African Acacias

Genetic Evaluation
Phase II

R.D. Barnes, C.T. Marunda, D. Maruzane and M. Zirobwa
DFID Forestry Research Scheme R.6550

Final Report

Oxford Forestry Institute and Zimbabwe Forestry Commission

1999

DFID Research Scheme R.6550

African *Acacias*

GENETIC EVALUATION

Phase II

1 April 1996 to 31 March 1999

FINAL REPORT

R. D. Barnes[1], C. T. Marunda[2], D. Maruzane[2], and M. Zirobwa[2]

[1]Oxford Forestry Institute
Department of Plant Sciences
University of Oxford
Oxford
United Kingdom

and

[2]Forest Research Centre
Zimbabwe Forestry Commission
Harare
Zimbabwe

1999

Cover photograph. The Gungunyana (Zimbabwe) provenance of *Acacia karroo* in trial EV172A on Chesa Forest Research Station 20 months after planting. At Gungunyana this species grows on the forest edge in a high rainfall area. At Chesa FRS, in a much drier climate, it out-performs most of the other 22 range-wide provenances including the local population.

EXECUTIVE SUMMARY

There is an urgent need for trees in agricultural systems in the semi-arid parts of Africa to provide fuelwood, fodder and shelter, to maintain soil fertility, to rehabilitate degraded land and particularly to increase the productivity of non-arable land. In the early 1980s it was recognized that suitable species were most likely to be found among the natural pioneer species, particularly the acacias, the natural invaders of degraded land and, at the same time, providers of life-supporting products and services.

Six species of *Acacia* have been recognized as being likely to have greatest potential for improvement through selection and better management. These are *Faidherbia (Acacia) albida, Acacia nilotica, A. tortilis* and *A. senegal,* all with Africa-wide distribution, and *A. erioloba* and *A. karroo,* both widespread in southern Africa. Although there is some overlap between them, these acacias could be used to increase productivity in agricultural systems in a large array of environments.

To realize the full benefits of the acacias, knowledge is required most urgently on their current and potential socio-economic value in the farming systems, how to manage the natural stands for maximum production, their genetic variation, matching species and provenances to site, how to integrate new material into agricultural systems and how to control their invasive propensities.

Research on the African acacias started at the Oxford Forestry Institute (OFI) in 1987 when the first of four research schemes on the study and assembly of the genetic resources was funded by the Forest Research Programme (FRP) of the Overseas Development Administration of the United Kingdom Government (ODA), now the Department for International Development (DFID). By 1993 the objectives of these three projects had been achieved and they were followed by the first evaluation project in which screening trials were established across a wide range of sites in Zimbabwe to provide the information required for deciding on the location, composition and design of the main trials. The project that is the subject of this report, R6550, has sought to:- complete the establishment of the main trials in Zimbabwe; make early assessments of genetic variation; gain some information on the productivity in natural stands of the species near the trial sites; evaluate the current and potential uses of acacias in small-holder agricultural systems in the region of the trials; devise methods of integrating new genetic material into those systems; promote the establishment of four more trial centres in Africa; and to produce a field guide to the acacias of the country. The activities on and the achievements of each of these objectives are summarized in this report. The reader is referred to the relevant publications, internal reports and other outputs from this project for full accounts.

The results of the screening trials were used to decide on the location, composition and design most suitable for the main trials of each species; these had been established for all six species by the end of the project period by which time 52 trials had been established over 18 diverse sites. Soil type and frost were among the main determinants of trial location. There were early indications in the screening trials of large differences in growth rate between provenances of most species and those that were obviously poor performers under some, or all, conditions were left out of the main trials on the appropriate sites. Wide spacings and single tree plots were used as the best compromise to avoid early competition and, at the

same time, encompass enough replications to be able to impose selection and management studies on the experiments in the future. It is considered that this objective to establish the trials was achieved in full although the Zimbabwe Forestry Commission is still to publish the trials manual which is in draft form.

Assessments were carried out in all the screening trials and in the main trials of *Acacia karroo, A. senegal* and *Faidherbia albida*. The main trials of *A. tortilis, A. erioloba* and *A. nilotica* had not reached their first measurement age before the end of the project. The data have been analyzed and papers are being prepared for submission to appropriate journals. In this report, a brief summary of the main findings is given for each species. The southern African provenances of *F. albida* grew faster than those from North and West Africa with the exception of those from higher altitudes in Ethiopia which did better than all other provenances on the heavier soils and the frostier sites. The West African provenances were the poorest performers of all although by the fourth year there was some indication that they might be coming into their own on the frost-free wind-blown Kalahari sands site. The performance of the *A. erioloba* provenances was almost perfectly and negatively correlated with latitude of origin with the northern-most Makatoolo population from Zambia growing faster almost everywhere. *A. erioloba* was the most frost-tolerant of all species tested. *A. karroo* was the next most frost resistant species although there was considerable variation between provenances in this trait as there was in growth rate. The fastest-growing provenances were not necessarily the least frost-tolerant and the Jedibe Island population in the Okavango Delta in Botswana out-performed the local provenance in the trials suggesting that there are prospects for increasing the wood productivity of this species very considerably by introducing exotic provenances, even where the species is indigenous. Of the eight sub-species of *A. nilotica* under test, *kraussiana*, the southern African taxon, has been most successful in the trials and there has been considerable variation within it. The superior growth rate may have been partly due to its better frost-tolerance as there are some indications of it being out-performed by single trees of the more northerly subspecies *tomentosa* on the frost-free sites. Of the three varieties of *A. senegal*, only *senegal* is of interest in these trials because of its potential to produce high quality gum arabic. The growth rate has been excellent for most provenances on the frost-free sites but only the northern provenances have produced gum. Frost-tolerance has also been an important factor in *A. tortilis* and it is apparent that there is potential to use this valuable species more widely for pod production in Zimbabwe with the introduction of the more frost-tolerant provenances from further south in Botswana and South Africa. Some of the northern provenances are doing well on frost-free sites. Overall, this objective was fully achieved in that all assessments, measurements and laboratory analyses planned were completed, statistical analyses performed and results interpreted. The journal papers are in draft form.

The natural stand studies were confined to *Acacia erioloba, A. tortilis* and *A. nilotica*. An intensive study of *A. erioloba* showed that a parkland of 15 trees per hectare could produce twice as much crude protein and nearly as much metabolizable energy as the average small-holder grain crop in the area. Crude protein percent in the pods and seeds of *A. erioloba* and *A. tortilis* were slightly higher than in those of *A. nilotica*; assessment of the differences in availability of that protein will be made in a feeding trial project now being funded under DFID=s LPP programme. The planned studies in the natural stands were accomplished as far as was possible in the short time span of the project. The phenological studies of flowering and fruiting time proved to be too difficult toaccomplish given the remoteness of the study sites from the research station; and reliable estimates of pod production in the stands will only be available after several more years of counts because of the large annual fluctuations in pod production.

There were three phases to the socio-economic team=s study of the current and potential uses of acacias in small-holder agricultural systems. These were:- a literature review of the linkages between acacias and livestock systems; community studies of the role of acacias in agro-pastoral systems; and market studies of important acacia products. Although the literature review did suggest that acacia pods were valuable livestock feed, quantitative data on how the pods translate into weight gains and milk production are not yet available. The review also highlighted the complexity of the effects of acacias on grass in the range and showed that most research had been done on commercial farms rather than in communal areas. The conclusion of the community studies was that research should focus on exploring the markets for locally produced gum arabic and pods and stimulating the demand for these products to provide the incentive for enhanced management and planting. Although the work on this objective did not come up with all the answers required, it made it possible for the team to identify the areas where information was most urgently needed and the type of research that should be conducted to fill the gaps which they have described in a series of four draft concept notes for projects.

The socio-economic team=s conclusion in regard to developing methodologies for introducing new genetic material into small-holder agricultural systems was that it was premature to promote the wide-scale planting of introduced acacias at this stage in the communal lands, firstly, because the genetic evaluation studies have not yet delivered conclusive results on the traits that are of most relevance to farmers and, secondly, efforts to promote planting may encounter resistance from farmers unless long term environmental or indirect benefits can be translated into more direct and immediate benefits. This objective, although not achieved, was researched in principle by the team who have given recommendations as to how to proceed.

The establishment of four more acacia network trials centres in Africa has now passed out of the hands of the project and the OFI and rests with the national and regional institutions to which the seed has been sent. All have received comprehensive sets of provenances of all six species and some trials have already been planted. There may be some delay in establishing some of these trials due to funding problems but the project=s immediate objective has been achieved.

The Field Guide to the Acacias of Zimbabwe was published by the end of the project. Although a commercial publisher has been used to produce the book, arrangements were made for about 750 free copies to be distributed to collaborators, appropriate institutions and libraries and to forestry and agricultural extension workers in Zimbabwe. This objective has been entirely accomplished and there has been good feedback on the product.

An all-encompassing and important general objective of this project and its predecessor has been to create a resource of information on and materials of the African acacias that can be used for future research into the genus. The hope has been that this resource would attract funding from international agencies for projects from a wide variety of disciplines. This had started to happen before the end of the project period and substantial funds are now assured for using acacias to restore fertility to degraded land, on-farm evaluation of *Acacia* species and livestock feeding trials with acacia pods. The Acacia Trials Manual describes the material resource created by the OFI/FRP acacia projects in great detail and it will be available to both national and international scientists who wish to use the resource in which to conduct their research.

ACKNOWLEDGEMENTS

Many people have had an input to this project. They are too numerous to mention individually but the authors would like to acknowledge and express their thanks for the cooperation and hard work that was willingly given by many of their colleagues in the Research and Development Division of the Zimbabwe Forestry Commission, the Oxford Forestry Institute, the Matopos Research Station and small-farmer communities in the communal lands, commercial farmers and various societies and NGOs in Zimbabwe. Without this, the project could not have succeeded . The authors also acknowledge the valuable input of the project consultants.

The project was funded by the Forest Research Programme of the United Kingdom Department for International Development. The support of the Programme Manager and his staff during the conduct of the project was much appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND BACKGROUND TO THE PROJECT

Human population pressure is bringing about deforestation and severe land degradation over extensive areas in Africa. In many parts, the most useful tree species from the climax plant communities have been removed and have no prospect of re-establishment. Trees are needed to in agricultural systems to provide fuelwood, fodder and shelter, to maintain soil fertility, to rehabilitate degraded land and particularly to increase the productivity of non-arable land (FAO, 1980). Exotic species have rarely proved to be successful in this situation and it is becoming increasingly clear that the solution is most likely to lie among the natural pioneer species, particularly the acacias whose potential to resolve these issues was recognized in the early 1980s (FAO, 1980; Palmberg, 1981). The acacias are in fact the natural rehabilitators of degraded land in Africa. Being indigenous, they do not pose a threat of invasion other than in a pioneering capacity. On the other hand, their valuable contribution to agriculture can be sustained through management to make them effectively climax species in the agricultural system (Barnes *et al.*, 1996).

Six species of acacia have been recognized as being both widespread in Africa and as having the capacity to fulfil various combinations of roles in different environments in which there is a critical demand for their ameliorating qualities (Barnes and Fagg, 1995). The species are *Faidherbia (Acacia) albida, Acacia nilotica, A. tortilis* and *A. senegal*, all with Africa-wide distribution, and *A. erioloba* and *A. karroo*, both widespread in southern Africa. Each of these species has a distinct ecology and suite of uses. *Faidherbia albida*, *Acacia erioloba*, *A. nilotica* and *A. tortilis* all produce large crops of nutritious pods but at different times of the year covering, between them, the entire six-month dry season. Although there is some overlap, each species is particularly well adapted to certain conditions where the others will not thrive, for example, *F. albida* on river sands, *A. erioloba* in true desert dune conditions, *A. nilotica*, depending on the sub-species, on both harsh, heavy, dry soils and under flooded conditions and *A. tortilis* on alkaline soils. *A. karroo* and *A. senegal* are known for their ability to improve soil fertility and to produce high quality fuelwood and gum arabic. Depending on provenance, *A. karroo* can thrive over extraordinary extremes of climate and soil type, including high concentrations of salts of sodium and calcium, from summer to winter rainfall and from heavy clays to sand dunes. Between them, these acacias can be used to increase productivity in agricultural systems in a large array of environments.

To realize the full benefits of the acacias, knowledge is required most urgently on:-

- their current and potential socio-economic value in the farming systems
- how to manage the natural stands for maximum production
- their genetic variation
- matching species and provenances to site
- how to integrate new material into agricultural systems
- how to control their invasive propensities

Lack of knowledge in these areas constitutes constraints on their use that have been recognized not only by scientists in national agricultural research institutes and international agencies, but by the farmers themselves. For example, in a recent survey in the Mutambara Communal Area in Zimbabwe, it was shown in a wild food and tree-based resource valuation exercise that *Acacia* species alone showed an increase in productivity over time while only a few other products even remained stable (Campbell *et al*., 1994). Tangible recognition of the value of acacias in agricultural systems is now being demonstrated by communal farmers themselves in parts of Zimbabwe and they are starting to make requests for research and materials (Clarke, 1994). The Oxford Forestry Institute has conducted research aimed at resolving the first five of these constraints over the past 12 years. The sixth constraint requires extensive research to establish the specific set of environmental conditions that must prevail for cohort establishment for each of the invasive species and what management practices to use to direct development of the cohort into a useful stand.

Research on the African acacias started at the OFI in 1987 when the first of four research schemes, R4348 (African acacias: study and acquisition of the genetic resources) was funded by the Forest Research Programme (FRP) of the Overseas Development Administration of the United Kingdom Government (ODA). This project was followed by three more:- R.4526: *(Acacia karroo*: evaluation and acquisition of genetic resources); R4583 (African acacias: study and assembly of genetic resources); and R5655 (African acacias: study and assembly of genetic resources (extension)). All four of these projects were concerned with the study of the resource and the collection and assembly of seed for comprehensive genetic evaluation of six of the most important *Acacia* species, *viz*., *Acacia erioloba, A. karroo, A. nilotica, A. senegal, A. tortilis* and *Faidherbia* (previously *Acacia*) *albida*. Their distributions have been comprehensively sampled to cover their genetic variation as indicated by geography, climate, soils, ecology, phenotype and molecular genotype. This work has been done in consultation, cooperation and collaboration with international agencies (*e.g.* CIRAD-Forêt, DFSC, FAO, ICRAF) and national research institutes throughout Africa, many of whom have also supplied seed for the unique assembled resource of 141 provenances of the six species that is now available for evaluation.

The next project, R.5653 (Genetic evaluation of African *Acacia* species: phase 1), had as its principal objective the establishment of field trials, with the seed that had been assembled in the previous four, at a first trial centre near Bulawayo in Zimbabwe. Screening trials were established across a wide range of sites and provided the information required for selecting the sites for, and setting the designs of the main trials for each species.

The project that is the subject of this report, R6550 (Genetic evaluation of African *Acacia* species: phase II) succeeded R5653 from 1 April, 1996, has sought to complete the establishment of the main trials in Zimbabwe, make early assessments of genetic variation and promote the establishment of four more trial centres in Africa. It also had a socio-economic objective to assess the current and potential value of the acacias in small farmer systems in Zimbabwe and to produce a field guide to the acacias of the country.

OBJECTIVES OF THE PROJECT

The objectives of the project were, for *Acacia erioloba, A. karroo, A. nilotica, A. senegal, A. tortilis* and *Faidherbia albida*, to:-

- create a resource of trials in which the full genetic variation of each species is reflected on sites that represent the environmental conditions in which they are likely to make most impact on enhancing agricultural production in Matabeleland, Zimbabwe; these trials are intended to constitute a structured framework in which there is good control of the genetic and environmental variation for short and long term basic and applied research into management to make full use of the potential of these *Acacia* species over the full life cycle of the trees;

- determine early performance of the provenances of each species on each site in regard to survival, drought tolerance, frost resistance, growth rate and browse quality; explain and measure genetic variation to provide a sound basis for the estimation of potential benefits from selection and breeding and matching species to site;

- determine growth rate, pod production and phenological variation in a natural population of each species growing in the vicinity of the appropriate trial; provide advance quantitative data on growth, yield and quality for use in socio-economic studies;

- evaluate the current and potential use of the six *Acacia* species in small-holder agricultural systems in the semi-arid zones of Matabeleland, Zimbabwe.

- devise and test a methods of integrating the best genetic material into the agricultural systems of small-holder farms in the vicinity of each trial;

- establish up to three more main trial centres in Africa using the DFID material, designs and knowledge;

In January 1998, a seventh objective was added to the project:-

- publish a Field Guide to the Acacias of Zimbabwe

A summary of the work done on each of these seven objectives and the extent to which they were achieved is given in the seven main sections of the report below. A full account of the work for each section is given is one or more publication or internal report and is referred to under the heading “dissemination” in each section.

ESTABLISHMENT OF THE TRIALS

The objective was "*to create a resource of trials in which the full genetic variation of each species is reflected on sites that represent the environmental conditions in which they are likely to make most impact on enhancing agricultural production in Matabeleland, Zimbabwe; these trials are intended to constitute a structured framework in which there is good control of the genetic and environmental variation for short and long term basic and applied research into management to make full use of the potential of these Acacia species over the full life cycle of the trees*".

Trial location, site details, composition and design

Screening trials were established in Phase I (Project R5653: African Acacias: Genetic Evaluation: Phase I) of the two genetic evaluation projects of which this constitutes the second. Eight trials containing a spread of 70 provenances of the six species were established over a comprehensive range of sites in a randomized complete block design with 35 replications of single tree plots (analyzed as seven replications of 5-tree discontinuous plots) at one metre square spacing. The aim was to get information rapidly that could be used to aid in deciding on the location, constitution, and design of the main trials of each species. There were early indications of which species should be planted where, what the spacing in the trials should be and the value of the single-tree plot design. This information was used in designing the main trials of *Acacia karroo* that were planted during the Phase I project and in designing the main trials of *A. erioloba, A. nilotica, A. tortilis, A. senegal* and *Faidherbia albida* that have been planted in the Phase II project which is the subject of this report. One of the reasons for using the single-tree plot design for the main trials is that it allows for the maximum number of replications and the potential in the future to superimpose different management regimes or destructive sampling procedures in subsets of replicates without prejudicing the statistical validity of interpreting the later genetic information from the experiment.

Figure 1 on the next page shows the location of the trial sites superimposed on a mean annual rainfall map for Zimbabwe. Figures 2 and 3 are maps showing soils and natural farming areas of the western part of Zimbabwe where the trials are located. A description of all the trial sites and a complete list of trials, giving the constitution and design of each, are given in the following Tables 1 and 2.

The Acacia trials manual (Barnes, Marunda, Maruzane and Zirobwa, 199), being published by the Zimbabwe Forestry Commission in its *Zimbabwe Bulletin of Forestry Research* series, gives a detailed and complete description of each trial. This publication also gives details of all the seed available from the OFI, the distribution of seed to the main centres of the African Acacias Trials Network. Further, it includes the complete trial protocol developed in Zimbabwe:- from pre-germination of the seed, container preparation, sowing, nursery maintenance, labelling and measurement; through trial design, site preparation, planting, labelling and protection; to management, assessment and analysis. It is intended that this manual should be used not only for day to day management of the trials but also as a reference work for any agency that might wish to use the trials for projects designed to answer specific, and maybe as yet unformulated, questions through sampling or imposing different management regimes on the existing trials, and also as a guide for scientists establishing African *Acacia* trials elsewhere.

Table 1. Descriptions for African *Acacia* trial sites in Zimbabwe

Site Name and map ref. number	Latitude Longitude	Altitude (m)	Mean Annual Rainfall (mm)	Temperature Mean annual Hottest month Coldest month (°C)	Topo-graphy	Geological Formation	Soil Description
Chesa Forest (1)	20°04. 'S 28°16. 'E	1240	650	20.0 23.7 14.5	Flat	Deep windblown Kalahari sands	Regasols with <10%clay
Chesa FRS Blacks (2)	20°14.062'S 28°35.669'E	1372	650	18.1 20.9 12.4	Gentle N face slope	Meta-sediments	dark grey sandy clay vertisols pH 6.5
Chesa FRS Sands (3)	20°13.888'S 28°35.687'E	1372	650	18.1 20.9 12.4	Gentle S face slope	Meta-sediments with overlaid sand	Fine-grained sand
Chivi (4)	20°18'S 30°34'E	950	542	20.0 14.6 23.0		Granite	Granite sands
Cyrene Road (5)	20°23.664'S 28°27.357'E	1310	570	18.5 21.4 11.4	Flat	Granite	loamy sand overlying mottled illuviated clay
Grants Farm (6)	19°29'S 27°57'E	1090	609	20.5 14.6 24.4	Flat	Kalahari sands	Fine wind-blown ands
Guyu (7)	21°22.596'S 28°58.565'E	700	350	20.0 24.1 13.9	Flat	Granite (paragneiss)	Coarse sandy loam with gravel layer at 30cm
Guyu Irrigation (8)	21°22.596'S 28°58.565'E	700	350	20.0 24.1 13.9	Flat	Granite (paragneiss)	Coarse sandy loam with gravel layer at 30cm
Insuza (9)	19°12.355'S 27°49.666'E	950	625	21.1 14.3 25.5	Flat	Kalahari sands overlying basalt	Redeposited wind-blown snad
Lucydale (10)	20°24.601S 28°27.326E	1341	570	18.5 21.4 11.4	Gentle N face slope	Granite	Colluvial sandy loam pH 5.2
Mabutweni (11)	20°03'S 28°52'E	1300	644	18.4 12.8 22.0	Flat	Intrussive granite	Shallow granite sands
Madlulani (12)	19°58.405'S 28°13.652'E	1220	650	20.0 23.7 14.5	Flat	Windblown sand overlying sandstones	Re-deposited Kalahari sand pH 5.9
Mafanisa (13)	19°57'S 28°52'E	1350	644	18.4 12.8 22.0	Flat	Intrussive granite	Shallow granite sands
Mahiye (14)	20°18.288'S 28°32.001'E	1402	490	18.5 22.0 12.7	Flat	Meta-volcanics	Red-brown sandy clay pH 5.2
Mbembezi (15)	19°10'S 27°54'E	1050	625	21.1 14.3 25.5	Gentle E face slope	Kalahari sands overlying basalt	Redeposited wind-blown sand
Mbongolo (16)	19°56'S 28°10'E	1220	650	20.0 23.7 14.5	Gentle SE face slope	Kalahari sands	Fine wind-blown ands
Tonbridge (17)	20°17''S 28°.33'E	1375	490	18.5 22.0 12.7	Gentle SE face slope	Meta-volcanics	Red-brown sandy clay
Fort Tuli (18)	21°55.978'S 29°11.461'E	550	300	23.0 16.5 27.1	Flat	Basalt	Sandy-clay loam (pH 7.6) overlying fractured bedrock

Table 2. List of African *Acacia* provenance trials in Zimbabwe

Trial Number	Site No.	Species	Date planted	Number of entries			Trees per plot	Replic-ations	Spac-ing (m)	Area (ha)
				Sp	Prov	Fam				
EV149A	14	*Acacia* spp	25.11.94	6	70	0	1	35	1x1	0.25
EV149B	5	*Acacia* spp	25.11.94	6	70	0	1	35	1x1	0.25
EV149C	10	*Acacia* spp	02.12.94	6	70	0	1	35	1x1	0.25
EV149D	7	*Acacia* spp	20.01.95	6	70	0	1	35	1x1	0.25
EV149E	1	*Acacia* spp	20.01.95	6	70	0	1	35	1x1	0.25
EVA49F	12	*Acacia* spp	20.01.95	6	70	0	1	35	1x1	0.25
EV149G	2	*Acacia* spp	19.02.95	6	70	0	1	35	1x1	0.25
EV149H	18	*Acacia* spp	29.03.95	6	70	0	1	35	1x1	0.25
EV167A	3	*Faidherbia albida*	10.12.96	1	30	0	1	50	3x3	1.35
EV167B	10	*Faidherbia albida*	24.11.96	1	30	0	1	100	3x3	2.70
EV167Ci	15	*Faidherbia albida*	13.12.98	1	4	100	1	25	3x3	2.3
EV167Cii	15	*Faidherbia albida*	13.12.98	1	30	0	1	75	3x3	2.0
EV167Ciii	15	*Faidherbia albida*	13.12.98	1	5	0	1	50	3x3	0.3
EV167D	8	*Faidherbia albida*	29.01.97	1	30	0	1	50	3x3	1.4
EV172Ai	2	*Acacia karroo*	03.12.95	1	20	0	1	120	3x3	2.9
EV172Aii	2	*Acacia karroo*	03.12.95	1	20	0	9	10	1x1	
EV172Bi	10	*Acacia karroo*	05.12.95	1	20	0	1	120	3x3	2.9
EV172Bii	10	*Acacia karroo*	03.12.95	1	20	0	9	10	1x1	
EV172Ci	14	*Acacia karroo*	11.12.95	1	20	0	1	120	3x3	2.9
EV172Cii	14	*Acacia karroo*	11.12.95	1	20	0	9	10	1x1	
EV173A	3	*A. senegal* var. *senegal*	13.01.97	1	15	0	1	50	3x3	0.7
EV173B	14	*A. senegal* var. *senegal*	01.01.97	1	15	0	1	50	3x3	0.7
EV173C	15	*A. senegal* var. *senegal*	24.01.97	1	14	0	1	50	3x3	0.6
EV173D	7	*A. senegal* var. *senegal*	20.12.96	1	15	0	1	100	3x3	1.4
EV173E	11	*A. senegal* var. *senegal*	12.12.96	1	14	0	1	50	3x3	0.6
EV173F	13	*A. senegal* var. *senegal*	12.12.96	1	8	0	1	50	3x3	0.4
EV174A	11	*Acacia karroo*								
EV174B	13	*Acacia karroo*								
EV175A	3	*Acacia tortilis*	31.12.97	1	25	0	1	30	3x3	0.7

Trial Number	Site No.	Species	Date planted	Number of entries			Trees per plot	Replic-ations	Spac-ing (m)	Area (ha)
				Sp	Prov	Fam				
EV175B	14	*Acacia tortilis*	26.01.98	1	1	25	1	8	3x3	0.2
EV175C	17	*Acacia tortilis*	17.02.98	1	9?	110	1	20	3x3	2.0
EV175D	10	*Acacia tortilis*	02.02.98	1	5?	25	1	25	3x3	0.6
EV175E	13	*Acacia tortilis*	27.01.98	1	14?	25	1	20	3x3	0.5
EV175F	16	*Acacia tortilis*	02.01.98	1	16?	36	1	20	3x3	0.7
EV175G	6	*Acacia tortilis*	01.01.98	1	15?	36	1	20	3x3	0.7
EV175H	9	*Acacia tortilis*	03.01.98	1	36	0	1	20	3x3	0.7
EV175J	7	*Acacia tortilis*	28.01.96	1	36	0	1	36	3x3	1.2
EV175K	7	*Acacia tortilis*	27.01.98	1	6	36	1	25	3x3	0.8
EV176A	3	*Acacia erioloba*	31.12.97	1	6	66	1	5	3x3	1.7
EV176B	10	*Acacia erioloba*	02.01.98	1	6	0	1	30	3x3	0.2
EV176C	16	*Acacia erioloba*	03.01.98	1	6	70	1	21	3x3	1.3
EV176D	6	*Acacia erioloba*	31.12.97	1	6	36	1	25	3x3	0.8
EV176E	7	*Acacia erioloba*	27.01.98	1	6	0	1	30	3x3	0.2
EV177A	3	*Acacia nilotica*	01.01.99	1	18	0	1	50	3x3	0.8
EV177B	3	*Acacia nilotica*	01.01.99	1		80	1	10	3x3	0.7
EV177C	17	*Acacia nilotica*	14.12.98	1	18	0	5	5	3x3	0.4
EV177D	11	*Acacia nilotica*	04.12.98	1	13	0	5	5	3x3	0.3
EV177E	13	*Acacia nilotica*	11.12.98	1	18	0	1	50	3x3	0.8
EV177F	13	*Acacia nilotica*	06.12.98	1	4	80	1	20	3x3	1.4
EV177G	6	*Acacia nilotica*	10.12.98	1	14	0	5	5	3x3	0.3
EV177H	8	*Acacia nilotica*	08.12.98	1	16	0	5	5	3x3	0.4
EV177J	4	*Acacia nilotica*	22.12.98	1	13	0	5	5	3x3	0.3

The project objective of completing the establishment of main trials of all six *Acacia* species over an appropriate range of sites in Zimbabwe was achieved. A total of 52 trials was planted, 41 of them during Phase II, the project that is the subject of this report, over 18 different sites that were selected as being those where the services and products of African acacias were most likely to make a contribution to agricultural productivity in small farmer communities.

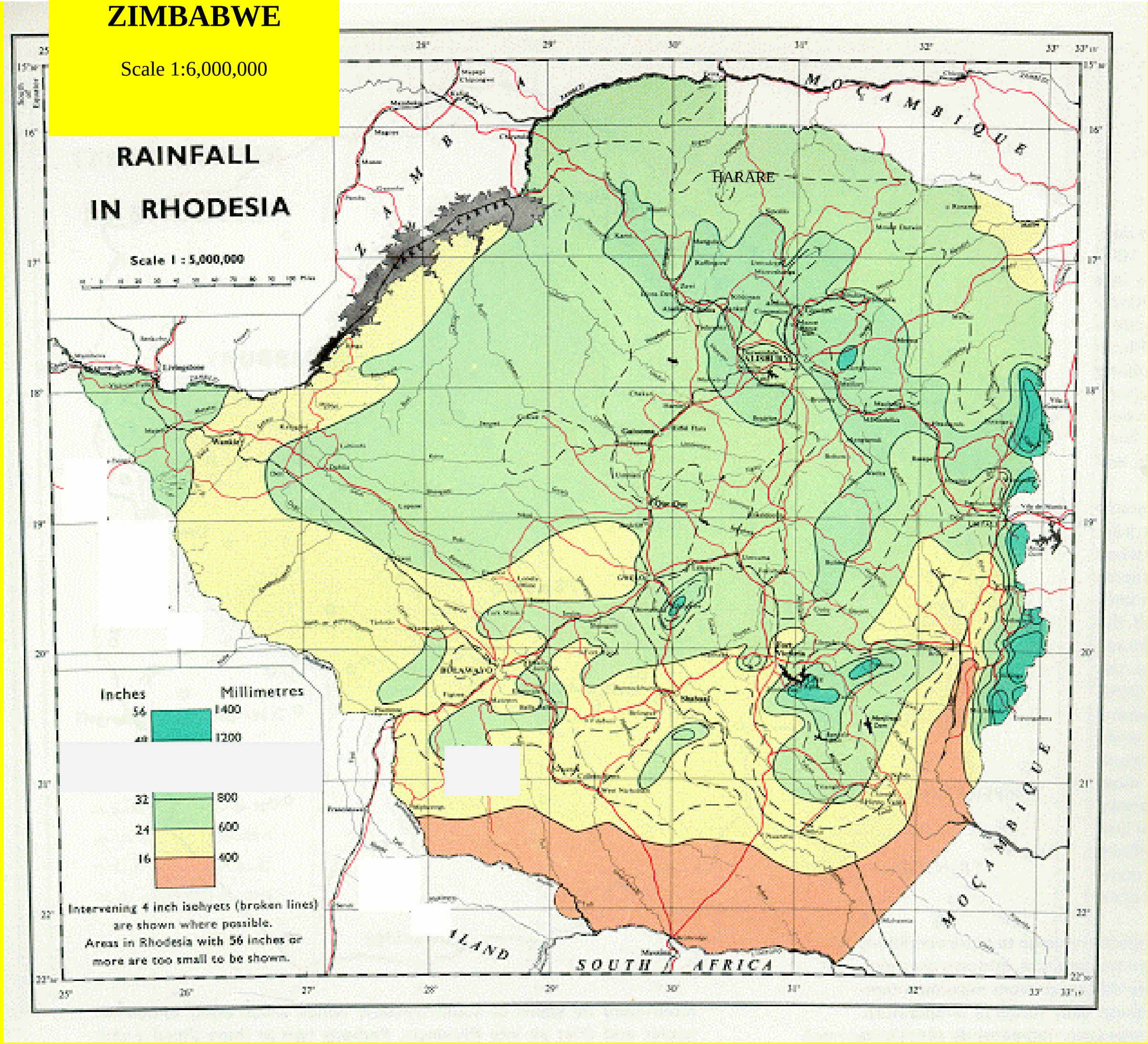
Dissemination

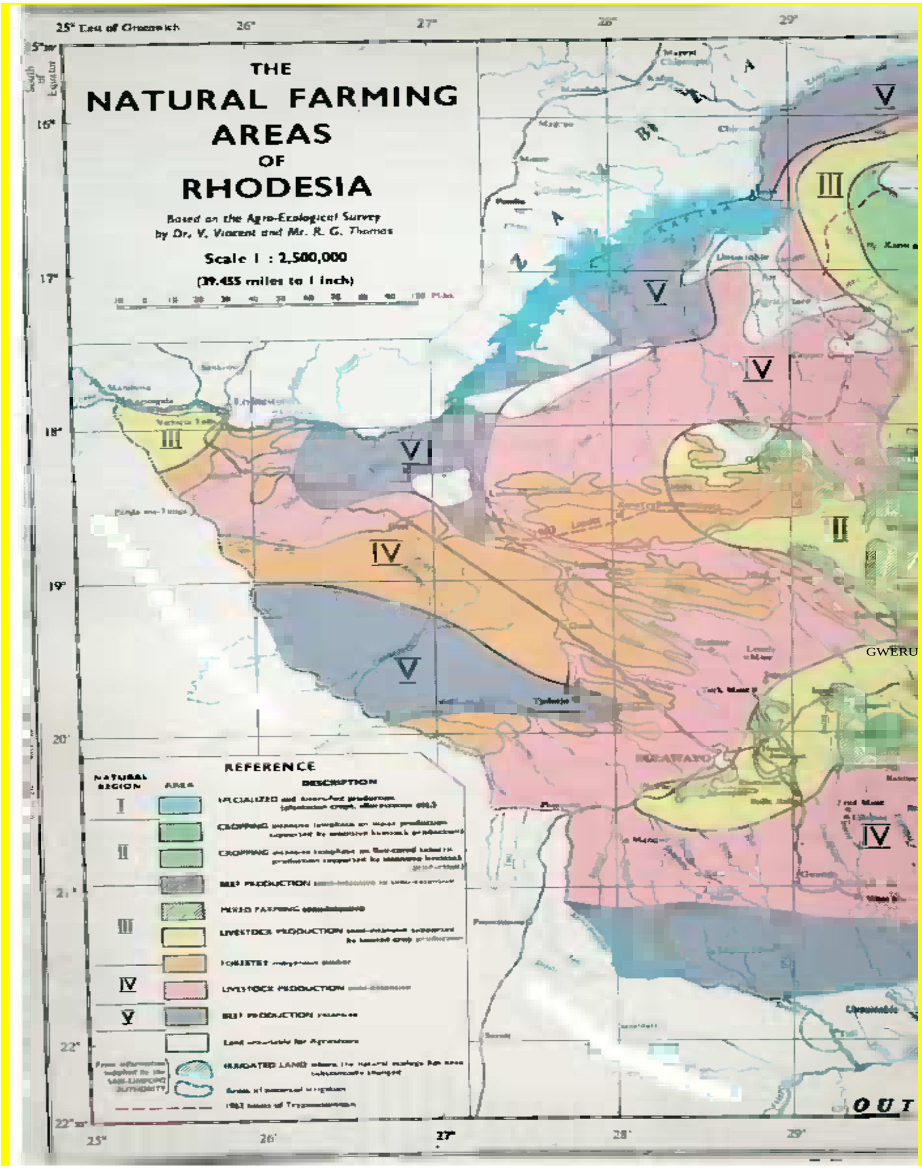
BARNES, R.D., MARUNDA, C.T., MARUZANE, D. and ZIROBWA, M (in prep.) African

Acacias Trial Manual - Zimbabwe. The Zimbabwe Bulletin of Forestry Research No. ?? Zimbabwe Forestry Commission, Harare, Zimbabwe. --- pp. (A)

MEAN ANNUAL RAINFALL IN ZIMBABWE

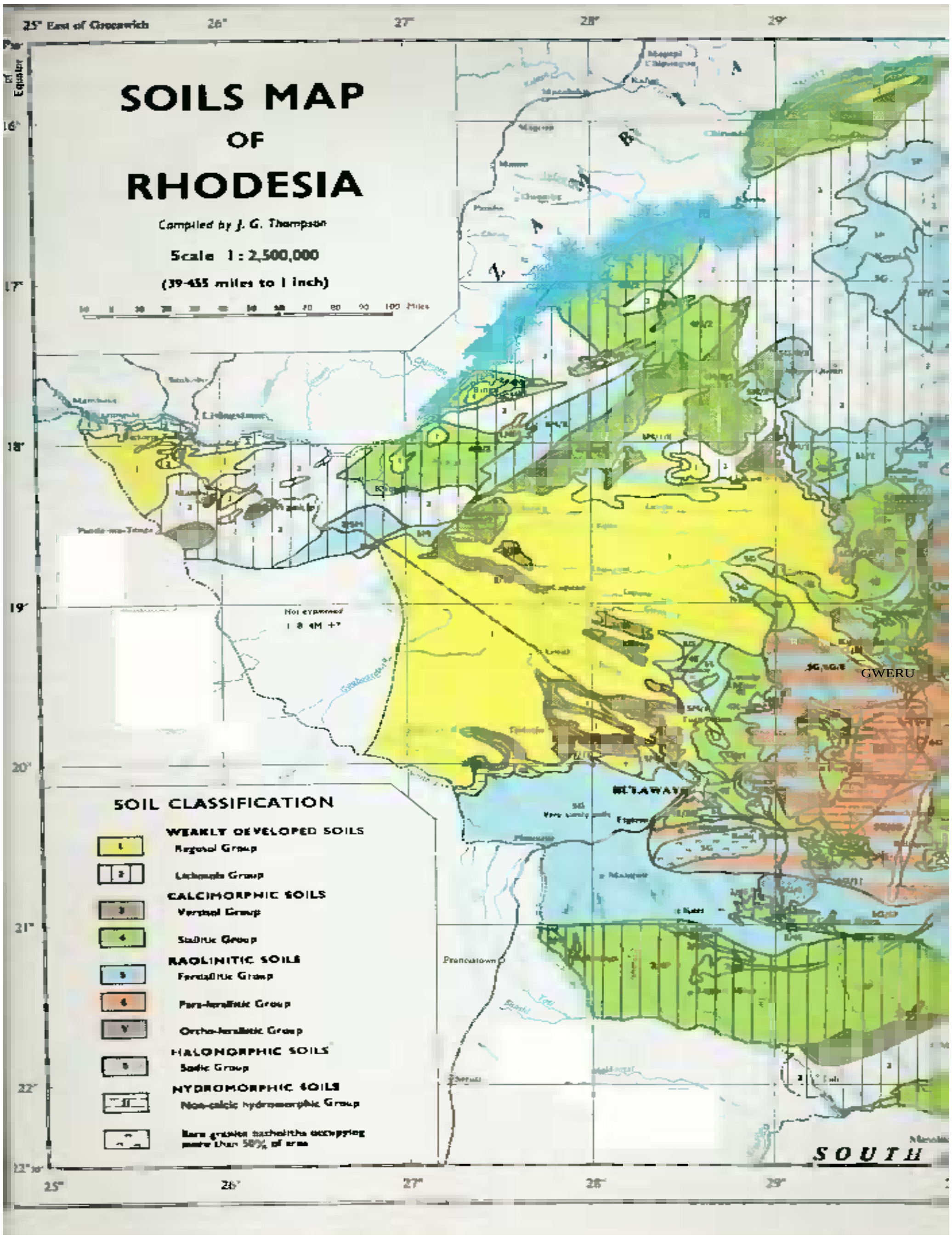
Scale 1:6,000,000





Παγε –6–

Hwange



Hwange

EVALUATION OF PERFORMANCE IN THE TRIALS

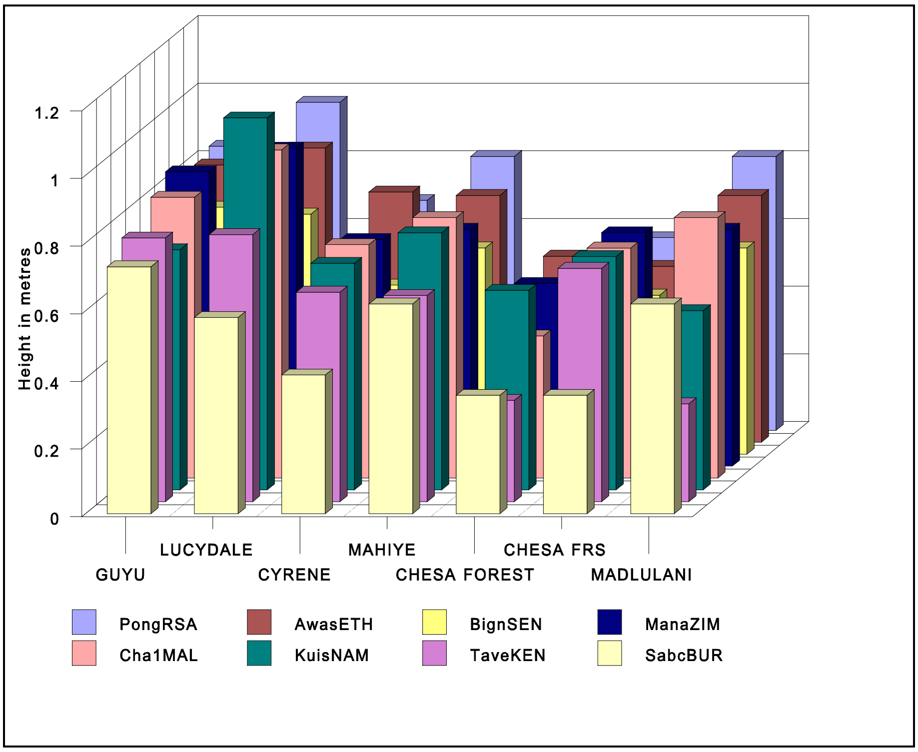
The objective was "*to determine early performance of the provenances of each species on each site in regard to survival, drought tolerance, frost resistance, growth rate and browse quality; explain and measure genetic variation to provide a sound basis for the estimation of potential benefits from selection and breeding and matching species to site*".

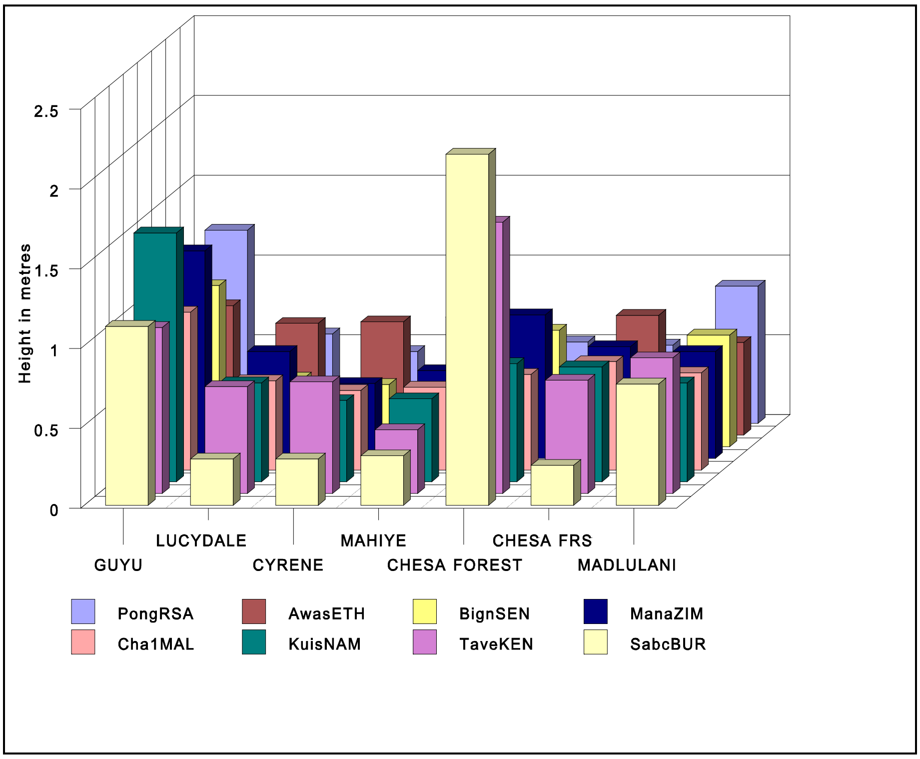
Faidherbia albida

A total of 21 provenances of *Faidherbia albida* was included in the screening trials which were planted across eight sites. After the first year, during which there were only light frosts, the species had done best on the granite-derived soil sites of Guyu and Lucydale and not so well on the heavier soils and the Kalahari sands (Figure 4). By the fourth year, however, heavy frosts had cut the species back on all sites except for Guyu and Chesa Forest (Figure 5). The species coppiced repeatedly even after being frosted to the ground and the coppicing shoots were very vigorous, especially in the first year after planting. Generally, the southern African provenances did best. The high altitude provenances from Ethiopia did better than all other provenances on the heavier soils and on the frostier sites. The West African savanna provenances were poorest at one year but by the fourth year there was some evidence that they might be taking the lead on the Kalahari sands at Chesa Forest although survival of these provenances was low at this site and the reversal of trend is based on very few trees.

The screening trials indicated that, for the main trials, frost-free sites should be sought on alluvial soils and sands. The main trials were therefore sited on a pocket of sand at high altitude relatively free from frost on the Chesa FRS and at lower altitude on an alluvial flat beside the Mbembezi River. A third main trial was sited on the young granite sands at Lucydale so that the effects of frost on a wider range of provenances and over a longer period of time could be studied. A satellite trial were planted on Kalahari sands at Chesa Forest to investigate further the indication of a late start in the West African provenances on that site. At one and a half years old, there were highly significant differences between provenances for height and diameter growth at all four sites. Once more the southern and east African provenances were out-performing those from the rest of Africa except for those from high altitude in Ethiopia. Certain southern Africa provenances were the best performers across sites, *viz.* Guija (on the Limpopo River near the coast of Mozambique), Sesame, Gwayi and Tambaharta (Zimbabwe) and Chawanje (Malawi)

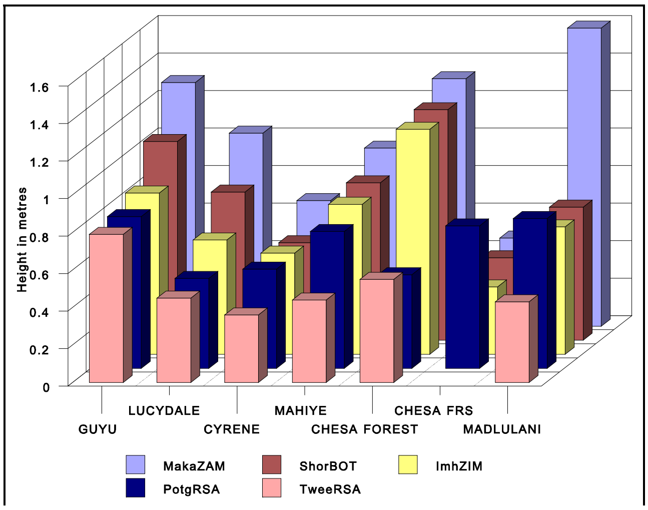
Faidherbia albida is exclusively a riverine species in east and southern Africa and regenerates only on newly-formed sand and silt banks after flooding along rivers where there is no frost, or at least where frost is periodically infrequent enough to allow the species an opportunity to put on sufficient height growth to get above the frost layer. However, the species can grow and perform extremely well away from the rivers in the right climate and on the right soils where man has removed the competition from grass and woody regrowth during the establishment phase. In Malawi, *F. albida* now grows in cultivated fields away from the rivers round the lake. Here, the artificial weed-free environment and the tree's usefulness to farmers has resulted in a symbiosis that has helped the species to extend out of its natural environment. Very large specimens of *F. albida* are also often seen in gardens and on farms in southern Africa where they have been planted and kept weed-free for a few years. It is possible, therefore, that the species could be used far more widely than it is if it is afforded just a little attention in the first few years. In the medium term, the trials that have been established should show whether this is practicable and, if so, which provenances should be used to achieve fastest growth and greatest pod production.


1.2
1
0.8
0.6
0.4
0.2
0
Height in metres
GUYU
LUCYDALE
CYRENE
MAHIYE
CHESA FOREST
CHESA FRS
MADLULANI
PongRSA
AwasETH
BignSEN
ManaZIM
Cha1MAL
KuisNAM
TaveKEN
SabcBUR


2.5
2
1.5
1
0.5
0
Height in metres
GUYU
LUCYDALE
CYRENE
MAHIYE
CHESA FOREST
CHESA FRS
MADLULANI
PongRSA
AwasETH
BignSEN
ManaZIM
Cha1MAL
KuisNAM
TaveKEN
SabcBUR

Acacia erioloba

Five provenances of *Acacia erioloba* were represented in the screening trials. At three years the tallest trees were in at Madlulani, the worst site for the most of the other species. It did comparatively better on the Kalahari sands at Chesa Forest than the other species as might be expected because it is indigenous on those soils. It fared worst on the heavier soils. *A. erioloba* was less affected by frost than any other species, regardless of provenance. The furthest north provenance, Makatoolo in Zambia, grew fastest at six out of the seven sites shown in Figure 8. It grew faster than the Imhohloweni provenance that was local to the trials. Ranking of provenances was remarkably consistent between sites and there was almost perfect positive correlation between height growth and latitude.

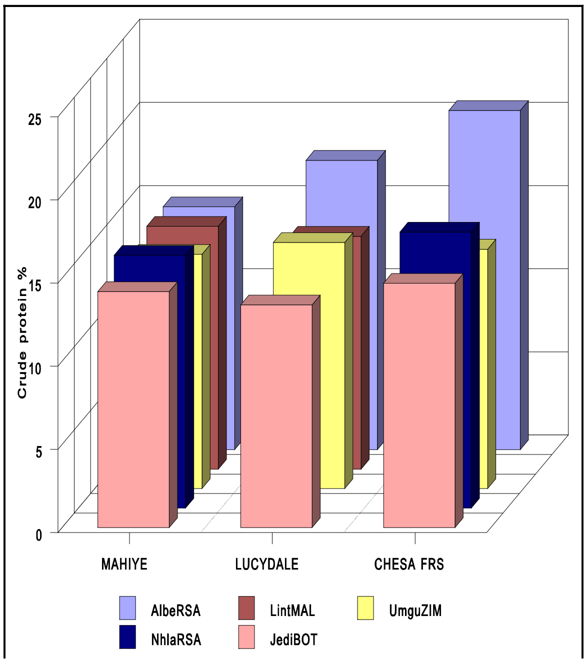


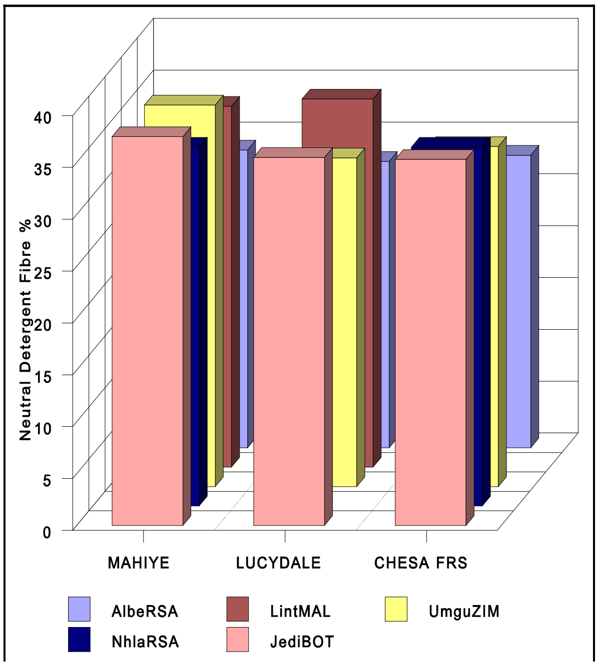
The early above-ground growth rate of *Acacia erioloba* is very slow. There are indications that during this time it puts its resources into establishing a very deep root system so that the tree can remain in contact with permanent soil moisture. After about five years, the aerial growth rate is much faster and appears to be maintained more or less independent of the annual rainfall which, in some parts of its range, can be measured in just a few tens of millimetres. For this reason, the screening trials, planted at one metre square spacing, were not long term enough to give a clear indication of where to site the main trials for an assessment of long term potential. The species' distinctive ecology suggests that it is especially adapted to shallow to medium depth, and sometimes even deep, infertile sands, possibly of high alkalinity, where the tree can access groundwater with dissolved nitrates at depth with its extensive rooting system. Its presence seems to be determined by the presence of surface sand that may extend over only a few hundred square metres. It is not clear whether heavier surface soils inhibit its establishment because of competition from other species or whether the species depends on the sand for the rapid expansion of its root system. The screening trials do suggest the latter. The function of the main trials should therefore be to provide some indication of whether the species will grow on acid (granite) as well as high pH sands if it is aided in the establishment phase as well as which are the most productive provenances. Morphological observations suggest that much of the variation in the species is within rather than between populations and therefore provenance trials with a family sub-structure should be planted.

Four sites were selected for the main trials, Lucydale (young granite sands), Chesa FRS (shallow sand overlying metavolcanis), Chesa Forest (medium depth Kalahari sand overlying basic rocks) and Grant's Farm (deep Kalahari sands overlying basic rocks). The main trials were planted in the 1997/1998 rainy season but the 18-month measurement had not been made by the end of the project.

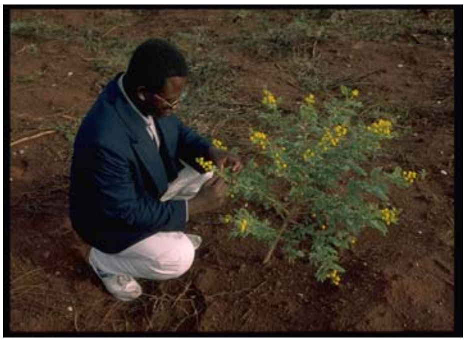

178
79
222
172

The Matopos Research Station collaborated in assessing foliage samples collected from the screening trials. One study was set up to assess the variation in protein and fibre in the foliage of five provenances of *Acacia karroo* on three sites at three different times of the year. Not all the analyses had been completed by the end of the project period. Figures 13 and 14 do show, however, that the Prince Albert provenance had consistently higher crude protein % and consistently lower neutral detergent fibre across sites compared to the other provenances and that there were no significant differences between sites.





Mr John Dube of the Matopos Research Station also used foliage collected from the screening trials when he visited the University of Wisconsin in the United States of America to study the use of advanced equipment and techniques to assess anti-nutrients in animal feeds. Antinutrients in feeds reduce intake and may interfere with their digestibility. Some antinutrients are toxic to the animal. Therefore quantification of antinutrients is necessary to predict their effect on the animal. Analytical methods used included assessment of phenolics by precipitation with trivalent ytterbium, the Folin-Ciocalteau method, the Butanol-HCl method and by HPCL analysis. This work is the subject of a graduate degree and the results will be available when the thesis has been completed.

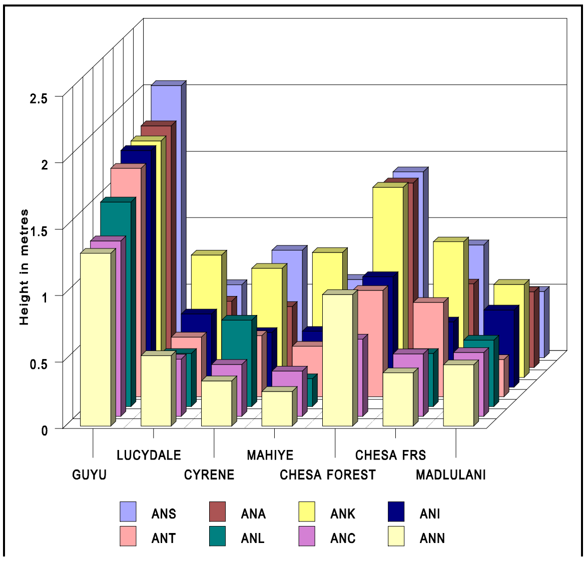


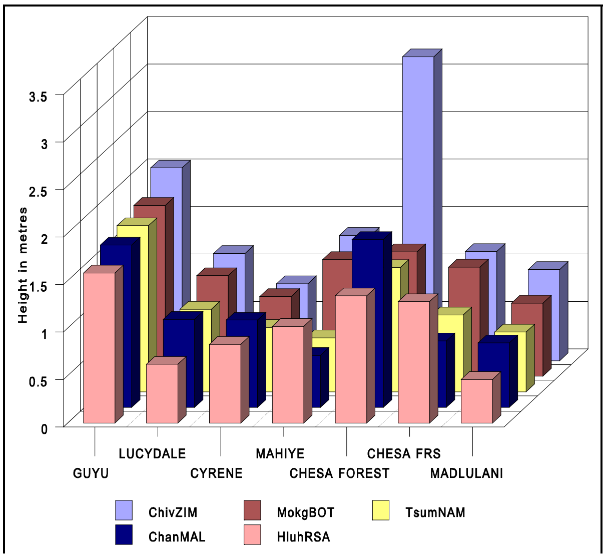
Acacia nilotica

Eight sub-species of *Acacia nilotica* were included in the screening trials, *adstringens* (3 provenances), *cupressoides* (1 provenance), *indica* (1 provenance), *kraussiana* (5 provenances), *leiocarpa* (1 provenance), *nilotica* (1 provenance), *subulata* (1 provenance), and *tomentosa* (2 provenances). The species did best on the frost-free granite soil site at Guyu and next best at Chesa Forest on Kalahari sands, probably because that site is frost-free (Figure 19). The species would be expected to have done better on the heavier soils at some of the other sites but its potential on these may have been masked by the effects of frost. By the end of the second year, *A. nilotica* ssp. *kraussiana* ranked highest on average across all sites probably because of its greater frost tolerance (Figure 19). At the best frost-free site, Guyu, however, it was challenged by ssps. *subalata* and *adstringens*. In the fourth year from planting ssp. *kraussiana* was still overall the fastest-growing taxon with trees between 2 and 3 m tall on the granite and clay soils. However, there were some anomalies on the Kalahari sands at Chesa Forest where some individual trees of ssp. *tomentosa* had attained heights of over 3 m; and individuals of ssp. *tomentosa* were also the tallest trees on the granite sands at Guyu. The Chivu (Zimbabwe) provenance of ssp. *kraussiana* was best overall (Figure 20).

The results of the screening trials demonstrated the very large amount of genetic variation in *Acacia nilotica* and were beginning to show the interaction of this variation with site and age. Of all the species in the trials, *A. nilotica* obviously merits testing over the widest range of, principally frost-free, sites in long term experiments, especially as it produces highly nutritious pods and can be tolerant of low rainfall and difficult soils. The main trials have, therefore, been planted over seven sites to cover the conditions in which it could contribute to increasing productivity on small farms in the semi-arid parts of Zimbabwe. The main trials were planted in the 1998/99 rainy season and had not been measured by the end of this project period.

The photographs (Figures 21-23) show variation in *Acacia nilotica* in the nursery and also the fastigiate crown form of the ssp. *cupressoides* which could be of interest for growing in cropping areas.

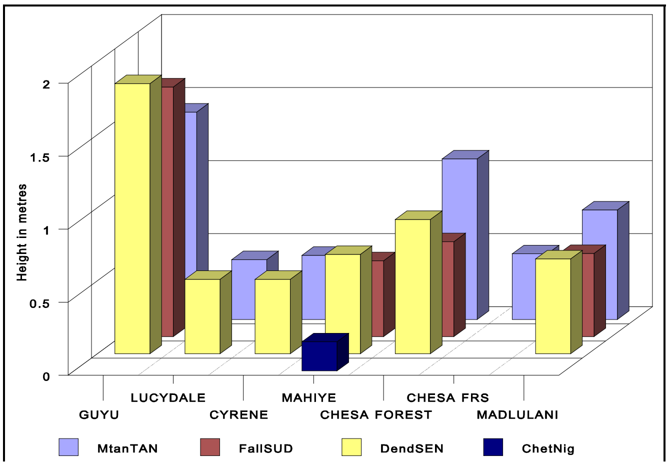





203
227
174
225
291
226
186

Acacia senegal

Two varieties of *Acacia senegal* were included in the screening trials, var. *senegal* (4 provenances) and var. *leiorhachis* (1 provenance). Only one provenance of *leiorhachis* (from east Africa) and none of var. *rostrata* was included because it was considered doubtful that these taxa, especially the southern African provenances, would have any economic potential. The results of the screening trials showed the species to being doing best at Guyu, a frost-free site on granite-derived soils (Figure 24). Surprisingly, the next best sites were the harsh Kalahari sand localities of Chesa Forest and Madlulani. By the second year after planting, gum was being produced, without tapping, from the northern (Niger, Senegal and Sudan) provenances of var. *senegal*; no gum has yet been produced by the var. *leiorhachis* or by the southern (Tanzanian) provenance of ssp. *senegal*.



The results of the screening trials indicate that main trials of this important species should be focussed on testing the northern provenances of var. *senegal* only on granite and Kalahari sand soils in frost-free localities. There is already a gum arabic industry in the Matabeleland province of Zimbabwe based on natural production from *Acacia karroo*. *A. senegal* var. *senegal* is, however, a more copious producer of a higher quality gum arabic that fetches a much better price on the world markets. The value of its gum and also of its soil-ameliorating propensities in Sudan are well known and could be utilized by introduction of selected material to suitable parts of the rural areas in Zimbabwe. Considerable importance has, therefore, been placed on establishing the main trials across six sites to cover the range of conditions indicated above.

Sixteen provenances of *Acacia senegal* var. *senegal* have been included in the main trials. Second year assessments have shown that an Ethiopian provenance, Arba Nosa, is giving best growth. Observations in the third year have confirmed that the northern provenances are producing gum from natural lesions in the stem without tapping whereas the Tanzanian provenances, although they have some of the better growth rates, are not producing gum yet.

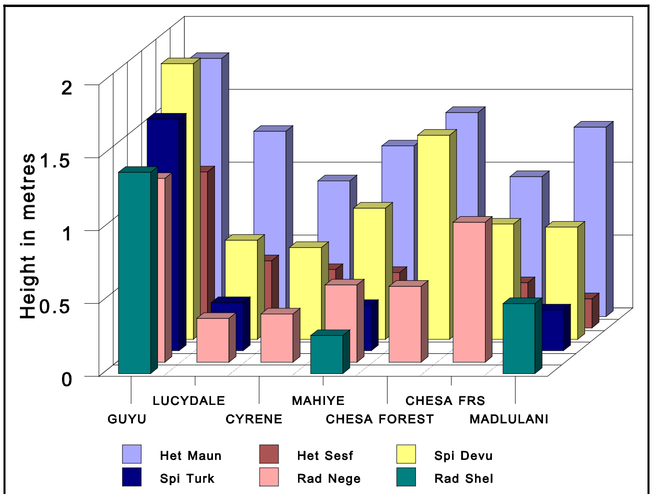
Acacia senegal seedlings in the nursery are shown in Figure 26. The very small seedling on the right is of the var. *rostrata* which was not included in the trials. Var. *leiorhachis* is the large seedling on the left. The central four seedlings are all var. *senegal*. Several trees flowered after only 18 months in the field and therefore the pods shown are likely to contain viable seed (Figure 35). The prospect of invasion might be worrying except that the products and services of the species are such that should it thrive, the benefits derived from it are likely to outweigh bush encroachment problems where there are already several indigenous species with that propensity. The gum is exuded in spherical nodules from regular points on the stem that are associated with a morphological feature (Figure 27).

Trees of the Tanzanian provenances are shown standing out clearly from the paler green of the northern provenances (Figure 28).


228
205
294
295

Acacia tortilis

Three sub-species of *Acacia tortilis* were included in the screening trials, *heteracantha* (4 provenances), *spirocarpa* var. *spirocarpa* (4 provenances), *spirocarpa* var. *crinita* (2 provenances) and *raddiana* (5 provenances). Second year results showed ssp. *heteracantha* to be least affected by frost, ssp *raddiana* most and ssp. *spirocarpa* to be intermediate. Within ssp. *heteracantha* itself, there was variation in frost tolerance; Maun from Botswana was least affected. Growth performance was in the same order as frost tolerance, with *heteracantha* first, but the two traits were not correlated. Fourth year assessments in the screening trials indicated that individual trees of ssp. *spirocarpa* had assumed a tree form earlier and caught up somewhat with *heteracantha*, which still tended to keep a bush form. Although the southern African provenances of ssp. *spirocarpa* have maintained their average superiority in growth rate over those from East Africa throughout the life of the trials so far, the tallest individuals in the trials (up to 4 m) now are in the latter provenances. Some of the subspecies *raddiana* provenances are also catching up with the *heteracantha*. Figure 29, however, shows the superiority of the Maun provenance of *heteracantha* in the fourth year, the variability of provenance performance within subspecies and the good performance of all provenances of all species on the frost-free granite sands at Guyu.



The results of the screening trials have been decicive enough to indicate that certain provenances of ssp. *heteracantha* should be tested on a wider range of soils in frosty areas. The most frost-resistant provenance is not indigenous to Zimbabwe and therefore there are prospects for extending the range of this very important species in the country. There is also a great deal of genetic variation to investigate in the other two subspecies, *spirocarpa* and *raddiana*, in frost-free environments. The main trials of *Acacia tortilis* have therefore been established over nine sites to cover these needs.

The main trials of *Acacia tortilis* were planted in the 1997/1998 rainy season and the second-year assessments had not been done before the end of this project.

Some photographs are included on the next page. They show the typical bushy habit of the southern African subspecies *heteracantha* (Figure 30) compared to the tree form of the subspecies *spirocarpa* from east Africa (Figures 31 and 33). They also show the differences between subspecies and provenances within subspecies at the early seedling stage (Figure 34). The yellow labels being tied to each seedling were found to be the best way to retain tree identity into the field position before the trial was mapped - when the labels were removed (Figure 32).


187
207
213
212
211
210
182
209
231
232
208
230

Dissemination

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.a) Screening Trials of Range-wide Provenances of Six African *Acacia* Species in Zimbabwe – Second-year Results. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.b) Screening Trials of Range-wide Provenances of Six African *Acacia* Species in Zimbabwe - Three-year Results. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.c) Third-year Results from Provenance Trials of *Acacia karroo* on Three Soil Types in the Semi-arid Region of Zimbabwe. (A).

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.d) Second-year Results from trials of *Acacia senegal* in the semi-arid regions of Zimbabwe. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.e) Second-year Results from Trials of *Faidherbia albida* in the Semi-arid Regions of Zimbabwe. (A)

DUBE, J.S. (1996) Report on a Visit to the University of Wisconsin, USA, to Analyse Leaf Samples from provenances of six African *Acacia* species. Back to Office Report. Bulawayo. Matopos Research Station. 15pp. (C)

DUBE, J.S. and NDHLOVU, R. (1998) Collaborative work between the Zimbabwe Forestry Commission and the Matopos Research Station. Report on analyses performed on African acacias. Matopos Research Station. 6pp. (C)

EVALUATION OF PRODUCTIVITY IN NATURAL STANDS

The objective was "*to determine growth rate, pod production and phenological variation in a natural population of each species growing in the vicinity of the appropriate trial; provide advance quantitative data on growth, yield and quality for use in socio-economic studies*".

In the event, the natural stand studies were confined to *Acacia erioloba, A. tortilis* and *A. nilotica* since the productivity in a natural stand of *A. karroo* had been completed under the previous project, there were no natural stands of *Faidherbia albida* near the trials sites and *A. senegal* var. *senegal* does not occur in Zimbabwe.

Acacia erioloba

Natural populations on Umgusa Valley Estates were selected for this study. There were two components. The first involved counting and weighing all pods produced from large trees growing at a parkland spacing in grassland of about 12 trees per hectare to gain some indication of the total potential yield of the species when mature (Figure 35). The second was based on a 500-tree plot in a *c*. 20-year-old, even-aged population that had regenerated when the land had reverted from arable to rangeland (Figure 39). This was a more intensive study in which increase in production with age, year to year variation in production on both tree to tree and unit area bases, and tree to tree variation in nutritional value were assessed. The data from the mature tree study and the nutritional variation of pods from tree to tree have been analysed and published in poster and article form (Barnes *et al.*, 1996a&b, 1997, 1998).

Table 3. Nutritional value of *Acacia erioloba* pod and seed meal compared to maize grain and maize stover

	Acacia erioloba	Maize grain	Maize stover
CP (%)	16.5	9.6	4.2
CF (%)	27.3	2.3	39.8
EE (%)	6.3	4.9	1.2
Ash (%)	3.8	1.6	7.4
ME (MJ/kg	9.4	13.3	4.6

The findings so far indicate that the milled *Acacia erioloba* pods have a higher crude protein content than maize (Table 3). Individual mature trees can yield more than 150 kg of pods per year. A parkland of 15 mature trees per hectare can produce more than twice as much crude protein and almost as much metabolizable energy as the average small-holder grain crop without any input costs except for the collection of pods. The availability of the protein to the animal is now being assessed in Goat feeding trials at the Matopos Research Station. In addition, the trees make a significant, although as yet unquantified, contribution to the production of nutritious grasses beneath their canopies. Substantial variation has been found in tree and pod sizes, pod production and nutritional value within the even-aged natural stand. (Table 4) There are indications that at least some of this variation is under genetic control and that there could be considerable

EVALUATION OF PRODUCTIVITY IN NATURAL STANDS

The objective was "*to determine growth rate, pod production and phenological variation in a natural population of each species growing in the vicinity of the appropriate trial; provide advance quantitative data on growth, yield and quality for use in socio-economic studies*".

Acacia erioloba

Natural populations on Umgusa Valley Estates were selected for this study. There were two components. The first involved counting and weighing all pods produced from large trees at a parkland spacing in grassland of about 12 trees per hectare to gain some indication of the total potential yield of the species when mature (Figure 35). The second was based on a 500-tree plot in a c. 20-year-old, even-aged population that had regenerated when the land had reverted from arable to rangeland. This was a more intensive study in which increase in production with age, year to year variation in production from both tree to tree and unit area bases, and tree to tree variation in nutritional value were assessed. The data from the mature tree study and the nutritional variation of pods from tree to tree have been analysed and published in poster and article form (Barnes *et al.*, 1996, 1997, 1998).

The findings so far indicate that the milled *Acacia erioloba* pods have a higher crude protein content than maize (Table 3). Individual mature trees can yield more than 150 kg of pods per year. A parkland of 15 mature trees per hectare can produce more than twice as much crude protein and almost as much metabolizable energy as the average small-holder grain crop without any input costs except for the collection of pods. In addition the trees make a significant, although as yet unquantified, contribution to the production of nutritious grasses beneath their canopies. Substantial variation has been found in tree and pod sizes, pod production and nutritional value within the even-aged natural stand. (Table 4) There are indications that at least some of this variation is under genetic control and that there could be considerable potential to increase yield and quality by selection

Table 3. Nutritional value of *Acacia erioloba* pod and seed meal compared to maize grain and maize stover

	Acacia erioloba	Maize grain	Maize stover
CP (%)	16.5	9.6	4.2
CF (%)	27.3	2.3	39.8
EE (%)	6.3	4.9	1.2
Ash (%)	3.8	1.6	7.4
ME (MJ/kg DM)	9.4	13.3	4.6
IP (Absorb.	10.0	0.0	3.2

EVALUATION OF THE CURRENT AND POTENTIAL USES OF ACACIAS IN SMALL HOLDER AGRICULTURAL SYSTEMS

The objective was "*to evaluate the current and potential use of the six Acacia species in small-holder agricultural systems in the semi-arid zones of Matabeleland, Zimbabwe*".

This socio-economic component was included among the objectives so that, by the end of the project, the users' view of the acacias could be taken into account in developmental work with the materials and their promotion once their cultural and genetic potential had been demonstrated. **The socio-economic team that did the work comprised two consultants from the United Kingdom, an economist and a sociologist, and a forest economist and a resource economist from the Zimbabwe Forestry Commission. The following summary of the work of the team is based on the executive summary and conclusions of their full final report (Maruzane, McGregor and Mukwekwerere, 1999) *q.v.***

The research had three main components:

1. a literature review of the linkages between acacias and the livestock system;

2. village/community studies of the role of acacias in agro-pastoral systems;

3. market studies of important *Acacia* products.

A literature review of the linkages between acacias and the livestock system

The literature review highlighted areas for field investigation. It revealed the inappropriateness of valuation techniques used in the literature for assessing the value of acacias to communal area farming systems. It reviewed quantitative data on browse consumption by stock, showing the differential preferences of different types of livestock, and differences between the six *Acacia* species selected for intensive study. Significantly, it indicated the heightened value of *A. erioloba, A. tortilis* and *A. nilotica* pods as cattle feed; *A. karroo* is of lesser value to cattle, though the foliage is much browsed by goats. In terms of palatability and digestibility, the pods are rich in protein and compare very favourably with commercial pen feeds, but the protein in acacias is bound to tannins and can be relatively indigestible. Research on how pods as supplementary feed can translate into weight gain and milk production are planned in Zimbabwe: results are not yet available, though the literature suggests positive effects. Survey of the large literature on the effects of acacias on grass showed the complexity of the many factors involved, and highlighted the importance of grazing intensity in promoting either a facilitation or a suppression of grass. The substantial literature on bush encroachment and its control has addressed conditions on commercial rather than communal lands; further field investigation in this area would be valuable.

Village/community studies of the role of acacias in agro-pastoral systems

The village studies explored the role of acacias in a range of four different settings.

1. *Acacias and the livestock systems of Matabeleland (Ntabazinduna, Gwanda and Inkosikazi).* These studies showed that, despite farmers' appreciation of the value of

acacias to their livestock directly in the form of leaves and pods and indirectly in their facilitation of grass, farmers were not generally interested in an increased abundance of acacias because of their thorniness, and because there was not perceived to be a scarcity of *Acacia*-derived products. Where farmers have managed acacias, they have concentrated not on increasing the stock of trees, but on transforming the behaviour of the trees and the structure of *Acacia* woodlands, reducing the number of small stems by thinning, and increasing the height by pruning. Most were not in favour of additional planting. The exception to this finding was in places where a market in pods had developed (for sale to commercial farmers or pen feeding projects within the communal areas). Under such circumstances, farmers' need for cash sometimes translated into an enthusiasm for planting. The further development and promotion of *Acacia* pods as a supplementary feed, therefore, might provide the conditions for the successful introduction of high quality pod-bearing species.

2. Faidherbia albida *and the cropping systems of the Sebungwe Valley and the SE Lowveld. Faidherbia albida* plays an important role in enhancing crop yields in the sandy alluvial soils of the Sebungwe Valley, but does not have comparable effects on crops planted on the black soils of the Mwenezi valley. Even where *F. albida* is an important part of agricultural systems, there is little scope for additional planting. Management is opportunistic and farmers focus on facilitating regeneration in places where tree density is low; much effort is devoted to thinning and removing unwanted regenerating trees. Although there is no perceived scarcity and little scope for further planting, there are many profitable avenues for further research.

3. *Promotion of acacias as living fences*. The assessment of projects in Zimbabwe that have tried to promote the planting of acacias as live fences concluded that only under exceptional circumstances were these popular or successful with farmers. Implementers have tried to overcome farmers' reluctance to plant by linking unpopular acacia fence planting to projects that farmers really want (such as donated fencing for vegetable gardens), but this rarely translates into successful tree-planting. Such linkages appear to be an inappropriate methodology for promoting tree-planting, nor should they be an avenue for introducing new genetic material. Live fencing/tree planting projects should only be pursued in exceptional places where farmers show enthusiasm for this *per se*.

4. *The village studies*. The major conclusion of the village studies was that future research should focus on the prospects of developing improved acacia products and on the potential to stimulate demand. This demand would then be the incentive for enhanced management or the promotion of planting. The most promising avenue for promoting the enhanced management or additional planting of acacia species is through the development of products that can bring immediate high value or preferably cash returns. Long term conservation benefits are not sufficient to promote either *Acacia* planting on a significant scale or improved management in the communal areas. The most potentially rewarding avenue for developing products of this sort, is to explore the market for locally produced gum arabic and the market for pods.

Market studies of important *Acacia* products

A market study of gum arabic included a review of world production and markets and the opportunities and constraints to the production of *Acacia karroo* gum in Africa, with particular reference to Zimbabwe. It highlighted the recent collapse in international prices for the two main types of gum arabic (high quality gum from *A. senegal*, and low quality gum from *A. seyal*. Naturally-produced Zimbabwean *A. karroo* gum is comparable in quality to the low quality *A. seyal* and therefore at the lower end of the price range and likely to realize only marginal profits. Changes in the international specifications for gum arabic may, however, lead to the inclusion of species such as *A. karroo* and result in enhanced opportunities for its sale.

The biggest user of gum arabic is the food and drinks industry, though there are many other users. The main consumers are the countries of the West, though Asian markets may expand, and smaller domestic markets are mostly unquantified. The main producers of gum arabic are Sudan, Chad and Nigeria; the smaller producer, Kenya, has recently tried to enter the market, with lessons of value to Zimbabwe. Considerations of quality are essential, are reflected in prices and are geographically varied with the highest quality product being supplied by Sudan. The organization of production in Sudan also has lessons for Zimbabwe:- the need for tight quality control; the annual announcement of anticipated export prices and government intervention to secure a minimal price; the role of producer organisations to ensure best returns to producers; and the role of the Forestry Commission in extension.

Although the quality of naturally produced Zimbabwean gum is a major constraint, it is possible that domestic and international markets for *Acacia karroo* gum could be more fully exploited. The South African market is particularly promising as there is a history of *A. karroo* use. This potential market should be explored by submitting gum samples for testing. Samples should be collected from several different sites to identify differences in quality; introduced species should be tried only after conclusions are reached on local *A. karroo*. The United Kingdom market should also be tested to give a second opinion and explore the possibilities of exporting further afield. Gaining the confidence of the buyer is critically important in this industry, which is demand led. Stability in quantity and quality of supply would be essential.

Further research into the domestic, regional and international markets is necessary, firstly for the natural stands of *Acacia karroo.* Research should also investigate questions of supply: the scale and logistics of supply; regional variation in the resource; information on yields and tapping methodologies; calculations of likely profitability and feasibility. The question of how production could be organized to maximize returns to producers should also usefully be explored.

Conclusion

The report's overall conclusions are that large-scale planting of new genetic material is premature at this stage; not only are relevant results from trials not yet available, but farmers' knowledge of the multiple benefits of acacias does not translate into a perception of scarcity of *Acacia* products and current management entails thinning and

removing regenerating/encroaching trees. However, farmers' resistance to increasing stocks of acacias could be altered if immediate and cash returns were to be forthcoming. In this respect, the project highlighted the value of the following areas for further research:-

- ***Research into the development of acacia-derived products*, particularly the potential of gum arabic which could deliver cash returns significant enough for planting to be promoted in some of the driest parts of Zimbabwe.**

- ***Submission of Zimbabwean gum to local and international buyers to assess its potential*; questions of current and potential supply from natural stands should be documented, with attention to quality as well as yield, regional variation and collecting methods. The logistics and potential organization of supply for maximal benefit to producers should also be explored.**

- ***Development of pods as a supplementary feed*. In this respect, other important pod bearing species could also be included in the research, e.g. *Piliostigma thonningii*, which farmers consistently ranked more highly than *Acacia* pods in the areas where it grows, due to its ease of handling, and because the pods are less `bitter' than acacias.**

- ***On farm experimental trials with farmers, and on farm investigation of unanswered aspects of the acacia's socio-economic and ecological role, management and usage should include:-***

  a) research into the relationship between acacias and grass and the impact of different stocking rates on this relationship

  b) investigation of the relationship between browse consumption and weight gain or milk production in communal area stock

  c) investigation of the relationship between *Faidherbia albida* and crop yields on different sites

  d) investigation of the effects of pruning and different management regimes

  experimental work with enthusiastic farmers of new material (*e.g.* in Inkosikazi, where there may be the potential for establishing trials of new high quality pod-bearing acacias); such trials could be accompanied by `side' species such as *Moringa*

  experimental work on acacias as live fences with keen individuals (such as some of those identified in Chivi) in areas where degradation is severe.

- *Further monitoring of the genetic trials established in Zimbabwe during this project*: the trials will begin to deliver important information on acacia products as the stands mature. The trial measurements will be a critical counterpart to the development of acacia products, and can be exploited also for valuable results on questions of management, site variation, and so on.

Dissemination

ARNOLD, J.E.M. (1996) Genetic Evaluation of African *Acacia* Species: Evaluating Current and Potential Uses. Project R6550 Report. Oxford. Oxford Forestry Institute. 14pp. (C)

COPPEN, J.J.W. (1998) Gum Arabic: a Review of World Production and Markets and the Opportunities and Constraints to the Production of *Acacia karroo* Gum in Africa. Project R6550 Report. Oxford. Oxford Forestry Institute. 43pp. (C)

MCGREGOR, J. (1997) A Preliminary Literature Review Integrating the Genetic Trials and Socio-Economic Studies. The Role of Acacias in Livestock Systems of Matabeleland: Review of PRAs: Work Plan. Project R6550 Report. Oxford. Oxford Forestry Institute. 24pp. (C)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. Geographical Paper No. 35. The University of Reading. 25pp. (A)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. (Submitted to Agroforestry Systems) (A)

MARUZANE, D. and MUKWEKWERERE, M. (1998a) The Role of African Acacias in Livestock Systems: the Case of Inkosikazi Co-operative, Siganda . Project R6550 Report. Oxford. Oxford Forestry Institute. 4 pp. (C)

MARUZANE, D. and MUKWEKWERERE, M. (1998b). African Acacias: Trip Report to Chivi, Zaka and Chiredzi. . Project R6550 Report. Oxford. Oxford Forestry Institute. 4pp. (C)

MARUZANE, D., and MUKWEKWERERE, M. (1998c) Uses of African *Acacia* Species in Ntabazinduna Communal Area: Results of PRA Workshops. Project R6550 Report. Oxford. Oxford Forestry Institute. pp. 12. (C)

MARUZANE, D., MCGREGOR, J. and MUKWEKWERERE, M. (1999) The Role of African Acacias in Communal Area Farming Systems in Zimbabwe - Final Socio-Economic Report. Project R6550 Report. Oxford. Oxford Forestry Institute. pp. 35. (C)

MUKWEKWERERE, M. and MARUZANE, D. (1998a) Uses of Thorny Species in Gwanda Communal Area: Results of PRA Workshops. . Project R6550 Report. Oxford. Oxford Forestry Institute. 10 pp. (C)

MUKWEKWERERE, M. and MARUZANE, D. (1998b) The role of *Faidherbia albida* in farming systems of the Sebungwe Basin, Zambezi Valley. Project R6550 Report. Oxford. Oxford Forestry Institute. 4pp. (C)

METHODOLOGIES FOR INTRODUCING NEW GENETIC MATERIAL INTO SMALL-HOLDER AGRICULTURAL SYSTEMS

The objective was “*to* *evaluate the current and potential use of the six Acacia species in small-holder agricultural systems in the semi-arid zones of Matabeleland, Zimbabwe*”.

Methodologies for integration

The socio economic team was asked to report on the reaction of farmers to planting acacias and to advise on whether or not the project proposal to devise and test methods of integrating the best genetic material into the agricultural systems was premature.

The team's conclusion, given in more detail in their final report (McGregor, Maruzane and Mukwekwerere,1999) was that it was not possible to test and define appropriate methodologies in abstract before it is decided what type of trees are to be introduced for what purpose. So it is important to have conclusions from the genetic trials, or at least a decision about the product for which the species are to be introduced, prior to developing strategies for introducing new varieties to the communal areas on a large scale. They did think that small scale experimentation with individual enthusiastic farmers could nevertheless be rewarding. If trees are to be introduced for gum harvesting, it may be important to isolate the improved acacias from others in the communal area in a demarcated, protected plot. It would be important that the trees were not mixed with existing trees, because the improved species would have been introduced because of their better quality gum, and it is difficult to identify which is an improved and which is a non-improved species if the pods are simply fed to livestock. If, on the other hand, acacias are to be introduced simply to enhance the rangeland or supply of timber, it may be less important to isolate the introduced trees.

Isolation may also be important to prevent crossing. The trials are pure stands, but once introduced to communal areas, will start crossing with existing stocks. It is unlikely that people will continue to buy or order pure seed, yet nothing is known about the crosses that will emerge in the communal areas. The issue of seed supply, availability and cost needs to be considered from the outset when methodologies for introducing new genetic material are being designed.
It was therefore considered to be premature to promote the wide-scale planting of introduced acacias at this stage in the communal lands, firstly, because the genetic evaluation studies have not yet delivered conclusive results on the traits that are of most relevance to farmers; and secondly, efforts to promote planting may encounter resistance from farmers unless long term environmental or indirect benefits can be translated into more direct and immediate benefits.

Further research in several key areas has the potential to provide the necessary direct and/or cash returns to stimulate improved management and make the promotion of planting feasible. It would also work towards the development of sufficient knowledge about acacia's behaviour and performance to provide the technical background essential to the promotion of improved usage or planting. To this end, the team have recommended research specifically in three areas and prepared draft project concept notes which are given in an Appendix to their main report.

Dissemination

ARNOLD, J.E.M. (1996) Genetic Evaluation of African *Acacia* Species: Evaluating Current and Potential Uses. Project R6550 Report. Oxford. Oxford Forestry Institute. 14pp. (C)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. Geographical Paper No. 35. The University of Reading. 25pp. (A)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. (Submitted to Agroforestry Systems) (A)

MARUZANE, D., MCGREGOR, J. and MUKWEKWERERE, M. (1999) The Role of African Acacias in Communal Area Farming Systems in Zimbabwe - Final Socio-Economic Report. Project R6550 Report. Oxford. Oxford Forestry Institute. pp. 35. (C)

ESTABLISHMENT OF THE ACACIA TRIALS NETWORK IN AFRICA

The objective was "*to establish up to three more main trial centres in Africa using the DFID material, designs and knowledge*".

The trial centres in Africa

The aim in this objective was to facilitate the establishment of five acacia trial centres in Africa plus one in India. Ideally those in Africa would be sited in East Africa, North Africa, West Africa, South Africa and south central Africa to provide coverage of the major phytochoria as defined by White. Initial promotion was through an article in FAO's Forest Genetic Resources journal entitled "African acacia trials network: a seed collection of six species for provenance-progeny tests: held at the Oxford Forestry Institute" (Fagg, Barnes and Marunda, 1977). Enquiries were followed up with provision of the full seed lists and advice on trial constitution and design. Potential leading collaborators for the main trial centres were identified and they were sent copies of the final reports of Projects R5653 and R5655 to provide more background knowledge. Their names, organizations and addresses are given below with an indication of progress made with the establishment of the trials by the end of the project. Collaborators will receive copies of the Zimbabwe Acacia Trials Manual (Barnes, Marunda, Maruzane and Zirobwe, in prep.) as a reference work for information on availability and distribution of seeds, trial constitution and design and procedures for raising planting stock and planting, protecting, managing and assessing the trees.

Crispen Marunda, Coordinator, Plantation Forestry Research, Forest Research Centre, Zimbabwe Forestry Commission, POBox HG595, Highlands, Harare, Zimbabwe. Tel: 263 4 496878, Fax: 263 4 497070, email: frchigh@harare.iafrica.com

DFID has funded two projects to establish trials in the first of the Acacia Trials Network Centres. This is at Bulawayo in Zimbabwe. These projects have now been completed. Initially, screening trials of a representative set of 70 provenances of the six species were established on eight sites. The results of these were used to establish main trials of all six species appropriately constituted and designed. A total of 52 trials has now been planted across a wide range of sites. The trials manual currently being produced in this project will provide a basic source of information and guide for all collaborators in the Acacia Trials Network.

Dr. Abd el Azim Mirgani, General Manager, Forests National Corporation, Ministry of Agriculture and Forests, POBox 658, Khartoum. Fax: 249-11-472 659

Seed of a full set of the main provenances of all six species has been sent to Sudan. The intention is to establish trials over a wide range of sites. There are prospects of funds for the establishment of trials on private farms and for the sponsorship of a research student

Dr. A. J. Simons, Programme Leader, Tree Domestication, ICRAF, POBox 30677, Nairobi, Kenya. Tel: 254 2 521 450, Fax: 254 2 521 001, email: t.simons@cgnet.com
internet: http://www.cgiar.org/icraf

Seed for three sets of full provenance trials for all six species has been sent to ICRAF. The intention is that ICRAF will establish trials in appropriate sites through their stations in West Africa. One of their principal interests is finding species and provenances that are suitable for live fences.

4141Ebby Chagala, Principal Research Scientist, Kenya Forestry Research Institute, POBox 20412, Nairobi, Kenya. Tel: 254 154 32891, Fax: 254 154 32844, email kefri@arcc.or.ke

Seed for full sets of the principal provenances of all six species have been sent to KEFRI. They have been experiencing some difficulty in securing funds for the establishment of the trials but, despite this, they expect to plant trials containing all the material on two sites in 1999 and on a further 3 sites when they have sourced funds.

Kay Nixon, Geneticist, Institute for Commercial Forest Research, POBox 375, Pietermaritzburg 3200, South Africa, Tel: 27 331 62314, Fax: 27 331 68905, email: kay@icfr.unp.ac.za

Kay Nixon at the ICFR in South Africa was the first collaborator in the Acacia Trials Network outside Zimbabwe. A full set of provenances of *Acacia karroo* was sent to her in 1994. It was sown soon afterwards and trials were planted in two localities, one in Zululand (Figure 41) and one near Pietermaritzburg, in December of that year. The trees in the Zululand trial have been the fastest-growing of all trials. Seed for a full set of *Faidherbia albida* provenances was sent in 1995, sown in January, 1996 and planted in Zululand in August, 1996. Seed of full sets of provenances of *A. nilotica* and *A. tortilis* was sent in early 1999 and will probably be sown this year. Although this collaborator does not have access to the wide-ranging sites available to Environmentek in South Africa, she is considered to be important because of the link with industrial forestry and the opportunity that this offers for private forestry companies to contribute towards research into non-industrial species.

Dr Khouja Med Larbi, Chargé de Recherche, Laboratoire de Génétique, Institut National de Recherches en Genie Rural (INGREF), Eaux et Forêts, B.P.No.22080, 2080 Ariana, Tunis, Tunisia. Tel: 216 1 718 055, Fax: 216 1 717 951

Seed for full sets of provenances for all six species has been sent to INGREF. It is understood that the seed was sown in April 1999.

Dr Steve Verryn, Geneticist, Envromentek, Water, Environment and Forestry Technology, Council for Scientific and Industrial Research, Private Bag X11227, Nelspruit 1200, South Africa, Tel: 27 13 741 3864, Fax: 27 13 741 3869, email: sverryn@csir.co.za: internet: http://www.csir.co.za

There has been correspondence with Dr Steve Verryn of Environmentek, Professor Gerrit van Wyk of the Forestry Faculty at Stellenbosch University and Mr C.J. Esterhuyse of the Department of Water Affairs and Forestry about their establishing African acacia trials over 12 principal experimental sites that give very good coverage of the environments in which acacias might be important in the country. Inclusion of Environmentek in addition to the ICFR in the Network is important because of their potential for very much more comprehensive site coverage. Unfortunately, although these approaches have started up on several occasions, they have evaporated, mainly because of lack of visible funding for the trials. No seed has yet been sent.

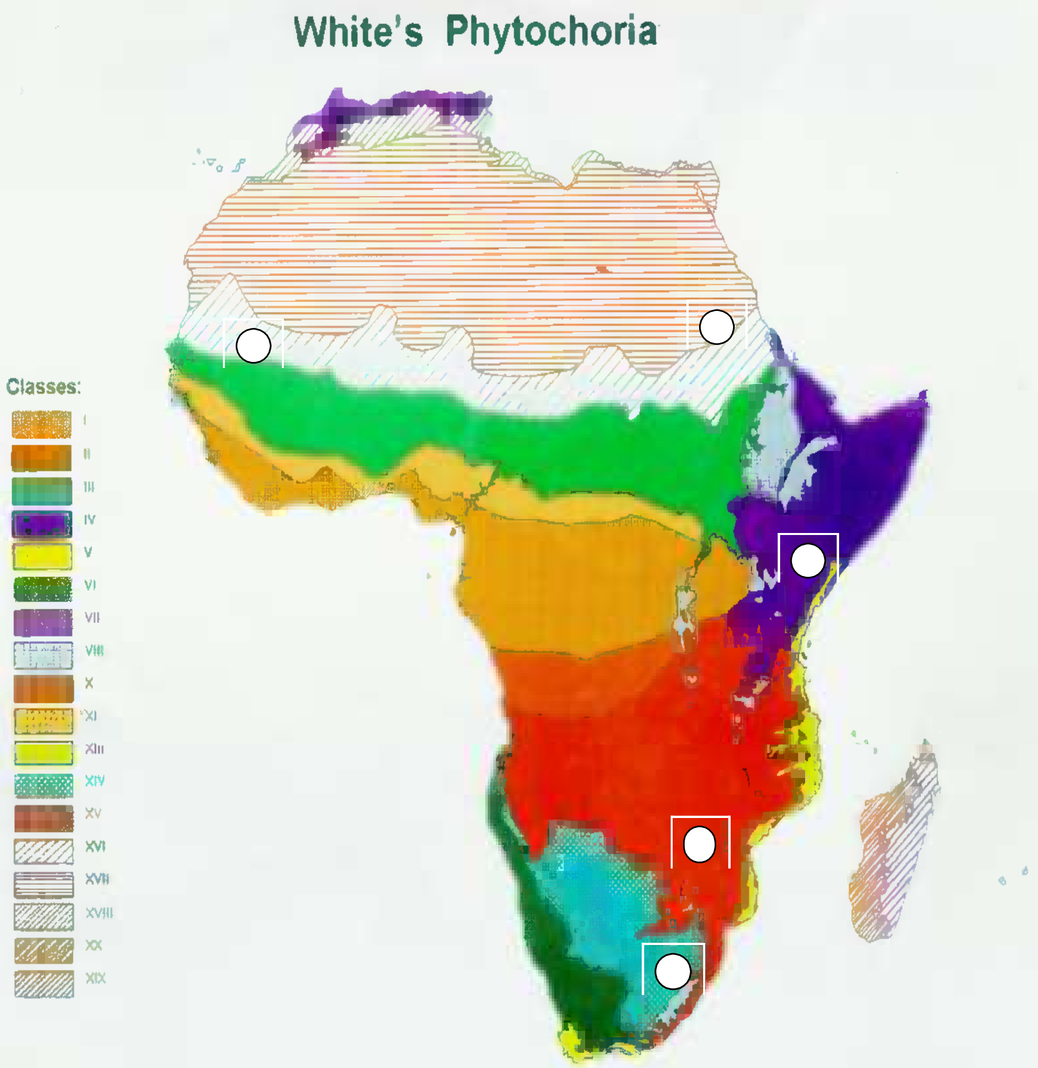
B.V. Prasad Reddy, Silviculturist, Biotechnology Research Centre, Akkarampalle Road, POBox 10, Tirupathe 517507, India. Tel 91 8574 23602, email: cyrenet@cyberservices.com

Mr Reddy expressed great interest in establishing acacia trials in the 300-600 mm rainfall zones in India and the experimental plans are awaited for advice to be given on species and provenance constitution.

Dissemination

FAGG, C.W., BARNES, R.D. and MARUNDA, C.T. (1997). African acacia trials network: a seed collection of six species for provenance-progeny tests: held at the Oxford Forestry Institute. Forest Genetics Resources No. 25:39-50 (A)

TIMBERLAKE, J.R., FAGG, C.W. and BARNES, R.D. (1999) Field Guide to the acacias of Zimbabwe. CBC Publishing, P.O.Box 4611, Harare, Zimbabwe. 160pp. (Book)



I. Guineo-Congolian regional centre of endemism. **II**. Zambezian regional centre of endemism. **III**. Sudanian regional centre of endemism. **IV**. Somalia-Masai regional centre of endemism. **V**. Cape regional centre of endemism. **VI**. Karoo-Namib regional centre of endemism. **VII**. Mediterranean regional centre of endemism. **VIII**. Afromontane archipelago-like regional centre of endemism, including **IX**. Afroalpine archipelago-like region of extreme floristic impoverishment (not shown separately). **X**. Guinea-Congolia/Zambezia regional transition zone. **XI**. Guinea-Congolia/Sudania regional transition zone. **XII**. Lake Victoria regional mosaic. **XIII**. Zanzibar-Inhambane regional mosaic. **XIV**. Kalahari-Highveld regional transition zone. **XV**. Tongaland-Pondoland regional mosaic. **XVI**. Sahel regional transition zone. **XVII**. Sahara regional transition zone. **XVIII**. Mediterranean/Sahara regional transition zone. **XIX**. East Malagasy regional centre of endemism. **XX**. West Malagasy regional centre of endemism. (White, 1983)

THE FIELD GUIDE TO THE ACACIAS OF ZIMBABWE

The objective was "*to publish a Field Guide to the Acacias of Zimbabwe*".

The field guide

A draft of the text, keys and botanical drawings for a field guide to the acacias of Zimbabwe was completed as an output from ODA Project R6349, *Dissemination and information on African acacias*, which ended on 31 March 1997. At the end of that project, a number of copies of the draft were produced and distributed to foresters, taxonomists, ecologists, extension workers and other prospective users in Zimbabwe for field testing and comments. The completion work was then taken up as an additional output from Project R6550. This consisted of assessing the reviews and including relevant comments in the text and keys, modifying the drawings to take reviewers' comments into account, producing the maps in their final form, testing and adjusting the identification keys and, finally, publishing the book.

The Corporate Brochure Publishing Company (CBC) in Zimbabwe was selected as the publisher. CBC agreed, for the £8000 available in the project, to meet publication costs and to have a first print run of 3000 copies with 750 to be made available free to the project for distribution to collaborators and prime users. Distribution to a list of addressees, provided by the project, in the SADC countries was to be at the publisher's expense. The publisher would market the remaining 2250 copies through his network of outlets in the SADC countries and have further print runs to meet future demand.

The field guide had been printed, the books delivered and the distribution plan was in place by the end of the project. The distribution list has included national and international collaborators in the acacia projects, libraries and prime users in the field, mainly forestry and agricultural extension workers in Zimbabwe. The purpose and clientelle for the book are best described by the following extract which is included on the cover.

"For many people concerned with land management, whether agriculturalists, wildlife managers or interested naturalists, the species of *Acacia* (thorn trees, muunga or mukaya) found over much of Zimbabwe are a typical component of the bush, but can pose great problems in terms of identification. Some of the species can indicate soil type and land potential, some are of significant economic value in themselves for browse or fencing, whilst others have great potential for improvement of degraded lands or for various products such as gums. To date there has been no readily available and usable guide to the acacias of the country and much of the information on the 40 species found in Zimbabwe is scattered and inaccessible to the layman.

This book on the Acacias of Zimbabwe sets out to provide a practical field guide to all the species found in the country with information on their distribution, ecology and uses. It is hoped that it will not only give those managing the land and natural resources, in whatever way, greater insight into their task, but also encourage a greater understanding and knowledge among the interested public on this fascinating group of trees and shrubs. Finally, it is hoped that it will stimulate further research so that we understand better the role that these species play in the environment."

Dissemination

Timberlake, J.R., Fagg, C.W. and Barnes, R.D. (1999) Field Guide to the Acacias of Zimbabwe. CBC Publishing, POBox 4611, Harare, Zimbabwe. 160 pp.

ADMINISTRATION AND INFRASTRUCTURE

Staff and labour

The **Project Leader** has been Dr. Richard Barnes, Senior Research Officer at the Oxford Forestry Institute and the **Project Coordinator** in Zimbabwe Mr. Crispen Marunda, Deputy Manager of the Forest Research and Development Division of the Zimbabwe Forestry Commission. Mr Oliver Makoni was **Trials Manager** in the previous Phase I project and took on this position in the new Phase II project until December 1996 when he left to take up a place that had been awarded to him in the College of Forestry in Mutare. Mr Makoni made a valuable contribution and it is sad to record that he died soon after leaving the project. Mr Makoni was succeeded as Trials Manager by Memory Zirobwa who continued in the post to the end of the project. As was the case in the previous project, Mrs Zirobwa has been responsible, through the **Officer in Charge, Chesa Forest Research Station**, Mr Dzidzai Maruzane, to the Project Coordinator in Harare. Mr Maxwell Mukwekwerere was seconded to the project on a part-time basis as part of the **Socio-economic Team** with Mr Dzidzai Maruzane and the ex-patriate consultant to the project on this subject, first Mr Michael Arnold and later Dr JoAnn McGregor. All Zimbabwean project staff and labour were employees of the Forestry Commission and therefore came under that body for all matters regarding their employment. The project paid the consultants' fees and expenses and the Trials Manager's full time salary; the Forestry Commission paid the salaries of all part-time Zimbabwean staff. The Forestry Commission provided labour or contracted labour to work on the project as required but the project paid all labour costs. In the Phase II project there has been collaboration with the Matopos Research Station in the nutritional analysis of pods and foliage. The project provided chemicals for this work and paid the salary of a **Laboratory Technician**, Mr Robert Ndhlovu.

Budget control

The major part of direct expenditure on the project has been controlled again by the Forestry Commission in Zimbabwe. The Trials Manager made allocations to and purchases on the project; these were authorized by the Officer in charge CFRS. He, in turn, was responsible to the project coordinator in Harare. Accounts were processed through the Forestry Commission's accounts branch at its Head Office in Harare. An official of the Accounts Branch (Mr Mrewa) and the Project Coordinator signed quarterly returns showing expenditure against budgeted amounts under heads that matched those in the project document and these were submitted to the Accounts Office at the OFI through the Project Leader. The Project Leader arranged for funds to be transferred quarterly to the Zimbabwe Forestry Commission by the Accounts Office in the OFI. This system worked well except that the Forestry Commission understandably could not submit a signed return of expenditure until after the end of a quarter and this made it necessary to arrange for the OFI to send quarterly advances to the Zimbabwe Forestry Commission. The overall budget of the project was controlled by the Project Leader at the OFI.

Facilities and equipment

The Trials Manager continued for the whole project period to occupy the office at Chesa Forest Research Station that was allocated to the post during Phase I. He/she had access to telephone, fax and e-mail. Full nursery facilities were made available near the office. The Forestry Commission also provided a house for the Trials Manager on the station.

The Toyota Hilux single cab 4x4 diesel truck purchased during Phase I(*c.* £11,000) was passed on to Phase II for the sole use of authorized personnel working on the project. Likewise, the project computer and printer purchased during Phase I was passed on to Phase II. All other equipment required by the project from time to time, *e.g.* replacement vehicle when the project vehicle was in for servicing or repair, incubator for pre-germinating seed, tractor of land preparation various tools, *etc.*, were all provided by the Zimbabwe Forestry Commission.

FOLLOW-UP AND FUTURE RESEARCH

The whole suite of African *Acacia* projects, conducted by the OFI and funded by DFID's FRP since 1987, has produced a large amount of well-documented information and materials. The information is available, or will be available, in the public domain and the materials are available as seed or as trees in trials on the ground. It has always been intended that they should provide a firm base for future research and development in managing and domesticating the acacias to increase agricultural productivity in the semi-arid lands in Africa and elsewhere. The socio-economic studies have shown where the deficiencies lie in quantifying the benefits of acacias and how their products and services can be promoted among the small-scale farmers in the communal areas of Zimbabwe. The biological studies have shown how the materials can be exploited to their full potential. These results should be followed up with projects to relate input to production, to integrate acacias into farming systems and to exploit the genetic variation within them.

New projects are already at an advanced stage of preparation and funding in all these areas. Experimental work on feeding goats with acacia pods has been started under a research project being funded under DFID's LPP Programme. NORAD will provide over USD1 million for restoration of degraded lands in the semi-arid regions of Zimbabwe in which the acacias will play the major role.. DANIDA is providing Z$300,000 for on-farm evaluation of promising tree species and establishment technologies that will include planting the best provenances of *Acacia karroo* on boundaries and contours and establishing small plots to produce fodder for pen-feeding goats and cattle, and to produce fuelwood. and gum. In addition, interest has been shown by scientists in a number of external institutions in suing materials from the trials for further taxonomic and molecular research, for example an investigation into exploiting polyploidy to increase wood productivity in *Acacia karroo* .

The Zimbabwe Forestry Commission itself is funding the maintenance and continued assessments in the trials and their management for seed production although it is hoped that externally-funded projects that use information or materials from the trials will include a component to contribute to these costs. In addition, the very promising early performance of, and gum production from , *A. senegal* var. *senegal* has prompted the Forestry Commission to plan a workshop, identify farmers wh are willing to cooperate, procure seed, raise stock, distribute seedlings, assess success and send samples to the gum broker and to laboratories for analysis.

The socio-economic team of this project has produced four concept notes for further work on the acacias that would use the information and materials from the previous projects (Maruzane, D., McGregor, J. and Mukwekwerere, M, 1999). These are:-

- *Acacia* gum:- market potential for the expansion of domestic production in Zimbabwe
- **A*cacia* pods:-the development and promotion of African *acacia* pods as supplementary stock feed**
- **Q**uantification of the effects of *Faidherbia albida* on maize production in the Sebungwe and Mwenezi basins.
- **Management studies of African *Acacia* browse**

The Zimbabwe Forestry Commission will actively seek partners and external funding for these projects.

REFERENCES

The following is a consolidated list of publications and other outputs from this project and external documents referred to in the report.

ARNOLD, J.E.M. (1996) Genetic Evaluation of African *Acacia* Species: Evaluating Current and Potential Uses. Project R6550 Report. Oxford. Oxford Forestry Institute. 14pp. (C)

BARNES, R.D. and FAGG, C.F. (1995) The potential of the African acacias in agricultural systems in the dryland tropics. Invited paper, IUFRO XX World Congress. 6-12 August, 1995, Tampere, Finland. 12 pp. (A)

BARNES, R.D., FAGG, C.W., MARUNDA, C.T., STEWART, J.L. and CHIMBALANGA, J. (1996) *Acacia erioloba*: a Tree of Life in Semi-arid Lands. pp. 421. In: Tree Improvement for Sustainable Tropical Forestry. (Eds.) Dieters, M.J., Matheson, A.C., Nikles, D.G., Harwood, C.E. and Walker, S.M. Proc. QFRI-IUFRO Conf., Caloundra, Queensland, Australia. 27 October - 1 November 1966. Publisher: Queensland Forest Research Institute, Gympie, Queensland 4570, Australia. p. 421. (A)

BARNES, R.D., FAGG, C.W., MARUNDA, C.T., STEWART, J.L. and CHIMBALANGA, J. (1996b) *Acacia erioloba*: a Tree of Life in Semi-arid Lands. Format, Newsletter of the Research and Development Division , Zimbabwe |Forestry Commission. Harare, Zimbabwe. 8 (4):1-3.

BARNES, R.D., FAGG, C.W., MARUNDA, C.T., STEWART, J.L. and CHIMBALANGA, J. (1997) *Acacia erioloba*: a Tree of Life in Semi-arid Lands. FRP/ODA Poster Series - 4. (B)

BARNES, R.D., FILER, D.L. and MILTON, S.J. (1996) *Acacia karroo*: Monograph and annotated bibliography. Tropical Forestry Papers No. 32. Oxford Forestry Institute. 80 pp. (A)

BARNES, R.D., MARUNDA, C.T., MARUZANE, D. and ZIROBWA, M (in prep.) African Acacias Trials Manual - Zimbabwe. The Zimbabwe Bulletin of Forestry Research No. -- Zimbabwe Forestry Commission, Harare, Zimbabwe. --- pp. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.a) Screening Trials of Range-wide Provenances of Six African *Acacia* Species in Zimbabwe – Second-year Results. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.b) Screening Trials of Range-wide Provenances of Six African *Acacia* Species in Zimbabwe - Three-year Results. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.c) Third-year Results from Provenance Trials of *Acacia karroo* on Three Soil Types in the Semi-arid Region of Zimbabwe. (A).

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.d) Second-year Results from trials of *Acacia senegal* in the semi-arid regions of Zimbabwe. (A)

BARNES, R.D., ZIROBWA, M., MARUZANE, D. and MARUNDA, C.T. (in prep.e) Second-year Results from Trials of *Faidherbia albida* in the Semi-arid Regions of Zimbabwe. (A)

CAMPBELL *et al*. (1994) Local level economic evaluation of savanna woodland resources: village cases for Zimbabwe. CIDA, Zimbabwe Forestry Commission and University of Zimbabwe. 118pp. (C)

CLARKE, J. (1994) Building on indigenous natural resource management. Zimbabwe Forestry Commission. 55 pp. (D)

COPPEN, J.J.W. (1998) Gum Arabic: a Review of World Production and Markets and the Opportunities and Constraints to the Production of *Acacia karroo* Gum in Africa. Project R6550 Report. Oxford. Oxford Forestry Institute. 43pp. (C)

DUBE, J.S. (1996) Report on a Visit to the University of Wisconsin, USA, to Analyse Leaf Samples from provenances of six African *Acacia* species. Back to Office Report. Bulawayo. Matopos Research Station. 15pp. (C)

DUBE, J.S. and NDHLOVU, R. (1998) Collaborative work between the Zimbabwe Forestry Commission and the Matopos Research Station. Report on analyses performed on African acacias. Matopos Research Station. 6pp. (C)

FAGG, C.W. and BARNES, R.D. (1995) African acacias: study and assembly of genetic resources. Final report, Project 5655, Oxford Forestry Institute. 173 pp. (C)

FAGG, C.W., BARNES, R.D. and MARUNDA, C.T. (1997). African acacia trials network: a seed collection of six species for provenance-progeny tests: held at the Oxford Forestry Institute. Forest Genetics Resources No. 25:39-50 (A)

FAO (1980) Genetic resources of tree species in arid and semi-arid areas. FAO/IBPGR. (A)

MCGREGOR, J. (1997) A Preliminary Literature Review Integrating the Genetic Trials and Socio-Economic Studies. The Role of Acacias in Livestock Systems of Matabeleland: Review of PRAs: Work Plan. Project R6550 Report. Oxford. Oxford Forestry Institute. 24pp. (C)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. Geographical Paper No. 35. The University of Reading. 25pp. (A)

MCGREGOR, J., MARUZANE, D. AND MUKWEKWERERE, M (1999) Deforestation in Zimbabwe's communal lands: perceptions of forest resource scarcity and value. (Submitted to Agroforestry Systems) (A)

MARUZANE, D., MCGREGOR, J. and MUKWEKWERERE, M. (1999) The Role of African Acacias in Communal Area Farming Systems in Zimbabwe - Final Socio-Economic Report. Project R6550 Report. Oxford. Oxford Forestry Institute. pp. 35. (C)

MARUZANE, D. and MUKWEKWERERE, M. (1998a) The Role of African Acacias in Livestock Systems: the Case of Inkosikazi Co-operative, Siganda . Project R6550 Report. Oxford. Oxford Forestry Institute. 4 pp. (C)

MARUZANE, D. and MUKWEKWERERE, M. (1998b). African Acacias: Trip Report to Chivi, Zaka and Chiredzi. . Project R6550 Report. Oxford. Oxford Forestry Institute. 4pp. (C)

MARUZANE, D., and MUKWEKWERERE, M. (1998c) Uses of African *Acacia* Species in Ntabazinduna Communal Area: Results of PRA Workshops. Project R6550 Report. Oxford. Oxford Forestry Institute. pp. 12. (C)

MUKWEKWERERE, M. and MARUZANE, D. (1998a) Uses of Thorny Species in Gwanda Communal Area: Results of PRA Workshops. . Project R6550 Report. Oxford. Oxford Forestry Institute. 10 pp. (C)

MUKWEKWERERE, M. and MARUZANE, D. (1998b) The role of *Faidherbia albida* in farming systems of the Sebungwe Basin, Zambezi Valley. Project R6550 Report. Oxford. Oxford Forestry Institute. 4pp. (C)

PALMBERG, C. (1981) A vital fuelwood gene pool is in danger. Unasylva 33 (133) 22-30. (A)

TIMBERLAKE, J.R., FAGG, C.W. and BARNES, R.D. (1999) Field Guide to the acacias of Zimbabwe. CBC Publishing, P.O.Box 4611, Harare, Zimbabwe. 160pp. (Book)

Appendix 1. Provenance details for the six *Acacia* species in the screening trials

PROVENANCE	COUNTRY	CODE	LAT. LONG.	ALT. (m)	MAR (mm)	MAT (°C)	SEED TREES	Seed I.D. AH.CIRAD.FAO (ZFCFRC)
Acacia erioloba **(AE)**								
Imhohloweni	Zimbabwe	IMHO-ZIM	19.58S 28.31E	1195	541	19.6	25	18/92.-.-(23172)
Makatoolo	Zambia	MAKA-ZAM	15.56S 26.54E	1000	871	21.0	30	165/92.-.-(23177)
Potgietersrus	S.Africa	POTG-RSA	24.12S 29.01E	1020	622	18.7	25	176/92.-.-(23179)
Twee Rivieren	S.Africa	TWEE-RSA	26.29S 20.37E	900	197	20.1	25	177/92.-.-(23222)
Shorobe	Botswana	SHOR-BOT	17.37S 23.43E	945	453	21.9	51	169/92.-.-(23178)
Acacia karroo **(AK)**								
Lake Nhlabane	S. Africa	NHLA-RSA	28.39S 32.16E	10	1054	21.1	20	24/92.-.-(23196)
Umgusa	Zimbabwe	UMGU-ZIM	19.58S 28.30E	1180	541	19.6	25	21/90.-.-(23195)
Mutorashanga	Zimbabwe	MUTO-ZIM	17.10S 30.42E	1450	873	15.3	80	170/92.-.-(23182)
Linthipe	Malawi	LINT-MAL	14.10S 34.08E	1200	905	16.9	80	171/92.-.-(23223)
Udu Dam	Zimbabwe	UDUD-ZIM	18.17S 32.42E	1500	973	16.5	50	174/92.-.-(23183)
Signal Hill	S. Africa	SIGN-RSA	33.56S 18.25E	150	630	17.4		5/94.-.-(23184)
Bazaruto Island	Mozambique	BAZA-MOZ	21.31S 35.29E	5	1000	24.0	25	11/94.-.-(23180)
Jedibe Island	Botswana	JEDI-BOT	19.02S 22.33E	885	501	22.1	25	7/94.-.-(23185)
Opuwo	Namibia	OPUW-NAM	18.38S 13.43E	1350	306	21.5		76/94.-.-(23173)
Calitzdorp Spa	S. Africa	CALI-RSA	33.40S 21.47E	450	254	17.9	25	13/94.-.-(23181)
Acacia nilotica **ssp.** ***kraussiana*** **(ANK)**								
Chantulo	Malawi	CHAN-MAL	14.19S 34.48E	490	826	24.2	45	73/92.-.-(23200)
Chivu	Zimbabwe	CHIV-ZIM	19.05S 30.46E	1375	653	17.9	25	61/90.-.-(23199)
Mokgware	Botswana	MOKG-BOT	22.45S 26.35E	1000	431	19.5	20	31/90.-.-(23198)
Tsumeb	Namibia	TSUM-NAM	19.05S 17.51E	1200	518	21.9		75/94.-.-(23174)
Hluhluwe	S.Africa	HLUH-RSA	28.05S 32.02E	180	1127	19.9	25	26/92.-.-(23197)
Acacia nilotica **ssp.** ***leiocarpa*** **(ANL)**								
Sabaki	Kenya	SABA-KEN	03.11S 40.07E	20	1053	26.5	26	82/90.-.-(23201)
Acacia nilotica **ssp.** ***adstringens*** **(ANA)**								
Laf Madiam	Cameroun	LAFM-CAM	10.17N 14.14E	450	784	29.0		-.-.-(23292)
Umm Ruwoba	Sudan	RUWO-SUD	12.55N 30.25E	580	380		25	7/93.-.-.-
Keur Sabakhane	Senegal	KEUR-SEN	16.30N 15.30E					-.-.-(23291)
Acacia nilotica **ssp.** ***subulata*** **(ANS)**								
Makueni	Kenya	MAKU-KEN	01.35S 37.13E	1600	745	19.2	26	81/90.-.-(23202)
Acacia nilotica **ssp.** ***nilotica*** **(ANN)**								
Wad. Nimir	Sudan	WADN-SUD	14.30N 32.10E	400	300		40	1644/86.-.-(23226)
Acacia nilotica **ssp.** ***indica*** **(ANI)**								
Nalgonda	India	NALG-IND	17.27N 78.28E	545	764		50	1219/83.-.-(23186)
Acacia nilotica **ssp.** ***cupressiformis*** **(ANC)**								
Pune	India	PUNE-IND	18.32N 73.51E	559	714		25	1082/82.-.-(23225)
Acacia nilotica **ssp.** ***tomentosa*** **(ANT)**								
Ngaoule	Senegal	NGAO-SEN	16.38N14.58W	6	311	28.3	20	64/88.-.-(23203)
Hariri Forest	Sudan	HARI-SUD	13.05N 33.56E	430	588		25	1053/82.-.-(23227)
Acacia senegal **var.** ***senegal*** **(ASS)**								
Dendoudi	Senegal	DEND-SEN	15.22N 13.31E	60	600		26	-.-.-(23294)
Fallatu Forest	Sudan	FALL-SUD	13.10N 30.14E	570	365		27	15/93.-.-.-
Chetmari	Niger	CHET-NIG	13.10N 12.25E	309	236	27.5		-.-.-(23295)
Mtandika 2	Tanzania	MTAN-TAN	07.30S 37.43E	900	365	23.0	31	14/92.-.-(23205)
Acacia senegal **var.** ***leiorhachis*** **(ASL)**								
Oltepesi	Kenya	OLTE-KEN	01.33S 36.24E	1400	588	22.2	33	83/90.-.-(23228)
Acacia tortilis **ssp.** ***heteracantha*** **(ATH)**								
Birchenough Bridge	Zimbabwe	BIRC-ZIM	19.57S 32.22E	500	408	22.3	25	14/90.-.-(23206)
Maun	Botswana	MAUN-BOT	19.56S 23.30E	745	453	21.9	30	166/92.-.-(23187)
Sesfontein	Namibia	SESF.NAM	19.10S 13.48E	600	98	24.0	27	69/92.-.-(23207)
Gungundhlovu	S.Africa	GUNG-RSA	28.26S 31.15E	700	808	19.2	15	27/92.-.-(23284)
Acacia tortilis **ssp.** ***raddiana*** **(ATR)**								
Negev	Isreal	NEGE-ISR	30.47N 35.12E	100	40		20	1284/84.-.-(23231)
Guidick Mbane	Senegal	GUID-SEN	16.55N 15.53W	6			30	1195/83.-.-(23232)
Bara (N. Kordofan)	Sudan	BARA-SUD	13.48N 30.12E	400	300		25	1240/84.-.-(23230)
Bouza	Niger	BOUZ-NIG	14.14N 05.38E	365	519	28.0		-.-.-(23293)
Shela	Kenya	SHEL-KEN	02.17S 40.54E	10	917	26.6	18	72/92.-.-(23208)
Acacia tortilis **ssp.** ***spirocarpa*** **var.** ***spirocarpa*** **(ATSS)**								
Turkwell	Kenya	TURK-KEN	03.07N 35.37E	507	179	29.3	21	70/92.-.-(23188)
Tomali	Malawi	TOMA-MAL	16.09S 34.47E	95	811	26.3	25	129/91.-.-(23209)
Devure	Zimbabwe	DEVU-ZIM	20.10S 32.10E	550	516	21.6	25	46/90.-.-(23210)
Gwai River	Zimbabwe	GWAI-ZIM	18.37S 27.10E	900	665	21.6	25	18/90.-.-(23212)
Acacia tortilis **ssp.** ***spirocarpa*** **var.** ***crinita*** **(ATSC)**								
Tsumeb	Namibia	TSUM-NAM	19.16S 17.39E	1311	518	21.9	23	10/90.-.-(23211)
Makueni	Kenya	MAKU-KEN	01.35S 37.13E	1600	745	19.2	30	85/90.-.-(23213)
Faidherbia albida **(FA)**								
Sabce (Kongoussi)	Burkina Faso	SABC-BUR	13.13N 01.35W	338	400		10	-.8005038.-(23290)
Matameye	Niger	MATA-NIG	13.25N 08.28E	450	560		20	-.8005035.-(23289)
Gutale	Cameroun	GUTA-CAM	10.57N 13.55E	450	850		22	-.-.-(23288)
Bignona	Senegal	BIGN-SEN	12.45N 16.25W	10	1408	26.5	20	8/92.-.-(23193)
Taveta	Kenya	TAVE-KEN	03.24S 37.42E	760	545	23.5	34	179/92.-.-(23283)
Wagingombe	Tanzania	WAGI-TAN	08.51S 34.38E	1450	819	20.6	74	5/92.-.-(23175)
Bolero	Malawi	BOLE-MAL	10.58S 33.43E	1100	701	21.0	25	78/90.-.-(23219)
Chawanje	Malawi	CHA2-MAL	14.39S 34.48E	600	824	24.2	71	7/92.-.-(23218)
Chawanje	Malawi	CHA1-MAL	14.39S 34.48E	600	824	24.2	9	80/90 -.-.- (23220)
Mana Pools	Zimbabwe	MANA-ZIM	15.45S 29.20E	360	628	25.1	35	23/90.-.-(23215)
Gona-re-Zhou	Zimbabwe	GONA-ZIM	21.18S 32.22E	130	548	20.5	25	30/92.-.-(23191)
Kuiseb	Namibia	KUIS-NAM	23.34S 15.02E	400	20	16.8	25	84/90.-.-(23221)

PROVENANCE	COUNTRY	CODE	LAT. LONG.	ALT. (m)	MAR (mm)	MAT (°C)	SEED TREES	Seed I.D. AH.CIRAD.FAO (ZFCFRC)
Pongola River	S. Africa	PONG-RSA	27.02S 32.16E	40	1200	21.5	25	88/93.-.-(23176)
Kapula	Zimbabwe	KAPU-ZIM	18.42S 26.17E	975	568	24.0	25	23/93.-.-(23216)
Kunene River	Namibia	KUNE-NAM	17.15S 12.26E	250				15/94.-.-(23233)
Rama	Ethiopia	RAMA-ETH	14.23N 28.48E	1350				17/94.-.-(23189)
Wad Medani	Sudan	WADM-SUD	14.16N 33.38E	200			16	22/94.-.-(23214)
Obeid	Sudan	OBEI-SUD	12.48N 30.00E	200			19	23/94.-.-(23217)
Mojo	Ethiopia	MOJO-ETH	08.29N 39.10E	1800				81/94.-.-(23194)
Lake Awassa	Ethiopia	AWAS-ETH	07.03N 38.28E	1650				24/94.-.-(23190)
Hoanib River	Namibia	HOAN-NAM	19.14S 13.23E	350	98	24.0	6,40	6/92.-.-(23192)