0.36	0.75	1249

1. The hedgerows were established (planted) in November 1984; they were evened-up by pruning uniformly at 30 cm height in March 1985 (1st cut). Later, the cutting-height treatments were introduced for *L. Leucocephala* (only) in October 1985 (2nd cut). *Cassia siamea* had not grown tall enough by October 1985 to allow cutting heights of 60 and 90 cm, but they have now grown very well and will be cut at these heights in March 1986 and thereafter. *G. sepium*, established by stem cuttings will be cut, for the first time, in March 1986.
2. The yields of Leucaena include harvesting in March and October 1985 as mentioned in (1) above.
3. The trial is laid out on gently sloping land. The narrower spacings fall on the more sloping area with shallower soils and therefore those hedgerows are generally less vigorous than the widely-spaced ones.

Table 7. Central American Hardwood Species being tried on ICRAF Field Station, Machakos

Species	Family	Characteristics			
		Form	Ecology	Propagation	Uses
Acacia deamii (Brittar & Rose) Standl.	Leguminosae (Mimosoideae)	Small multi-stemmed tree reaching to 8 m high	Altitudes of 200-1000m	Seed	A favoured fuelwood in Honduras but little known; untested
Acacia farnesiana (L.) Willd.	Leguminosae (Mimosoideae)	A shrubby invader of pastures in dry areas of tropical America growing to 10 m high	Dry areas	Seed	Fuelwood, perfume, manufacture, fodder (fruits), N-fixation on infertile sites
Acacia pennatula (Schlecht. & Cham.) Benth.	Leguminosae (Mimosoideae)	Small tree to 8-10 m; coppices and pollards easily	-	Seed	Firewood, posts, shade, live fence and fodder
Albizia lomatopoides Britton & Rose	Leguminosae (Mimosoideae)	Fast growing, drought tolerant tree to 15-20 m high	-	Seed	Fuelwood, sawn wood, posts, shade and live fence
Alvadora amorphoides Liebm.	Simaroubaceae	Fast growing non-legume to 15m high; coppices and pollards extremely vigorously	-	Seed	Considerable agroforestry potential providing good firewood, posts, tool handles, construction timber and good fodder
Apoplanesia paniculata Presl.	Leguminosae (Papilionoideae)	A rare papilionoid growing to 10 m; coppices easily	Very dry areas; susceptible to grazing pressure	Seed	Posts, live fence and firewood
Ateleia herbert-smithii Pittier	Leguminosae (Papilionoideae)	Tree up to 15 m high; tree coppices and pollards well	-	Seed	Fuelwood, fodder and live fence
Caesalpinia coriaria (Jacq.) Willd.	Leguminosae (Caesalpinioideae)	Tree growing to 8 m	-	Seed	Tannin extract, firewood, posts, shade and live fence. Fruits have some fodder value
Caesalpinia eriostachys Benth.	Leguminosae (Caesalpinioideae)	Tree to 15 m	-	Seed	Fuelwood, posts, shade and live fence
Caesalpinia velutina (Britton & Rose) Standl.	Leguminosae (Caesalpinioideae)	Tree to 10 m with rapid growth rate	-	Seed	Fuelwood, posts and livefence
Colophospermum mopane (Kirk ex Benth) Kirk ex J.	Leguminosae (Caesalpinioideae)	Moderately tall tree to 32m	Rainfall as low as 125mm p.a. and high summer temperatures; tolerates dry, saline and badly drained soils	Seed	General construction, ornamental, parquet, livestock/game fodder
Dioclolobium cyclocarpum (Jacq.) Griseb.	Leguminosae (Mimosoideae)	Very distinctive tree to 40 m high; coppices and pollards well	Dry areas of Central America	Seed	Animal fodder, fuelwood
Eucalyptus camaldulensis Dehnh.	Myrtaceae	Slender-stemmed tree to 25 m but may reach to 40 m in sub-tropical south	Widely distributed	Seed	High quality fuel (4800 kcal/kg) construction, shelterbelts, shade, bee forage and pulpwood.

Table 7 continued

Species	Family	Characteristics			
		Form	Ecology	Propagation	Uses
Haematoxylon brasiletto Karst.	Leguminosae (Caesalpinioideae)	Slow-growing tree to 8 m.	-	Seed	Firewood, dye
Leucaena diversifolia (Schletcht.) Benth.	Leguminosae (Mimosoideae)	Tree to 12 m. coppices and pollards well	-	Seed	Fuelwood, fodder, posts, food, shade and live fence
Leucaena shannoni Donn. Smith	Leguminosae (Mimosoideae)	Small tree to 8 m	Survives in drier areas than *L. leucocephala*. Good coppicing and pollarding ability	Seed	Bee forage, firewood, fodder, posts, live fence
Mimosa tenuifolia (Willd.) Poir	Leguminosae (Mimosoideae)	A small, shrubby, very spiny bush growing to 5m; good coppicing ability	Thrives on saline sites	Seed	Fuelwood, posts
Myrospermum frutescens Jacq.	Leguminosae (Papilionoideae)	Rare tree growing to 5m (rarely to 20m); coppices and pollards well	-	Seed	Fuelwood, posts, sawnwood and live fence
Pithecelobium dulce (Roxb.) Benth.	Leguminosae (Mimosoideae)	Large, nearly evergreen tree to 20 m high	Dry areas; wide range of soils	Seed/cuttings	Firewood, general construction, food-drink, livestock forage, tanning extract and bee forage
Senna atomaria (L.) Irwin & Barneby	Leguminosae (Caesalpiniodeae)	Shrub	Widely distributed	Seed	Fuelwood, living fence, posts.

Table 8.

Yield of maize grain (g/m row length ± s.e.) near and away from *Leucaena trees, September 1985

Tree Arrangement		Leucaena (K-8)				Leucaena (Peru)			
		With Mulch**		Without Mulch**		With Mulch**		Without Mulch**	
Between-row spacing (m)	Within-row spacing (tree-to-tree distances) (m)	Nearer the tree row (c. 90 cm)	Away from tree row (>180 cm)	Near	Away	Near	Away	Near	Away
3	2	495.26 (65.30)	522.55 (92.66)	430.33 (53.34)	460.57 (25.95)	432.69 (40.60)	481.38 (39.61)	409.55 (56.06)	498.50 (70.17)
	3	378.23 (12.90)	389.90 (11.10)	327.27 (25.64)	437.98 (27.31)	303.46 (44.44)	460.48 (35.04)	275.89 (38.45)	393.23 (21.10)
	4	338.87 (30.76)	420.47 (53.39)	259.14 (27.73)	350.25 (43.99)	415.82(100.10)	475.32 (33.88)	357.28 (15.04)	504.55 (49.21)
4	2	292.60 (66.99)	292.22 (16.13)	183.45 (26.44)	293.32 (74.46)	478.12 (24.87)	459.63 (37.31)	318.07 (52.97)	559.30 (42.78)
	3	328.65 (30.91)	265.82 (35.37)	186.71 (20.88)	344.05 (41.11)	449.57 (19.28)	436.57 (36.36)	322.94 (40.15	376.63 (34.18)
	4	283.27 (48.23)	314.90 (33.54)	218.42 (20.99)	307.65 (59.24)	475.42 (22.19)	551.47 (25.72)	317.71 (90.58)	404.83 (29.92)
5	2	492.37 (25.75)	521.42 (67.73)	273.25 (44.37)	342.30 (70.04)	445.19 (14.48)	366.48 (28.08)	170.23 (36.64)	260.87 (50.89)
	3	460.54 (31.74)	308.67 (24.03)	233.70 (55.75)	265.43 (25.73)	245.18 (65.21)	377.38 (27.03)	251.94 (33.15)	347.83 (44.49)
	4	437.02 (28.72)	465.22 (55.33)	223.15 (51.62)	283.41 (19.62)	301.73 (55.47)	439.05 (48.56)	295.13 (26.73)	424.03 (58.80)
6	2	160.97 (30.33)	344.93 (45.31)	192.73 (32.85)	323.10 (45.94)				
	3	231.75 (57.74)	312.58 (33.69)	175.78 (17.90)	238.70 (56.75)				
	4	240.04 (36.34)	301.30 (51.83)	177.19 (39.61)	223.17 (51.62)				

* Trees planted in November 1981 have been side-pruned occasionally. There were two cutting heights, 50 and 100 cm; the figures are the average for the two.

**The Leucaena leaf material obtained from pruning the trees was applied as mulch in half of the area only in each tree arrangement treatment. The quantity of mulch added varied depending on the tree arrangements (see Table 4)

Yield of crops and growth observations are recorded regularly. From the 1984-85 and 1985-86 trials, crop yields were recorded from sample rows near and away from tree rows in different plots, in order to prepare yield profiles in relation to nearness to trees. The 1984-85 results are given in Table 8.

4.12. Pigeonpea Germ Plasm Testing

(Crop Science Department, University of Nairobi)

This is a part of the Crop Science Department (University of Nairobi)'s pigeonpea improvement project consisting of field testing and evaluation of pigeonpea germplasm in different parts of Kenya. It is being carried out at the Field Station in view of the importance of pigeonpea as a grain legume in the semi-arid areas, and its agroforestry potential. Kenya ranks second in the world, after India, in pigeon pea production, Machakos and Kitui being the main pigeonpea-growing districts.

The trial consists of a breeding nursery, established in October 1985, with over 100 lines being screened for desirable agronomic characteristics and plant types, drought tolerance, and resistance to pests and diseases. The material includes local collections and accessions from other countries, especially ICRISAT (India).

Additionally, two trials have also been set up to study:

(a) the effects of intercropping pigeonpea cultivars with maize, sorghum, beans and cowpea at varying plant populations and row arrangements; and

(b) the response of three pigeonpea cultivars (including a local cultivar commonly used by the farmers) to quantity, source and method of fertilizer application.

4.13. Live Hedges

(P.G. von Carlowitz and P.K.R. Nair)

With the objective of demonstrating the use of woody species as live hedges and their value in boundary demarcation and protection, a few woody perennial species have been planted along the fences right from the beginning of the Station. The species include:

Acacia mellifera

Cupressus lusitanica

Dovyalis caffra

Parkinsonia aculeata

Prosopis spp. *(alba, chilensis, juliflora,* etc.)

It is planned to establish such live hedges all around the farm as well as around different permanent plots and installations (nursery, meteorology unit -- low hedge --, etc.). Management treatments will also be undertaken on them, e.g., planting arrangement, combination of species in the same hedge, pruning regimes, and so on.

5. SUPPORT SERVICE ACTIVITIES ON THE STATION

In accordance with the overall objectives of the Station (Section 3.1), and to cater for the needs of the trials and demonstrations on the Station, the following "service" facilities (in addition to the physical facilities - Section 3.4) are being organized at the Station.

5.1. Agrometeorological Observations

(T. Darnhofer and D. Gatama)

5.1.1. The agrometeorological unit

In addition to providing assistance to the various other activities on the Station and offering demonstration facilities for training purposes, the regular monitoring and evaluation of the agrometeorological data on the Station are essential for developing methodologies and technologies for agroforestry research.

As a first step in this direction, an agrometeorological unit was set up on the Field Station in May 1983. It consists of a CR.7 automatic measurement and control unit and appropriate sensors. At this agrometeorological station regular measurements have been made and data recorded of:

- air temperature and humidity
- soil temperature and humidity at 3 levels
- wind speed and direction
- global radiation and net radiation balance (the latter since February 1984)
- rainfall
- evaporation

The "metrologger" data output is 712 data points a day. (672 hourly values plus 40 daily values of the various parameters). To handle this considerable amount of data, a micro-computer (WANG PC) is used and appropriate data management software has been adapted for the processing and presentation of the data. A sample of the monthly summary data is given in Table 9.

The CR. 7 measurement and control system was used for monitoring micro-climatic data from one of the on-going trials, viz, the tree shelter trial (1982-84; concluded), where the measurements included:

- temperature and humidity profiles inside and outside the tree shelters (two observation series a day, using a portable temperature and humidity probe);
- two continuous temperature and humidity measurements inside and outside a tree shelter (CR.7).

The Unit is now being used for similar measurements in the "sunken planting trial" (Section 4.3), and is planned to be used in the "Tree-Crop Interface Studies" (Section 4.5).

5.1.2. Agrometeorological conditions

Based on the data measured at the ICRAF Field Station since June 1983, the agrometeorological water availability situation is being analysed regularly. Table 10 summarizes monthly data for various components of the water budget equation (rainfall, evaporation, water balance) and Fig. 9 shows a "water availability diagram" based on 10 day-data.

The methodology used to calculate the potential evaporation and evapotranspiration is the one recommended by FAO (Penman Formula). The thresholds for optimal and minimal water needs as well as the

Table 9

CLIMATIC SUMMARY ICRAF MACHAKOS (PART 1)
LAT.: 1.33 S LONG.: 37.14 E ALT.: 1596 m

FEBRUARY 1986

DATE	TM	TX	TXT	TN	TNT	UEM	UED	GR	NR	NH	FFM	RR	EP	ETP	EPC
21	20.9	28.6	1420	14.8	622	13.8	11.8	2709	1531	11.3	11.8	0.0	7.0	5.6	7.9
22	21.0	29.0	1528	12.5	649	11.7	14.3	3248	1885	11.8	9.2	0.0	8.7	7.0	7.0
23	22.2	29.7	1520	15.8	653	14.2	13.5	3180	1929	9.8	11.5	0.0	9.1	7.4	7.9
24	21.2	28.3	1358	17.3	639	15.8	9.6	2378	1441	7.9	13.0	0.0	6.8	5.4	8.9
25	21.3	28.8	1438	17.2	0	15.7	10.1	2653	1652	11.2	14.5	0.0	8.8	5.4	7.9
26	20.9	28.6	1507	13.0	632	13.7	12.0	2757	1618	11.2	10.4	0.0	7.3	5.9	6.4
27	21.7	30.9	1529	12.0	651	11.1	18.4	3254	1803	11.4	10.8	0.0	9.6	8.0	7.3
28	22.3	30.5	1425	13.1	651	9.8	18.7	3091	1885	11.2	8.8	0.0	8.9	7.5	9.9
29	21.9	30.5	1542	11.5	655	10.2	17.2	2921	1568	10.7	11.5	0.0	9.2	7.8	8.9
210	22.7	30.9	1322	15.1	546	9.6	18.2	3024	1557	11.8	10.8	0.0	8.6	7.1	8.8
AVEA	21.8	29.6		14.2		12.5	14.3	2922	1667	10.8	11.3	0.0	8.2	6.7	8.1
211	22.4	31.9	1416	11.2	648	0.0	20.8	3170	1644	11.0	11.1	0.0	10.5	9.0	10.4
212	22.7	32.0	1451	11.8	641	8.6	20.6	3233	1702	11.8	11.2	0.0	10.5	9.0	10.0
213	22.3	32.3	1443	11.9	641	11.5	16.9	3049	1870	11.0	10.7	0.3	9.4	7.9	9.9
214	22.0	30.3	1402	13.9	630	12.8	14.5	3057	1754	7.7	10.9	0.0	9.5	8.0	8.4
215	21.9	31.0	1520	12.0	700	10.5	16.7	3277	1736	11.7	11.2	0.0	9.9	8.2	8.5
216	21.7	31.0	1528	11.0	643	9.1	18.4	3229	1718	11.4	11.0	0.0	10.1	8.5	11.8
217	22.3	30.6	1408	13.6	643	10.6	17.4	3083	1624	11.5	12.5	0.0	9.4	7.9	10.0
218	20.9	29.6	1503	12.5	629	11.9	13.9	3065	1874	10.8	10.9	0.0	8.7	7.2	8.1
219	21.3	30.2	1439	13.1	550	12.2	14.4	3161	1734	11.2	10.3	0.0	8.9	7.3	9.8
220	21.7	30.7	1443	12.9	647	10.9	18.3	3313	1755	9.9	12.8	0.0	10.6	8.9	9.3
AVEB	21.9	30.9		12.3		10.6	17.0	3164	1701	10.8	11.3	0.3	9.7	8.2	9.7
221	21.3	29.4	1441	15.7	325	12.3	13.8	2589	1301	10.1	14.9	0.0	7.5	6.3	10.0
222	21.0	28.5	1452	15.6	244	11.7	13.9	3058	1640	11.2	13.2	0.0	8.2	6.7	6.2
223	21.2	30.2	1420	12.0	651	8.3	18.2	3360	1752	11.7	10.5	0.0	9.6	8.2	8.8
224	21.7	31.5	1512	11.1	648	8.9	18.6	3221	1858	10.0	10.9	0.0	10.3	8.8	9.3
225	21.8	30.1	1505	18.4	0	13.4	13.8	3070	1693	10.0	13.3	0.0	8.4	6.9	8.5
226	20.8	27.5	1337	15.4	840	15.0	10.1	2431	1343	7.4	13.1	0.0	6.8	5.6	8.9
227	21.7	29.6	1506	14.8	400	13.6	13.2	3169	1777	11.3	11.8	0.0	8.7	7.1	7.0
228	22.0	31.2	1415	13.1	644	10.9	16.8	3324	1799	11.4	10.0	0.0	8.5	6.0	8.7
AVEC	21.5	29.7		14.5		11.8	14.8	3025	1820	10.5	12.2	0.0	8.7	7.2	8.7
AVED	21.7	30.1		13.6		11.6	15.4	3038	1868	10.7	11.5	0.3	8.9	7.4	8.8

DATE MMDD MM-MONTH DD-DAY
TM MEAN AIR TEMP. CENTIGRADE
TX MAXIMUM AIR TEMP.
TXT TIME OF MAX. AIR TEMP.
TN MINIMUM AIR TEMP.
TNT TIME OF MIN. AIR TEMP.
UEM MEAN AIR WATER VAPOR PRESSURE IN MB
UED MEAN AIR SATURATION DEFICIT IN MB
GR GLOBAL RADIATION IN J/CM2*DAY
NR TOTAL NET RADIATION IN J/CM2*DAY
NH DURATION OF SUNSHINE HOURS (KATUMANI)
FFM MEAN WINDSPEED IN KM/H
RR RAINFALL IN MM
EP POTENTIAL EVAPORATION PENMAN IN MM
ETP POTENTIAL EVAPOTRANSPIRATION PENMAN IN MM
EPC EVAPORATION CLASS A PAN IN MM
AVEA 1st DECADE AVERAGE
AVEB 2nd DECADE AVERAGE
AVEC 3rd DECADE AVERAGE
AVED MONTHLY AVERAGES

Table 9 (cont'd)

CLIMATIC SUMMARY ICRAF MACHAKOS (PART 2) FEBRUARY 1988

DATE	URX	URXT	URN	URNT	URM	FFX	FFXT	FFM	FD	DD	DS	TS2	TS5	TS10	US2	US5	US10
21	83	714	33	1847	57	31.8	1104	11.8	10.7	81	23	22.0	22.1	22.1	N	N	N
22	88	852	24	1810	50	28.1	1527	9.2	7.7	88	33	21.8	22.2	22.1	N	N	N
23	84	302	32	1832	56	29.0	1451	11.5	10.1	88	28	22.3	22.3	22.2	N	N	N
24	88	821	44	1532	64	32.1	1830	13.0	12.2	90	21	22.7	22.6	22.3	N	N	N
25	88	715	34	1451	64	31.0	1505	14.5	13.7	78	19	22.7	22.7	22.4	N	N	N
26	89	645	32	1747	59	29.0	2023	10.4	7.8	64	40	22.7	22.8	22.4	N	N	N
27	88	703	14	1724	40	33.3	2015	10.8	7.5	60	43	22.8	22.8	22.5	N	N	N
28	84	658	10	1833	41	29.8	1204	9.8	7.4	51	40	22.8	22.8	22.5	N	N	N
29	80	700	17	1830	42	29.8	1238	11.5	8.3	83	43	22.8	22.9	22.6	N	N	N
210	80	728	12	1847	38	27.8	1408	10.8	9.0	59	32	22.8	23.0	22.6	N	N	N
AVEA	83		25		52	30.0		11.3	9.4	71	32	22.5	22.8	22.4	N	N	N
211	88	643	11	1553	34	31.8	1512	11.1	8.0	49	43	23.0	23.0	22.7	N	N	N
212	64	703	9	1549	34	33.6	1543	11.2	8.3	53	42	23.2	23.2	22.8	N	N	N
213	81	544	15	1545	47	33.3	1357	10.7	7.8	71	43	23.5	23.4	22.8	N	N	N
214	79	634	31	1612	50	33.3	1656	10.9	8.3	81	39	23.7	23.5	22.9	N	N	N
215	84	711	15	1518	46	33.6	1410	11.2	9.7	85	30	23.8	23.7	23.0	N	N	N
216	75	700	14	1536	38	34.1	1205	11.0	8.4	74	39	23.8	23.7	23.1	N	N	N
217	80	650	17	1439	43	35.9	1613	12.5	11.2	87	27	23.9	23.8	23.2	N	N	N
218	76	700	27	1547	50	29.8	1504	10.9	8.9	83	35	23.9	23.9	23.2	N	N	N
219	88	703	18	1633	53	34.1	2052	10.3	8.9	75	30	23.9	23.9	23.3	N	N	N
220	88	709	8	1533	48	33.6	1710	12.8	11.0	68	30	24.0	24.0	23.4	N	N	N
AVEB	78		16		44	33.3		11.3	9.0	71	38	23.7	23.8	23.0	N	N	N
221	85	734	29	1635	51	37.0	2102	14.9	13.9	71	21	24.1	24.1	23.5	N	N	N
222	87	514	27	1721	50	32.4	1242	13.2	11.9	79	25	24.0	24.1	23.8	N	N	N
223	81	658	9	1553	39	33.0	1511	10.5	8.7	83	34	23.8	24.1	23.5	N	N	N
224	74	651	11	1514	38	33.3	1430	10.9	8.2	78	40	23.9	24.1	23.8	N	N	N
225	88	614	24	1533	54	30.4	1319	13.3	12.1	81	26	24.3	24.2	23.7	N	N	N
226	88	743	35	1529	64	31.3	1117	13.1	12.1	88	23	24.4	24.4	23.8	N	N	N
227	88	610	26	1538	56	32.1	1251	11.8	10.5	85	27	24.3	24.3	23.8	N	N	N
228	85	658	8	1411	47	27.8	2332	10.0	8.1	95	36	24.5	24.4	23.8	N	N	N
AVEC	84.2		21.1		49.9	32.2		12.2	10.7	82.3	29	24.2	24.2	23.8	N	N	N
AVED	81.8		20.9		48.7	31.8		11.5	9.7	74.2	33	23.4	23.4	23.0	N	N	N

DATE MMDD MM-MONTH DD-DAY
URX MAX.AIR REL. HUMIDITY %
URXT TIME OF MAX. AIR RH.
URN MIN AIR REL.HUMIDITY %
URNT TIM OF MIN. AIR RH.
URM MEAN AIR REL.HUMIDITY %
FFX MAXIMUM 10 SEC.WINDSPEED
FFXT TIME OF MAX.10 SEC. WINDSPEED
FFM MEAN WINDSPEED IN KM/H
FD MEAN WIND VECTOR MAGNITUDE KM/H
DD MEAN WIND VECTOR DIRECTION DEG.
DS STANDARD DEVIATION OF WINDDIR. DEG.
TS2 MEAN SOIL TEMP. -20 CM
TS5 MEAN SOIL TEMP. -50 CM
TS10 MEAN SOIL TEMP.-100 CM
US2 SOIL MOISTURE POT. -20 CM BAR AT 24H
US5 SOIL MOISTURE POT. -50 CM BAR AT 24H
US10 SOIL MOISTURE POT.-100 CM BAR AT 24H
AVEA 1st DECADE AVERAGE
AVEB 2nd DECADE AVERAGE
AVEC 3rd DECADE AVERAGE
AVED MONTHLY AVERAGES

Table 9 (cont'd)

CLIMATIC SUMMARY ICRAF MACHAKOS (PART 3) FEBRUARY 1986
WIND REGIME AT 2m ABOVE GROUND

DATE	FFM	FD	DD	DS	FFX	FFXT	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	>>27
21	11.6	10.7	81	23	31.0	1104	3.2	11.2	17.6	23.2	18.4	14.7	8.1	2.6	0.8	0.0
22	9.2	7.7	88	33	28.1	1527	10.8	16.0	13.8	18.0	15.8	11.6	5.0	0.9	0.1	0.0
23	11.5	10.1	88	28	29.0	1451	5.5	17.9	12.4	15.0	19.5	16.6	9.6	2.7	0.8	0.0
24	13.0	12.2	80	21	32.1	1630	1.5	6.9	10.8	20.9	26.4	19.1	10.4	3.3	0.6	0.0
25	14.5	13.7	78	19	31.0	1505	0.0	0.6	6.0	24.2	27.6	21.5	13.8	4.8	1.4	0.3
26	10.4	7.6	64	40	29.0	2023	9.8	22.1	10.4	16.0	17.3	13.8	7.8	2.0	0.6	0.0
27	10.0	7.5	80	43	33.3	2015	9.1	18.8	14.0	17.7	16.4	12.1	8.0	2.9	0.8	0.2
28	9.8	7.4	51	40	28.8	1204	10.9	22.2	13.8	18.4	15.2	10.7	6.2	1.9	0.5	0.1
29	11.5	8.3	83	43	29.8	1236	4.5	20.7	13.5	12.9	16.8	15.9	10.6	3.9	1.1	0.2
210	10.8	9.0	50	32	27.8	1408	8.2	19.1	15.4	16.3	18.4	14.4	7.5	2.2	0.4	0.0
AVEA	11.3	9.4	71	32	30.0		7.0	15.6	12.8	18.3	19.2	15.0	8.7	2.7	0.7	0.1
211	11.1	8.0	43	43	31.8	1512	3.6	19.2	17.9	14.4	19.0	15.3	8.7	2.3	0.5	0.2
212	11.2	8.3	53	42	33.8	1543	5.2	16.8	16.3	18.5	16.7	13.1	8.5	3.4	1.3	0.2
213	10.7	7.8	71	43	33.3	1357	7.0	14.7	15.2	23.8	17.5	10.7	6.6	2.5	0.8	0.3
214	10.9	8.3	81	39	33.3	1656	9.8	19.8	11.2	16.0	15.7	13.4	9.1	3.3	1.4	0.3
215	11.2	9.7	85	30	33.6	1416	12.3	14.6	11.2	16.7	18.1	13.1	6.6	4.5	2.2	0.7
216	11.0	8.4	74	39	34.1	1205	7.9	24.3	8.3	12.6	18.9	14.2	9.2	3.2	1.3	0.4
217	12.5	11.2	87	27	35.9	1613	12.3	9.3	7.6	14.5	18.8	15.7	12.7	5.9	2.6	0.9
218	10.9	8.9	83	35	29.8	1504	18.8	13.5	7.7	11.8	18.9	15.8	10.3	3.9	1.1	0.2
219	10.3	8.9	75	30	34.1	2052	21.2	8.9	10.5	18.5	17.4	13.2	8.7	2.9	0.6	0.0
220	12.8	11.0	68	30	33.6	1710	10.6	14.4	8.8	9.7	13.1	18.4	14.9	7.7	3.3	1.1
AVEB	11.3	8.0	71	36	33.3		10.9	15.6	11.5	15.5	16.9	14.1	9.7	4.0	1.5	0.4
221	14.9	13.9	71	21	37.0	2102	0.5	5.5	13.9	11.8	16.8	19.7	17.1	8.7	4.7	1.4
222	13.2	11.9	79	25	32.4	1242	2.8	9.3	12.9	17.1	18.8	17.3	13.5	5.5	2.2	0.8
223	10.5	8.7	83	34	33.0	1511	20.1	13.7	7.2	16.4	14.7	13.0	8.9	4.1	1.5	0.5
224	10.9	8.2	78	40	33.3	1438	7.3	25.3	9.0	12.3	18.9	15.3	9.7	3.0	1.0	0.2
225	13.3	12.1	81	28	30.4	1319	8.9	5.8	14.8	12.4	15.9	16.5	14.7	7.3	2.7	0.5
226	13.1	12.1	88	23	31.3	1117	6.0	10.2	11.5	14.9	18.3	16.7	15.0	6.8	2.3	0.4
227	11.8	10.5	85	27	32.1	1251	10.8	11.8	13.2	14.2	15.1	15.8	12.2	5.3	1.4	0.3
228	10.0	8.1	85	38	27.8	2332	8.6	19.9	14.7	21.5	17.5	10.5	5.3	1.8	0.4	0.0
AVEC	12.2	10.7	82.3	28.0	32.2		8.3	12.6	12.1	16.1	16.5	15.8	12.1	5.3	2.0	0.5
AVED	11.5	9.7	74.2	32.8	31.8		8.7	14.7	12.1	16.4	17.8	14.9	10.0	3.9	1.4	0.3

DATE MMDD MM-MONTH DD-DAY
FFM MEAN WIND SPEED IN KM/H
FD MEAN WIND VECTOR MAGNITUDE KM/H
DD MEAN WIND VECTOR DIRECTION DEG.
DS STAND. DEV. OF DIRECTION DEG.
FFX MAXIMUM 10 SEC WIND SPEED KM/H
FFXT TIME OF MAX. WIND SPEED

0-3 , 3-6 , 6-9 , 9-12 , ETC.
FREQUENCY DISTRIBUTION OF 10 WIND SPEED RANGES IN KM/H EXPRESSED IN % OF THE TIME INTERVAL (24 H) AND BASED ON 8640 OBSERVATIONS

Table 10.

ICRAF Fieldstation 10 DAY WATERBALANCE 1985/86

DEC	EP	ETP	.4*EP	.2*EP	RR	WB	Gch	Gst	RAT1	RAT2	CLS
JUL185	46.0	39.0	18.4	9.2	1.3	-37.7	-20.0	0.0	0.03	0.46	3
JUL285	36.0	27.0	14.4	7.2	0.0	-27.0	0.0	0.0	0.00	0.00	1
JUL385	45.1	37.1	18.0	9.0	0.0	-37.1	0.0	0.0	0.00	0.00	1
AUG185	43.4	35.9	17.4	8.7	0.8	-35.1	0.0	0.0	0.02	0.02	1
AUG285	43.9	36.2	17.6	8.8	0.0	-36.2	0.0	0.0	0.00	0.00	1
AUG385	46.2	38.9	18.5	9.2	0.0	-38.9	0.0	0.0	0.00	0.00	1
SEP185	49.4	41.1	19.8	9.9	0.0	-41.1	0.0	0.0	0.00	0.00	1
SEP285	79.6	64.9	31.8	15.9	0.0	-64.9	0.0	0.0	0.00	0.00	1
SEP385	76.0	61.8	30.4	15.2	1.5	-60.3	0.0	0.0	0.02	0.02	1
OCT185	76.9	62.7	30.8	15.4	15.3	-47.4	0.0	0.0	0.20	0.20	1
OCT285	77.4	62.7	31.0	15.5	0.0	-62.7	0.0	0.0	0.00	0.00	1
OCT385	67.0	63.8	26.8	13.4	69.8	6.0	6.0	6.0	1.04	1.04	4
NOV185	64.0	51.2	25.6	12.8	29.0	-22.2	-6.0	0.0	0.45	0.55	3
NOV285	70.0	55.3	28.0	14.0	21.3	-34.1	0.0	0.0	0.30	0.30	2
NOV385	61.0	49.2	24.4	12.2	41.5	-7.7	0.0	0.0	0.68	0.68	3
DEC185	57.0	46.0	22.8	11.4	61.3	15.3	15.3	15.3	1.08	1.08	4
DEC285	63.0	50.0	25.2	12.6	5.0	-45.0	-15.3	0.0	0.08	0.32	2
DEC385	70.4	56.1	28.2	14.1	67.8	11.7	11.7	11.7	0.96	0.96	4
TOTAL85	2138	1731	855	428	978	-753	-60	12	0.46	0.49	3

1986

DEC	EP	ETP	.4*EP	.2*EP	RR	WB	Gch	Gst	RAT1	RAT2	CLS
JAN186	63.0	50.0	25.2	12.6	65.0	15.0	15.0	26.7	1.03	1.03	4
JAN286	68.0	54.0	27.2	13.6	0.0	-54.0	-26.7	0.0	0.00	0.39	2
JAN386	82.5	66.0	33.0	16.5	5.0	-61.0	0.0	0.0	0.06	0.06	1
FEB186	82.0	67.0	32.8	16.4	0.0	-67.0	0.0	0.0	0.00	0.00	1
FEB286	97.0	82.0	38.8	19.4	0.3	-81.8	0.0	0.0	0.00	0.00	1
FEB386	69.6	57.6	27.8	13.9	0.0	-57.6	0.0	0.0	0.00	0.00	1

Notes:
- EP Potential Evaporation in mm (calculated with"PENMAN)
- ETP Potential Evapotranspiration in mm --"--
- .4*EP Minimum Plantwaterrequirements (generalized)
- .2*EP Wiltingpoint (generalized)
- RR Rainfall in mm
- WB Waterbalance (Rainfall minus ETP)
- Gch + Groundcharge in mm (+ WB up to max. 200mm Groundstorage)
- Gch - Groundcharge in mm (- WB down to 0 mm Groundstorage)
- Gst Groundwater storage in mm (max. assumed 200 mm)
- RAT1 Ratio : RR / EP
- RAT2 Ratio : (RR + Absolut Value of neg. Gch) / EP
- CLS Classification :
  - 1 :RAT2 < 0.2 arid
  - 2 :RAT2 0.2 - 0.4 semi-arid
  - 3 :RAT2 0.4 - 0.75 sub-humid
  - 4 :RAT2 > 0.75 humid

WATER AVAILABILITY DIAGRAM

ICRAF Fieldst. 1984/85/86 10 day data

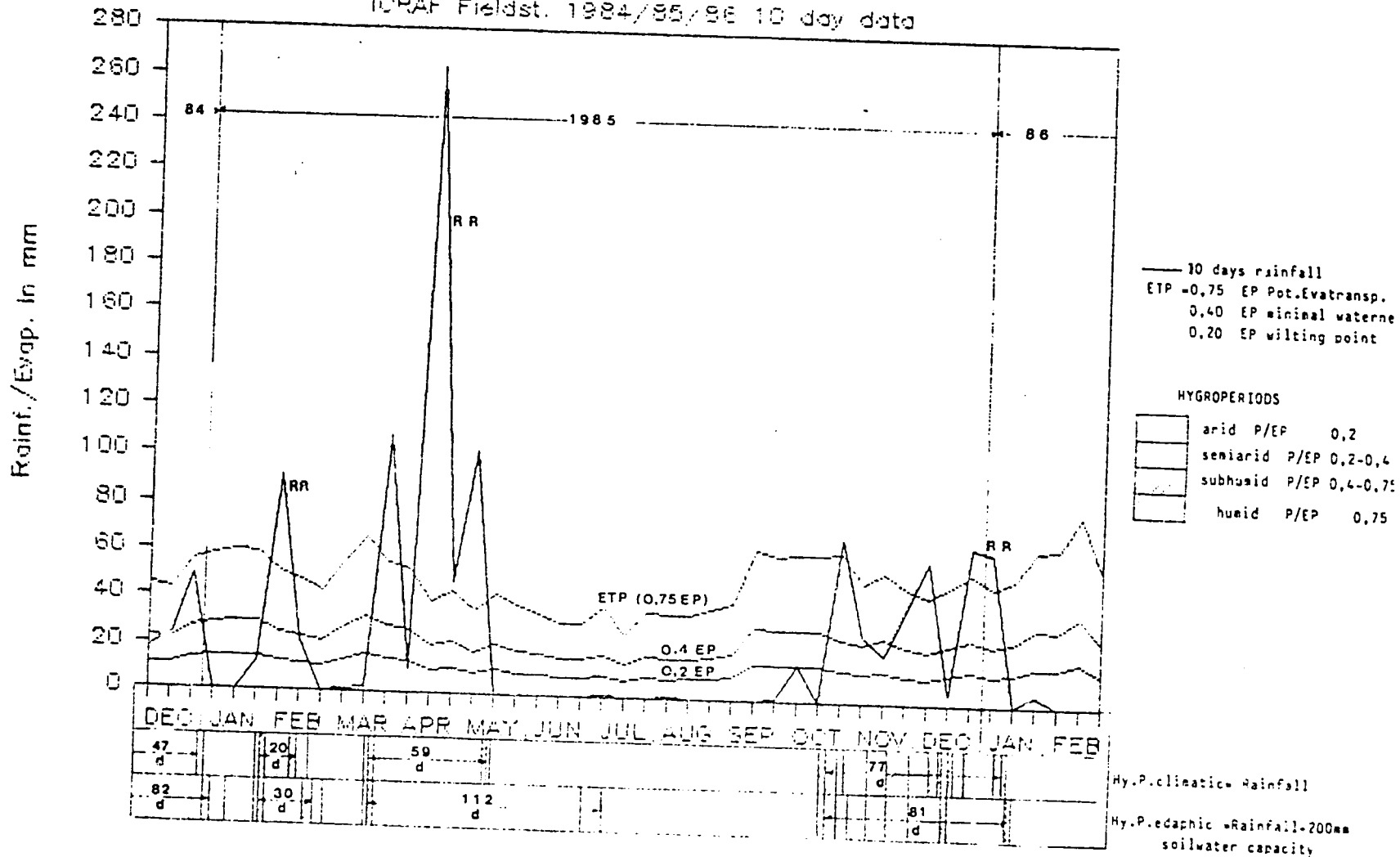


Fig. 9

Table 11.

Table: ICRAF Fieldstation MACHAKOS Rainfall and Evap.Pattern 1985/86

1985 Month	Rainf. Aver.	Rainf. 1985	Rain Days	Pot.EP Aver.	Pot.EP 1985	Pot.ETP 1985	Waterbal. 1985	Ratio RR/EP	Classific. 1985
Jan	52.2	12.0	1	189.0	220.7	177.4	-165.4	0.05	arid
Feb	49.5	113.5	12	206.6	174.6	142.2	-28.7	0.65	sub-humid
Mar	92.0	111.6	8	218.6	222.5	178.1	-66.5	0.50	sub-humid
Apr	162.4	321.7	17	165.6	174.0	137.0	184.7	1.85	humid
May	64.7	104.0	8	135.3	149.0	118.0	-14.0	0.70	sub-humid
Jun	10.3	0.5	0	112.5	125.0	99.0	-98.5	0.00	arid
Jul	6.0	1.3	0	106.2	127.1	103.1	-101.8	0.01	arid
Aug	4.4	0.8	0	124.0	133.5	111.0	-110.2	0.01	arid
Sep	10.2	1.5	1	161.0	205.0	167.8	-166.3	0.01	arid
Oct	39.0	85.1	8	201.0	221.3	189.2	-104.1	0.38	semi-arid
Nov	149.5	91.8	16	156.5	195.0	155.7	-63.9	0.47	sub-humid
Dec	85.1	134.0	12	155.9	190.4	152.1	-18.1	0.70	sub-humid
Year	725.3	977.8	83	1932.2	2138.1	1730.6	-752.8	0.46	sub-humid

1986 Month	Rainf. Aver.	Rainf. 1986	Rain Days	Pot.EP Aver.	Pot.EP 1986	Pot.ETP 1986	Waterbal. 1986	Ratio RR/EP	Classific. 1986
Jan	52.2	70.0	4	189.0	213.9	170.5	-100.5	0.33	semi-arid
Feb	49.5	0.3	0	206.6	249.2	207.2	-206.9	0.00	arid

Rainfall Aver : Monthly rainfall average as calculated for ICRAF Fieldstation,using data from Katumani and Machakos Dam (Period 1963-1983)

Rainfall 85/86 : Rainfall measured at ICRAF Field Station

Rain Days : Number of days with rainfall >0.99mm

Pot.EP Aver. : Potential Evaporation as measured with a Class A Pan in Katumani and adjusted by dividing,by 0.93

Pot.EP 1985/86 : Potential Evaporation as calculated with the Penman formula using data measured at the Field Station

Pot.ETP 1984/85: Potential Evapotranspiration as calculated with the Penman formula using data measured at the Field Station

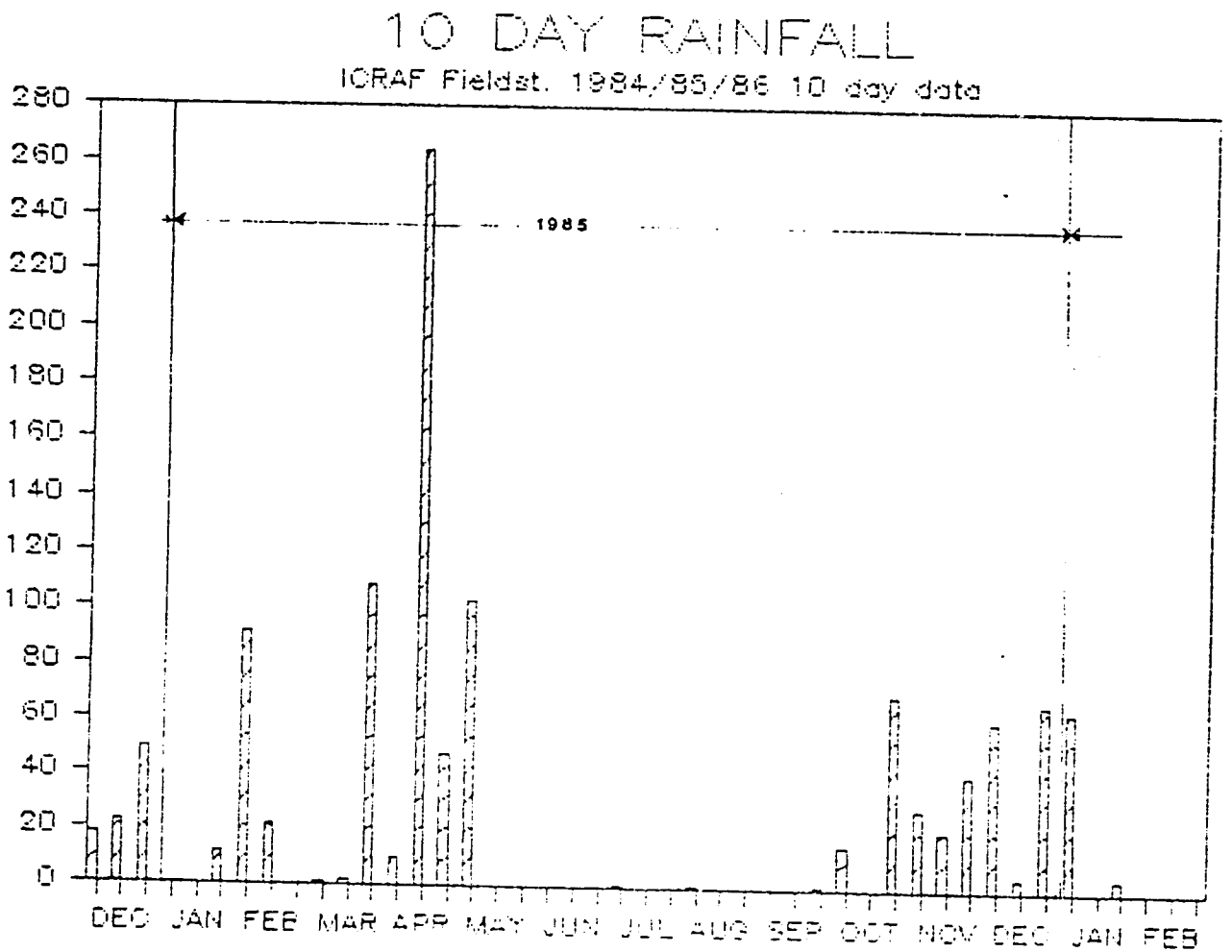
Waterbalance : Rainfall 1985/86 minus Pot. ETP 1985/86

Ratio : Rainfall 1985/86 divided by Pot.EP 1985/86

Classification :

< 0.2 arid
0.2 - 0.4 semi-arid
0.4 - 0.75 sub-humid
> 0.75 humid

Fig. 10


10 DAY RAINFALL
ICRAF Fieldst. 1984/85/86 10 day data
Rainfall in mm
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1985
DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB

Wilting point and the corresponding moisture classes (humid, sub-humid, semi-arid and arid) are generalized ones, as used in various publications (FAO, Jaetzold). Therefore, they do not refer to water requirements of specific crop species.

During 1985, a total of 987 mm of rain was received in 83 days as against the 20-year average of 725 mm. This included unusually rainy spells in February (113.5 mm against the long-term average of 49.5 mm) and April (321.7 mm vs 162.4 mm). The water balance (difference between rainfall and potential evapotranspiration) was, on average, such that the month of April was classified as humid; February, March, May, October, November and December were sub-humid and the remaining five months arid. Except for the sub-humid conditions in February, the climatic conditions during the year were in accordance with the long-term average for the locality (Table 11).

5.2. Soil Monitoring (A. Young, D. Wambuguh and P.K.R. Nair)

A soil monitoring programme for the Field Station was designed, consisting of a comprehensive baseline sampling in 1983, establishing a statistically solid basis for soil chemical properties over the whole area of the Station, to be followed by annual sampling of those parts under demonstration plot. The objective is to test, or if successful demonstrate, methods by which changes in soil properties under agroforestry can be monitored.

The baseline sampling was completed in July-August 1983, when a total of 636 samples was collected, comprising samples from three depths -- 0-20; 20-45 and 45-55 cm) and their pre-treatment (prior to analysis) completed. Subsequently, in 1984 and 1985 annual soil

samplings of the macroplots was carried out in August each year, when the upper horizons only (up to 20 cm depth) were sampled.

The first report of the 1983 soil sampling programme was completed. It contains detailed statistical analysis of coarse fraction (stones and gravel) percentage, with maps showing its distribution both on a grid interpolation basis and according to average for soil mapping units. The report has been produced as an ICRAF Internal Report in November 1984.

From the 1983 soil sampling programmes, 174 samples were got analyzed by the National Agricultural (Kenya Soil Survey) laboratories, Nairobi. Of these, 48 samples are for basic characterization of the soils of the Station as a whole, as a baseline for whatever may be the changes under present and future management practices, and 126 for fertility analysis (organic carbon and major nutrients) on the intercropped macroplots.

Cross-checks of microvariability and reliability have been built in.

5.3. Nursery (P.G. von Carlowitz and H. Arnold)

Action was initiated in early 1984 to set up a professionally-run, medium input nursery on the Station. The objectives are:

- to demonstrate the set-up and management of an MPT nursery, including various low-cost shading techniques and use of vines and other climbing plants as live-shades;
- to supply MPT seedlings for the Field Station needs (e.g. experiments, live hedges, shelterbelt, etc.);

- to raise seedlings for other ICRAF-involved projects in Kenya (e.g. the COSPRO project at Kakuyuni);
- to multiply stocks of potentially useful AF plant materials (e.g. specific strains of agricultural crops);
- to facilitate small-scale distribution of rare MPT seedlings and other AF species to farmers in the vicinity (MPT and AF promotion).

The nursery is now operational.

5.4. Field Laboratory

(I. Darnhofer/P.K.R. Nair)

The main objective of the "miniature laboratory" that has been set up on the Station is to provide basic facilities to field workers to undertake scientifically appropriate procedures in collecting, pre-treating, processing, etc. of plant and soil samples. The facility is being availed of for the Field Station activities, as well as for other ICRAF-involved projects in Kenya, e.g. the Dryland Agroforestry Research Project of the Kenya Agricultural Research Institute, being carried out at the Katumani Research Station fields adjacent to the ICRAF Field Station.

5.5. Training Facilities

The Station is already being used by various types of trainees, both ICRAF-sponsored and others. The former include On-The-Job Trainees, Research Fellows, participants to ICRAF training courses, students, etc., who use the Station for conducting field demonstrations and training exercises on measuring and recording

various biological (plant, soil) and physical (climate) parameters in agroforestry. This activity is planned to be expanded during the coming years for which the facilities at the Station will need to be expanded accordingly.

5.6. Visitors to the Station

Although the Station is still not fully developed, its existence seems to have been well acknowledged and its potential greatly appreciated. In fact, judging from the number and kind of people who visit the Station, it is even wondered whether the Station has not raised excessive expectations. An average of over 300 visitors per year have recorded their visits to the Station since 1982. They included individuals from far and near as well as groups who have been undertaking specific programmes in Kenya.

Based on this large number of visitors alone, it can be surmised that the Station is effectively performing the role of a training and demonstration ground for agroforestry.

6. OUTLINE OF ACTIVITIES PROPOSED FOR 1986-87

- Continuation of existing trials and demonstrations;
- Initiation of new trials: three such trials are planned (as of early March, 1986);
- Raising seedlings of various MPT species for fuelwood/fodder and planting them for reclamation of degraded areas according to the 1984 "short-term master-plan for FS development" -- this activity, originally planned

to be initiated in 1985 had to be delayed consequent to the difficulty in importing seeds from outside Kenya, but this difficulty has now been overcome and the procedure for such importations straightened-out.

Completion of the proposed extension to the Field Station building.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

SHORT NOTES ON SOME OF THE MULTIPURPOSE TREES GROWN AT THE ICRAF FIELD STATION, MACHAKOS, KENYA

MARCH, 1986

ICRAF
INTERNATIONAL COUNCIL FOR
RESEARCH IN AGROFORESTRY
P.O. BOX 30677, NAIROBI, KENYA, TEL: 29857
TELEX: 22048 CABLE: ICRAF

'93'

List of Multipurpose Trees Assembled at ICRAF Field Station
(as of March 1985)

Species	Date of planting
Acacia albida	28 October 1981
A. allophanta	04 January 1984
A. cyanophylla...	09 November 1981
A. deamii...	02 November 1984
A. farnesiana	02 November 1984
A. holosericea...	26 April 1982
A. mellifera	03 December 1983
A. nilotica.	03 January 1984
A. pennatula	02 November 1984
A. saligna..	18 May 1984
A. tortilis.	09 November 1981
A. victoriae	26 April 1982
A. xanthophloea..	09 November 1984
Adansonia digitata	29 October 1984
Albizia allophanta	04 January 1984
Albizia longependata..	06 November 1984
Atriplex nummularia...	30 October 1981
Azadirachta indica	29 November 1983
Balanites aegyptiaca..	19 April 1982
Calliandra calothyrsus	10 May 1982
Cassia elata	14 November 1981
C. siamea...	07 December 1981
C. sturtii..	07 December 1983
Casuarina equisetifolia	05 April 1982
Cedrella odorata.	29 June 1984
Citrus sinensis..	02 February 1982
Colosphospermum mopane	02 November 1984
Cordeauxia edulis	29 June 1982
Croton megalocarpus...	29 October 1984
Erythrina abyssinica..	11 December 1982
Eucalyptus camaldulensis...	24 October 1984
E. cladocalyx	17 May 1984
Gliricidia sepium	21 December 1983
Grevillea robusta	23 December 1982
Leucaena diversifolia (K.195)...	13 June 1984
L. glauca...	09 November 1984
L. leucocephala..	
(Cunningham, K 8, K 67, Peru).	09-12 November 1984
(K 4, K 4, K29, K 156, K 500, K 636) ...	17 December 1983
Melia azedarach..	22 November 1983
Moringa oleifera.	23 April 1982
Parkinsonia aculeata..	29 October 1981
Persea americana.	11 December 1981
Prosopis alba	22 November 1983
Prosopis chilensis	22 April 1982
P. juliflora	27 October 1981
P. nigra	23 April 1983
P. pallida..	29 October 1981
P. tamarugo.	22 November 1983
P. velutina.	09 November 1984
Robinia pseudoacacia	22 May 1984
Samanea saman	01 July 1982
Sesbania grandiflora..	19 April 1983
S. sesban...	22 November 1983
Simmondsia chilensis..	14 November 1981
Tamarindus indica	26 April 1982
Terminalia brownii	29 October 1984
Zizyphus mauritania...	23 April 1982

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA ALBIDA Del.

Synonyms: *A. gyrocarpa* Hochst., *A. leucocephala*
Faidherbia albida (Del.) A. chev

Family: Leguminosae (Mimosoideae)

Trade/Local name: Apple ring Acacia

Distribution: Widespread (natural occurrence) in the semi-arid and arid regions.

Ecology: Prefers dry areas having high water table; commonly found in altitudes of 100-2500 m; average annual rainfall above 500 mm or root access to high water table; adapted to different soil types, but loamy and sandy types seem to be best.

Description: Large tree, up to 25 m height and 5 m girth, with a spreading crown. Flowers cream, sessile to subsessile. Pods large, bright orange, indehiscent, falcate or curled into ¾ circular coil. Seeds elliptic.

The tree sheds its leaves during the rainy season but leaves reappear at the end of the rainy season.

Propagation: Can be direct seeded or grown in pots in a nursery. The seed should be scarified by nicking or soaking. Plant germinated seeds in 2 cm deep moist soil. Seedlings ready for transplanting from nursery within 4 months.

Seeds store well if kept free from insects in a dry place. One thousand seeds weigh approximately 110 g. Seeds available in semi-arid and arid region of Africa.

Uses: A nitrogen fixer; leaves that fall in the rainy season make a good green manure. A good source of fodder for goats in the later dry season when pods fall. The tree is deep rooted and does not compete with agricultural crops. It is grown mixed with agricultural crops extensively.

Wood used for farm construction purposes; but only marginal use as a firewood.

Limitations: Early growth is rather slow.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA CYANOPHYLLA Lindl. OR *A. SALIGNA* (Labill) Wendl

Family:	Leguminosae (Mimosoideae)
Local/trade names:	Orange wattle, Blue-leafed wattle
Distribution:	Native to the southwest coastal strip of western Australia. Found also in Uruguay, Mexico, the Middle East and N. Africa.
Ecology:	Can grow throughout the tropics; temperature range 13-30°C; mean annual rainfall 300-700 mm; 4-8 dry months per year; can tolerate a wide range of soils, but prefers freely drained neutral to alkaline soils.
Description:	A dense bushy evergreen short tree of 3-8 m height; can be managed under coppiced system; drought tolerant; can withstand some shade.
Propagation:	Seeds germinate readily and the plant is easily raised in the nursery. Pretreat the seed by nicking, soaking in boiling water and allowing to cool. Seeds weigh about 125 g/1000; can be stored in dry cool airtight containers. Seedlings compete well with weeds.
Uses:	Good as low-level wind-breaks and for sand dune fixation; an understorey species in widely-spaced fuel and timber species; leaves and pods edible by goat and sheep mainly when other fodder is in short supply; not a very popular fuelwood; wood used for various farm implements and construction.
Limitations:	Because of its hardiness and profuse reproducing abilities, it can become a weed.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA HOLOSERICEA

Related spp.: *A. brachystachya, A. mangium, A. lysiophloia*

Family: Leguminosae (Mimosoideae)

Distribution: A native of the semi-arid parts of Northern Australia. Found in overgrazed land in Senegal and other semi-arid parts of Africa.

Ecology: It is a lowland species that springs up quickly in denuded or disturbed sandy sites. Will grow up to 1500 m if temperatures are not very high. Prefers 400-800 mm rainfall per annum.

Description: A small, fast-growing tree, that branches from just above ground level into a spreading crown.

Propagation: The seed must be either boiled and soaked or nicked prior to sowing. Seeds are small. Sow about 1 cm deep in sandy soil. Requires about four months in the nursery. Seeds store well if kept cool and dry. Unlike most Acacias, pods do not fall before releasing seeds; therefore, pods must be collected while on the tree.

Uses: In Australia, it has been used to restore areas after mining. It is N-fixing and its large phyllode (adapted stem-like leaf) makes a good fodder. Aboriginals in Australia used to use roasted seeds as a food source. It is a good firewood, windbreak and live fence.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA MELLIFERA (Vahl) Benth.

Synonym:

Family: *Leguminosae*

Trade/Local name: Blackthorn, wait-a-bit, hookthorn.

Distribution: Northern South West Africa to tropical Africa.

Ecology: Found in drainage basins in arid areas and is often co-dominant with *Acacia reficiens*. Tolerates salinity and some waterlogging.

Description: A shrub or small tree to 5 m depending on management.

Propagation: By coppice and seed.

Uses: Fodder and shade (in tree form), valued for the flavour of its honey. Its thorny branches make good fencing material. It pollards well.

Limitations: If unmanaged, it could form an absolutely impenetrable, tangled, thorny growth.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA NILOTICA (L.) Willd. ex Del.

Synonyms: *A. arabica; A. arabica* var. *indica; A. nilotica* var. *indica; A. scorpioides; Mimosa arabica; Mimosa nilotica*

Family: Leguminosae (Mimosoideae)

Trade/Local name: Egyptian thorn; Babul (India); Sunt (Arabic)

Distribution: Subspecies *indica* (Benth.) is native to the dry western parts of India and adjoining parts of Pakistan which is now cultivated throughout India and Pakistan. Subspecies *nilotica* is native to Africa where it is widely planted in the semi-arid and arid African savannas.

Ecology: Commonly found in low altitude having low and unpredictable rainfall and high temperatures. It prefers alluvial soils, but grows well on heavy black cotton as well as poor soils.

Description: A moderate-sized tree that can grow up to 20 m in good sites, but usually less than 10 m high; could be a shrub in very unfavourable conditions. Flat or umbrella-shaped crown, easily identifiable by its sweet-smelling gray or black pods. During the hot season the tree is in full leaf. Seeds blackish-brown, smooth, compressed, sub-circular. Trees coppice occasionally.

Propagation: Usually direct sown; fresh seeds can be sown without seed treatment, but stored seed should be soaked or nicked. Sow 2 seeds per pot, 2 cm deep.

Seeds when dry can be stored in cold airtight chambers for several years. Seed weight about 125 g/1000.

Uses: The hard tough wood is termite-resistant, and is used for a variety of farm uses. A good firewood with high calorific value (4,950 k cal/kg heartwood). Leaves and pods are good fodder, high protein value. A gum similar to that of *Acacia senegal* can be obtained. It is thorny and makes a good living fence.

Limitations: Extremely thorny. Growth depends on environmental conditions. Wood borers may attack the tree sometimes.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA SENEGAL (L.) Willd.

Synonyms: *A. verek* Guill et Perrott.

Family: Leguminosae (Mimosoideae)

Trade/Local name: Gum arabic, Hashab (Arabic).

Distribution: Commonly found in the drier parts of the southern Sahara from Senegal to Somalia. Important forest resource of the Sudan which supplies 80% of the world's gum arabic.

Ecology: Where the tree grows in the Sudan, the average temperatures are between 14° and 43°C, and in India between -4° and 48°C. Grows up to 1700 m above sea level; is very drought resistant; prefers 300-450 mm rain. Grows in sand, but also in clay where there is no waterlogging or excessive rainfall.

Description: A small thorny tree to about 13 m height, but can also be a shrub. Flowers are whitish spikes.

The tree coppices well.

Propagation: Natural regeneration is common. Can be easily raised from seed; sow pre-soaked seed 1-2 cm deep; ready for transplanting in about 4 months. Needs weeding during the early stages.

Seeds store well in cool dry airtight containers; but seeds are very susceptible to beetle attack.

Uses: The hard heavy wood is an excellent firewood. Wood is used for poles and agricultural implements. Gum arabic is used in foods and beverages, pharmaceutical preparations and a wide range of industrial applications. The tree foliage and pods are important feed for camels, sheep and goats. The tree is used for erosion control and soil rehabilitation. It is used for dryland agroforestry, mixed with millet, simsim, grasses, etc.

Limitations: Slow growing; seedlings subject to goat damage. The tree can form a thorny thicket.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA TORTILIS (Forsk.) Hayne

Synonyms: *A. raddiana* Savi,
A. spirocarpa Hochst. ex A. Rich.

Family: Leguminosae (Mimosoideae)

Trade/Local name: Umbrella thorn (Africa); Israeli babool (India), Seyal (Arabic).

Distribution: An African native, spread throughout the arid and semi-arid parts. There are 4 subspecies: *tortilis*, *raddiana*, *spirocarpa*, and *heteracantha*. The different subspecies are found in different ecological zones.

Ecology: Best adapted to low lands, but grows in areas up to 1500 m altitude in Kenya. Grows well in hot, arid and semi-arid regions with 100-1000 mm rainfall. Favours alkaline soils. It can grow in very shallow soils too.

Description: A medium sized (4-15 m tall) tree with irregularly spreading crown. Under extreme aridity or shallowness of soil, it becomes a shrub.

There are two types of thorn - long, straight and white and small, hooked and brownish. Flowers white and fragrant; pods contorted or spirally twisted. In full leaf during the rains, often retaining leaves for a long time in dry season. The plant coppices well.

Propagation: Seed coat is very hard; seeds should be put in boiling water and allowed to cool. Plant about 2 cm deep in moist sandy soil; seedlings ready for transplanting from nursery in 3-5 months.

Seeds store well in dry cold airtight containers. Seed weight 100 g/1000.

Uses: Excellent as firewood and for charcoal; calorific value high (4,400 k cal/kg heartwood). Good fodder tree for camel, goat, and giraffe. Pods are highly preferred by goats. Good as living fence and for sand fixation. Used for building and other farm construction.

Limitation: Spreading root system may be a disadvantage for agro-forestry. Since it is especially palatable, protection

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ACACIA VICTORIAE Benth

Synonym: *A. acutis* F. Muell

Family: Leguminosae (Mimosoideae)

Distribution: Semi-desert areas of inland Australia.

Ecology: Wide range of soil and climatic conditions in arid and semi-arid region; also grows in saline soils.

Description: Shrub

Propagation: Seed; scarify with hot water before sowing. Other aspects similar to other Acacias.

Uses: Mainly a fodder shrub.

Limitations: Long sharp thorns or hooked prickles; toxicity due to cyanogetic glucosides; pods of some species give an odour to milk and hence should not be fed immediately before milking time.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ATRIPLEX NUMMULARIA

Family: Chenopodiaceae

Trade/Local name: Saltbush

Distribution: Grown in salty and saline areas of arid and semi-arid subtropics; found extensively in Australia, Israel, southern USA, Tunisia.

Ecology: Found in arid and saline-alkaline areas with as little as 100-200 mm annual rainfall. It resists temperatures as low as -10°C and withstands heavy soils and salinity in soil or water; laboratory experiments have demonstrated that it will grow adequately when irrigated with saline nutritive solution containing as much as 30,000 mg/l of sodium chloride. They excrete salt by forming small salt-filled bubbles (vesicles) on the leaf surface. When full, the vesicles burst, releasing salt to the wind.

Description: Low-branching, many-stemmed, ever-green shrub that rarely reaches over 3 m height.

Propagation: Seed, cutting or layering. Seedlings or cuttings are grown in a nursery for 3-6 months.

Uses: A high-protein (about 12% of dry matter) forage; first grazing when plants are 1.5 m high. In Israel, sheep prefer them in the dry season.

Can be used for reclamation of salt-affected soils.

Limitations: Oxalic acid accumulation leading to mammalian toxicity can be a problem. Young plants likely to be attacked by rodents and wild animals.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

AZADIRACHTA INDICA A. JUSS.

Synonyms: *Melia indica* (A. Juss.) Brandis, *Melia azadirachta* L.

Family: *Meliaceae*

Trade/Local name: Neem, nim.

Distribution: Native to dry forest areas of the Indian subcontinent. Widely cultivated in arid regions of India and Africa.

Ecology: Neem survives great heat (shade temperatures of upto 44°C). It grows at altitudes from 50 to 1500 m. Thrives best in arid tropical and subtropical zones with a mean annual rainfall of 450-1150 mm but it will tolerate as little rainfall as 130 mm annually and long dry seasons. It grows well on most soils but prefers soils with a pH of about 6.2. Does not tolerate waterlogging or salinity.

Description: Neem is a deep-rooted, medium-sized tree 10-15 m, broad-leaved and usually evergreen, except in periods of extreme drought. It has a short bole with wide spreading branches forming a rounded/oval crown. The tree coppices freely and early growth from coppice is faster than growth from seedlings.

Propagation: Seedlings and direct sowing. In the field, the plants establish an extensive root system before aerial growth becomes rapid.

Uses: It has long been used for fuel in India and Africa. The calorific value of its wood is very high. The wood resembles mahogany, resists decay and insects, is tougher than teak and is excellent for construction and furniture making. The poles are straight and strong and are seldom attacked by insects. The seeds contain upto 40% oil which is used in lamps and as a machinery lubricant. The pulp surrounding the seed is a promising substrate for generating methane gas. Neem has been used as a wind break and for shade. Its leaves and twigs have successfully been used as a mulch and fertilizer. The seed cake is an excellent organic fertilizer. The bark contains 12-14% tannins and the oil is used in soaps and disinfectants and in pharmaceuticals and cosmetics. The seeds and leaves yield azadrachtin, a systemic pesticide as well as an insect/nematode repellant.

Limitations: Neem seeds have to be sown within 2 or 3 weeks of harvest after which they lose their viability. Neem grown among other crops could become aggressive.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

BALANITES AEGYPTIACA (L.) Del.

Synonyms: *Ximenia aegyptiaca* L.;
Agialida senegalensis van Tiegh;
Balanites ziziphoides Mildbr. et Schlechter.

Family: Balanitaceae

Trade/Local name: Desert date; Soap berry tree

Distribution: Widespread in the semi-arid and arid tropical regions throughout Africa (especially the northern parts) and Asia.

Ecology: Grows up to 2000 m above sea level in areas having an annual rainfall of 350-1000 mm. It is drought tolerant and can withstand some waterlogging; grows under very hot and dry conditions as in Egypt and parts of Indian sub-continent. Although it grows well in sandy soils, it can also be found on thin black cotton soils with sand or more porous soils beneath.

Description: Shrub to tree of up to 10 m height; spherical crown; yellow-green flowers; fruit green at first turning to yellow as it ripens, containing a large seed surrounded by yellow-brown, sticky, edible flesh.

Propagation: The seed should be soaked overnight in lukewarm water. Sow the seeds vertically with the end previously attached to the stem down and the top just beneath the soil surface. Seedlings ready for transplanting in 4-6 months.

Seeds store well in cool dry airtight containers.

Uses: The fruit is edible. Leaves are a favourite of camels and goats; sometimes used as a cut and carry fodder. The wood is heavy, good for charcoal making and as a fuelwood; also for carving and agricultural implements. An emulsion made from the fruits in lethal to fresh-water snails which act as intermediary hosts for Bilharzia. The emulsion is also lethal to water-flee, the carrier of Guinea worm. Strong emulsions may be poisonous to fish.

Limitation: A slow grower; must be protected from goats during its early stages.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

CALLIANDRA CALOTHYRUS Meissn.

Synonym: *C. confusa* Sprague Riley

Family: Leguminosae (Mimosoideae)

Trade/Local name: Calliandra

Distribution: Native to Central America, but seeds were introduced from Guatemala to Indonesia in 1936, where it is very popular.

Ecology: The plant grows in altitudes between 150 and 1500 m in Java (Indonesia); preferred rainfall over 1000 mm per year, but it can withstand drought. Grows in a variety of soils including infertile as well as heavy clay types.

Description: A shrub that rarely reaches more than 10 m tall, with a maximum diameter of 20 cm. It has excellent coppicing ability and very quick growth.

Propagation: Direct seeding or seedlings. Seeds should be soaked in water for 24 hours; seedlings compete well with weeds; ready for transplanting after 4-6 months in the nursery.

Uses: Excellent firewood - it can withstand repeated harvests in annual intervals, initial growth of 2.5-3.5 m in 6-9 months reported in Indonesia. It is a very good species for soil erosion control because of its quick growth and dense roots; also good for rejuvenating degraded soils. A good soil improver because of nitrogen fixation. The plant is an excellent fodder for livestock. Also used as bee forage and firebreaks.

Limitation: Very little is known about the adaptability of the species in different situations. It can assume weed proportions.

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PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

CASSIA ALATA L.

Synonym: *Herpetica alata* (L.) Raf.

Family: Leguminosae (Caesalpinioideae)

Trade/Local name: Ringworm bush

Distribution: Native to tropical America; also common in the Indian subcontinent and East and West Africa.

Ecology: A tropical to subtropical plant found from sea level to ca 1000 m altitude. Tolerates annual rainfall of 600-4000 mm, and temperatures of 14°-30° C. No special preferance to soil provided it is moisture-holding.

Description: Short-lived evergreen shrub, 3-5 m tall, with few thick branches; spirally arranged leaves; pods 12-18 cm long.

Propagation: Seeds; usually good germination.

Uses: Best known as a medicinal herb; bark contains a tanning material; root juice used in West Africa for tattooing or tribal markings; no fodder value, but useful in apiculture; highly ornamental.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

CASSIA SIAMEA Lam.

Family: Leguminosae (Caesalpinioideae)

Trade/Local name: Cassia

Distribution: Native to Southeast Asia from Indonesia to Sri Lanka; now widely distributed also in Africa and American tropics.

Ecology: It is normally a lowland species, but it grows well around Nairobi area at about 1700 m altitude. Although it is most prevalent in areas with monsoon rains of over 1000 mm per year, it adapts well to a wide range of climates from dry to humid.

Mean annual temperature 22-28°C. Prefers neutral to acid, deep, fairly rich soils. Good drainage is very important.

Description: A medium-sized, evergreen ornamental tree with a dense crown of foliage and smooth, gray bark, attractive yellow flowers and long pods hanging in clusters. Coppices; produces root suckers vigorously; fairly termite resistant.

Propagation: Fresh seed is the best; seeds sown within a month after picking do not need any treatment. Old stock of seeds need to be scarified by hot water or sulfuric acid. Can be direct seeded. Seedlings compete well with weeds.

Dry seeds can store under ambient temperatures for several years.

Uses: Good firewood; heartwood makes attractive timber for furniture. Used also as building poles. Also useful as dense windbreaks and for reclamation of denuded areas. Used in India as a host for sandalwood, *Santanum album*, a valuable parasitic tree. Also good as a fodder.

Limitations: Young seeds must be protected from livestock and wild game. Pods are reported to be poisonous to pigs. Does not compare well with *Gmelina arborea* and *Eucalyptus* spp. in forestry (timber production) programmes.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

CASSIA STURTII R. Br.

Synonyms:

Family: *Leguminosae (Caesalpinioideae)*

Trade/Local name: -

Distribution: Arid and semi-arid regions of southern Australia. Has been introduced into Israel as an ornamental plant.

Ecology: The plant yields well in areas of 200-250 mm of winter rainfall but also thrives in areas of higher rainfall. It will grow in a variety of soil types, including sandy and slightly alkaline soils, but does best in loamy soils.

Description: A perennial fodder bush.

Propagation: By seed. Seedlings prepared in a nursery may be transplanted to the field 6-12 months after planting. In direct sowing, the seedlings grow slower than transplanted seedlings.

Uses: Considered unimportant as a forage in its native Australia. However, it is providing nutritious forage in experimental projects in Israel's arid region. The leaves have about 12% protein content.

Limitations: Sheep and cattle rarely graze *Cassia sturtii* in Australia. Hence more research is needed to establish its palatability before large-scale planting.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRA

CASUARINA EQUISETIFOLIA L.

Synonym: *C. littoralis* Salisb.
(Among the nearly 35 species of *Casuarina*, *C. equisetifolia* is the most widely used; but it is often confused with other *Casuarina* spp.)

Family: Casuarinaceae

Trade/Local names: Casuarina, she-oak, Australian pine, Australian beefwood.

Distribution: Native to tropical Indian Ocean coasts, Australia and Polynesia.

Ecology: A species of warm to hot subtropical and tropical climates with monthly mean temperatures of 10° - 33° C, in altitudes from sea level up to 1500 m, rainfall of 700-2000 mm and 6-8 dry months. But also grows in areas with much less rainfall.

Tolerates calcareous and slightly saline soils, but grows poorly in heavy clays. Can withstand partial waterlogging.

The tree has root nodules containing nitrogen-fixing actinomycetes; therefore they are not dependent on soil nitrogen for good growth.

Description: Evergreen trees, generally 15-25 m tall, having long, drooping, gray-green needles and small cones; open to feathery crown that appears leafless but the leaves are actually reduced to small sheaths on the needle-like branches.

Propagation: Produces seeds abundantly. Seeds should be treated to repel ants and inoculated with crushed root nodules from established trees; ready for transplanting in 4-6 months.

Seeds are reported to store well in cool, dry, airtight conditions.

Uses: Has a variety of uses, known as the best firewood in the world (calorific value of 4,900 k cal per kg), it burns readily even when green. Timber used as building poles, fence posts, transmission poles. A dye and tannin are found in the bark. Good pulp can be obtained from the wood. Excellent windbreak. Very efficient in erosion control in coastal areas because of its salt tolerance.

Limitations: Some Casuarinas coppice well, but not *C. equisetifolia*. It is said to exhaust moisture and lower water table in the soil.

Best Available Document

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

CORDEAUXIA EDULIS Hemsl.

Family: Leguminosae (Caesalpinioideae)

Trade/Local names: Ye-eb, jeheb-nut, hebb.

Distribution: Native to the arid, semi-desert border region between Somalia and Ethiopia.

Ecology: An open savanna, bush growing at altitudes of 300-1000 m having rainfall of 250-400 mm, and red sandy extremely poor soil.

Description: A dwarfed, evergreen many-stemmed shrub, usually about 1.6 m tall, but growing up to 2.5 m tall in favourable conditions, massive and long root system.

Propagation: By seed. Pods are formed in plenty after 3-4 years; 1-4 round to avoid seeds per pod. In natural conditions, the plant re-seeds itself but grows very slowly in the seedling stage when it establishes its massive root system.

Uses: Ye-eb is a staple of the poorer people in the Somali hinterland; it is much relished and often preferred to the cereals. The seeds can be cooked or eaten raw and are rich in protein (13%), sugar (24%) and fat (11%).

Leaves contain a brilliant red dye that stains the hands; it is also used as a commercial dye. Livestock relish the leaves.

Limitations: Long tap root makes transplanting difficult. Getting viable seeds is a problem. Seedling grows very slowly.

ICRAF

ERYTHRINA ABYSSINICA Lam. et DC

Synonym: *E. tomentosa* R. Br. et A. Rich

Distribution: Widespread in East Africa.

Ecology: Commonly found in low altitudes with low and unreliable rainfall and high temperatures.

Description: Deciduous tree of up to 12 m tall in savanna or scrub; yellowish-brown bark; precocious, coral-red to scarlet flowers. Long pods (10-15 cm); seeds shiny and black.

Propagation: Easily propagated from large cuttings. Dry seeds can be stored in cold airtight containers.

Uses: Fencing, fuelwood, ornamental.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

GLIRICIDIA SEPIUM (Jacq.) Steud.

Synonym: *Gliricidia maculata* (H.B.K.) Steud.

Family: *Leguminosae (Papilionoideae)*

Trade/Local name: Mother of cocoa, Mexican lilac.

Distribution: A native of Central America; has been introduced to West Indies where it is becoming naturalized. It has also been introduced to Africa and Asia and has become naturalized in the Philippines.

Ecology: Temperature 22-30°C, grows at elevations upto 1600 m but mainly below 500 m. Rainfall 1500-2300 mm per yea plus. Prefers moist or dry soil.

Description: A small, thornless tree growing upto 10 m high. It has an open crown and an open contorted trunk rarely exceeding 30 cm in diameter. It coppices easily.

Propagation: Easily propagated by seed; however the natural regeneration of large cutting (often nearly 2 m long) is a simple method of getting large specimens quickly. The seeds should be soaked in hot water, cooled off during the night and sown the following morning.

Uses: Firewood (calorific value 4900 k cal per kg). The wood has a fine finish and the timber is used for furniture, agricultural implements and tool handles. Because it is resistant to termites and decay, the wood is used for posts and heavy construction. Because of the ease of establishment from cuttings, *Gliricidia sepium* makes a very effective living fence while periodic trimming of these fences every month or two during the rainy season provides large amounts of foliage for fodder or green manure. It is used as an ornamental shade and honey forage. The leaves contain over 20% crude protein and are nutritious for cattle.

Limitation: The roots, bark and seeds are poisonous. The leaves may also be toxic to humans although they are eaten in some parts of the tropics. Perhaps cooking inactivates the toxin.

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PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

GREVILLEA ROBUSTA A. Cunn.

Family: Proteaceae

Trade/Local names: Silk oak; Silver oak

Distribution: Native of subtropical coastal areas of N.S.W. and Queensland in Australia; now cultivated in semi-arid, temperate and subtropical climates in India and Sri Lanka, East Africa, Hawaii and Jamaica.

Ecology: A sub-tropical tree; grows well in tropical midlands and highlands up to 2500 m altitude. Drought tolerant; can grow in areas with as low as 400 mm annual (but bimodal) rainfall, but also in areas with up to 2500 mm rainfall.

Grows in variety of soils, but deep and well drained sandy and loamy types preferred. Does not tolerate waterlogging.

Description: Growing up to 35 m tall; long and beautiful, dense racemes of golden flowers; briefly deciduous in late winter; leaves covered with silky gray hairs.

Propagation: A prolific seeder; propagated by fresh seeds or seedlings found commonly under old stands. Sow the seeds shallow (1-5 mm) in the nursery. No seed treatment required.

Seeds usually not viable after 3 months unless dried and stored in a refrigerator.

Uses: Originally introduced to tropical highlands as a shade tree for coffee and tea; grows moderately fast producing good fuelwood. The timber resembles oak, has good grain and works well. Flowers profusely making it a good ornamental and for honey production.

Limitation: Can become a weed; branches can break off in high winds.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

LEUCAENA LEUCOCEPHALA (Lam.) de Wit

Synonym: *L. glauca* Benth.

Family: Leguminosae (Mimosoideae)

Trade/Local names: Leucaena, Ipil-Ipil (Philippines); Koo-babul (India).

Distribution: Originally from the midlands of southern Mexico; it was introduced to the Pacific islands and the Philippines. Now it is truly pantropical.

Ecology: Grows best in hot, humid locations with over 1000 m annual rainfall at low elevations (up to 600 m). It continues to grow at high altitudes, but with less vigour.

Tolerates a wide array of soil conditions, except that it grows poorly in acidic soils (and much of the humid tropical lowlands have acid soils!). Deep well-drained soils preferred.

Description: Depending on the type, Leucaena is either a tall, slender tree that may go up to 20 m, or a rounded many-branched shrub less than 5 m high. Has feathery leaves and bunches of long brown pods. The plant coppices well.

There are several varieties (types) of Leucaena:

- Hawaiian type -- short bushy plants to 5 m in height; flowers when very young and throughout the year;
- Salvador or Guatemala type -- tall tree-like plants to 20 m in height having large leaves, pods and seeds and thick trunks; some extremely-high-timber yielding cultivars are known as "Hawaiian Giants" (e.g. K8, K28, K67 etc.);
- Peru type -- tall plants to 15 m, but with extensive branching even low down on the trunk; high foliage production;
- Cunningham -- dark-green, vigorous, leafy type derived from crossing Salvador- and Peru-types; produces up to 50% more edible dry matter than other forage varieties in Australia.

Propagation: By seed; seeds prolifically. Soak the seed 24 hours and plant about 2 cm deep; transplanting in 3 months. Direct seeding also possible. Seed stores well over long periods if kept dry and insect free.

Uses: A truly multipurpose plant having a large number of uses - fodder, fuelwood, wood, soil conservation and improvement, reforestation, interplanting (hedgerow) with agricultural crops, green leaf manure.

Limitations: It can become a weed; foliage contains mimosine that is toxic to ruminants if consumed in excessive quantities.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

MELIA AZEDARACH

Synonym:

Family: Meliaceae

Trade/Local name: China berry, pride-of-India, pride-of-China, Persian-lilac.

Distribution: Native of Southern Asia, it is now widespread from Iran and India to China from low altitudes to 2000 m in the Himalayas.

Ecology: Tropical to warm temperate. Drought-hardy species grow with 600-1000 m annual precipitation. Best growth on well-drained deep sands but found on a wide range of soils. Young plants frost tender, older plants tolerate temperatures down to -8°C.

Description: Small to medium-sized deciduous tree becoming 6-15 m tall and 30-60 cm in trunk diameter, with crowded abruptly spreading branches forming hemispherical or flattened crown.

Propagation: Easily propagated through seed, cuttings, stump sprouts and root suckers.

Uses: Used as fuelwood, for furniture, tool handles, plywood, toys, cabinet making and turnery articles. The wood is however, very susceptible to termite attack. Some species have insecticidal properties (leaves/dried fruits protect stored clothing from insects). Various plant parts have medicinal value. Oil suitable for illumination has been extracted experimentally from the berries. The bony centres of seeds are extracted and used for beads.

Limitations: Berries toxic to animals; have killed pigs but cattle and birds reportedly eat the fruits.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

MORINGA OLEIFERA Lam.

Synonym: *M. pterygosperma* Gaertu.

Family: Moringaceae

Local/Trade name: Horse raddish tree, drumstick tree

Distribution: Native to the Indian peninsula; also grows on the East African coast.

Ecology: Grows well in low altitudes of less than 600 m with annual rainfall between 700 mm and 1200 mm and high temperatures (18-35°C).

Description: Small tree with light canopy and weak branches; flowers white but irregular; fruits long (about 1 m) with 3-angled seeds.

Propagation: By seeds.

Uses: Tender fruits used as a vegetable; sometimes leaves used as a spinach. Can be planted as a good live fence.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PARKINSONIA ACULEATA L.

Family: Leguminosae (Caesalpinioideae)

Trade/Local names: Jerusalem thorn, horse bean tree, sessaban (Arabic)

Distribution: Native to American tropics extending from Southeast USA to Argentina. Now naturalized in India, Israel, Jamaica, East and Southern Africa.

Ecology: This drought tolerant plant grows in areas with 300-1000 mm annual rainfall and up to 9 months dry season, usually at altitudes less than 1400 m. It can withstand high temperatures and light frosts; is salt tolerant but does not withstand waterlogging. Occurs in poor, gravelly or sandy soils and in desert grasslands.

Description: A small, fast-growing, often crooked tree, growing to 10 m tall, with a green trunk up to 40 cm in diameter; has thorny drooping branches; tiny leaflets are borne on long, flat leaves that look like blades of grass. Numerous bright yellow flowers occur in loose racemes. Tree regrows quickly after pruning.

Propagation: Seed; seeds are produced prolifically; soaking the seeds for 3-4 days in water or scarifying and then soaking for a day produces quick germination. Ready to transplant in 6-10 weeks.

Seeds store well in cool, dry, closed containers.

Uses: The wood that is hard, heavy and brittle makes good firewood and charcoal. Used on dry sandy sites for soil stabilization and erosion control. Pods and leaves are used as fodder in cut and carry system. A good ornamental live fence.

Limitations: Can become a weed; seedlings are susceptible to termite attack.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS ALBA Griseb.

Synonyms: -

Family: *Leguminosae (Mimosoideae)*

Trade/Local name: Algarrobo blanco, ibopé or ibope-pará, tacu.

Distribution: Arid zones of northern Argentina, Paraguay and Bolivia.

Ecology: It grows in areas with an average winter temperature of 15°C; not forst hardy, prolonged high temperatures are required to initiate and sustain flowering, nectar secretion and pod production. The plant is native to the flatlands and low Sierras (upto 1000 m at 30°S latitude). It is very drought resistant growing in areas with 100-500 mm rainfall. Grows best on sand with a high clay content but tolerates some salt in the soil.

Description: A round-crowned tree, 5-15 m tall with a trunk upto 1 m diameter. Sapwood is yellow while the heartwood is dark brown. This is a thorny tree but thornless varieties are available. It can fix nitrogen like all *Prosopis* species.

Propagation: Seedlings or seed. The seeds are sown in the nursery and transplanted when 2-3 months old. The seeds have to be scarified.

Uses: Mainly as a firewood. However it is also used for fodder (pods contain about 25% glucose sugar and 10% protein) and as a food (fruit milled into a flour that is used in baking goods for human consumption). The tree is valuable as a windbreak and for roadside planting.

Limitation: All *Prosopis* species cross-pollinate. Research on clonal propagation is needed to obtain plantations with known properties.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS CHILENSIS (Mol.) Stuntz

Family: Leguminosae (Mimosoideae)

Trade/Local names: Algaroba, mesquite

Distribution: A native to the Pacific coast of Peru, central Chile and eastern Argentina, *P. chilensis* is naturalized in Hawaii and is common in thickets along the tropical coasts.

Ecology: A drought tolerant tree in arid and semi-arid zones with 200-400 mm (or higher) rainfall; can grow in a temperature range of 0° to $40^{o}C$. Usually found in less than 1500 m elevation, but also grows up to 2900 m in Peru. Adapted to light soils.

Description: Grows 8-15 m high; shallow spreading root system; branches freely; flowers are greenish yellow; has a slender seed pod.

Propagation: By seed; does best if grown in a nursery for 3 months prior to planting out. Nicking or soaking the seed coat produces rapid germination.

Seeds should be removed from the pods, a hard sticky process, and stored in a cool, dry container, free from insects.

Uses: A very useful fodder plant for hot dry zones; is probably nitrogen fixing; has proved suitable for planting in subdesert regions of Africa. The wood is hard, heavy and strong and is a good firewood.

Limitations: An aggressive plant that can become a weed in overstocked pastures with depleted grass cover.

PLANTS GROWN AT THE MACHAKOS FIELL STATION

ICRAF

PROSOPIS CINERARIA (L.) Druce

Synonym: *P. spicigera* L.

Family: Leguminosae (Mimosoideae)

Trade/Local names: Khejri (India), Jand (Pakistan); ghaf (Arabic)

Distribution: Occurs in the dry and arid regions of northwestern India and extends into Pakistan, Afghanistan, Iran and Arabia.

Ecology: An arid region plant that can withstand both slight frost (- 6°C)and high temperatures of up to 45°C . It is a low-altitude tree that grows on alluvial and coarse sandy, often alkaline soils. Tolerates high alkalinity (up to pH 9.8). Annual rainfall of 75-800 mm.

Description: A thorny tree that grows 5-9 high; has an open crown and deep tap root. It is leafless for a short period before flowering.

Propagation: Reproduces freely by root suckers and establishes well from seed. Seeds should be soaked in water for 24 hours before sowing. Seeds remain viable for long.

Uses: Excellent firewood (5000 k cal per kg heartwood); one of the best browseplant for livestock (in terms of availability, palatability and nutritive value); an important afforestation species for arid and semi-arid zones; timber is used for building poles etc.; combines very well with agricultural crops and is revered by farmers in dry parts of Indian subcontinent because of the increased soil fertility beneath its canopy.

Limitations: The tree is thorny; it can be a weed in sub-humid regions.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS JULIFLORA (Swartz) DC

Synonym: *Mimosa juliflora* Swartz

Related species: *P. algarrobilla; P. caldenia; P. tamarugo*

Family: Leguminosae (Mimosoideae)

Trade/Local name: Mesquite, algaroba

Distribution: Native to the American tropics, but is now planted in many arid zones of the world, especially in Africa and India.

Ecology: The tree thrives best in dry areas, where rainfall is often less than 150 mm per year. However, annual rainfall in its natural areas ranges from 150-750 mm. It grows up to 1500 m if the region is frost free. Grows on a variety of soils, but does well on sandy soils. It can grow even in rocky sites if the root growth is not impeded.

Description: A thorny deciduous, large-crowned, and deep-rooted bush or tree growing up to 10 m or more. Leaves are dark green; long fleshy pods are straw-coloured when ripe.

The tree has a very deep root system. Under high rainfall conditions, it can be an aggressive weed. It is said to have allelpathic effects on range species. The tree coppices well.

Propagation: Seeds germinate quickly if the hard seed coat is nicked. Sow the seed 1 cm deep, 2 per pot. Transplanting after 10-12 weeks. Natural propagation is usually through root suckers.

Seeds store well in a cool dry place.

Uses: An excellent fuelwood source; the wood is hard, heavy and burns slowly with high heat and little smoke; the wood is termed "wooden anthracite" because of its high heat value. The wood is very durable and is used for fence posts, construction, carpentry, etc. Pods are eaten by livestock and may also be ground for human consumption. Flowers are a valuable source of nectar of high quality honey.

Limitations: Potentially weedy especially in well-watered sites.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS PALLIDA (Humboldt et Bonpland) H.B.K.

Synonym: *P. limensis* Bentham

Family: Leguminosae (Mimosoideae)

Trade/Local name: Algarrobo, algaroba

Distribution: Native to drier parts of Peru, Colombia and Ecuador along the Pacific coast; naturalized in Hawaii and Puerto Rico and introduced into India and Australia.

Ecology: Best suited to dry areas like other *Prosopis* spp.; but is more frost sensitive than others; thrives well in low altitudes up to 300 m from sea level. The tree requires from 250 mm to 1250 mm rainfall per year. Not very specific to soil types.

Description: A tree or shrub of 8-20 m high, with a trunk of up to 60 cm diameter. Leaves are small, pallid greyish-green when dry; is usually spiny. Roots are shallow.

Propagation: From seed; the seeds should be inoculated with mesquite rhizobia when planted in new locations.

Uses: A valuable tree for forage - both leaves and pods are fed to cattle, donkeys and other livestock. Pods are sweeter than those of other *Prosopis* species. In the native habitat, the pods are made into a sweet syrup that is used to prepare various drinks. The wood is of high calorific value and is used largely as a charcoal. Also used for fence posts, agricultural implements, etc.

Limitations: Can become a weed forming thickets; because of shallow roots, wind storms easily blow many tree down.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS TAMARUGO F. Philippi

Synonym:

Family: *Leguminosae (Mimosoideae)*

Trade/Local name: Tamarugo

Distribution: Native to the Pampa del Tamarugal of the Atacama desert (northern Chile) where there are now stands covering about 25,000 ha (planted in 1965 after former natural stands were reduced to scattered woodlands due to over-exploitation for firewood.

Ecology: Tolerates wide temperature range (-12° to 36°C). Grows at altitudes of 1000-1500 m in its natural habitat but could grow at other altitudes. Thrives at very dry sites - it has the ability to absorb condensed atmospheric moisture through the leaves. The tree is found on salty-sandy or clay loam soils, sometimes with a 40 cm salt encrustation on the surface.

Description: A deciduous, open-crowned tree, reaching 8-15 m in height with a trunk upto 80 cm thick. The tree produces a dense mat of lateral roots and a quick-growing taproot that may be 6 m deep on a plant 15 m tall. The tree coppices easily and regenerates from seed.

Propagation: Seeds. The seeds germinate well after soaking in water for 48 hours. They can be scarified with sulfuric acid.

Uses: Firewood and charcoal. The wood is also used for furniture although it is difficult to work as it is very hard. Sheep and goats browse on the fallen leaves, pods and young shoots. Pods must be thoroughly leached before human consumption.

Limitations: Seedlings have to be well watered during the first years of establishment. In more equable climates, the plant could spread uncontrollaby and become a weed.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

PROSOPIS PALLIDA (Humboldt et Bonpland) H.B.K.

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Description: A deciduous, open-crowned tree, reaching 8-15 m in height with a trunk upto 90 cm thick. The tree produces a dense mat of lateral roots and a quick-growing taproot that may be 6 m deep on a plant 15 m tall. The tree coppices easily and regenerates from seed.

Propagation: Seeds. The seeds germinate well after soaking in water for 48 hours. They can be scarified with sulfuric acid.

Uses: Firewood and charcoal. The wood is also used for furniture although it is difficult to work as it is very hard. Sheep and goats browse on the fallen leaves, pods and young shoots. Pods must be thoroughly leached before human consumption.

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PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

SESBANIA GRANDIFLORA (L.) Pers.

Synonym: *Agati grandiflora* (L.) Desv

Family: Leguminosae (Papilionoideae)

Trade/Local name: Agati, katurai (Philippines) chogache, gallito (India)

Distribution: Native to India and Southeast Asia; widely distributed in the Caribbean, southern Mexico, and Central to South America.

Ecology: Grows up to 800 m above sea level in areas with annual rainfall of over 1000 mm and only a few months of dry season. Grown extensively in Asian rice paddies. Adaptable to a wide range of soils, even poor ones.

Description: A fast-growing small tree, growing up to 10 m tall, with a trunk diameter of about 30 cm. The bole is straight and cylindrical; wood white and soft; bark light grey, deeply furrowed. Leaves feathery, pods long (up to 60 cm). The tree has extraordinarily high nodulation and rapid growth rate.

Propagation: Propagates easily by cuttings or seedlings. It requires little maintenance and can readily be planted on a large scale by direct seeding, even by aerial sowing.

Uses: Truly multipurpose: produces firewood, forage, pulp and paper, food and green manure. Young leaves, tender pods and giant flowers are favourite Asian vegetables; cattle relish leaves and pods; foliage makes excellent green manure; excellent support (nurse) crop for betel and pepper vines; is used extensively as a pulp source; the bark, when cut, exudes a clear gum that has been used as a gum arabic substitute; very good for reclaiming degraded lands; combines well with crops; good as a windbreak.

Limitations: Very susceptible to nematode attack.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

SAMANEA SAMAN (Jacq.) Merrill.

Synonym: *Pithecelobium saman* (Jacq.) Benth.

Family: Leguminosae (Mimosoideae)

Trade/Local names: Raintree, saman, monkeypod.

Distribution: Indigenous to Venezuela and Trinidad; now widely planted in many tropical regions.

Ecology: Grows best in frost-free sub-humid climates at altitudes from sea level to 1500 m and in areas with 600 mm or more rainfall per year. It is drought resistant; can grow in poor soils and can withstand seasonal water-logging.

Description: A fast-growing tree with a huge umbrella-shaped canopy of feathery leaves. Carefully tended specimens often reach 18 cm in diameter in 5 years. Pods have edible pulp that is sugary and sweet.

Propagation: Can be direct seeded or propagated from seed in a nursery. The seed coat is very hard. Sow about 3 cm deep; seedlings are sensitive to too much or too little watering. Ready for transplanting in 3 months. Seeds have a long viability if kept dry and cool, free from beetles.

Uses: The pods are edible; its pulp is relished by children. The pods are a favourite food of cattle and goats after falling. The pods can also be dried and ground as an animal feed. The wood is highly prized for its work-ability and beauty. Farmers value the tree in their pastures - grass grows well under the tree.

Limitation: The tree, because of its large crown, is not good for crop lands.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

SESBANIA SESBAN (L.) Merr.

Synonym: *Sesbania aegyptiaca* Pers.

Family: *Leguminosae (Papilionaceae)*

Trade/Local name: Frother

Distribution: South and South West Africa; widely spread over Africa and Asia.

Ecology: The tree grows along rivers in East, Central and Southern Africa. Tolerates waterlogging and is hence good for clayey soils.

Description: The tree is small reaching a height of 8 m particularly along streams. It has a somewhat sparse form with thin branches, blue-green compound leaves made up of numerous narrow, oblong leaflets under 2.5 cm long, which close up in the evening. It is short-lived (10-15 years).

Propagation: By seed.

Uses: In areas where fuel is scarce the tree is sometimes planted to provide firewood. It is also used as coffee shade and the stem yields a useful fibre. It has also some medicinal value. Young leaves cooked as a vegetable.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

SIMMONDSIA CHINENSIS (Link) Schneider

Family: Buxaceae

Trade/Local names: Jojoba (pronounced ho-ho-ba) and several other names.

Distribution: Arid regions of northern Mexico and southwestern USA.

Ecology: A true drought resistant desert plant that can tolerate extreme desert temperatures of - 8°C to 45°C (or even higher); however seedlings are sensitive to light frosts of 3-4° below freezing. Thrives under soil moisture conditions that are unsuitable for most agricultural crops. Annual rainfall of 200 mm; best growth with over 300 mm. Can tolerate soil salinity of up to 7000 mg/l of sodium chloride.

Description: An evergreen, dioecious shrub growing up to 3 m high, bust usually only 60-90 cm tall; deep tap root and profusely branching root system; thick, leathery, bluish-green leaves and brown nut-like fruit. Natural lifespan appears to be over 100 years.

Propagation: By seeds. Also possible to propagate vegetatively (apical soft wood); hardwood cuttings are unsuitable for propagation.

Uses: The seeds produce a liquid wax similar to sperm whale oil. It withstands repeated heating at high temperatures and therefore has several industrial applications. The seeds contain about 50% liquid wax; after the wax has been extracted, the residual seed meal contains up to 35% protein which can be used as a feed for livestock.

Limitations: Lack of seeds of uniform quality; cuttings are difficult to root.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

TAMARINDUS INDICA L.

Family: Leguminosae (Caesalpinioideae)

Trade/Local name: Tamarind

Distribution: Native to the dry savannas of tropical Africa; was introduced to Asia by Arab traders in the early times; today the plant's botanic and common names both point up its association with India. Also introduced to the Caribbean and Latin American countries.

Ecology: The tree is well adapted to both dry savanna regions and monsoon areas with well-drained soils at altitudes up to 1500 m above sea level.

Description: A handsome, long-lived, short-trunked tree with a spreading frame of branches that may reach 25 m in height; has a dome-shaped crown of graceful, airy leaves. Is drought resistant and hurricane-resistant. Showy clusters of pale-yellow, pink-veined blossoms turn into long, flat, rust-coloured, slightly curved pods. Pods contain dark-brown, pasty pulp that encloses hard, shiny, brown layer seeds.

Propagation: The seed germinates quickly when the hard seed coat is nicked; ready for transplanting in about 12 weeks; direct seeding also possible. The seed stores well if kept cool and dry.

Uses: The pulp is often eaten fresh, but is pressed into flavoursome loaves and marketed; used for seasoning many foods. Young leaves, flowers and immature pods are edible, and are used for seasoning foods.

The wood is hard and termite-proof; works well and takes a fine finish. Wood is also valued as a fuel and for charcoal making.

Flowers are a good source of honey. The seeds are ground and used as a cattle feed. Powdered seed is a good adhensive.

The tree is also planted in strips among forest plantations as a firebreak; also used for beautification.

Limitations: Slow early growth; grows well only in areas with extended dry spells.

PLANTS GROWN AT THE MACHAKOS FIELD STATION

ICRAF

ZIZYPHUS MAURITIANA Lam.

Synonym: Z. (also spelled *Ziziphus*) *jujuba* (L.) Lam., non Mill.

Related species: Z. *nummularia* DC

Family: Rhamnaceae

Trade/Local names: Indian (Chinese) jujube, Indian cherry, ber, and many others.

Distribution: Native to South Asia and grows wild, particularly in sub-Himalayan hill country. Now found in the dry regions in many parts of Asia, Australia, tropical America and Africa.

Ecology: An extremely robust plant that can withstand severe heat as well as frost or drought or waterlogging; is a low-altitude species for cultivation about 600 m in elevation; is widespread in areas with annual rainfall of 300-500 mm, but also grows in areas with 2500 mm.

The species has no particular soil preference.

Description: Normally spiny; grows to about 12 m or more in height; spreading crown; appears as a shrub of 3-4 m height in very adverse conditions. The fruit looks like glossy crabapples, light reddish-brown in colour. The tree coppices well and grows vigorously from stumps and root-suckers.

Propagation: Crack open the hard outer shell using light taps with a hammer; carefully remove the one or two seeds inside; plant 1½ cm deep, 2-3 seeds per pot; germination in 2-3 weeks; transplanting in 4-6 weeks.

Seeds store well in cool dry places.

Uses: Primarily a fruit tree; the fruit is rich in vitamins; normally eaten fresh or semi-dried.

Most *Zizyphus* species are thorny and make good hedgerows and living fences.

The wood is hard and heavy and is a good firewood. The leaves can be used to feed Tasar silkworms and as a host for lac insects. The foliage and fruits are relished by livestock.

Limitations: The plant disseminated by birds and animals feeding on the fruits can lead to a profusion of dense prickly clumps.