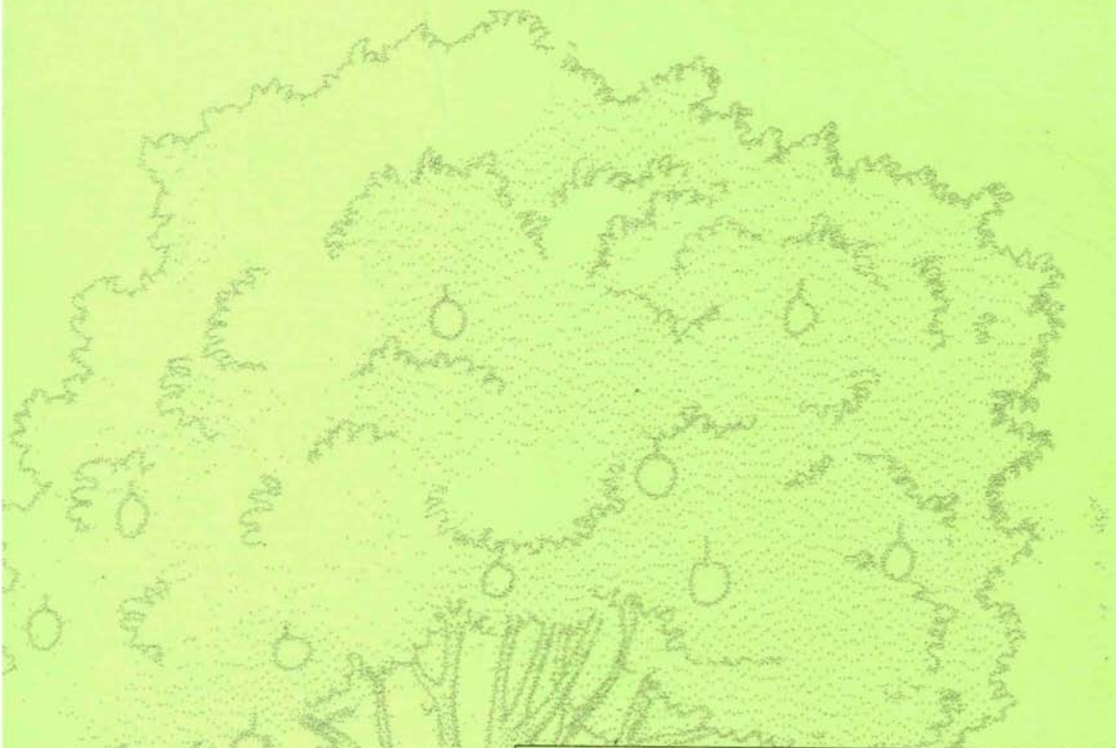

Proceedings of the International Consultation on the Development of the ICRAF MPT-Germplasm Resource Centre

Nairobi, 2-5 June 1992

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The International Centre for Research in Agroforestry (ICRAF) is an autonomous, non-profit organization with a mandate to initiate and support research on agroforestry. It is governed by a Board of Trustees with equal representation from developed and developing countries. Established in 1978, ICRAF has its headquarters in Nairobi, Kenya.

ICRAF is a member of the Consultative Group on International Agricultural Research (CGIAR). Financial support is provided by bilateral, multilateral and private donors. In 1993, these included the World Bank (International Bank for Reconstruction and Development), the African Development Bank, the International Fund for Agricultural Development (IFAD), the International Development Research Centre (IDRC), the Swedish Agency for Research Cooperation with Developing Countries (SAREC), the Ford Foundation, and the Governments of Australia, Canada, Finland, France, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom (UK), Belgium, Ireland, Spain, and the United States of America (USA).

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A special thank you goes to our sister International Centres viz ILCA, IITA, CIAT, IBPGR, and CIFOR in coming to the Consultation and supporting our ideals as regarding MPT germplasm collection, evaluation, conservation and use. Two regional networks are also thanked viz F/FRED (Winrock) in Asia and T.S.C.N. (CIDA) in Southern Africa for providing funds so that their representatives could attend.

ACRONYMS

AFRENA	Agroforestry Research Network for Africa - HULWA (Humid Lowlands of West Africa) - SALWA (Semi-Arid Lowlands of West Africa) - East Africa Afrena - Southern Africa Afrena
CAMCORE	Central America and Mexico Coniferous Resources Cooperative, USA
CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica
CGIAR (CG)	Consultative Group on International Agricultural Research - IRRI (International Rice Research Institute) Philippines - IITA (International Institute for Tropical Agriculture) Nigeria - IPGRI (International Plant Genetic Resources Institute) Italy - ILCA (International Livestock Centre for Africa) Ethiopia - ICRISAT (International Research Institute for Semi-Arid Tropics) India - CIFOR (Centre for International Forestry Research) - CIAT (Centro Internacional de Agricultural Topical) Colombia
CILSS	Comite Inter-Etats de Lutte Contre la Secheresse au Sahel - Centre National de Semences Forestieres, Burkina Faso
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
CTFT	Centre Technique Forestier Tropical, France
DFSC	Danida Forest Seed Centre, Denmark
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brazil
FAO	Food and Agriculture Organisation (United Nations), Italy
ICRAF	International Centre for Research in Agroforestry
ISTF	International Society for Tropical Forestry
ITE	Institute for Terrestrial Ecology, United Kingdom
IUFRO	International Union of Forestry Research Organisations - SPDC (Special Program for Developing Countries)
KARI	Kenya Agricultural Research institute
KEFRI	Kenya Forestry Research Institute
MPT-GRC	Multipurpose Tree Germplasm Resource Centre
NARS	National Agriculture Research Services. This generic term is also used to imply National Forestry Research Services
NFTA	Nitrogen Fixing Tree Association, Hawaii, USA
NifTAL	Nitrogen Fixation by Tropical Agricultural Legumes, Hawaii, USA
OFI	Oxford Forestry Institute, United Kingdom
SADCC	Southern Africa Development Coordination Conference
ZFRC	Zimbabwe Forest Research Centre

INTRODUCTION

World attention on agroforestry in general and MPT germplasm in particular has increased substantially in recent years. This can be seen from the increase in literature and research on agroforestry and the development of new national forest seed centres in many developing countries. Among the many benefits claimed for trees on farmlands are wood for fuel and poles, leaves for soil improvement and fodder, edible fruits, and environmental benefits such as control of soil erosion and inputs of nitrogen through rhizobia. One feature rarely mentioned but very important is that of conservation of biodiversity whereby many MPTs (over 2000 species) are conserved either *in situ* or *ex situ th*rough use on farm lands. It is only a short step from trees on farms to conserving and dispensing germplasm from well established germplasm research centres.

ICRAF, in taking a decision to develop a MPT-Germplasm Resource Centre, believed that it should consult widely with all major players to avoid any future duplication of effort. It is in this spirit that ICRAF management called together participants for the consultation.

ICRAF was particularly aware that several sister CGIAR centres had interests in MPT germplasm. These were ILCA (fodder legumes in sub-saharan Africa), IITA (legumes for soil improvement and growth on difficult sites e.g. acid soils), IRRI (aquatic legumes), CIAT (legumes for fodder and acid soils), and ICRISAT (perennial pigeon peas). It would seem, therefore, that within the CGIAR system there could be a diffusion of effort. The CG therefore asked ICRAF to develop the MPT-GRC as a global focal point for MPT-germplasm within the CGIAR. With these thoughts in mind it was considered useful to involve sister CG centres in discussions, as early as possible.

Invitations to participate were sent to; CGIAR Centres involved in MPTs, developed country seed centres active in the international arena e.g. OFI, CSIRO, etc. and regional seed banks active in developing countries through networks e.g. Asean/Canada Forest Tree Seed Centre. FAO, who has been very active internationally in forest seed issues over a number of years was invited. It was felt that at this stage it would be more fruitful to learn from major international groups rather than from country specific programmes. Country programmes can be brought in later in ecoregional linkages as they develop in relation to MPT germplasm issues. Two important exceptions to this decision were the invitations sent to KEFRI Tree Seed Centre (Kenya) and Tree Seed Centre (Forest Research Centre (Zimbabwe) because of their active role as near neighbours to ICRAF in East Africa. In total the consultation attracted 57 participants (see Part C for list of names of participants). The Agenda for the consultation approximately followed the contents for these Proceedings.

It was ICRAF's desire that the consultation would be a good opportunity for participants to:-

(a) react to the ICRAF discussion paper on the development of the Centre. (This discussion paper was previously circulated (in February 1992) to potential consultation participants)

(b) formally present their current and future plans for MPT germplasm.

(c) through well-structured working groups develop a practical research and development programme to help ICRAF commence the MPT-GRC without duplication of effort.

We were most fortunate in obtaining the services of Professor Jack Hawkes, University of Birmingham to provide the special guest lecture and so set the scene for this important consultation.

I wish to acknowledge the following persons for kindly accepting the position of Chairman of Sessions during the Consultation *viz.* J. Burley, J. Turnbull, J. Brewbaker, J. Maghembe, B. Dvorak, P. Sanchez; and as Rapporteurs P. Cooper, J. Weber, F. Kwesiga, A. Higa, P. Singleton. The participants also went on a field trip to Machakos and thanks go to Drs M.R. Rao and C. Ong for organising an enjoyable visit.

As an historical record of the meeting ICRAF undertook to publish the Proceedings. Two additional papers were tabled but not formally presented at the Consultation *i.e.* one by J. Brewbaker and another by D. Rukuni and D. Gwaze. Both papers are included in these Proceedings.

D.J. Boland

Rest stop on a high mountain in Ecuador. Jack Hawkes in the Centre at the back on his first collection expedition in 1939.

SUMMARY PROFILE OF HIGHLIGHTS OF PROF. JACK HAWKES' CAREER

Professor Hawkes has had an illustrious career in the conservation and use of crop germplasm. He -

- obtained both a Ph.D. and D.Sc. from Cambridge University
- undertook many expeditions to South America and Mexico to collect wild potato germplasm for evaluation and use in potato breeding.
- was associated with FAO from 1961 onwards in the creation of crop genetic resources as a scientific discipline. In collaboration with others he made a blueprint for the creation of IBPGR.
- chaired EUCARPIA (European plant breeders association) gene bank committee and genetic resources section for 27 years.
- founded the first ongoing genetic resources Master of Science training course at Birmingham University in 1969. This course still continues and has trained over 250 to M.Sc. level and about 100 others undertaking short intensive courses on genetic resources.

Keynote Consultation Address

Genetic Conservation of World Crops

/ G *Hawkes*
University of Birmingham
Birmingham, United Kingdom

Introduction

It seems highly probable that the first scientist to recognize the value of genetic diversity to crop plant breeders was the now world-famous geneticist, NI Vavilov. Before Vavilov's time it was assumed that the rather small range of diversity available to breeders in their own countries was a sufficient basis for new variety production.

As is well-known at present, Vavilov, even as a student, began to explore the genetic diversity within crops - especially those of the southern and central Asian regions of his own country. He and his colleagues in the Institute of Plant Industry in Leningrad studied and classified this diversity and the particular agricultural systems in which it was employed (Hawkes 1987). Over the years they undertook a vast number of collecting expeditions to most parts of the world and amassed some 250,000 collections in total. These were regularly grown out in experimental fields throughout the USSR and used as a basis for breeding new varieties, resistant to pests and diseases and able to withstand a wide range of environmental stress (Vavilov 1926,1951).

It must thus be accepted that Vavilov was the founder of the science of genetic resources exploration, conservation and use in plant breeding. However, he did not seem to be aware of the loss of genetic diversity, which is so prevalent nowadays. For this he should perhaps not be blamed, since this process had hardly taken place to any significant extent until after his imprisonment in 1940 and death in 1943.

Vavilov's major contribution - and it was a very large one - is to have made the scientific community aware of the extremely important range of genetic diversity present in the ancient land races that had developed over several millennia in different parts of the world under traditional agricultural systems. He and his colleagues also drew attention to the wild and weedy forms related to the cultigens and capable of exchanging genes with them, thus enriching the gene pool of the cultigens. Vavilov's theories of crop plant origins contributed to the theoretical background of his work, in this respect following on from the seminal studies in the previous century of Charles Darwin (1868) and Alphonse de Candolle (1882).

A point of great significance at that time was the discovery that crop plant diversity was not spread uniformly throughout the world, but was concentrated in some eight major centres (or areas) in different parts of the world, where Vavilov thought that the crops occurring in them had been originally domesticated. These centres of diversity, commonly known as "gene centres" have been frequently described, modified or even denied (Harlan 1971; Hawkes 1983). Nevertheless it is quite clear that there are or were certain regions of the world which for various reasons developed far more genetic diversity in their crop plants than in other regions. This is not the time or place to go into details but the importance of such "gene centres" has had great influence on genetic diversity conservation, and has played an important role in early attempts to explore and conserve crop plant diversity.

Overlapping Vavilov by over 30 years was the barley breeder, Harry Harlan, who died in 1944. It seems that they never met. Unlike Vavilov, however, Harlan saw the danger of what we now call "genetic erosion" in barley crops; and he and his assistant published a warning (Harlan and Martini, 1936) long before others had come to recognize this danger. Harlan's book (posthumously published by his son, Jack Harlan, in 1957) makes the point very clearly:

"Every bit of evidence we have indicates the need for speed. If we are to save the heritage that has come to us we must do it now. Valuable genes that may never reoccur are being lost every year. It is not time to argue about whether we can improve barley better than did the peoples who came before us. As long as we do not know, the obligation is upon us to pass along all we can to the better-informed generations that follow, for that may well be our greatest contribution. For ourselves and for the sake of generations to come we must collect all we can of this unlimited material that beckons to us in endless variety from every mountain terrace and remote valley of half the world. It has accumulated for thousands of years and must contain many things which we will need some day. Tucked away in the hills of China or Nepal may be a barley that will one day save the crop of Montana from a disease we have never seen. This barley may be gone tomorrow." What an incredibly prophetic statement this was for someone writing in the 1930s!

So even in Vavilov's day the genetic diversity of crops was in fact beginning to disappear, and in the 1950s various agronomists working at FAO were also to show awareness and concern about this trend.

History of Genetic Resources Conservation

This concern brought the decision to hold a Technical Meeting on Plant Exploration and Introduction (FAO, 1961) which was held at FAO headquarters in Rome, the organisers being Jose Vallega, Robert Whyte and G Julen (Whyte and Julen 1963). Scientists from 28 countries attended, and the report clearly emphasized the threat to genetic resources now occurring in the Vavilov gene centres and elsewhere. It further recommended that "Exploration Centres" should be established at or near such gene centres after a careful evaluation had been made of the genetic diversity in them. Proposals were made for the establishment of exploration centres in north-west Argentina, north Pakistan and Turkey. The establishment of Introduction Stations to hold the materials collected, information on phytosanitary measures, the need for practical field training, research, quarantine stations, etc. were also stressed. The Conference further recommended that an expert panel should be set up to "assist and advise" the Director of the Plant Production and Protection division in this field.

As with many such meetings, the recommendations mostly failed to be carried out. An Exploration Centre was established in Turkey, however, but with considerable misunderstanding between FAO and the Turkish Government as to its true nature. An Expert Panel did eventually materialise, but not until 1965, and was named "The FAO Panel of Experts on Plant Exploration and Introduction". It met six times, the final session being in 1974, the year in which The International Board for Plant Genetic Resources (IBPGR) was established. Permanent members were Sir Otto Frankel (Canberra), myself (Birmingham) and Erna Bennett, from the newly established Crop Ecology and Genetic Resources Branch of the FAO Plant Production and Protection Division. Frequent participants were John Creech (USA), Marzocca (Argentina), Pal (India), Jack Harlan (USA), Swaminathan (India), Mengesha (Ethiopia) and several others.

During this period also, the Genetic Resources and Crop Ecology Unit began publishing a Genetic Resources Newsletter, successor to FAO's Plant Introduction Letter.

The task of the Expert Panel was to identify priorities for exploration and to expedite a survey of gene resources in the field - later to be edited by O H Frankel (1973) and published by FAO and IBP - The International Biological Programme. The panel also accorded top priorities to genetic resources conservation in Ethiopia and Central America. Their advice was taken up later by the Government of West Germany who established centres to conserve what were now being called "genetic resources".

Running in parallel was the work of Eucarpia, the European Association for Research in Plant Breeding, which established a Gene Bank Committee in 1966 of representatives from Sweden (Ellerstrom), West Germany (Lein) and Holland (Lamberts). At Vienna in 1968 the committee recommended that three regional gene banks be established for Europe to conserve European genetic resources, even though Europe did not figure as one of the Vavilov Centres. In later meetings it was suggested that there might be a bank for southern European crops (established later in Bari, Italy), western European crops (Braunschweig, West Germany) and far northern crops. This later matured as a Nordic gene bank cooperatively funded and controlled by the five Nordic countries - Denmark, Finland, Iceland, Norway and Sweden. Eastern crops were covered by the long-established Vavilov gene bank at Leningrad. Although this regional concept had been widely canvassed it in fact failed, apart from the Nordic countries; thus little by little nearly every European country established its own bank or "genetic resources centre" as the FAO panel termed it. (See Hawkes and Lange 1973).

We must now retrace our steps a little to another important genetic resources event, namely, the second FAO/IBP Conference on genetic resources held at Rome in 1967 (Bennett 1968).

This conference, the proceedings of which were later published as a book (Frankel and Bennett 1970) really began to establish genetic resources as a discipline in its own right, even though it drew expertise from many sources. It became clear that taxonomists were needed to identify and define the morphological and geographical ranges of crop plants and their wild relatives; that population geneticists were required to suggest sampling techniques that would capture the maximum amount of genetic diversity possible; ecologists were needed to understand the diversity in wild ecosystems and in agro-ecosystems (in both field crops and in forestry); pathologists were needed to deal with quarantine problems; evaluation and utilization were also debated; conservation of genetic resources was also addressed, as well as information storage and retrieval systems.

Thus, the stage was set, and although it cannot be claimed that most of the problems were solved, at least they were brought into the arena for discussion. Furthermore, the conservation of eight major field crops was discussed, with a chapter on temperate zone tree fruits.

Much discussion had also centred on possible organization and funding of what was clearly to be a gigantic world task.

When I returned to Birmingham after this extremely valuable conference I was suddenly struck by the fact that there had been no discussion on who was to accomplish all these tasks. Although by then it had become clear to me that there might possibly be nearly as much genetic diversity outside the Vavilov gene centres as there was inside them, much of the most interesting genetic resources materials was to be found in the tropic to warm temperate zones. Perhaps about 20 of us possessed the technical abilities to deal with the problem but this small number was clearly inadequate. What could be done to solve this problem?

Since I was Professor and Head of a Department of Plant Biology I decided (after discussing the matter with FAO) to establish a Masters course so as to provide genetic resources experts for the future. The course began in 1969 and is still continuing, having trained over 250 participants to Masters level, and nearly 100 3-month option students. Naturally, other valuable single training courses have been offered in various parts of the world from time to time, and thus a cadre of trained personnel has gradually become available.

Two other important events took place at the end of the 1960s and in the early 1970s. The first was the establishment of the United Nations Environment Programme which allocated money for genetic resources, and particularly in the area of training. The second was that the Consultative Group for International Agricultural Research (CGIAR) adopted a resolution of its Technical Advisory Committee (TAC) to support a network of genetic resources centres and to promote the establishment of gene banks in each of its own IARCs, such as CIMMYT, CIP, CIAT, IITA, IRRI, etc. These latter would of course include only the major crops and wild relatives for which each Centre has a remit.

For the former part of the resolution the FAO panel of experts met at Beltsville, USA, to work out such a network of genetic resources centres, established on a regional basis throughout the world.

The plan was adopted, funded by Foundations and Donor Countries (as was the existing CGIAR network). As a result, the International Board for Genetic Resources (IBPGR) was created in 1974, linked to FAO and having its headquarters within FAO in Rome. By the end of this year, 1992, IBPGR will become an autonomous organization, with Rome as its headquarters. It will then be designated as the International Plant Genetic Resources Institute (IPGRI). For further details see Diversity, 1992. We shall return to its activities later.

We must now return to the conference supported by FAO and IBP which took place in 1972 at FAO headquarters in Rome. This conference resulted in the publication of perhaps the most innovative of all genetic resources efforts in the decade, namely an IBP book entitled Crop Genetic Resources for Today and Tomorrow (Frankel and Hawkes, 1975). It dealt with exploration, sampling theory and practice, conservation and storage, evaluation, documentation and information management, and, finally, gave some examples of genetic resources centres.

I believe that by far the most valuable aspects of the conference and the book that followed it lay in the areas of sampling strategies (Part I) and conservation (Part IV) though this is not to belittle the other sections.

Sampling had been discussed in the previous volume (Frankel and Bennett, 1970) but from the 1975 volume we really had a clear directive on which to work (Marshall and Brown 1975; Jain 1975a). Evaluation problems were outlined and were of considerable interest, though a systematic methodology was to come later, with IBPGR.

Conservation and storage was perhaps the most important of all, since we had expert seed physiologists and tissue culture workers speaking on the problems of *ex situ* (off site) storage, as well as *in situ* (on site) conservation. (See especially Roberts, 1975; Villiers 1975; Morel 1975; d'Amato 1975; Jain 1975b).

The pace of development of computer hardware and software systems has been so rapid as to render obsolete the section of documentation, which was nevertheless an excellent attempt to describe the situation some 15 years ago (Rogers et al 1975).

After this conference the stage was clear for IBPGR to provide technical advice and funding for national genetic resources centres, which they carried out brilliantly, making use of experts working within and outside the organization. Funding was clearly insufficient for all the equipment needed, especially for seed and tissue culture storage and computer hardware. Much of this was undertaken by international and national donor agencies, who made much use of IBPGR's expertise.

Present Genetic Resources Technologies

The proceeding section must sound rather confusing but the period from 1961 to 1975 was an extremely exciting and rewarding one. At the beginning very few people knew or cared about genetic resources. At the end, largely due to the energy and drive of Otto Frankel, awareness and concern were mobilized and the technological foundations for all the main facets of this discipline had been established. There was much to be done, but FAO and IBPGR were well able to carry most of it out, together with the CGIAR International Agricultural Research Centres.

It seems appropriate now to try to sum up the state of the art for different Genetic Resources aspects, as follows.

Exploration and Survey

It is quite clear that much time and money can be wasted by going into the field without a knowledge of the taxonomy, distribution and ecological adaptation of the crops and wild species that it is proposed to collect. Literature and herbarium research are thus essential prerequisites for a collecting expedition, which may be confined to one crop (wheat, for example, including related wild species) or several crops (cereals and legumes, for example, of a specific region).

Sampling

For seed crops the procedure recommended by Marshall and Brown (1975) is generally followed whenever possible by bulking up 50 seeds each from 50 to 100 plants taken at random from a field by making some evenly spaced transects through it (see also Bennett 1970).

Selective sampling is not recommended, but if it is done it should be by making another sample. Small fields or plots must be sampled by taking smaller samples but still at random, whilst if the crops are harvested, random spikes or handfuls (if in a grain store) can be taken. This gives a 95% certainty of at least one copy of each allele having a frequency of greater than 5%.

For wild plants, generally with smaller populations, random sampling or an equal number of seeds from each plant can be taken.

For clonally propagated crops the technique recommended by myself (Hawkes 1975) is to take a sample of every identifiable clone (by examining tubers) in each market area. This involves much duplication but is safer than trying to remember the shape, colour and patterning of a sample taken several days or weeks before. Duplicates can later be eliminated in the experimental field.

For crops and wild relatives samples should be taken from throughout their total ranges whenever possible.

For tree crops, because individual trees of a target species may occur at only wide intervals, random sampling may not always be possible (Sykes 1975). In this case it may be best to take seeds from every few Km distance but on an unbiased basis. Such sampling of provenances in an unbiased or random form may not suit the aims of agroforestry, and possibly other techniques might have to be followed.

Seed conservation (ex situ)

(a) Orthodox seeds

The types of seed described below are spoken of as "orthodox", and respond to the following storage conditions.

Seeds when cleaned and dried should be put through quarantine and given a germination test. The standard storage procedure is based on Roberts (1975, 1991) who recommends bringing the moisture content down to 4-5% in a drying chamber or over silica gel. They are then cooled - generally to -18°C, which is the usual temperature of a deep freeze chamber. Lower temperatures do no harm apparently but are expensive to run, especially in the tropics. Germination tests should be run every 5-years to ascertain whether germination is declining. If this is happening, to say 50% germination, evidence shows that the mutation rate has increased very considerably. Thus the general advice is to regenerate the seeds if the viability drops below 85% of what it was when the seeds first went into store.

The Panel of Experts had previously accepted two main types of storage namely-

Base collections - where long-term storage is envisaged. These are the conditions mentioned above. Base collections must be sent to other gene banks, preferably in another country or even continent for safe keeping, to avoid total loss caused by man-made or natural disaster.

Active collections - where material is kept for shorter periods and distributed to breeders and evaluators. The seeds need not be dried so much as with base collections or kept at temperatures lower than zero. However, some gene banks like to keep both base and active collections under the same conditions. Working collections consist of material in direct use by plant breeders and do not need to be stored under special conditions.

(b) Recalcitrant seeds

The above type of seeds, known as orthodox, contrast with another group, known as "recalcitrant" which cannot be dried and cooled in the usual way, since they die very quickly under those conditions. Such recalcitrant seeds are particularly common in trees native to the humid tropics and thus pose a large problem for agroforesters. An intermediate group has also been identified, which include such important economic species as *Coffee arabica* and papaya *(Carica papaya),* which can be dried to 10% moisture content but die quickly at 0°C or below (Ellis et al 1990,1991).

It is suggested that recalcitrant-seeded species could perhaps be stored as tissue transplants, but generally much research is needed to obtain the correct conditions. Another possible method is "seedling storage" (Hawkes 1982) but again the necessary research for this has not yet been attempted.

One further line of research lies open to investigation - that of storage of fully imbibed seeds. The door was opened slightly by Villiers (1975) who found that fully-imbibed lettuce seeds could repair X-ray damage to their membranes - a very useful feature under long-term storage. Villiers was working with lettuce seeds which need a light stimulus to start germination. Many other seeds of course do not. Nevertheless, we know that fully imbibed seeds in soil seed banks in nature remain dormant. Possibly recalcitrant seeds do so also. One needs to find out the factors involved here. Constant low temperature and low oxygen may be part of the reason, since seeds brought up to the surface germinate at once, with high oxygen and fluctuating day/night temperatures. Here is an interesting and important problem for the seed physiologists!

In Vitro Storage (ex situ)

This is a promising method of storage of recalcitrant seeded and of vegetatively propagated crops.

The technology has been researched over a wide field and the literature is too voluminous to quote here. However, a useful recent summary has been published by Withers (1991). Whilst it is doubtful whether *in vitro* techniques can be considered yet as constituting base storage they can be very useful in combination with others. Certainly, both at CIP (International Potato Center) and CIAT (International Center for Tropical Agriculture) good programmes for potatoes and cassava respectively are in progress (Roca 1965). Cryopreservation techniques are also being investigated (Withers *I.e.).*

Field Gene Banks (ex situ)

A method of storage when seed or tissue culture techniques are unavailable is in plantations - named by IBPGR as Field Gene Banks. These are useful for herbaceous, shrubby or woody perennials which for various reasons cannot be stored as seeds or tissue cultures. They apply particularly to clonal material where the exact genotypes need to be preserved (e.g. bananas, cassava cultivars) or to recalcitrant or intermediate-seeded materials as described before. Collections of strains of aromatic or medicinal herbs are often grown in this way.

The disadvantages of field gene banks is that they can be destroyed by environmental disasters (floods, frosts, hail storms, etc.) and, so far as trees are concerned, occupy a very large space if a reasonably wide range of genotypes needs to be conserved.

Conservation (in situ)

It has frequently been maintained that conservation of genetic resources in their natural environment is likely to be the best way of all. It certainly allows the natural processes of evolution to continue, whereas these could be considered to be "frozen" in a seed or tissue-culture bank, or even deflected in a disadvantageous way. In particular, the natural balance between the plants on the one hand and their pests and pathogens is maintained.

Biosphere or nature reserves for wild species however, have their drawbacks:

i) Material is not immediately available to breeders for evaluation and use.

ii) Major climate fluctuations may cause their extinction unless the reserves enclose a very wide range of ecosystems.

iii) Unless sufficient individuals occur in the reserve, genetic drift or inbreeding depression may cause extinction.

iv) Reserves may suddenly be sequestered for other uses - roads, airports, cities, factory sites, etc.

v) The reserves can only contain a small part of the diversity known to be present in a very widespread species.

vi) No-one knows how large a reserve should be for a particular species or group (Jain 1975b). My guess is at least 500 - possibly up to 1000 individuals (Hawkes 1992 in press).

vii) Conservation of cultivars or land races by farmers may be possible but only to a restricted degree.

Summary of Conservation Methods

We have come a long way during the last three decades in devising ways of genetic resources conservation. The main point to understand is that there should be no antagonism between *ex situ* and *in situ* methods or between seed and tissue storage. For each situation or crop, choice must be made, often combining more than one of the methods available.

Evaluation

Genetic resources conservation is not altogether an end in itself. It is best considered as a heritage for present and future generations of plant breeders. Indeed it is necessary for each breeder of a particular crop to inform himself as to the qualities of the crop or related wild species that will be of use to him.

IBPGR devised a system of characterisation using descriptors and descriptor states to focus on morphological and highly heritable agronomic characters. This work can be very time-consuming and perhaps not so useful in the long run. There is no doubt that a national genetic resources centre ought to be in touch with breeders and should invite them to inspect the materials from the gene bank when grown out in the field.

Otherwise, so-called secondary evaluation may be of very great importance. This is the IBPGR name for screening for pest, disease, drought, salinity, etc. resistance. It would be difficult for a gene bank manager to carry out all aspects of this type of evaluation, but he should indeed act as a catalyst to see that it is done by experts in each particular field wherever possible. Thus the genetic resources material can be used in the breeding of new varieties, with better adaptation and resistance to diseases and pests. In this way the yields can be increased and standards of living will thus be improved.

Summary and Conclusions

One can look on genetic resources work as a series of impacts in a chain (see Fig.l), whereby each link has a good or bad impact on the next, according to how well it is being carried out (Hawkes 1989).

I have not yet returned to documentation. This is so clearly necessary - to store information on the "passport data" of collections and on the evaluation results mentioned above. However space will not allow a full discussion in this report.

Many details of genetic resources work, as it developed in the late 1960s and 1970s and 1980s have been omitted for lack of space. I hope to have conveyed, however, the sense of excitement and urgency that helped to inspire us during the times when the whole subject of crop genetic resources was being developed. I am delighted to have been asked to contribute to this Symposium and to see how the whole system of forest genetic resources is now being discussed.

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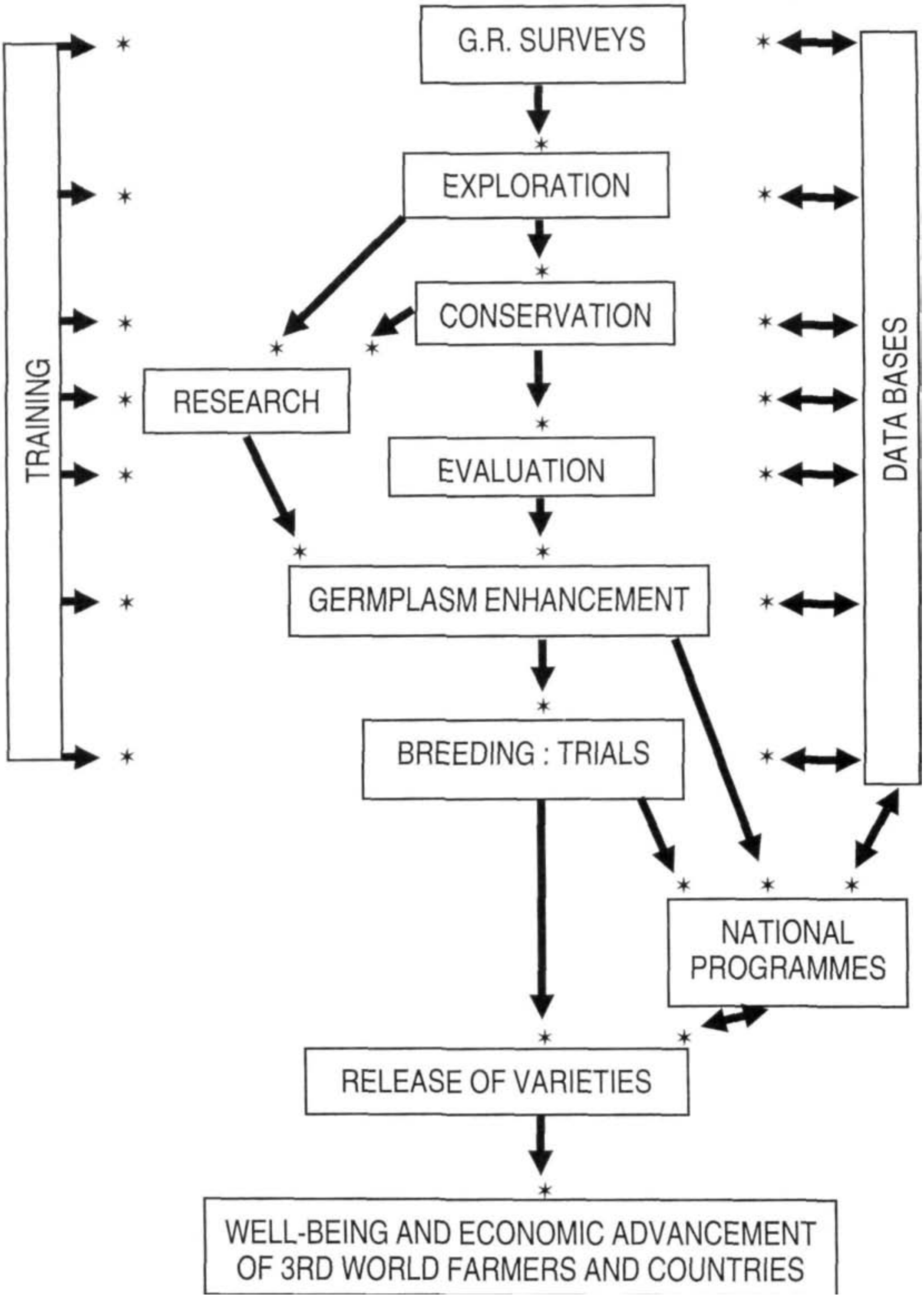
Fig.1: Genetic resources impact chain (redrawn from Hawkes 1985)



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1. Ques. I would appreciate learning more about some of your experiences with self versus cross-pollinated species; regarding germplasm preservation and evaluation. J. Brewbaker

Ans. There are problems with seed multiplication for germplasm centres in the case of cross pollinators. These must be isolated and pollinated artificially in greenhouses or screenhouses or in gauze tents in the field. By contrast, self-pollinators are easier to multiply.

2. Ques. The definition for the term recalcitrant is not very specific. For example seed of *Fagus silvatica* (considered recalcitrant) can't be dried and stored subzero temperatures until dormancy is broken and seeds start to germinate. Seeds treated like this have high survival rate even after 3-4 years storage. Seeds dried and stored at other stages of development fail to survive. Hans Muhs

Ans. We are now coming to realize that there are several intermediate stages between orthodox and recalcitrant seeds, as I mentioned in my address.

3. Comment The gene bank at Gatersleben (formerly G.D.R.) as a Central European Gene Bank has not been mentioned. This centre has done a lot of work in the field of plant genetic conservation. The gene bank at Gatersleben and Braunschweig (F.R. Germany) will collaborate in future, probably jointly in the same organisation. Hans Muhs

Ans. Yes, indeed. I have always been very impressed by the work of the Gatersleben Gene Bank and am glad to know that it will continue to be supported.

4. Comment Sample sizes used in Central European activities for conservation of forest genetic resources are much larger than the minimum number recommended (500) by Prof. Hawkes. Sample sizes contain several thousand up to 100,000 seeds/site. It has been found that forest trees have a high genetic diversity compared with crop species. Therefore sample size depending on species, should not be too small. Hans Muhs

Ans. Forest trees are wild and have thus not been selected by man for uniformity, as has been done with crop species. However our method is still valid for wild crop relatives, we believe. Another point concerning forest trees is that large amounts of seeds are required for distribution and storage, whilst with annual crops more seeds can be obtained by sowing seeds each year. This short turn-round cannot be accomplished with trees which may not bear seeds for a decade or more. I am still doubtful, however, as to whether there is a greater amount of genetic diversity in trees as compared with wild crop relatives.

PART A: PAPERS PRESENTED

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SOME NOTES ON ICRAFS RESEARCH AGENDA ON MULTIPURPOSE TREE IMPROVEMENT AND MANAGEMENT

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KENYA

Introduction

The aim of this presentation is to provide a summary overview of types of trees needed for specific agroforestry technologies and the strategies ICRAF is developing for MPT improvement. Such an introduction is necessary to set the background to the Consultation and indicate how the proposed MPT-GRC relates to ICRAF Programme 2 "MPT improvement and management" as a whole.

The overall goal of Programme 2 is "through selection, conservation, evaluation and management, identify and improve multipurpose tree species and provenances that have the proven potential to enhance the productivity, profitability, diversity and sustainability of small-scale farms in priority land-use systems."

Choice of priority species for improvement research

The following points should be considered when comparing forestry with agroforestry.

- About 400 tree species form the current production base of plantation forestry world wide.
- They are grown and managed for single or few products - fuelwood, timber pulp and paper etc.
- Emphasis is given to (i) broad site adaptability (ii) fast-growth (iii) crop ideotypes (iv) wood quality (v) pest/disease resistance.
- Silvicultural practices and management systems focused on maximum wood production with relatively little consideration of the sustainability of the production system.
- In contrast, thousands of multipurpose tree and shrub species could play valuable roles in both traditional and modern agroforestry systems
- Such species could be managed and improved for better production of food fodder, mulch, fuelwood, timber, etc.
- Improvement of such species should be attempted in the background of ecological interactions with companion crops.

Important characteristics of trees for agroforestry systems

These are at least six important characteristics of trees in agroforestry systems. These are:-

Characteristics of trees for fuelwood/pole production

- Total wood production
- Bole form
- Wood density
- Combustion properties

Characteristics of trees for fodder production

- Total annual fodder production
- Dry season fodder production
- Palatability
- Digestibility
- Animal performance

Characteristics of trees for soil improvement

- Total litter mulch production
- Litter/mulch quality (decomposition rate)
- Rooting habit (soil binding potential)
- Soil improvement through nitrogen fixation
- Better soil resource utilization through root symbionts

Tree adaptation to soil conditions

- Trees should be nutritionally variable i.e. should be able to grow well on a wide range of nutrient levels.
- Trees should have small nutrient needs and should have the ability to extract nutrients effectively from deficient soils.
- Trees should respond well to external inputs such as fertilizers and manure.
- Species screening should only be carried out on soils which have already been corrected for major nutrient deficits.
- Standardized inoculation with Rhizobium/mycorrhiza is a precondition to such multipurpose tree screening. Appropriate strains should be used recognizing specific strain interactions.

Specific tree adaptation characteristics

- Adaptation to drought
- Fire resistance
- Disease resistance/pest resistance

- Adaptation to acid soils
- Adaptation to saline soils
- Aerodynamic properties (windbreaks)

Other tree production characteristics

- Fruits and vegetables
- Valuable oils
- Resins
- Compounds for medicinal value
- Honey production

Priority tree species for specific agroforestry systems
The choice of priority species for defined agroforestry technologies/agroforestry systems in specific agro-ecological regions should be guided by:

- Potential of the tree species to solve specific landuse constraints pertaining in the agro-ecological region (e.g. soil fertility decline, fuelwood deficit etc.)
- Potential of the tree species to provide products (and beneficial ecological interactions with companion crops) for economic benefit to the farmer.
- Farmer-based preference and adoption surveys across the whole agro-ecological region
- Adaptation, growth and production information and data from multipurpose tree databases and literature
- Agroforestry technology research results within the region and elsewhere

Sequential considerations in the choice of species that deserve high research priority

Here we may consider at least three sequential considerations for choice of species.

Adaptation considerations

- Adaptability and good growth performance across the defined agro-ecological zones
- Adaptation to and the potential to improve specific soil conditions (e.g. acidic soils)
- Adaptation to and the potential to mitigate constraining soil water regimes (e.g. drought tolerance, soil microclimate changes).

Agroforestry technology considerations

- Compatibility with alternate crops (both below and above the ground)
- Special products and services (e.g. fodder, nitrogen fixation, fruits)
- Adaptation to intended tree management in specific agroforestry technologies
- Freedom from pests and diseases (including those of alternate crops)

Species-specific potential gains from improvement research

- Existing genetic variability as basis for further improvement (provenance, variety, intra-population variation in traits of importance)
- Demand projections for products of improved trees
- Market volume and value of products from improvement research

Species ICRAF has identified as important in three major regions of the tropics.

Through an iterative process ICRAF has found the following species to be important to agroforestry development in Africa, Asia and Latin America. These species are presented by region and in three Tables (Tables 1,2,3). These are:-

Table 1. Some important tree species for agroforestry systems in sub-sahara Africa (botanical name, common name and main uses)

Southern Africa		
Acacia albida	Gao	Timber, fodder, soil improvement
Calliandra calothyrsus	Calliandra	Poles, fodder, soil improvement
Leucaena leucocephala	Leucaena	Fodder, fuelwood, soil improvement
Sesbania sesban		Fuelwood, soil improvement
Gliricidia sepium		Fodder, mulch, fuelwood
Highlands of Eastern and Central Africa		
Calliandra calothyrsus	Calliandra	Poles, fodder, soil improvement
Leucaena diversifolia	Leucaena	Fodder, mulch, poles
Sesbania sesban	Sesbania	Fuelwood, soil improvement
Markhamia lutea	Markhamia	Timber, poles, mulch
Grevillea robusta	Silver oak	Timber, shade, mulch
Casuarinajunghuhniana	Casuarina	Poles, soil improvement
Semi-arid lowlands of West Africa		
Acacia albida	Gao	Timber, fodder, soil improvement
Prosopis africana	Prosopis	Fodder, timber
Combretum aculeatum		Fodder, timber/poles
Acacia nilotica		Timber, fodder, shade
Parkia biglobosa		Food, timber, shade
Butyrospermum parkii	Shea butter tree	Food, timber, mulch
Humid lowlands of West Africa		
Pentaclethra macrophylla		Food, poles, soil improvement
Acioa barterii		Food, poles, mulch
Dialium guineense		Food, timber, poles
Inga edulis		Poles, soil improvement
Gliricidia sepium	Gliricidia	Fodder, fuelwood
Calliandra calothyrsus	Calliandra	Poles, fodder, soil improvement
Irvingia gabonensis		Food, timber
Paraserianthes falcataria (syn. *Albizia falcataria*)	Falcata	Timber, poles, soil improvement

Table 2. Some important tree species for agroforestry development in humid lowlands of Asia (botanical name, common name, main uses)

Durio zibethinus	(Durian)	Food, fruits, timber, fodder.
Enterolobium cyclocarpum	(Earpod tree)	Fodder, saponin, nurse tree, food, timber, reneer, browse, forage, medicine.
Erythrinafusca	(Anii)	Food, fodder, green manure, pulp wood, N-fixation, shade.
Garcinia mangostana	(Mangosteen)	Food, green manure, timber
Gliricidia sepium	(Madre-cacao)	Shade, bee forage, fodder, erosion control.
Grevillea robusta	(Silky oak)	Bee forage, fuelwood, timber, shade.
Hevea brasiliensis	(Para rubber)	Latex, fuelwood, timber, soil conservation.
Leucaena leucocephala *Leucaena diversifolia*	(Ipil Ipil)	Soil improvement, fodder, food, contour hedgerows.
Mangifera indica *M. philippinensis* *M. altissima*	(Mango)	Food, fruit, timber, tool handles
Manilkara zapota	(Chico)	Food, gum, timber
Melia azedarach	(Persian lilac)	Fodder, medicine, essential oil, charcoal, bee forage, soil conservation.
Mimosa scabrella	(Mimosa)	N-fixation, shade, soil conservation
Paraserianthes falcataria (syn. *Albizia falcataria*	(Falcata, Moluccan sau)	Timber, fodder, soil conservation, fuelwood, pulpwood.
Pithecellobium dulce		Food, fodder, green manure, timber.
Prosopis pallida	(Prosopis)	Bee forage, food, fodder, soil conservation, N-fixation
Psidium guajava	(Guava)	Food, fuelwood
Sesbania grandiflora	(Katurai)	N-fixation, shelterbelts, soil conservation, food, pulp and paper.
Syzygium jambos	(Jambolan)	Food, medicine, shelterbelts.
Artocarpus altilis	(Breadfruit)	Vegetable, fruit, timber
Parkia speciosa	(Petai)	Fruit, fodder, soil improvement
Lansium domesticum	(Langsat)	Fruit, timber
Nephelium lappaceum	(Rambutan)	Fruit, timber
Artocarpus heterophyllus	(Jak fruit)	Fruit, vegetable, fodder
Cocos nucifera	(Coconut)	Food, fuelwood, fodder, fibre
Albizia lebbek	(Albizia)	N-fixation, fuelwood, veneer/plywood, soil conservation
Calliandra calothyrsus	(Calliandra)	Soil conservation, construction timber, fodder, green manure.

Table 3. Some important tree species for agroforestry systems in humid lowlands of Latin America (botanical name, common name, main uses)

Annona muricata	Graviola	Fruit, timber
Platonia insignis	Bacuri	Fruit, timber
Cordia alliodora	Cordia	Timber, shade
Erythrina poeppigiana	Erythrina	Shade, soil improvement
Swietenia macrophylla	Mahogany	Timber, shade
Theobroma grandiflorum	Cupuacu	Fruit, beverage
Bertholletia excelsa	Brazil nut tree	Timber, nuts
Bactris gasipaes	Pupunha	Heart of palm, fodder, fruit, timber
Gliricidia sepium	Gliricidia	Live fences, fodder, fuelwood
Inga edulis	Inga	Food, fodder, soil improvement
Garcinia mangostana	Mangosteen	Food/fruit, timber
Leucaena leucocephala	Leucaena	Soil improvement, fodder, food, fuelwood
Manilkara huberi	Macaranduba	Timber, shade,
Psidium guajava	Goiaba (Guava)	Fruit, poles
Hevea brasiliensis	Para rubber	Shade, latex, timber
Cocos nucifera	Coconut	Food, poles, shade
Carapa guianensis	Andiroba	Timber, shade
Acacia mangium	Mangium	Poles, soil improvement
Parkia speciosa		Fruit, fodder, soil improvement

Strategy for improvement of multipurpose trees for agroforestry systems

We have been considering a seven-step strategy for improving MPTs. These are-

Consideration of tree characteristics in the background of agroforestry technologies

- Figure 1 depicts modular relationships between landuse/farming systems, location of technology in systems, technology management specifications and the specification of tree characteristics.
- It is important that focus is maintained on those interrelationships in tree improvement research for agroforestry technologies.
- The real danger of losing this focus is a reversal to traditional tree improvement research under the name of agroforestry.
- Furthermore, consideration should be given to intended tree management and arrangement within agroforestry technologies.
- Technology-specific tree management options could include:-
  - — Coppiced trees in hedges (alley farming)
  - — Managed isolated trees on contour bunds/strips
  - — Pollarded trees in fodder banks
  - — Managed isolated trees in pasture/cropland
  - — Browsed trees in pasture
  - — Densely spaced trees in improved fallows

- Management of multi-strata, multi-species tree mixes
- Tree and crop mixtures in the early stages of tree plantation development (Taungya method)
- Isolated and densely planted trees as windbreaks
- Trees managed for live staking/live fencing

Defining ideal tree ideotype for agroforestry technology

- C.M. Donald introduced the concept of ideotypes in plant breeding using examples of rice and barley (see CM. Donald 1968).
- Essentially Donald extended plant breeder's concerns with (a) yield improvement and (b) defect elimination into ecophysiological adaptations of plant varieties.
- M.G.R. Cannell introduced the concept of ideotypes in tree breeding (see M.G.R. Cannell (1979).
- Cannell drew the distinction between "crop ideotype" and "isolation ideotype" among trees.
- The ideotype concept assumes even greater significance in selecting superior trees for agroforestry technologies as the breeder needs to consider ecological interactions between the tree and the accompanying crop(s).
- Furthermore, in defining the tree ideotype for an agroforestry technology, both above ground and below ground interactions should be considered.
- As examples, Figures 2 and 3 show contrasting ideotypes of *Calliandra calothyrsus* and *Sesbania sesban*

Determining superior trees for agroforestry technologies

- Based on the desirable ecological interactions with companion crops, the most desirable crown characteristics, should be determined together with appropriate superiority grading rules.
- Where possible desirable rooting patterns should be determined in the background of possible root competition with companion crops.
- It is important to take into account plasticity in various crown and rooting characteristics. Greater effort should go to improvement of those characteristics known to be under strong genetic influence.
- Due consideration should be given to intended tree planting densities within agroforestry technologies as planting density is known to have strong influence on crown form and size. Planting density could also influence rooting patterns.

Research steps from species screening to breeding programme

- Figure 4 shows progressive research steps for improvement of multipurpose trees and shrubs for agroforestry systems.
- It should be noted that the steps are essentially the same as for other tree improvement research for other species
- The significant deviating step highlighted in Figure 4 involves agroforestry technology evaluation of a species prior to provenance evaluation.

- Thus provenance research should not 'lead' agroforestry technology evaluation of the species. Provenance research should be 'guided' by agroforestry technology evaluation of the species.
- Furthermore, agroforestry technology evaluation should be agroforestry system/farming system - driven and should ideally involve the joint efforts of silviculturists, agronomists, soil scientists, animal husbandry experts and so on. This is the critical departure from the traditional tree species and provenance research.
- In contrast to the situation in tree improvement programmes for industrial forestry, it should be stressed that the target beneficiary of any improved germplasm is the small-scale farmer. Thus, at early stages of the research, farmer preference surveys and farm-level adoption/impact studies should be undertaken.
- Finally, arrangements should be made for farmers to benefit from any germplasm improvement on a timely basis. This would entail the timely flow of improved germplasm to national programmes for evaluation, multiplication and distribution to farmers.
- ICRAF has taken all the above into consideration in developing its strategy for improvement of multipurpose trees for agroforestry systems as shown in Figure 5. ICRAF intends to work collaboratively with national and regional network scientists in implementing the strategic research phase of the strategy. Furthermore, ICRAF will stimulate, guide and, where necessary, participate in the adaptive research phases of the strategy.
- ICRAF's general approach to accomplishing the task is shown on Figure 6.

Provenance/variety evaluation research

Beyond the choice of species and their traits of primary interest, the following should be explored:-

- Existing variation in traits of interest within the species natural range, known provenances, varieties and cultivars.
- Literature, botanical surveys and genecological studies will prove valuable for the above.
- Determination of factors controlling the specific traits
- Observations and experimental confirmation of large differences in traits among varieties, provenances and cultivars will provide useful first guide to genetic control of traits.
- The magnitude and direction of correlations with traits known to be under strong genetic control should be established.
- Tree management research should be initiated to determine the extent to which improvement in performance can be influenced by better silviculture.

Improvement through selection and breeding

- Beyond provenance and variety research, additional improvement can be achieved through selection and breeding within the best provenance/variety.

- In this effort, conventional tree breeding methods as shown in Figure 7 could be used.
- Currently, there is a great divergence of opinion among breeders as to whether these conventional methods are appropriate and justifiable in the urgent task of improving the very many potentially useful multipurpose trees the world over.
- Of particular concern to breeders, is the lack of information on such aspects as the breeding biology, farmer preference/seed demand projections and estimations of genetic parameters all of which would guide decisions in such conventional breeding strategies.
- The above has led some breeders to suggest that, for many multipurpose tree species with identified potential roles in agroforestry, improvement research effort should be focused on provenance/variety and first mass selection in wild stands and plantations. Thus, more advanced stages of breeding research should await the information which is currently lacking.
- Another line of thinking among breeders is that the time and other investments required for the improvement of the many useful multipurpose tree species through conventional tree improvement methods is unrealistic in the present circumstances. This line of thinking advocates the use of non-conventional methods such as clonal multiplication of varieties and the use of biotechnology.

Methods of selection

In most cases, the breeder will be attempting to improve a species for combination of various traits. To this end, the breeder using conventional breeding methods, could adopt tandem selection, selection by independent culling levels or index selection.

For a variety of reasons, index selection is the most desirable method for improving trees for various traits all together. It is indeed being used in many tree breeding programmes. However, the greater diversity of tree products and influences in an agroforestry technology calls for a major re-consideration of how the several tree traits could be combined in index selection. For example, combinations of such traits as nitrogen fixing capacity, fodder quality, fruit quality, wood density, etc. in an index need to be explored by breeders.

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Figure J. Modular relationship between landuse/farming systems, location of technology in systems, technology management specifications and the specification of tree characteristics

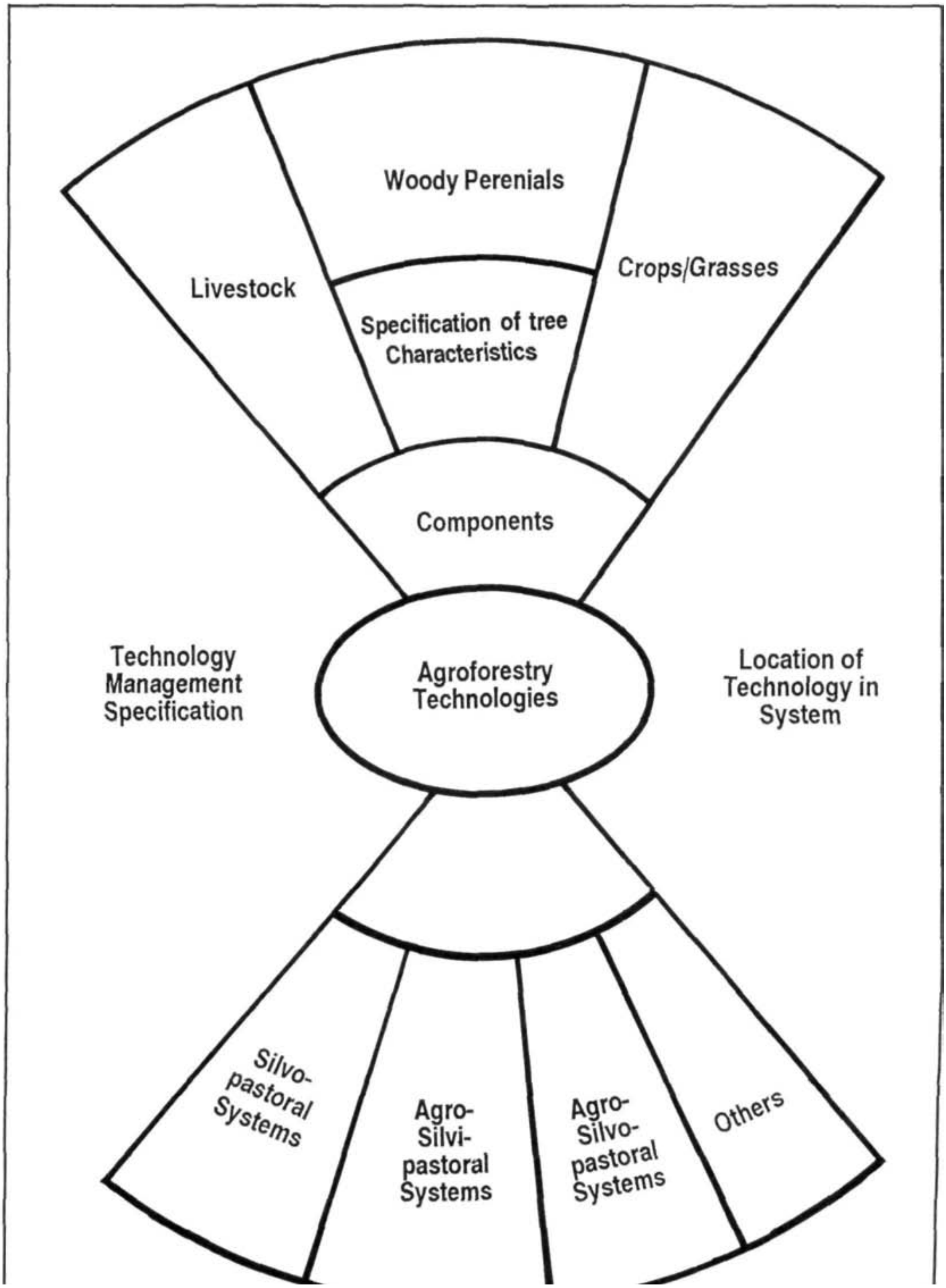


Figure 2. Artistic representation of contrasting ideotypes of Calliandra calothyrsus

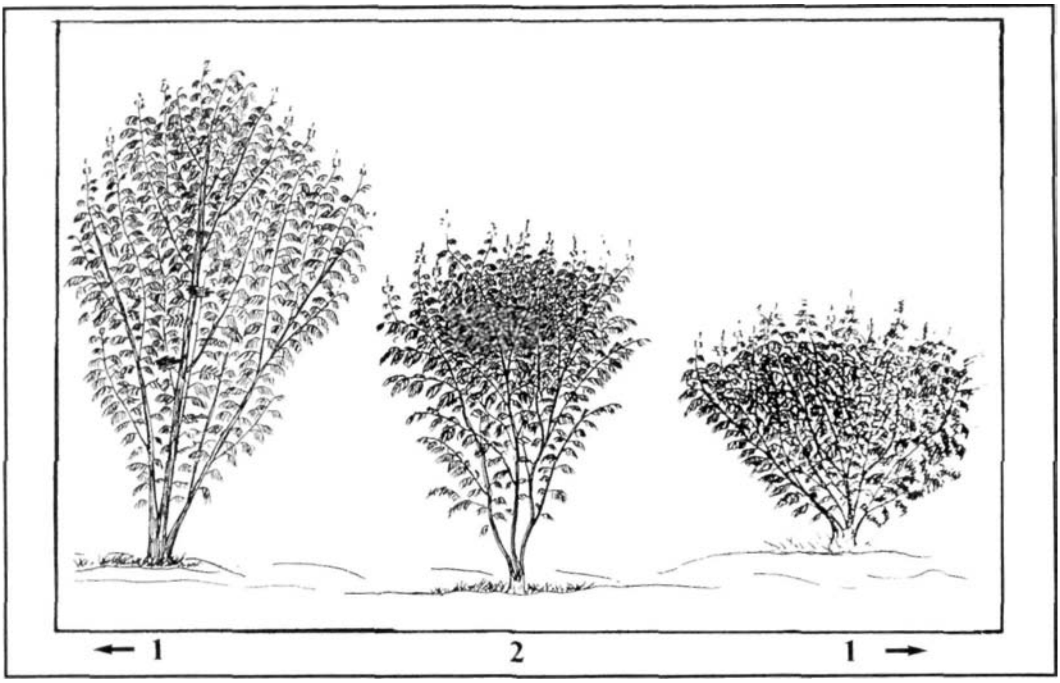
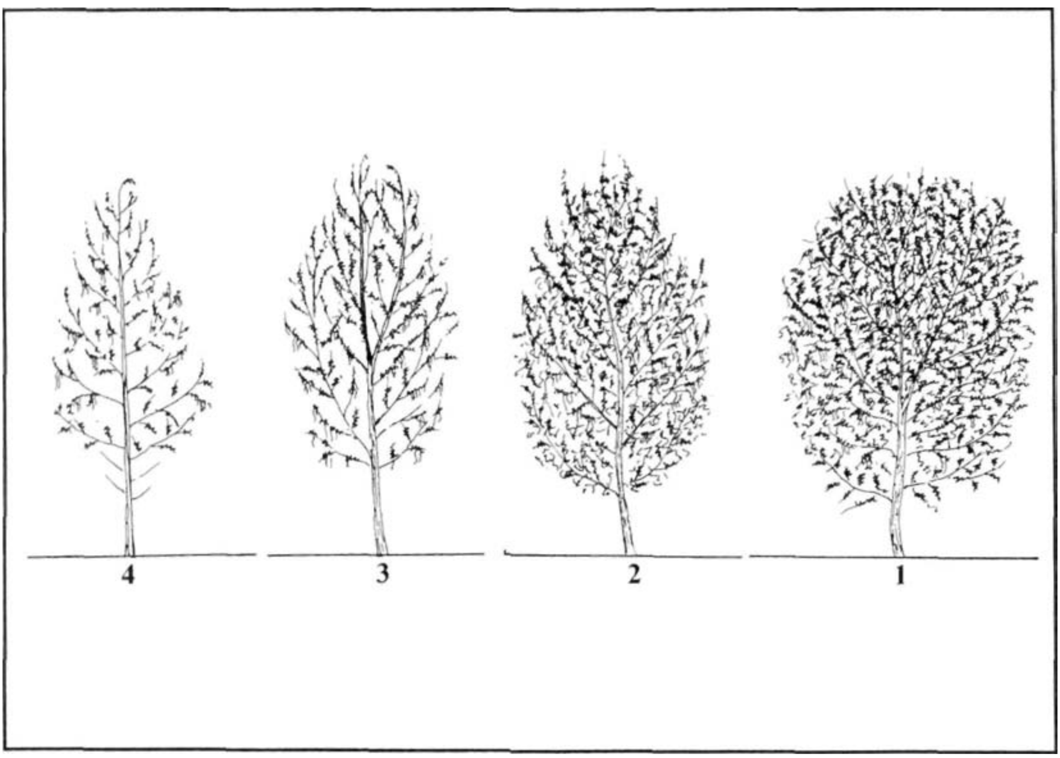


Figure 3. Artistic representation of contrasting ideotypes of Sesbania sesban



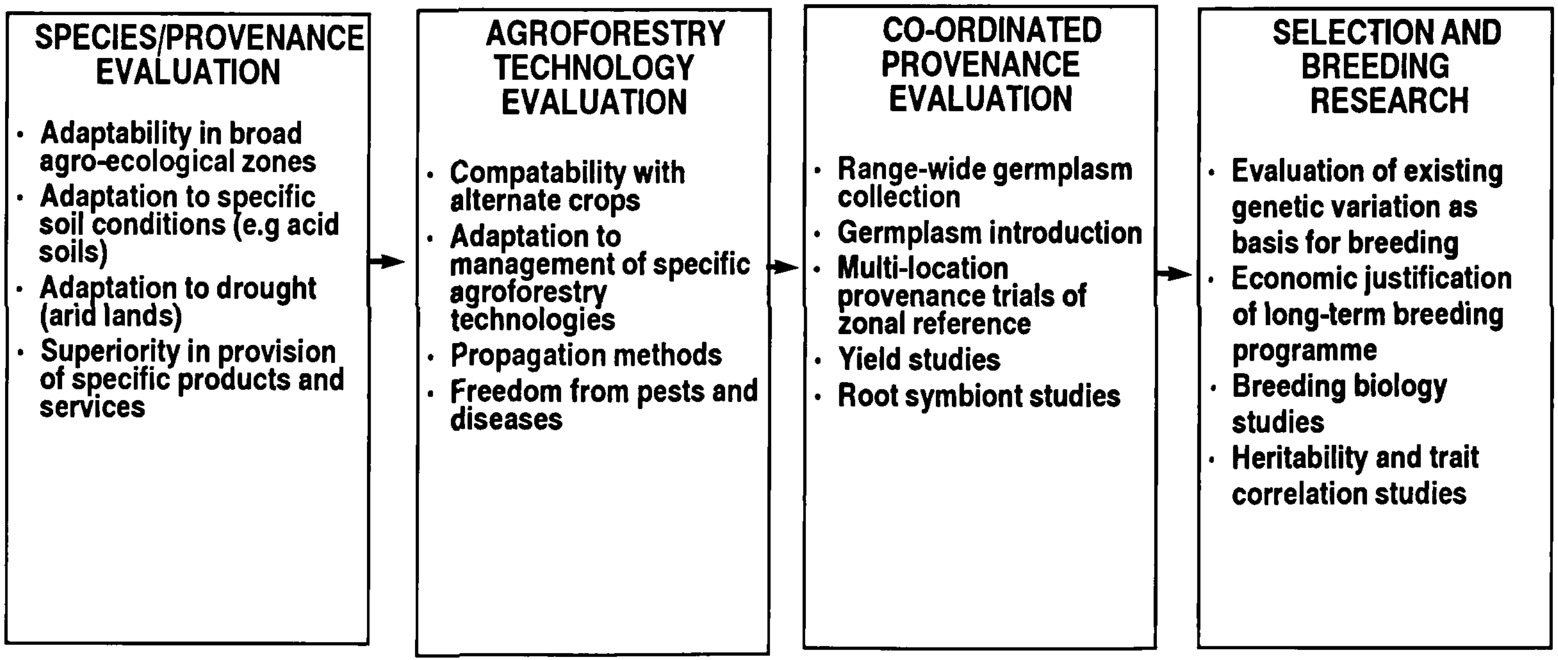


Figure 4. Progressive steps in multipurpose tree improvement research for agroforestry systems

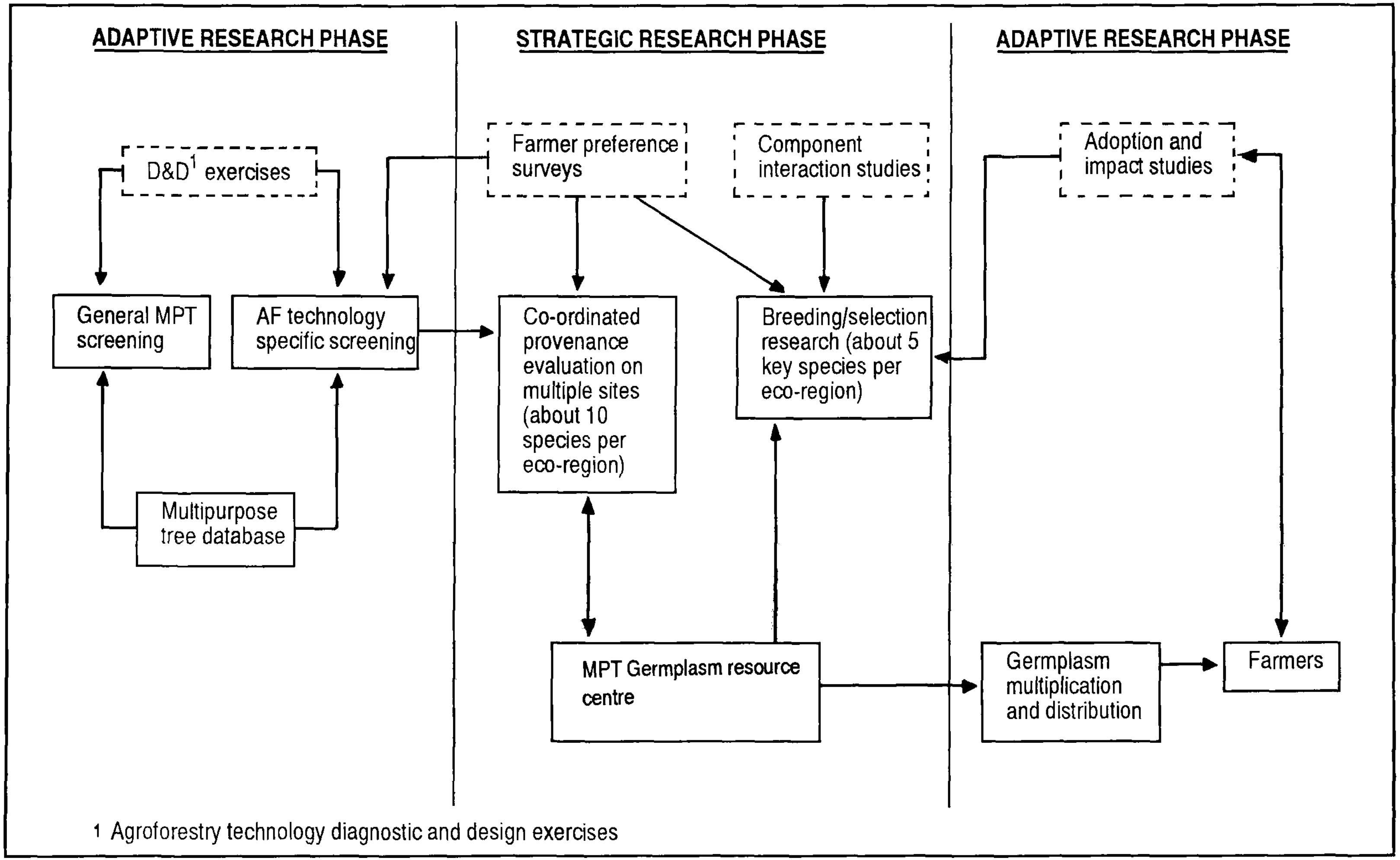
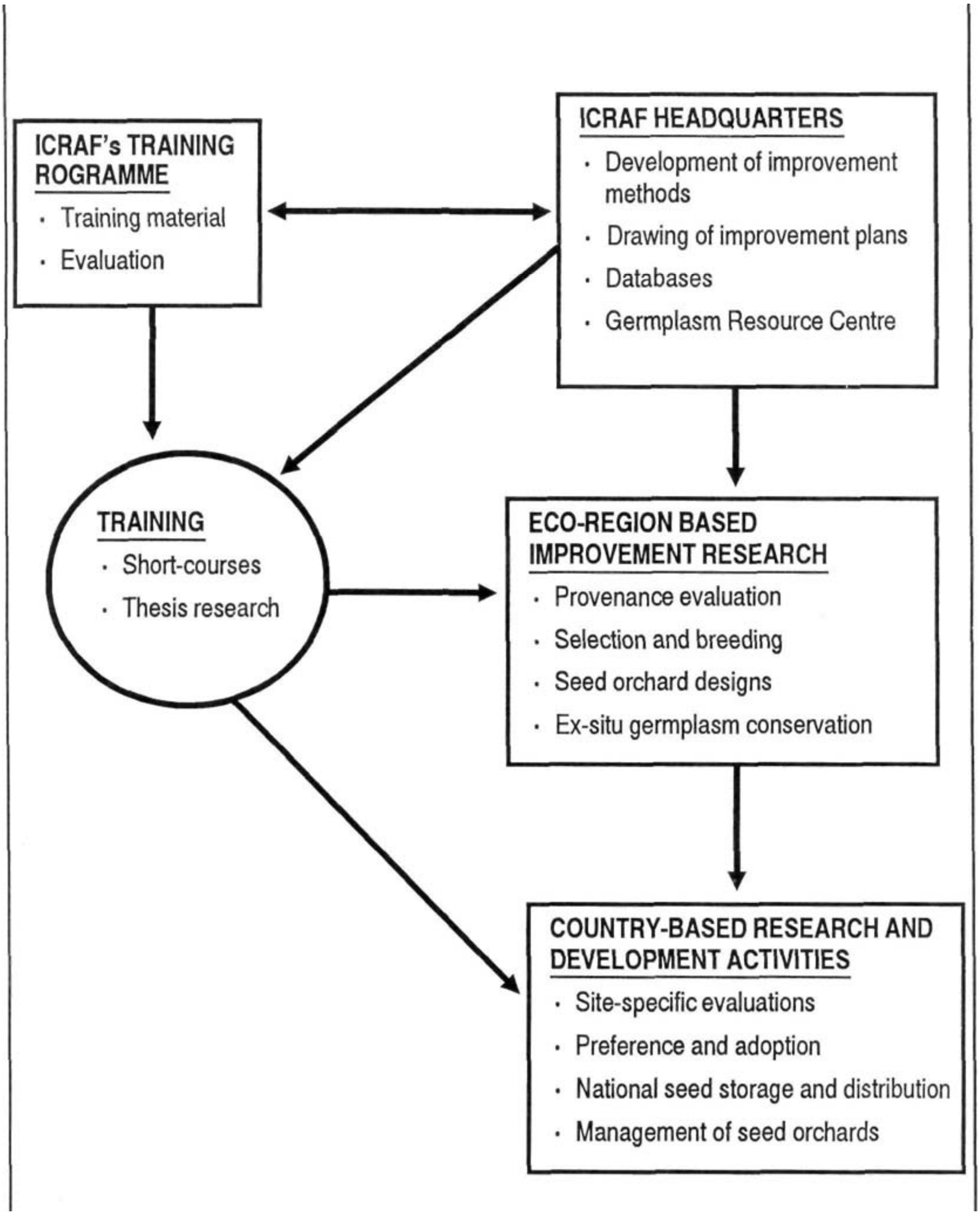


Figure 5. ICRAF's Strategy for improvement of multipurpose trees for agroforestry systems

Figure 6. General approach in collaborative tree improvement research



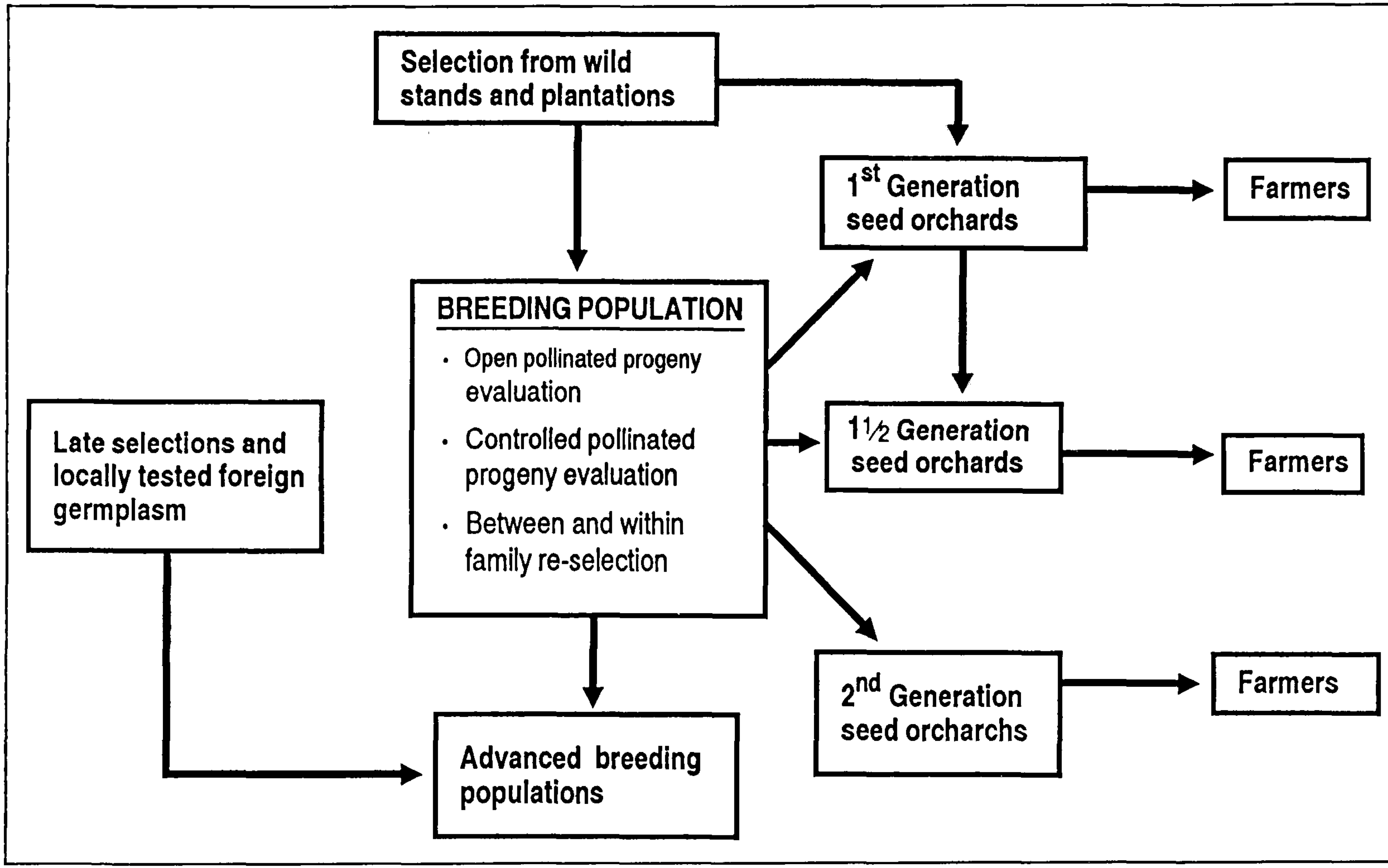


Figure 7. Tree improvement plan for short-time maximization of genetic gains and long-term germplasm base enrichment

PLANS FOR THE DEVELOPMENT OF THE MPT GERMPLASM RESOURCE CENTRE AT ICRAF

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KENYA

1. Summary

- ICRAF plans to establish a MPT Germplasm Resource Centre (MPT-GRC) to eventually serve as an important global focal point within the CG for MPT germplasm. The Centre will also function as an effective service unit for MPT germplasm in ICRAF networks. These themes have been approved by the ICRAF board and made known to other CG centres at Centres Week, Washington 1991. The Centre will have a strong practical focus.
- ICRAF *needs* to develop an MPT-GRC in order to take overall responsibility for the germplasm requirements for its tree improvement programmes and network field research. In addition a strategic international role is seen for the centre in the conservation of germplasm of target species for improvement, germplasm health requirements and safe transfer, framing and, eventually, advanced biotechnological innovations with MPT germplasm. In all these fields ICRAFs activities will seek to complement and not duplicate the activities of other centres. ICRAF wishes to help strengthen the activities of NARs in ICRAF networks in all matters related to MPT germplasm.
- A "dual phase" development of the MPT-GRC is proposed. In this model the main goal of the centre is to supply selected and later improved germplasm of MPT species, when this material becomes available from ICRAF research and development, primarily to ICRAF network NARs. Associated activities such as characterisation, evaluation of improved material, multiplication, conservation and perhaps regeneration of old material will also be undertaken in collaboration with the ICRAF MPT improvement group and others e.g. NARs, CG centres, etc. A key support activity is the collection of, in collaboration with NARs, provenance material of key MPT species and close relatives for tree improvement activities in various regions of the tropics. Initial focus will be on African species.

In addition there is an internal need for ICRAF to establish a centre to:

- — act as a germplasm resource information / acquisition / seed clearing house for research quantity seedlots and microsymbionts for coordinated ICRAF Networks. Larger quantities of seed per seedlot are required for ICRAF scientists engaged in physiological, management and extension trials both

on-station/on-farm. The guiding principle will be our scientists should consult local NARs first for germplasm before requesting assistance from the MPT-GRC (in acquiring germplasm).

- through active collaboration with other centres in the ICRAF networks (NARs), identify, and promote the collection of seed and testing of potentially new MPT species. Established Networks e.g. Afrenas (Agroforestry Research Networks for Africa) will have a key role in the identification and evaluation of this new material.

— serve as a training centre for all aspects of MPT germplasm resource management. A working centre is a key prerequisite to good training activities.

- Main recipients of the MPT-GRC germplasm are ICRAF scientists and collaborators (ICRAF Networks). It is anticipated that NARs will accept responsibility for the multiplication and utilization of improved germplasm. Some NARS may wish to develop their own breeding programmes for MPTs for specific ecozones and will benefit from ICRAF germplasm and advice on breeding programmes.
- It is proposed that the MPT-GRC needs staff with specialisation in (i) MPT germplasm exploration, (ii) biotechnology, (iii) microsymbiont research, (iv) germplasm health and safe transfer, and (v) tree breeding.

Introduction

2.1 Internal Situation at ICRAF in regard to MPT Germplasm

Since its inception in 1977 ICRAF has been well aware of the importance of good quality germplasm to the scientific development of MPTs for agroforestry. It has assisted potential users of MPT germplasm by publishing two seed directories (von Carlowitz 1986,1991) and by helping to organise an international conference on the global needs and problems related to the collection, storage and distribution of multipurpose tree germplasm (Burley 1985). These activities were in accord with ICRAFs Council type mandate.

With the development in 1985 of the AFRENA programme (Agroforestry Research Networks for Africa) an immediate priority became the internal need for quality seed for field agroforestry research. The situation then, as now, is that Afrena scientists solicit seeds independently. The major problem here, apart from the time involved, is that it is difficult for ICRAF non-germplasm specialist scientists to have access to good quality source identified research seedlots for species/provenance and for on-station/on-farm field trials. In addition the current situation makes it difficult to agree on and establish zonal network trials for site/genotype interaction evaluations - such trials have been rarely established by ICRAF to date. A coordinated, centralised, Nairobi-based ICRAF-Network germplasm resource information centre (and ancillary acquisition and despatch service when other methods of acquisition are unsuccessful), together with appropriate plant protection linkages, is urgently required to fulfil these needs. Herein after this facility is referred to as a Seed Clearing House. Table 1 provides some insight to the kinds of species currently in demand by ICRAF scientists but this list should not be misconstrued as the only species being sought.

Apart from service-type activities the recent development of the ICRAF MPT Improvement and Management Program has meant that there is a critical need to identify key MPTs for improvement, to collect appropriate germplasm for an improvement programme and to store and conserve this material. This material and breeder improved material will be provided to NARs for either (a) direct breeding or (b) multiplication of ICRAF improved material for local utilization. Network based trials of species studying site/genotype interactions will determine which approach is appropriate. ICRAFs new responsibility within the CGIAR for MPT germplasm has meant that a research agenda for MPT improvement is now required globally for ICRAF Networks e.g. for Africa, Asia and Latin America.

There is understandable concern that the ICRAF/MPT-GRC is not warranted because (a) other seed centres can do the job, (b) donor funding sources will be spread too thinly amongst too many centres, (c) new wave of National Forest Seed Centres in recent years limits the need for an international centre. For the first point an *initial* seed clearing house role recognises the importance of other centres activities and the *later* MPT germplasm improvement focus aims to complement the activities of most centres where this is usually not a strong focus. For the donor funding problem it is hoped that ICRAF can play an active role in promoting donor awareness to MPT germplasm issues thus assisting indirectly many current MPT germplasm centres in NARS. Collaborative approaches to donors by ICRAF and other centres could also be explored. The "new-wave" concern is also real but as many species transgress national boundaries ICRAF will seek to harness the skills of national centres to acquire germplasm where possible.

ICRAF seriously debated the idea of restricting MPT-GRC activities solely to handling material from tree improvement/breeding activities with the production, characterisation, evaluation and dissemination of this material being the key activity. In this scenario the service role to ICRAF networks would be considerably diminished. We were also attempting to restrict duplication of effort with other MPT regional/national seed centres where MPT tree improvement activities were not in the majority of cases a strong focus. We were also aware that breeding is a major activity in the other CG commodity crop centres and that it was tempting to develop along similar lines. We recognise that this should be the main goal of the ICRAF MPT-GRC centre in time.

2.2 Global Situation in regard to MPT Germplasm and ICRAF position

With ICRAFs entry into the CGIAR it was appreciated that one of the major success stories of the CG commodity and regional centres (CIMMYT, IRRI, IITA, etc.) has been the provision of improved crop germplasm and the exploration, conservation and use of wild relatives. Also in terms of extension of research results the release of improved germplasm to users has been very successful and one of the best available indices of judging the usefulness of CG centres. Not unnaturally a similar expectation is held for ICRAF in regard to MPT germplasm.

In developing ICRAFs germplasm collection activities it is of interest to assess the current position at other CG centres. There seems to be an increasing trend that CG centres are moving away from CG germplasm collection trips in favour of other alternatives. With better established national germplasm centres for crop plants the need to have international collections is thought by some to be not so great and coordinated national led collections are considered a better substitute. Issues such as sovereign rights for germplasm, the need to develop networks to evaluate the collected material, and also the training opportunities that the collaborative approach allows, lend weight to this approach. Other important issues such as preservation of existing crop germplasm in CG gene banks to arrest germplasm erosion of currently stored material is seen as an alternative priority activity e.g. Project Noah USAID objectives.

All the above issues are not strictly applicable to agroforestry germplasm because (a) national agroforestry gene banks are not so well developed in many countries, (b) little material is currently in store to warrant Project Noah type initiatives, and (c) a wide range of valuable material still needs to be identified, collected and characterised. The current destruction of biodiversity generally and expected climatic change in the future renders most MPT collection and conservation activities important.

The CG in requesting ICRAF *to* become a global focal point within CG for MPT germplasm was aware that several other CG centres had an interest in MPTs and were also collecting/acquiring germplasm. For example ILCA (viz Shenkoru *et al* 1991) has developed a large collection of germplasm on fodder trees, CIAT on perennial legumes for special environments, ICRISAT on perennial pigeon pea, and IRRI on acquatic woody legumes for soil improvement in rice paddies. Negotiations are currently underway with some of these centres to establish collaborative modes of benefit to all parties concerned.

As ICRAF expands its activities from Africa to Asia and Latin America additional species will be identified for species trialing, germplasm collection and tree improvement/breeding activities. There will also be an evolving need for ICRAF networkers in Asia and Latin America to acquire quality germplasm for on-farm/on station trials. Conservation activities *ex situ* (but *in situ* where appropriate) will focus primarily on those species and populations being improved (probably no more than say 20, plus close relatives, worldwide) but not to the total exclusion of other potentially promising but endangered MPTs. All these service, research and conservation activities require a well integrated MPT-GRC at a central location. The development of the MPT-GRC will follow CG tradition but should develop appropriate to ICRAF needs and in accord with the biological attributes of the species involved.

Currently there are many groups conducting MPT seed collection missions and breeding activities worldwide. It is difficult for NARs to keep up with what's going on where and a central body keeping abreast of germplasm collections available for research would provide a useful information service to ICRAF networks and all other outside groups. ICRAF as an international agroforestry centre in general and the MPT-GRC in particular could play a valuable coordinating information service role. This would form part of the activities of the seed clearing house. Close collaboration with IPGRI and FAO would be essential.

ICRAF, in developing our MPT-GRC, must recognise the past and continuing global importance of many other groups such as FAO, CSIRO, OFI, DFSC, etc. in developed countries and others in developing countries e.g. KEFRI, ZFRC, etc. in providing MPT germplasm. Given this scenario ICRAF could seek to complement their activities in a strategic sense through germplasm resources management training. This should be done in conjunction with other interested parties. ICRAF could also take a lead research role in MPT germplasm health and safe movement issues and on new biotechnologies with MPT germplasm. These are areas not currently well developed in NARS. Our overall aim will be to complement activities of NARS and not compete.

2.3 Summary of what activities should be covered by MPT-GRC to service ICRAF networks

Given the foregoing comments in 2.1-2.2 the MPT-GRC should undertake:

- information activities
  - — advice to NARs in the ICRAF network and others on where are the MPT germplasm research collections. Close collaboration with IPGR1 and FAO essential.
- service-type activities
  - — germplasm for on-farm, on-station trials (information role or acquisition as last resort)
  - — germplasm collection/acquisition of new MPTs for specific agroforestry technologies. Basically however ICRAF could play a role as a catalyst to NARs and Regional Centres in this area. The MPT species database provides a valuable support role in this area.
- research activities
  - — germplasm collections for tree improvement work
  - — biotechnology (tissue culture, microsymbionts)
  - — germplasm health and safe movement
- conservation activities
  - — for MPTs being improved (probably 20 species globally plus related close relatives)
  - — for potentially endangered MPTs
- support to CG Centres and NARs
  - — training in MPT germplasm resource management
  - — design of multiplication and *ex situ* conservation stands
  - — supply of raw material to NARs for breeding or supplying ICRAF improved material for multiplication
  - — collaboration in collection missions and later evaluations

These activities should form the basis of the aims and functions of the MPT-GRC.

3. Aims and functions of MPT-GRC centre

The overall aim is to establish a MPT-GRC to eventually serve as an important focal point within the CG for MPT germplasm and to function as an effective service unit for MPT germplasm in ICRAF networks. This has been approved by the ICRAF board and made known to other CG centres at Centres Week, Washington 1991. The concept of a MPT germplasm centre was indicated in our program of work for 1992 (Anon 1991a). In developing the MPT-GRC as an important focal point it is envisaged that the centre will, in time, become a "first point of contact" for enquiries on MPT germplasm. **This concept implies very active, strong and continuing collaboration with all existing centres and our function policy will reflect this attitude.**

Main functions:

- foster active collaboration with all existing MPT germplasm centres to assist both them and ICRAF to develop strong MPT germplasm programmes.
- develop a strong support role to ICRAF networks for MPT germplasm resources. Prime focus will be on supplying information on available genetic resources. Seed acquisition only when other means fail.
- commence germplasm provenance collections of ICRAF priority MPT species for tree improvement/breeding in various parts of the tropics in collaboration with NARs. Associated management of these collections will be undertaken.
- *later* acquire/collect and manage active collections of improved and selected MPT germplasm from ICRAF MPT improvement program. Main recipients of germplasm are NARS in ICRAF networks i.e. National MPT seed multiplication bodies (agriculture, forestry).
- acquire and manage long-term base collections for conservation of short-lived MPT species. Develop other *ex situ* conservation methods as appropriate to the species concerned. Duplication arrangements for germplasm also to be developed in collaboration with others. Conservation of other endangered but promising MPTs will be undertaken.
- develop and conduct characterisation, evaluation, multiplication and associated documentation procedures for priority MPT species. This will be achieved in collaboration with ICRAFs tree breeders, various networks and by NARs.
- act as a catalyst for germplasm exploratory programs for new MPTs in collaboration with other established centres.
- develop appropriate biotechnologies for MPT germplasm. Two identified areas are microsymbionts and tissue culture.
- training activities in MPT-GRC related activities
- produce a catalogue on germplasm available at MPT-GRC
- research germplasm health issues and safe movement appropriate for MPTs

4. Supporting details for aims and functions of MPT-GRC

To develop the facility in an orderly and practical manner it will be necessary to develop in stages according to our current needs and future expectations.

4.1 Seed Clearing House Role

Initially it is proposed that the MPT-GRC will have a practical focus addressing real issues for ICRAF networks. The seed clearing house role is a priority activity initially and the networks will be reliant on the good services of other active seed centres worldwide (see details later). In all cases ICRAF staff should consult local NARS first for seed before directing enquiries to the MPT-GRC. This will be our guiding principle of operation. If material is not available locally the MPT-GRC will acquire material on behalf of our networks. This applies particularly to integrated network provenance trials.

4.2 Tree Improvement/breeding

Figure 5 in F Owino's presentation provides a useful overview of the links between the MPT-GRC and the MPT tree improvement programme.

ICRAF has a strong commitment to tree improvement/breeding and the MPT-GRC is embedded within this programme. Table 2 indicates priority African species for germplasm collection and conservation and later species from Asia and Latin America will be added. Currently tree improvement/breeding activities are being undertaken for *Grevillea robusta, Sesbania sesban, Leucaena leucocephala, Calliandra calothyrsus, Markhamia lutea,* and *Acacia albida.* Each cycle of improvement will result in small quantities of seed being released for characterisation, evaluation, multiplication and conservation. Currently established seed orchards for some MPT species will also be generating some seed soon which can be processed through the MPT-GRC. It will be sometime before a useful range of improved material will be available for full comparative evaluation.

For ICRAF to take a lead role in developing principles for the evaluation and characterisation of MPT germplasm in tree improvement/breeding activities it should be closely involved in the field collection of a few target species. Familiarisation with the ecology of the species under natural conditions may result in more precise provenance selections. This will perhaps be even more important in areas, within the natural range of a species or in exotic situations, where tree species have been successfully mixed with agricultural crops. This additional cultivated germplasm may prove very important in species evaluations in future.

As a preliminary activity ICRAF could start to develop the necessary expertise in operating such a CG type germplasm centre by assembling and conserving long-term base collections of germplasm (or duplicate collections) of one or more short-lived candidate species. An ideal candidate could be *Leucaena leucocephala* and related close relatives. The University of Hawaii and collaborators (NFTA) have numerous selections and manipulated crosses available for various purposes.

This proposed activity by the MPT-GRC should be seen primarily as safe duplication of valuable world germplasm and hopefully other world seed centres may consider following suit by contributing select MPT germplasm of other species for long-term duplicate conservation at ICRAF MPT-GRC. ICRAF could develop standard guidelines, in collaboration with IPGRI and others, for characterisation, evaluation and conservation of important MPT species. If the University of Hawaii, NFTA and OFI were agreeable *L. leucocephala* would be an ideal species for the MPT-GRC to commence conservation seed storage. However, it is appreciated that these three centres could just as easily develop their own activities with this species and may not wish to involve ICRAF.

The commodity CG centres have given particular attention to crop wild relatives and a similar activity "tree crop close relatives" should be developed at ICRAF. This activity would be closely related to the tree improvement programme for key species identified for collection, tree improvement/breeding. In food crop plants close relatives are required for characterisation, evaluation and possible incorporation in breeding programmes. In an agroforestry context close relatives of tree crops can be assessed in their own right as well as for breeding purposes. Such developments have been going on for *Leucaena, Casuarina,* and *Acacia* but a fundamental precursor is good infrageneric taxonomy in which evolutionary relationships amongst species in the genus are considered. In our current ICRAF programme we have such thoughts for *Casuarina, Sesbania, Milletia, Pentaclethra, Grevillea,* etc. The identification of these species and promotion of their germplasm collection by ICRAF or other groups can be considered part of the activities of the MPT-GRC.

There are several quick options that ICRAF can take to multiply selected germplasm for use by ICRAF networks (on-station/on-farm scientists and collaborators). This calls for the development of seed stands of select material (provenances, etc.). This can be best accomplished initially by ICRAF scientists (possibly in ICRAF Networks) but also directly by NARs. A good current example is the ICRAF collaboration with OFI in Zambia to create a seed stand of a select provenance of *Gliricidia sepium* which has previously performed well in many sites. Similarly CSIRO has been active in developing commercial-type seed orchards of MPTs e.g. *Acacia auriculiformis.* These developments could be extended to some more key MPT species. Material resulting from such stands could be processed through the MPT-GRC primarily for ICRAF networks or processed directly by NARs. Such developments will relieve a current bottleneck and could fulfil a need worldwide. Material should be produced in large rather than as small research lots.

The financial and management mechanisms for promoting this kind of development (both establishment and management) need to be well thought through. The MPT-GRC could assist in this development in conjunction with scientists from NARs. ICRAF could consider initiating certain guaranteed seed buy back arrangements in order to foster this kind of development.

4.3 New MPT Species for Agroforestry Trials - Germplasm requirements

This activity should form a small but important part of the MPT-GRC. There are inherent risks in restricting too much of the activities of the MPT-GRC to tree improvement/breeding activities and the pay-off to farmers may not be as great as research into new species. ICRAF especially should have an open mind on this issue because of the difficulty in precisely defining traits to improve with MPTs.

Exploration of new agroforestry species has only just begun. Early exploration, dominated by the search for high shade trees for commercial crops e.g. tea, coffee, etc. resulted in many of today's more popular MPTs. More recent exploration by OFI in Central America and CSIRO in Australia has concentrated on exploring the potential of lesser-known MPTs. This work should be expanded to other regions of the world e.g. Brazil, Indian countries, West Africa, Himalayas, etc. The ICRAF MPT-GRC should serve as a catalyst to stimulate the identification, exploration and testing of this new germplasm i.e. ICRAF could do the work with others in partnership. Attention could also be given to selecting and testing new species especially fruit trees suitable for specific agroforestry technologies. This type of research should proceed in parallel with agroforestry tree breeding efforts and nicely complements ICRAFs past and present efforts on the MPTS database. One serious limiting problem for testing new species has been the recalcitrant nature of seeds of some potentially promising MPT species e.g. *Inga.*

ICRAF's particular strength in the area of new species is the grass roots approach to agroforestry research. ICRAF farmer surveys, Diagnosis and Design exercises, Ethnobotanical surveys etc. mean that the design requirements of tree species to fit particular specific agroforestry technologies can be circumscribed. This information should be passed onto NARs within similar ecoregions world wide to search for appropriate new species to trial. In addition information generated from Project 3 "Component Interactions" will hopefully determine particular species ideotypes that should be the focus of a species search programme.

Once material is available in NARs the MPT-GRC can alert ICRAF scientists and collaborators interested in trialing the new acquisitions. Collection and initial evaluation of such new species should ideally be undertaken by national and regional programmes before been made subject to intercontinental transfers.

The precise mechanism to stimulate a new species program through the MPT-GRC still needs careful thought. This kind of germplasm should ideally go direct to ICRAF networks from NARs by-passing the MPT-GRC. However two aspects should be recognized-

(a) NARs may require assistance in the identification and collection of material

(b) For proper screening it may take several years to gather together sufficient material to make a sensible comparative trial. In addition recalcitrant species involved in intercontinental transfers may require a safe live-storage site (seed multiplication field gene banks). This is an intermediate step before going into field trials.

In both these cases the MPT-GRC can assist to assemble material before going out for field testing for specific agroforestry technologies.

Table 3 has been constructed to demonstrate the potential relationships between the kinds of germplasm holdings to be held at the MPT-GRC. The Table brings together the tree breeding collections, conservation collections and hypothetical examples of specialist field screenings. The need is to assemble specific collections over several years before field testing.

4.4 Research and development

Initially the main research and development activities will be -

- to develop or adopt appropriate software to document MPT germplasm in the ICRAF/MPT-GRC
- to coordinate and consolidate the MPT collection programme. In collaboration with NARS this will involve literature surveys of target species, designing a seed collection programme given the distribution and biology of the species

- to develop germplasm information systems (collaboration IBPGR and CIFOR)
- biotechnology (tissue culture, identification and supply of microsymbionts)
- to develop appropriate plant protection procedures for MPT germplasm

Later with increasing staff and clearer perceived needs research activities could include -

- work on recalcitrant seeds
- biotechnology (cryopreservation, multiplication of select microsymbiont strains)

One key area of research missing in this agenda is genetics work related to population structures, breeding systems and pollination biology. These topics are relevant to sampling strategies and conservation issues. It is hoped that this work can be conducted by other established laboratories through partnership between the ICRAF germplasm explorer/tree breeder and established laboratories in NARs (developed and developing countries).

4.5 Biotechnology

Biotechnology will be an integral part of the centre and one early activity will be the development of a tissue culture laboratory. This facility will serve as a focal point with links to the tree improvement/breeding program and plant protection/disease screening related activities. Health issues are important especially since many MPTs are legumes and thus prone to various diseases e.g. viruses. ICRAF feels that it must maintain credibility in this area. ICRAFs proposed activities in wild fruit trees will further consolidate the need for a tissue culture facility in order to maintain select genotypes and to provide rapid multiplication for use. The tissue culture facility is also required for disease thermotherapy.

There is also a need for microsymbiont research in direct support of tree improvement/breeding programs in ICRAF networks. The aim would be to select, say, superior strains of rhizobia for improved tree growth rates and soil improvement purposes. The link with the MPT-GRC is for the identification, evaluation, multiplication, conservation and documentation of select genotypes. An early start to these developments would be a small clearing house role for microsymbionts developed elsewhere (see notes later on potential NifTAL links)

4.6 Conservation of Germplasm

ICRAF is primarily interested in germplasm for use and not nature conservation *per se*. ICRAFs planned activities will contribute to better conservation of germplasm of MPTs in the following ways:

- encouragement of use on farms of some 2000 so far identified MPT species (an indirect conservation measure)
- *ex situ* conservation of germplasm in storage in gene banks and duplication at other appropriate centres. This includes the concept of long-term conservation of base collections.

- *ex situ* conservation as part of tree improvement/breeding programmes
- recommendations to NARs of potentially valuable MPT species provenances worthy of national efforts for *in situ* conservation. FAO suggests we *support* NARs in this. Tree crop close relatives may also be involved here.

Base collections for conservation have not been well developed for forest tree species. Various arguments have been advanced for why this has not occurred in the past e.g. longevity of the tree species, etc. In the publication Managing Global Forest Tree Genetic Resources (Anon 1991a) there is a statement which is a clear call to action; "one conclusion that is inescapable is that long-term seed storage of tree species currently plays a very minor role in conservation efforts. This must be rectified quickly".

4.7 Training

ICRAF has a large training programme, facilities and lecturing infrastructure from which to launch suitable germplasm related training activities. To play a key role in training it is most desirable to have a fully functioning MPT-GRC in operation.

The MPT programme held one seed handling workshop with IBPGR in 1989 in conjunction with the local East Africa IBPGR representative based at KARI Gene Bank, Muguga. Other training opportunities include -

- seed collection operations (possibly with IPGRI)
- handling rhizobia from the lab to the field (possibly with NifTAL)
- germplasm resource management to assist development of national centres (possibly with IPGRI)
- component links on certain issues (e.g. seed orchards) with the MPT improvement/breeding training programme
- plant health and international movement of germplasm issues

The main clients for these exercises would be African, Latin American and Asian technicians and junior scientists involved in germplasm resource management. Linkages with established Germplasm Centres in providing training lecturers will be explored.

4.8. MPT-GRC Staff

Staff will consist of two persons initially expanding to more over time. A suggested staff development programme over a 10-year time frame is given in Table 4. However, we should monitor progress carefully and develop our programme according to needs.

Eight key specialist scientists are MPT germplasm explorers(4), a biotechnologist (tissue culture main focus), a microsymbiont specialist, a germplasm health specialist (a plant pathologist) and a tree breeder.

The eight key specialists and suggested activities for the MPT-GRC are as follows.

- Plant Explorer (tree Improvement/breeding). Three positions (Africa, Asia, South America)

- concentrate on species for tree improvement
- coordinate and make collections
- documentation of collections
- skills needed: population genetics, perhaps isozyme training, fieldwork.

- Plant explorer (New species and Service activities)
  - recommend species needed for ICRAF networks to fulfil specific agroforestry technologies.
  - act as a catalyst to NARs world wide to encourage collection of new species
  - service enquiries on germplasm required (both ICRAF network staff and others)
  - skills needed: general botanist, MPT background

- Tree breeder
  - link between MPT-GRC and Tree Improvement/breeding programme.
  - advise ICRAF network NARs on MPT tree breeding designs and assessment procedures.
  - advise ICRAF network NARs on design of seed multiplication stands and seed orchards.
  - conduct characterisation and documentation of tree breeding/improvement germplasm.

- Biotechnology
  - microsymbiont specialist
    - support for tree breeding activities in legumes
    - assist in storage of materials and documentation of collections
    - assist in collection of microsymbionts associated with seed collection programmes.
  - plant health specialist
    - plant pathology background
    - experience in disease thermotherapy using tissue culture
  - tissue culture specialist
    - wide background in tissue culture
    - works with plant health specialist
    - multiplication of select clonal lines e.g. fruit trees and specific tree ideotypes for agroforestry systems.

In addition the MPT-GRC will have an O.I.C. plus professional assistant whose tasks are to (a) develop and manage the centre, (b) integrate all work programmes (c) help ICRAF and others solicit funds for collections etc. (d) develop germplasm resources information systems for ICRAF networkers, (e) develop documentation procedures for MPT germplasm in storage.

The microbiologist will be initially shared between ICRAF Program 3 "Component Interaction" and Program 2 "MPT Tree Improvement and Management" leading perhaps eventually to a permanent appointment in the Centre.

The appointment of a plant health specialist has been strongly recommended by the ICRAF Board of Trustees. With the emphasis of the MPT-GRC on new and improved MPT germplasm it was felt that plant health issues need a special focus to help minimise the spread of serious pests and diseases.

In order to facilitate collaboration with national centres a strong element of staffing policy could be to encourage secondment from other established centres dealing with MPTs. This should help strengthen cohesion and direction amongst all groups. Ways of encouraging this development should be explored.

5. Collaboration between the ICRAF MPT-GRC and other National/International centres

This activity will form a major part of the aims and functions of the MPT-GRC but is treated separately to stress its importance.

5.1 **Germplasm acquisition from other centres** (both from developed and developing countries)

Facilitating germplasm acquisition by ICRAF networks will be a key function for the centre initially. This has been referred to earlier (and carefully) as a "Seed Clearing House Role". Figure 1 provides a good overview of the linkages that ICRAF has and can continue to develop with other centres. A good review of the aims and functions of some of the major MPT seed centres CSIRO, OFI, DFTSC, CTFT is available (Anon 1991b). Nearly all have a specific geographic focus of interest and none have an exclusive long term commitment to MPT germplasm. At present OFI, CSIRO and CTFT have been actively supplying research quantities of seed to ICRAR ICRAF would like to develop closer links with many other interested centres e.g. CG centres, CATIE, CAMCORE, EMBRAPA, Indian National Bureau of Plant Genetic Resources Gene Bank, etc. ILCA has not undertaken any major MPT collections since 1988 and a priority focus has been the evaluation of *S. sesban* for fodder production.

Because MPT species are legumes and it would be most desirable to develop strong links with NifTAL for the practical supply of select strains of Rhizobia. Preliminary discussions with NifTAL officials indicate that MPT-GRC may be able to be used as a secondary centre for the storage and timely despatch of microsymbionts. Later, depending on demand, an ICRAF facility, or a private laboratory or the existing facility at the University of Nairobi - Kabete could be considered for microsymbiont multiplication. NifTAL have been supplied with a list of our priority MPT legumes and have already supplied suitable strains of most. This supply role alone is a potentially useful complementary development for a MPT-GRC.

The Rhizobia technology is well developed and useable now. In future other microsymbionts (i.e. *Frankia*, mycorrhiza) could be added to the MPT-GRC.

5.2 Germplasm collection activities

ICRAF has and will continue to play a pivotal role in identifying priority MPTs for tree improvement. Depending on geographic region of occurrence of particular species ICRAF can encourage other established centres (CSIRO, OFI, CATIE, etc) to undertake the work. In which case cooperative efforts in securing funds for collections could be developed. A natural extension of this is to involve these centres with ICRAF in the design of trials and evaluation of this germplasm on a well coordinated basis. This has been attempted with CSIRO in regard to *Grevillea robusta* provenance trials.

Within Africa ICRAF will actively seek to undertake collections of priority species (see Table 2) in collaboration with existing national or regional centres e.g. in Zimbabwe (the Forest Research Centre) and for SALWA the CILSS sahelian programme. This approach creates cohesion of effort across countries for particular species, will result in sharing of resources, will promote training opportunities, and finally will help to strengthen National Seed Centres. In Africa for each of the AFRENAs arrangements can be quickly put in place to facilitate such activities under the existing ICRAF M.O.U.s with the countries concerned. Seed collection equipment and staff support will normally come from NARs. A similar approach will be developed in Asia and Latin America once the ICRAF program there is established. It is expected that half the germplasm collected will remain in the host country.

5.3 Collaboration with CG centres and FAO

Collaboration with IPGRI is considered to be beneficial to the early success of the MPT-GRC. Linkages are being developed with respect to the application/development of IPGRI software for germplasm documentation (including a MPT Germplasm Catalogue), guidelines for the safe movement of germplasm and training in germplasm resources management. IPGRI in conjunction with ICRAF and CIFOR are seeking a contract from ACIAR/AIDAB to conduct a survey of genetic resource research and database issues. A priority concern is an assessment of progress made in *ex situ* conservation of germplasm of valuable species. Germplasm health and guidelines for safe movement of germplasm are also areas where ICRAF should collaborate with IPGRI.

Collaborative arrangements in regard to MPT germplasm are being explored with ILCA, IITA, IRRI, ICRISAT and CIAT. Potentially links with CIFOR will be important and care will be exercised to avoid overlap. It is expected that ICRAF/MPT-GRC will be called upon to have inputs into world bodies discussing plant genetic resources e.g. CD/TAC Committee, FAO, etc. FAO organises regular meetings of its "Panel of Experts on Forest Gene Resources" and perhaps ICRAF should seek observer status.

ICRAF will basically be guided by the CGIAR on the legal status of MPT germplasm held at ICRAF. The CG is also currently exploring possible linkages with FAO for the long term legal security of base collections. The CG is considering a concept of Trusteeship of germplasm where beneficiaries are considered the key factor. ICRAFs guiding principle will be free access to the germplasm by all nations. The CG is also currently working on Intellectual Property Protection for improved germplasm and considering all issues related to this.

6. Building of germplasm storage facilities and laboratories

6.1 Current situation

Director, KEFRI (Kenya Forestry Research Institute) has kindly allowed ICRAF the use of the KEFRI Tree Seed Centre, Muguga, to store and despatch MPT seed on a trial basis for 1-year. This arrangement has worked relatively well so far. The

*Table 1. MPT Species in demand through ICRAF **H.Q. 1991***

l.Legumes (Rhizobia/non-rhizobia)

Leguminosae

subfam. mimosoideae	***subfam. papilionoideae***	***subfam. Caesalpinioideae***
Acacia albida	*Crotalaria anagyroides*	*Acrocarpus fraxinifolius*
**Calliandra calothyrsus*	*Chamaecytisus palmensis*	*Cassia siamea*
Inga edulis	*Desmodium distortum*	*Cassia spectabilis*
Leucaena diversifolia	*Desmodium discolour*	*Dialium guineense*
Leucaena leucocephala	*Flemingia macrophylla*	
Leucaena spp.	*Flemingia cordifolia*	
Mimosa scabrella	*Gliricidia sepium*	
Paras erianthes falcata	*Milletia thonningii*	
Pentaclethra spp.	*Pterocarpus mildraedi*	
Prosopis juliflora	*Sesbania sesban*	
Prosopis spp.	*Tephrosia Candida*	

2. Non-legumes (Frankia nitrogen fixers)	3. Non-nitrogen fixers
Alnus nepalensis	*Acoia barteri*
Alnus acuminata	*Grevillea robusta*
Casuarina cunninghamiana	*Irvingia gabonensis*
Casuarina equisetifolia	*Vangueria spp.*
Casuarina junghuhniana	*Saurauia naupalensis*
	Schima wallichii
	Terminalia spp.

Note:

1. Afrena scientists are using many more species but the list is restricted to those species for which seed was sought through ICRAF H.Q. The list probably reflects that Afrena scientists have been having greater difficulties than usual in getting seed of some of these species.
2. * denotes species in high seed demand.

Table 2. ICRAF priority African species for germplasm collection and conservation

Species	Dominant Uses	Region
1. *Pentaclethra spp.*	• Soil improvement • Fuelwood/fodder	• Humid lowlands of West Africa • (Central and South America)
2. *Dialium guinensis*	• Soil improvement • Fodder	• Humid lowlands of West AFrica
3. *Irvingia gabonensis*	• Food (fruits, vegetable) • Fuelwood	• Humid lowlands of West Africa
4. *Milletia spp.*	• Soil improvement • Fuelwood	• West Africa, Eastern and Central AFrica
5. *Prosopis africana*	• Fodder • Fuelwod	• Sudano-Sahel
6. *Vangueria spp.*	• Fruits • Fuelwood	• Miombo Woodlands of Southern Africa
7. Sesbania spp.	• Soil improvement • Fuelwood	• Eastern, Central and Southern Africa

ICRAF MPT-GRC currently has two full-time professionals (Julia Ndungu and myself) and a secretary.

In an initiative with DANIDA donor funds have been made available to support this initial development of the MPT-GRC through salary to support the Kenyan professional, a germination cabinet, a car, a computer for documentation, and funds for seed purchase from established centres. It is also envisaged that Danish tree breeder consultant will be available to assist in the development of the Centre.

6.2 Future building plans

A wide range of options were considered for the establishment of the ICRAF MPT-GRC. ICRAF has taken a decision to construct a complex at the ICRAF H.Q. site. Donors will be sought and it is hoped that the design of such facilities will be an important activity for the remainder of 1992.

7. Acknowledgement

I wish to acknowledge the many helpful and challenging discussions 1 had with F. Owino and P. Cooper in developing this presentation. An early draft was sent to participants for comment, prior to the Consultation, and 1 thank all for assistance. I am reluctant to single out those for special mention but nevertheless wish to record the sterling efforts of FAO, OFI, Danida, CIAT and ILCA in putting forward excellent debating points to stretch ICRAF's concept of what was involved in developing our Centre. Many thanks to all.

Table 3. A suggested matrix of types of collections to be either lodged at the ICRAF MPT-GRC or developed infield gene banks

Type of CoIlections	Tree Breeding and Conservation e.g. 5 species maximum per eco-region globally	Conservation of rare potentially useful MPTs	Examples of specialist field screening trials					ICRAF Ecophysiology and on-farm trials
			Soil Related		Product Related			
			Sod fertility enhancement (for improved fallows)	Legumes for acid soils	Fodder[2] supply	Fuelwood poles	Indigenous fruit trees	
Base	✗ ✓	✗ ✓	✗	✗	✗	✗	✗	✗
Active	✓	✓	✓	✓	✓	✓	✓	✗
Working	✓	✗	✗	✗	✗	✗	✗	✗
Ex situ field gene banks	✓	✓	✗	✗	✗	✗	✗	✗
General (semi-bulk)	✗	✗	✗	✗	✗	✗	✗	✓

Suggested percentage work effort

- Tree Breeding 60% Special selected species for ICRAF and collaborators
- Screening trials 10% (both acquisition from other centres and new collections). Material to be slowly accumulated in readiness for comprehensive trials.
- Conservation 10% Unique ICRAF identifications not lodged elsewhere
- Ex situ 10% Mostly part of tree breeding efforts field gene bank
- General 10% Only of seedlots in semi-bulk not available from National Seed Centres. Material for ICRAF field researchers (on-farm, ecophysiology)

Collaboration with IITA

2. Collaboration with ILCA

3. Collaboration with CIFOR

Table 3. A suggested matrix of types of collections to be either lodged at the ICRAF MPT-GRC or developed infield gene banks

Table 4. Suggested staff and activities development

1. Germplasm Management
   - (a) O.I.C.
   - (b) Assistant (graduate)
2. Four Germplasm explorers
   - (a) service activities
   - (b) species for tree improvement
   - (c) two technicians
3. Biotechnologists
   - (a) microsymbionts specialist
   - (b) tissue culture specialist
   - (c) support technicians (2)
4. Tree breeder - Advisory role to NARS and evaluator of improved germplasm
   - (a) one support technician
5. Germplasm health specialist
   - (a) one support technician

1992	93	94	95	96	97	98	99	2000	2001
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X
			X	X	X	X	X	X	X

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Discussion

1. Ques. What does the term MPT improvement/breeding mean? R. Schultz-Kraft

Ans. Improvement means screening of natural variation. Breeding implies genetic manipulation.

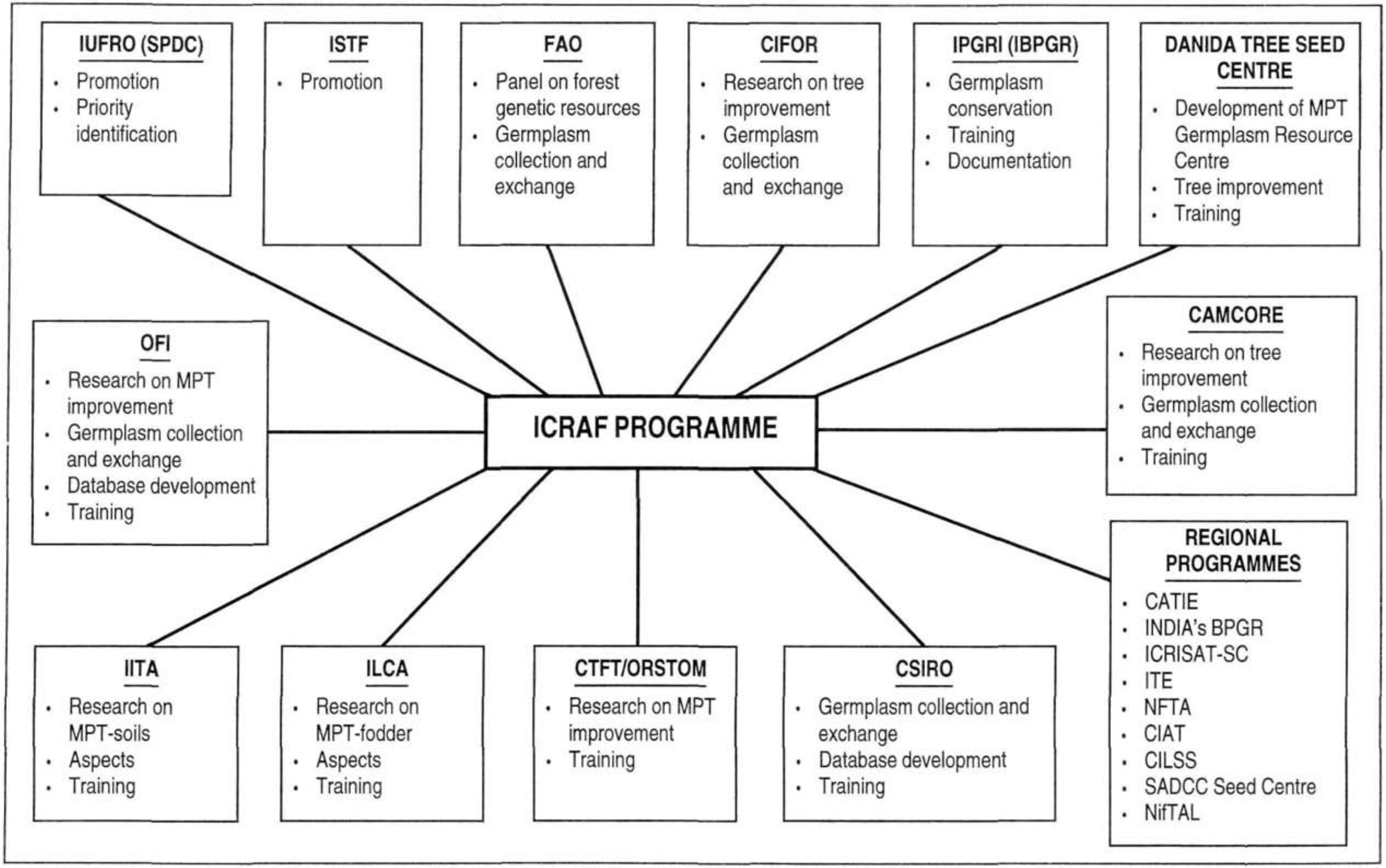

Figure 1: MPT improvement programme and MPT-GRC research links with other institutions (courtesy ofF. Owino)

Ques. Why the need for 4 plant explorers and how does this tie in with the need to collect new species. J. Brouard

Ans. There will be 2 plant explorers in Africa and one each in Asia and South America. Provenance seed collection for targeted species for tree improvement/breeding is the main objective. One of the explorers in Africa (Nairobi based) will specialize in new species exploration but main function will be to act as a catalyst to encourage others to collect e.g. national centres.

Ques. What's the difference between tree breeder and plant explorer? J. Brouard.

Ans. Plant explorer is a germplasm collector

Comment Need to address not only sanitation aspects of germplasm distributed but potential hazards such as weediness.

Ques. Will you develop according to the experience of NARs and will there be funds for NARs from ICRAF? J. Albrecht

Ans. a) ICRAF will be complementary in activities to NARs. It can't work without co-operation with NARs. D. Boland
b) ICRAF will consider joint funding depending on circumstances. P. Sanchez.

Ques. a) Will ICRAF be undertaking in-house genetic diversity studies?
b) Why do you insist that requesters of seed go to NARs first? R. van den Beldt

Ans. a) ICRAF will try to "farm-out" such studies
b) NARs must be involved and this is the best way of ensuring their involvement. They need also to be informed of what species are in demand.

FAO ACTIVITIES IN FOREST GENETIC RESOURCES WITH SPECIAL REFERENCE TO MULTIPURPOSE TREE SPECIES

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Introduction

According to its Constitution, the main functions of the Food and Agriculture Organization of the United Nations (FAO) are to -

- serve as an international forum and secretariat for food and agricultural matters (including fisheries and forestry),
- provide technical assistance in its field of competence, and
- promote exchange of information and know-how between nations.
- Assistance to member nations in the conservation and wise utilization of natural resources is clearly mentioned as being the responsibility of the Organization.

Plant genetic resources have been a concern of FAO since its early years. A Panel of Experts on Plant Exploration and Introduction was established in 1962 and the Organization has housed the International Board for Plant Genetic Resources (IBPGR) since its establishment in 1974.

This paper briefly presents FAO's activities related to forest genetic resources, with some emphasis on activities related to multipurpose tree species (MPTs).

Mode of operation

FAO's activities related to forest genetic resources are guided by the Panel of Experts on Forest Gene Resources, a Statutory Body of FAO established in 1968. The some 15 members of the Panel are appointed by the Director General of FAO in their personal capacity. They all have wide-ranging experience and knowledge of activities and issues related to forest genetic resources in their country, sub-region or region of origin. The Panel meets every 3 or 4 years. In addition to its recommendations for action in the short, medium and long terms, the Panel draws up and regularly updates a list of priority species by region and operation (exploration, collection, evaluation, conservation, utilization).

FAO works through, or in cooperation with, the national organizations of its member-countries. Although FAO is a technical assistance organization rather than a financing agency, modest Regular Programme funds are available for use as "seed-money" to support actions in response to needs identified by the Panel.

In addition, externally procured **funds contribute** importantly to FAO activities, particularly in technical assistance projects in the developing countries.

FAO cooperates closely and regularly with other international organizations (such as UNESCO, UNEP, IBPGR and IUFRO), with regional and sub-regional organizations (such as CILSS) and with bilateral cooperation agencies.

FAO activities on forest genetic resources

General Activities: Technical Support, Information, Coordination

Technical support, especially to developing countries, for the conservation and wise use of forest genetic resources is an important task of FAO's Forestry Department. This support includes all aspects of work, from programmes for the *in situ* conservation of forest genetic resources to assistance for the development of sound tree improvement programmes. It also includes assistance in the establishment of seed centres and advice on sustainable forest management (incorporating conservation concerns) and on appropriate seed sources for tree planting and reforestation projects. Assistance is provided, at request, directly to the national organizations or via field projects.

In addition to its supervision of and contacts with approximately 200 forestry field projects, the Department maintains close relations with over 60 seed centres and a similar number of research institutes and departments concerned with forest genetic resources conservation and improvement in developed as well as developing countries. The quality and wide range of contacts the Department maintains with institutions active in the field, contribute to the fulfilment of its information and coordination mandate. The Department helps in promoting cooperation between developed and developing countries as well as among developing countries.

FAO has over the years prioritized the dissemination and exchange of information to avoid overlap and duplication of efforts at a global level. Coordination of activities is facilitated by the work of the FAO Panel of Experts on Forest Gene Resources, which considers reports and information on on-going and planned activities of all relevant organizations. The FAO Forestry Department Newsletter, Forest Genetic Resources Information, published annually in three languages, is a valuable additional media in this regard, and regularly includes contributions from a range of institutions active in the forest genetic resources field. The formal and informal coordination of FAO in the forest genetic resources field has generally been acknowledged by all concerned; little duplication has occurred to date in such important and costly activities as the exploration and the evaluation of forest genetic resources, and this is at least partly considered to be due to such global coordination.

International Symposium on Seed Procurement and Legal Regulations for Forest Reproductive Materials in Tropical and Sub-Tropical Countries (Nairobi, Kenya 4 to 10 October 1992, IUFRO/GTZ/FAO/KEFRI); and Symposium and Workshop on Seeds (Ouagadougou, Burkina Faso 23 November to 8 December 1992, IUFRO/CILSS/FAO/Seed Centre-Burkina Faso)

Workshops and symposia are other means for information exchange, coordination and collaboration. FAO regularly organizes, co-sponsors or contributes to such meetings in cooperation with other national and international institutions. In 1992 two IUFRO meetings concerning forest seeds and genetic resources are being organized with the technical collaboration of FAO .

Exploration, Collection, Evaluation of Forest Genetic Resources

The first noteworthy results in internationally coordinated work in the field of forest genetic resources which convincingly demonstrated the value of systematic exploration/evaluation, originated in wide-ranging collections of *Eucalyptus camaldulensis,* carried out in the 1960s by the Forestry and Timber Bureau in Canberra, Australia, with technical and financial assistance from FAO's Forestry Department. FAO coordinated provenance trials were subsequently established on 32 sites in 18 countries.

Subsequent seed collections followed by internationally coordinated provenance trials include Oxford Forestry Institute/FAO and OFI/INIFAP/FAO collections of pines and hardwood species in Central America and Mexico, DANIDA/FAO collections of *Tectona grandis* and *Gmelina arborea,* CSIRO/FAO collections of *Acacia, Casuarina* and *Eucalyptus* species, and CTFT/FAO collections of moist and arid-zone hardwoods in West Africa. All these collections have systematically been made in cooperation with national institutes, and where moderate funding has been available from FAO, such funds have been channelled to permit the full and active participation of such institutes in the work.

In addition to the above, provenance collections for international trials and for genetic conservation purposes, have been recently carried out at the initiative, or with the assistance, of FAO, by the Governments of Mexico and a number of countries in South and Central America for a range of species including *Finns* and *Prosopis* spp.; the governments of Indonesia and Papua New Guinea for *Acacia, Araucaria* and *Eucalyptus* species; the governments of Burkina Faso, Senegal, Sudan, Yemen, Israel, India, Pakistan, Chile, Mexico and Peru for arid and semi-arid zone species of the genera *Acacia, Balanites, Parkia* and *Prosopis.*

Conservation of Forest Genetic Resources

Comprehensive trials are of little value if the tested provenances have disappeared by the time the results are known. FAO has given due attention to conservation of forest genetic resources both *ex situ* and *in situ.*

In collaboration with CSIRO, OFI and DANIDA, "semi-bulk" quantities of seed of proven provenances or provenances in danger of genetic depletion have been procured for the establishment of *ex situ* conservation stands in interested countries, as a medium-term conservation measure. The species concerned so far are mainly tropical pines, eucalypts, and *Acacia* and *Prosopis* species.

Through a recent UNEP-assisted FAO project on *in situ* conservation of forest genetic resources, pilot *in situ* conservation areas have been established in collaboration with the Governments of Cameroon, Malaysia, Peru and Yemen.

Utilization of Forest Genetic Resources

Wise and appropriate use of forest genetic resources requires building-up or strengthening of national expertise and facilities in developing countries, including assistance in establishing/strengthening national or at times regional tree seed centres and related improvement/conservation programmes. A large proportion of FAO's field projects include these activities within the framework of wider development programmes. Exchange of know-how, information and genetic resources, and collaboration between countries, are also promoted *i.e.* through the establishment of regional and international networks, as well as networking of institutes working in similar ecological conditions.

Activities concerning MPTs

FAO does not have a specific programme on genetic resources of MPTs. However, in pursuance of the overall goal to assist member countries in meeting the basic needs of all strata of their populations, on-going genetic resources programmes are concentrating on assistance to rural development and the rural poor; and aim at promoting the use of well-adapted, robust genetic material suitable especially for village woodlots, shelterbelts, fodder, etc (thus, involving mainly MPTS). The list of priority species drawn by the Panel of Experts on Forest Gene Resources reflects this preoccupation by the high proportion of MPTs included. The FAO Panel requested added focus and importance to be laid on multipurpose species as early as 1977 *(see* Report on the 4th Session of the Panel).

The following two projects are good examples of recent FAO activities on MPT genetic resources.

FAO/IBPGR/UNEP Project on genetic resources of arid and semi-arid zone arboreal species for the improvement of rural living

The project was initiated by FAO's Forestry Department in 1979 with financial support from IBPGR and UNEP.

The main aim of the project was to act as a catalyst for gathering genetic materials and information on arid and semi-arid zone woody species, and to aid countries in the practical applications of the results. Information on the project has been regularly published in "Forest Genetic Resources Information". Activities and achievements of the project are briefly reported here.

Eight countries originally cooperated in the project, and are involved in all phases of exploration, collection, conservation and evaluation viz Chile, India, Mexico, Pakistan, Peru, Yemen, Senegal and Sudan. The Land Development Authority of Israel, CSIRO (Australia), CTFT (France) and OFI (U.K.) also participated in the seed collection phase. Seed storage and distribution has been entrusted to the DANIDA Forest Seed Centre and Kew Gardens (this latter institute providing long term seed storage facilities).

A total of 281 provenances of 43 species, mainly of the *Acacia* and *Prosopis* genera, were identified and sampled. More than 1,600 Kg of well-documented seed was collected following precise, standard guidelines.

Trials have been established since 1983 by one or several institutes in 17 countries, using standard design and evaluation schedules to allow global comparison of results and to provide maximum information on performance of the species and provenances at local as well as global levels.

Semi-bulk quantities of seed of a number of provenances are kept in store, in view of the subsequent establishment of *ex situ* conservation stands of proven species and provenances.

The project, in spite of its limitations in funding and timeframe, has provided a framework for action, and has assisted national institutes in a range of countries in coordinating their activities aimed at wise utilization of species which occur in a number of countries and in which exploration, collection and conservation activities consequently should not be confined within national borders. To support the countries in strengthening their national institutions and to promote international cooperation, the project also provided minor funding for purchase of equipment, training and dissemination and exchange of information.

The project has also produced a number of technical publications on the main species concerned and the techniques used for seed collection, storage and utilization.

Although financing from IBPGR/UNEP has ceased, the project is confining using FAO Regular Programme funds; and through collaborative arrangements between FAO and the DANIDA Forest Seed Centre.

FAO Project on Genetic Resources of Multipurpose Woody Speciesin the Sahelian and North Sudanian Zones of Africa

As a follow-up to the IUFRO symposia on Forest Research Planning in Sahelian and North Sudanian countries of Africa, held in Nairobi in 1986 and 1987, this on-going project financed by French Trust Funds aims at assisting the concerned countries in building up and strengthening their expertise and capacity in the field of forest genetic resources conservation, improvement and utilization.

This project is carried out in collaboration with IUFRO which provided technical and financial support.

In cooperation with national authorities and with relevant regional organizations, the project has assisted in the formulation of 15 country-specific project documents. These documents generally include two components: (i) creation/strengthening of National Tree Seed Centres; and (ii) a Tree Improvement Programme, drawn up with due concern to genetic conservation aspects. A regional coordination project has also been prepared within this framework, to be administered and executed in cooperation with CILSS. These proposed projects have been officially given high priority by the countries in the sub-region and funding has been, or is about to be, secured for a number of them.The FAO project has also produced technical documents, among which a Directory of the Seed Sources (provenances) for Sahelian and North Sudanian Africa. The representative of CILSS at this consultation will complement the above remarks on this project, which is a good demonstration of practical application of our objectives as regards the promotion of wise management and use of forest genetic resources, carried out in close collaboration with national governments and regional organisations.

Future activities

Support to and strengthening of national institutes and the building up of technical expertise in member countries, especially in developing countries, will remain a main focus of FAO. Stress will also continue to be laid on networking between institutes, awareness raising and support for the exchange of technical know-how, information and genetic materials. This focus is based on the conviction that the conservation and wise use of genetic resources can only be achieved if local institutes and Governments are intimately involved in the planning and execution of related activities and are convinced about their importance in the immediate as well as the longer term.

Among the networks to which support will be continued is the one in the Sahelian/North Sudanian Zones of Africa, in which national Governments, CILSS and FAO will work closely together towards improved management and use of the genetic resources of local tree and shrub species. Appropriate links between this project and activities of Institutes in dry-zone countries in other regions and sub-regions, will also be promoted.

In Latin America, activities aimed at the conservation and enhancement of species native to the moist tropical forest, will be carried out in close collaboration with those of the FAO Coordinated Regional Networks on Protected Areas. High altitude species for local community development, will receive special attention within the framework of our Sub-Regional Project covering this ecological zone.

In Asia, in addition to the continuation of on-going activities related to *Acacia, Casuarina* and *Eucalyptus* species, we hope in the near future to help coordinate and support exploration and collection of *Azadirachta indica,* a multipurpose species of wide-ranging use in Asia, West Africa and Latin America e.g. Haiti.

In the general field of information, a project of a forest genetic resources Database to be developed by the Agriculture and Forestry Departments of FAO and by IBPGR, deserves special mention. The Directory of Seed Sources of dry-zone MPTs mentioned earlier, is also an important activity both *per se,* and as a study of methodology and *modus operandi.* On-going work in collaboration with CTFT aims at the development of software for seed bank management in developing countries; close contact is maintained in this respect also with CSIRO, OFI and DFSC. Work on databases for species/site matching is underway in collaboration with CSIRO and OFI, with contacts having been made also with ICRAF and NFTA.

Conclusion

During the more than 40 years of its existence, FAO has pioneered work in the field of forest genetic resources, coordinating, catalysing, and working closely with international and national organizations in developing as well as developed countries.

Although the achievements in the field of forest genetic resources to date are already noteworthy, there is still much to be done; support, collaboration and assistance from new actors such as IBPGR, ICRAF or CIFOR in confronting this challenge are welcome. Within the framework of its mandate and the programmes prioritized by its 162 member nations, FAO will continue to vigorously pursue collaboration, at equal standing, with other national and international institutes and organizations.

With an increasing number of organizations involved in forest genetic resources activities, coordination and exchange of information are more important than ever, and intensification of efforts in this regard is necessary to avoid unwanted duplication which has been to date minimal in the forestry field, thanks largely to the coordination of FAO and its Panel of Experts on Forest Gene Resources and the collaboration of national and international institutes concrened. The opportunity to discuss with colleagues from developing and developed countries the proposal put forward by ICRAF for the development of a multipurpose tree germplasm resource centre is welcomed as a step towards strengthening the activities in the forest genetic resources field in a coordinated and efficient manner.

Discussion

Comment IUFRO is a partner and co-sponsor of the Regional tree seed programme together with FAO and CILSS. This was not reflected in the presentation. E. Bonkoungou.

ACTIVITIES OF THE DANIDA FOREST SEED CENTRE

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Introduction

The DANIDA Forest Seed Centre (DFSC) is a project funded by the Danish International Development Agency (DANIDA). DFSC is based in Denmark but has its main activities in developing countries. The centre was established in 1981 as a continuation of the Danish/FAO Forest Tree Seed Centre, first established in 1969 as part of an internationally coordinated programme formulated by the FAO Panel of Experts on Forest Gene Resources in 1968. In January 1990 a new 5 year project was approved by DANIDA.

Objectives of Danida Forest Seed Centre

Long term objectives

Improve wood production (in quantity and quality) and provide other benefits from growing plants; contribute to the protection of the environment and to its restoration where it has been degraded; and help meet people's requirements for fuel, timber, poles, fodder, food, shelter and amenities.

Immediate objectives

Strengthening or establishment of national seed centres by the transfer and exchange of technology and expertise in seed procurement, tree improvement and gene-resource conservation.

Preparation of strategies for seed procurement which make it possible to cover the immediate seed demand and at the same time incorporate long term measures through tree improvement and gene conservation.

Contribution to research and development of improved techniques and methodology in seed handling and in evaluation of species and provenance trials.

Components of the DFSC Programme

The programme is divided into Base Programme and Project Support. Operationally these are closely integrated with regard to content and staff utilization. A breakdown of activities in each is as follows.

Base Programme

The main purpose of the base programme is to provide the knowledge necessary to support projects. The size of the programme will vary to some extent according to the number of projects. The following activities are conducted in the base programme:-

- Information and library service: publications and training are the main channels for the transfer of knowledge.

  DFSC's information service is primarily offered to countries to which DANIDA renders support.

  The DFSC publications appear at regular intervals in the following series: Circular Letters, Technical Notes, Species Seed Leaflets, Seed Handling Notes and Lecture Notes. They are announced in Circular Letters sent out once or twice a year to interested persons, projects and institutions.

  Three books have been issued: A Guide to Forest Seed Handling with special reference to the tropics (1985), evaluation of an International Series of Teak Provenance Trials (1986) and Evaluation of an International Series of Gmelina Provenance Trials (1987).

- Training/Courses of 2-3 weeks duration for groups of 25-30 persons and usually conducted on location in the countries receiving project support.

  Training courses are arranged according to local requirements and level of education. They are rarely, if ever, identical. They may put emphasis on technical matters like seed collection or seed handling or they may concentrate on subjects within tree improvement or conservation of forest gene resources.

  The series of Lecture Notes forms the basic reference material for the trainees.

- Research and Development

  Research and development includes activities within the fields of seed procurement, tree improvement and gene conservation, necessary for DFSC to maintain its position as a major centre of knowledge in tropical and sub-tropical tree seed, and to be able to provide the knowledge for support to projects and to DANIDA as a resource base.

  Research will be undertaken when information or developments for operational purposes are not already available for adaptation to meet the new requirements.

  First priority is given to multipurpose species. For the Sudano-Sahelian region species suited for semi-arid and arid conditions will be given highest priority.

  Industrial species will also be included to the extent it is deemed necessary for providing the priority countries with the requested technical support.

  The chosen multipurpose dry-zone priority species, to a large extent, will be the same for a number of the DANIDA supported African countries. In addition to the common priority species, the individual countries have specific priority species which may also be included in the activities of DFSC.

At present, research and development focus on:

a) Multipurpose Species

- Information on taxonomy, distribution and ecology, genetics and seed biology

- Information and evaluation of existing species and provenance trials. DFSC, in co-operation with FAO is presently evaluating field trials established within the framework of the FAO project on Genetic Resources of Arid and Semi-arid zone arboreal species and provenances.
- Seed supply for establishment of seed stands, gene conservation stands, pilot plantations and research.

b) Teak and Gmelina international provenance trials

- Second phase evaluation is presently being carried out by DFSC.
- Guidelines for choice of seed sources and seed supply.

c) **Tropical pines (Central American and Southeast-Asian pines)**

- Establishment of *Pinus kesiya* provenance and single tree trials, coordinated by OFI in consultation with DFSC.
- Establishment and development of stands for seed supply.

d) Seed Biology and Technology

- Development of methodology and equipment for seed handling, storage, testing, pretreatment and germination.

e) **Seed Bank**

- A seed bank attached to the DFSC provides seed handling and storage facilities.
- The activities include receipt, handling and distribution of seed for research purposes as well as for establishment of seed stands, conservation stands and pilot plantations.

Project Support

Project Support consists mainly of consultancy service and backstopping to current projects, primarily tree improvement/seed centre projects. However assistance regarding choice of species, seed procurement and gene conservation will also be given to other projects financed by DANIDA *viz* soil conservation, agroforestry and afforestation. Some support, technical advice and guidelines will also be provided from the Base Programme.

DFSC will emphasise support to projects which aim at building up national seed supply and tree improvement capabilities. Such projects should primarily be undertaken in countries which have active forestry sectors and sizable planting programmes. As a resource base for DANIDA, the DFSC's service will primarily be offered to countries to which DANIDA renders support.

Some of the promising species for Africa are indigenous to Central and South America, to Australia or to SE-Asia. This entails a need for international collaboration and direct links to Institutes in these regions to be carried out under the base programme.

At present project support is given to projects in:

Tanzania	Djibouti
Kenya	Burkina Faso
Uganda	Nicaragua
Ethiopia	Costa Rica
Sudan	Nepal

Discussion

1. Ques. What is your annual budget and staff numbers? T. Vercoe

Ans. 5 million Danish Kroner. Have eight professionals (includes 3 part-timers) plus ability to engage consultants as needs arise.

2. Ques. Please elaborate on how you make that link between research and extension? J. Chamberlain.

Ans. With reference to seed supply? In this case DTSC will help National Seed Centres get good quality seed if they can't procure it themselves.

3. **Ques.** Has DFSC experienced difficulties in obtaining semi-bulk quantities of seed of superior provenances of teak *(Tectona grandis)* and *Gmelina arborea* identified in DFSC international provenance trials. L. Thomson.

Ans. Yes in some cases it has been very difficult to recollect seed of important provenances e.g. India now has regulations that severely restrict export of Teak seed. One solution is to collect larger quantities of seed prior to testing and maintain a portion in long-term storage for future use.

FOREST GENE CONSERVATION AND GENETIC TESTING EFFORTS OF THE CAMCORE COOPERATIVE

W.S. Dvorak
CAMCORE, Raleigh, U.S.A.

Introduction

The Central America and Mexico Coniferous Resources (CAMCORE) Cooperative (a non-profit organisation) was formed at North Carolina State University (NCSU) in 1980 to preserve, test, and utilize forest species native to middle America. The program is unique because the driving force behind its formation was private forest industry in North and South America (Gallegos, *et al.,* 1981). At present, CAMCORE has 20 members in 11 different countries (Table 1). More members are expected to join the program in the next several years.

Table 1. Membership in the CAMCORE Cooperative in 1992

ORGANIZATION	**COUNTRY**	**YEAR***
Active Members		
Empresa Brasileria de Pesquisa Agropecuaria (EMBRAPA)	Brazil	1983
Klabin Fabricadora de Papel e Celulose S.A.	Brazil	1988
Igaras Papeis e Embalagens Ltd.	Brazil	1989
Pisa Florestal S.A.Brazil 1989Universidad Austral de Chile	Chile	1990
Smurfit Carton de Colombia, S.A.	Colombia	1980
Pizano/Monterrey Forestal Ltda.	Colombia	1983
SAPPI Forests Ltda.	South Africa	1983
Department of Water and Forestry (DWAF)	South Africa	1983
MONDI Forests	South Africa	1988
Smurfit Carton de Venezuela, S.A.	Venezuela	1986
Productos Forestales del Oriente C.A. (CVG PROFORCA)	Venezuela	1988
Contributing Members		
Jari Companhia Florestal Monte Dourado	Brazil	1983
Centra Agronomico Tropical de Invest, y Ensenanza (CATIE)	Costa Rica	1987
Weyerhaeuser Foundation	USA	1980
Honorary Members		
Banco de Semillas Forestales/DIGEBOS	Guatemala	1980
Escuela Nacional de Ciencias Forestales/COHDEFOR	Honduras	1982
Centra de Genetica Forestal (CGF)	Mexico	1986
Instituto Nacional de Invest. Forestales y Agropecurias (INIFAP)	Mexico	1983
Banco de Semillas Forestales/IRENA	Nicaragua	1990

Year association began

The CAMCORE approach emphasizes *ex situ* gene conservation (Dvorak, 1990). A small staff headquartered at the College of Forest Resources, NCSU, coordinates seed collections of threatened forest species in Mexico and Central America with the assistance of host government forestry organizations. Research amounts of seeds from the collection are distributed to its members throughout Latin America and Africa. Gene conservation banks and genetic tests are established on member's land using a standardized design; genetic tests are assessed at 3,5, and 8 years of age, and the data are analyzed at NCSU. Results from the testing program are made available to the public. Once good species and populations are identified, cooperative-wide tree breeding programs are initiated. The commitment of members to the CAMCORE program are to provide land for test establishment, plant and assess the field trials at the required time, and exchange genetic material with other participants once good genetic material has been identified.

CAMCORE seed collections are by individual mother trees. Provenance/progeny testing is done in one step rather than using the more traditional two-step approach of provenance testing followed by progeny testing. There are two reasons for combining provenance/progeny testing into one phase. First, populations of trees are under such severe pressure in Mexico and Central America that repeated seed collections over time may not be possible. Second, it was assumed that the greatest genetic variation, and therefore, the greatest genetic gains would occur by making family and within-family selections in the trials. The more quickly this stage is completed, the faster improved genetic material will be available to the wood user.

Since 1980, CAMCORE has selected 6400 trees of 25 conifer and broadleaf species in 230 locations in Mexico and Central America (Table 2 and 3). Each tree selected in natural stands has been given a pedigree number which is maintained on a data base at NCSU as well as in progeny trials. More than 1000 hectares of gene conservation banks and genetic tests have been established. More importantly, after 12 years of operations, 91% of all field plantings established still have survival better than 80% (Dvorak and Donahue 1992). This excellent record

Table 2. Coniferous species collected by CAMCORE since 1980

Species	**No. of Provenances**	**No. of Trees**
Abies guatemalensis	3	**120**
Pinus ayacahuite	16	394
Pinus caribaea	18	1021
Pinus chiapensis	16	374
Pinus greggii	9	169
Pinus herrerae	4	160
Pinus leiophylla	11	309
Pinus maximinoi	23	785
Pinus oocarpa	7	66
Pinus patula	22	510
Pinus pringlei	7	167
Pinus radiata	3	90
Pinus tecunumanii	45	1379
Pinus teocote	3	90

is unparalleled in international forest genetic testing in the Tropics and Subtropics, and demonstrates the dedication of the participants of the program.

A tree improvement plan has been written for the cooperative that is flexible to accommodate the many interests of its members. A selection index is now being used to choose the best individuals in the oldest genetic tests (Balocchi 1990).

The Tropical Broadleaf Program

Approximately 10% of CAMCORE's efforts are devoted to tropical hardwoods. The hardwood program began in 1984 on a small scale with seed collections of *Tabebuia rosea* and *Cordia alliodora* in Guatemala followed a year later with collections of *Bombacopsis quinata* and *Schizolobium parahybum* in Honduras. The program expanded in 1988 to include other species like *Albizia caribaea, A. guachepele, Alnus acuminata, Sterculia apetala* and *Vochysia hondurensis* when CATIE joined the CAMCORE program and a grant from AID was received to intensify seed collections.The goal of CAMCORE was to collect seeds from as many as 30 trees per population in as many populations as possible. The oldest CAMCORE broadleaf tests are five years old and are predominantly planted in Costa Rica, Colombia and Venezuela.

As with the conifers, CAMCORE's priorities in species selection of hardwoods was to choose those that were threatened but also had potential for reforestation. For example, *Bombacopsis quinata* is extremely endangered in parts of Central America and has great commercial potential for small farmers and private industry. The genetic base accumulated by CAMCORE is probably the largest available *ex situ,* and results from genetic tests have provided valuable information on genetic variation and the potential for improvement through breeding (Dvorak and Donahue 1992). Furthermore, silvicultural techniques developed by Pizano/Monterrey Forestal, Colombia, a CAMCORE member, for *B. quinata,* have been documented in a paper by Kane *et ah* (1992) to further assist those interested in growing the species.

Table 3. Broadleaf species collected by CAMCORE since 1984

Species	No. of Provenances	No. of Trees
Albizia caribaea	5	68
Albizia guachepele	3	44
Albizia saman	1	20
Alnus acuminata	5	71
Bombacopsis quinata	7	224
Cordia alliodora	13	97
Enterolobium cyclocarpum	3	60
Schizolobium parahybum	3	57
Sterculia apetala	2	38
Tabebuia rosea	3	86
Vochysia hondurensis	3	57

Future Activities

CAMCORE will continue to select one or two new species per year in Central America and Mexico for the next several years and begin range-wide seed collection and testing. The balance of 90%/10% workload with conifers and broadleaf species, respectively, will be maintained. Genetic material is available to any organization willing to support the seed collections and establish the gene conservation banks and genetic tests according to CAMCORE guidelines. Annual dues to support the program are currently US$18,500.

Results from across-site analysis are available for *Pinus tecunumanii* and will become available for many of the other pine species and *B. quinata* in the next 3 years.

Initial results suggest that provenance performance is stable across locations but that some half-sib families are interactive. Suggestions have been made to cooperators that families must be tested on all sites where they are to be operationally planted (Balochi 1990).

A recent emphasis in the CAMCORE program is to examine the efficacy of using genetic markers, like RAPD, to quantify levels of genetic diversity in natural populations as well as the effects of fragmentation upon population structure in natural stands. CAMCORE is in a unique position to examine patterns of genetic variability at the population-level because of NCSU's leading role in forest biotechnology and the fact that the Cooperative has generated the factual data on variation of metric traits through its hundreds of field plantings.

Potential Areas of Collaboration Between CAMCORE and ICRAF

ICRAF and CAMCORE would benefit by close collaboration in germplasm collections in Central America and Mexico. A CAMCORE-ICRAF linkage would provide a vehicle for technology transfer from forest industry in Latin America to the MPT Improvement Programme, Kenya. Joint research projects could be developed in the areas of forest gene conservation, applied tree improvement, vegetative propagation and reproductive biology with graduate students being involved in all phases of the research. ICRAF staff would have the opportunity to work with research staff of CAMCORE organizations to learn or up-date forestry skills. Forestry short courses could be held at ICRAF with faculty from NCSU sharing the responsibility for course introduction.

Conclusions

Approximately 10% of CAMCORE activities are devoted to tropical broadleaf species. Seeds are collected by mother trees in natural stands and distributed to CAMCORE's network of private forest industries and government agencies. Field *ex situ* conservation banks and genetic tests are then established. The most intensive work to date on a tropical hardwood has been done with *Bombacopsis quinata*, a predominantly dry-zone species, that is threatened in most parts of its native range, and has high commercial value. CAMCORE and ICRAF could work together to collect and test additional species for the benefit of both organizations.

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Discussion

1. Ques. I recently read draft scientific papers on your Camcore activities with broad-leaved species. The trials site received above 2500 mm per annum. How have these species performed in drier sites? J. Maghemebe

Ans. Trees died in trials in Colombia experiencing 1000 mm per annum.

2. Ques. What is your long term strategy in tree improvement/breeding? P. Cooper

Ans. To make more intensive cross-pollination programmes and to exchange improved materials.

3. Comment You mentioned the question -"what should ICRAF do with species that don't have much use? We don't have an answer to that yet. In our understanding with CIFOR, we (ICRAF) will handle species with potential agroforestry use and CIFOR will handle other species. P. Sanchez

CTFT/CIRAD ACTIVITIES: SEED BANK AND BIOTECHNOLOGIES

H.Joly
CTFT, Nogent-sur-Marne, France.*

Introduction

"Centre Technique Forestier Tropical" (CTFT) is the Forestry Department of "Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement" (CIRAD). There are 45 researchers working in different tropical countries on collaborative programmes with national and international institutes. Scientific backstopping is provided by the headquarters (30 researchers), based in Nogent-sur-Marne near Paris. The activities of CTFT/CIRAD are grouped in four programmes *viz* Agroforestry, Forest management, Tree improvement and Wood technology.

The activities of the tree improvement programme range from germplasm collection and conservation to genetic improvement. It has therefore developed a seed bank, based at headquarters, and it is also using new technologies as complementary tools for the production of improved material for plantation and for the preservation of the genetic diversity of woody species such as genetic markers (isoenzymes, RFLP), *in vitro* multiplication and genetic transformations. Studies of symbiotic nitrogen-fixing trees are also pursued in collaboration with ORSTOM (Institut Frangais de Recherche Scientifique pour le Developpement en Cooperation) at the joint laboratory "Biotechnologie des Symbioses Forestieres Tropicales" (BSFT), in Nogent-sur-Marne.

Seed bank

The seed bank at the headquarters of CTFT/CIRAD was established in 1974. Three large cold chambers permit the storage of large seed collections. More than 9 000 seed lots representing 300 species (Table 1) are stored at present. CTFT/CIRAD has been involved in collecting seed since 1973. Collaborative work has been carried out especially with CSIRO in the collection of eucalypt and acacia species. Since FAO classified African acacias as priority species for collection and conservation in the 1980's, CTFT has collected in collaboration with National Institutes in Burkina Faso, Burundi, Cameroon, Mali, Niger and Senegal, *A. albida, A. nilotica, A. tortilis* and/or *A. Senegal* (Table 2). These collections were carried out mostly for research purposes and all possible care was taken to ensure the correct identification of the seed lots. A seed collection report form was completed for each provenance (Table 3). Where possible single tree progenies were harvested

*CTFT recently renamed CIRAD-Foret

for at least 20 trees per provenance in order to be able to assess the heritability of some important traits in future trials. Trees, ideally, were distant enough geographically to avoid harvesting related individuals.

For the management of this large collection a data base has been developed. This allows the handling of incoming and outgoing seed lots and also assists in the retrieval of information about a given species either per provenance or per progeny. Information about seed lots from a given country or for given ecological conditions can also be obtained. In recent years CTFT/CIRAD has sent seed lots to more than 30 countries in Africa, Asia and South America. In exchange it receives on average 650 seed lots per year. Germination of seed lots is undertaken and some seed pretreatment studies are carried out to improve germination rates.

Table 1. Some information on seed lots in CTFT/CIRAD seed bank

	Number of provenances	Number of single tree lots	Total stock single tree lots (kg)
Acacia spp.		2 149	706
Faidherbia albida	66	742	445
Acacia Senegal	39	538	107
Eucalyptus spp.		3 485	74
E. urophylla	115	682	16
E. camaldulensis	148	651	31
Terminalia superba	34	395	545

Evaluation

Evaluation of the collection is underway both through provenance/progeny trials and using genetic markers (isoenzymes). In collaboration with national institutes CTFT has established many trials over the years. Since 1953 a large programme of introduction of *Eucalyptus* species has been undertaken in the Congo and provenance trials have been established for the most interesting species. Nowadays progeny and clonal testing are developed in the framework of an improvement programme based on a recurrent reciprocal selection scheme involving the production of interspecific hybrids. Industrial plantations were started in 1978 with clones of interspecific hybrids and these allowed an increase in production from 12 m3/ha/year to 25 m3/ha/year. Trials have also been established for *Terminalia, Gmelina, Tectonagrandis, Acacia mangium* and *A. auriculiformis. A* clonal seed orchard for *Tectona grandis* is now in production in Ivory Coast.

As an example of a complementary action using field trials and genetic markers to evaluate genetic diversity an EEC funded project is being conducted on the "Evaluation of genetic resources and the study of the reproductive biology of *Acacia albida* for its better use in agroforestry". This work involves scientists in Burkina Faso, France, Senegal and the United Kingdom. Similar work is under way for economically important rattan *(Calamus)* species in Malaysia. So far exploitation of rattan has mostly been carried out through harvesting in natural forests and therefore the genetic resources are endangered.

In vitro culture

Vegetative propagation is an important tool both for short term gains in production and for the mobilization of selected trees in seed orchards. It could also be important for the preservation of endangered genotypes.

Horticultural techniques sometimes fail because the species does not respond well and/or because the resulting plants do not possess the qualities of the original individuals. It frequently happens that even if horticultural techniques can be used to propagate young trees they are not efficient for older individuals. In this situation *in vitro* techniques could be developed to rejuvenate material.

CTFT/CIRAD is developing this technique mainly in three locations:

- at BSFT in Nogent-sur-Marne where *in vitro* techniques are used mostly as a tool for further research on the efficiency of symbioses (the main species under study are *Casuarina, Acacia mangium* and *A. albida)*
- at the joint ISRA/ORSTOM laboratory in Dakar (Senegal) where efforts are concentrated on the mobilization of mature trees of *Acacia Senegal* and *A. albida*
- at the joint ICSB (Innoprise Corporation Sdn Bhd)/CTFT *in vitro* laboratory in Tawau (Malaysia) where the main problems addressed are the rejuvenation of old trees of *Acacia mangium* and *Tectona grandis* and the improvement of techniques for the multiplication of rattans.

Genetic transformation

This work is carried out at BSFT (Table 4) in collaboration with universities and research institutes in France and elsewhere.

Genetically engineered *Casuarina* plants have been obtained after transformation with *Agrobacterium rhizogenes;* further research is been carried out on transformation using *Agrobacterium tumefaciens* and gene-coated particle bombardment. This technique will be mostly developed as a powerful tool for studying gene expression in trees and especially of genes involved in the nitrogen-fixation process of both casuarina and acacias.

In the long term, genes for a given effect could be incorporated in the genome of trees to enhance their productivity, the qualities of their products and/or their resistance to pests.

Genetic markers

Different genetic markers can be used to assess the level of the genetic diversity of populations of a given species. Some can also be used in improvement programmes for early selection and/or to follow the evolution of the diversity of the base population.

Isoenzymatic electrophoresis has been used to study the organization of the genetic diversity of *Terminalia superba* populations from Central African Republic, Cameroon, Congo and Ivory Coast. Work is also under way to study the genetic diversity of African acacias e.g. *A. albida* in collaboration with "Ecole Nationale du Genie Rural des Eaux et des Forets" (ENGREF) and with *A. Senegal* and *A. tortilis* under an EEC funded project coordinated by ORSTOM and based in Dakar. *A. albida* is a very variable species which exhibits two main groups one in East Africa and the other including populations from West and Central Africa ; study of the reproductive biology shows that it is likely to have some level of self-incompatibility.

Studies involving RFLP (Restriction Fragment Length Polymorphism) will be developed on *Eucalyptus* in order to establish a genetic map and to try to predict from the parent genotypes the performance of the hybrid progeny. RFLP is also being developed in order to identify the strains of rhizobium and mycorrhizae with more accuracy than is possible with isoenzymes or immunological techniques.

Conclusion

It is stressed that CTFT/CIRAD does not foresee development of biotechnologies as an end in itself ; they are used in the framework of the tree improvement programme. Therefore, after determining with the users the aims of the improvement programme, they should be considered as complementary tools to establish efficient improvement strategies for the short term as well as for the long term. More specifically genetic markers could be used to assess the organization of the genetic diversity and the breeding system of important multipurpose trees in order to develop, along with improvement programmes, strategies for *in situ* conservation and/or for collection in order to establish *ex situ* conservation programmes.

Table 2. Main seed collections undertaken by CTFT/CIRAD in cooperation with National Forest Organizations

AUSTRALIA		
	1973 :	Expedition organized with help of CSIRO and the Forest Departments of New South Wales, Queensland, Northern Territory and Western Australia. Large scale first phase prospection. Eucalyptus : 112 species (300 provenances) Other genera : 62 species (104 provenances)
	1980 /86:	Joint collections with CSIRO in Northern Queensland and Western Australia, to resample the good *Eucalyptus* provenances determined by the trials done after the first collection. 6 provenances of £. *camaldulensis* (22 to 40 trees collected in each provenance) 1 provenance of E. *tereticornis* (25 trees) 1 provenance of *E. tesellaris* (10 trees) 1 provenance of E. *alba* (8 trees) 1 provenance of E. *microtheca* (34 trees) kept in single tree seedlots.

Table 2. (continued)

1984: Joint expedition with CSIRO in a continental tropical arid zone of Australia (around Tanami Desert) yet unexplored as regards genetic resources of woody species. 51 species (91 provenances) were collected of which 38 ***(77*** provenances) were acacias: mainly *A. holosericea, A. cowleana, A. ligulata/bivenosa, A. acradenia, A. ampliceps, A. stipuligera, A. tumida.*

1986/88: Participation in expeditions organized by CSIRO in Northern and Queensland and Papua New Guinea
Acacia mangium : 25 provenances
Acacia auriculiformis : 8 provenances
Acacia crassicarpa : 11 provenances

INDONESIA

1973 & 1975: Expedition organized with the help of the Direktorat Jenderal Kehutanan and the Lembaga Penelitian Hutan (Indonesia) and the Reparticao Provincial dos Servicios de Agricultura e Florestas (former Portuguese province of Timor) involved collection in 7 islands of the Sunda Archipelago involved.

Eucalyptus urophylla : 86 provenances
Eucalyptus alba : 20 provenances

1979: Collection organized in cooperation with the Direktorat Jenderal Kehutanan and the Lembaga Penelitian Hutan.

Resampling of 3 good provenances of *Eucalyptus urophylla* determined by the trials done after the first prospection.
Kept in single-tree seedlots.

CENTRAL AND SOUTH AMERICA

1978 : Collection organized in cooperation with the Ministerio de Agricultura y Ganaderia (Nicaragua), the Corporation Hondurena de Desarollo Forestal (Honduras) and the C.F.I. (Oxford)

Pinus caribaea var hondurensis : 8 provenances

1988 : Collection organized in cooperation with Direccion Nacional Forestal in Ecuador
7 provenances of *Prosopis spp.* (259 trees).

AFRICA

Terminalia superba:

1981-1984: Collection organized in cooperation with the Forest Research Centre of Cameroon, the Office National des Forets of Central Africa and CTFT in the Congo and Ivory Coast.
30 provenances (420 trees) collected

Table 2. (continued)

Terminalia ivorensis:	
	Collection by CTFT in Ivory Coast
1982:	3 provenances
1986/87:	12 provenances
Faidherbia albida (syn. Acacia albida), Acacia Senegal, Acacia tortilis subsp. raddiana	
	Collections in cooperation with the Forest Research Centre of Cameroon, the Institut National de Recherche Agronomique in Niger, the Institut National de la Recherche Zootechnique, Forestiere et Hydrobiologique in Mali, the Institut Senegalais de Recherche Agronomique and the Direction de la Protection de la Nature in Mauritania.
1984	4 provenances
1985	6 provenances
1986	16 provenances
1987:	26 provenances

Discussion

1. Ques. Can you elaborate on success or difficulties in your international collection activities? H. Wolf

Ans. No problems in countries where CTFT is present but problems elsewhere.

2. Comment In regard to the previous question. It is difficult to organise collections thousands of km from base if no national expertise is available. We really need to develop national expertise. One example is the National Tree Seed Centre of Burkina Faso which was established with the assistance of CTFT O. Souvannovong

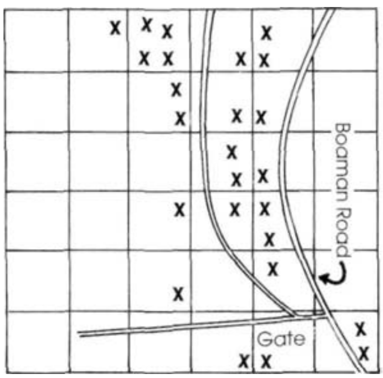
3. Ques. You mentioned tissue culture for *Acacia albida* and 1 would like to know if you have mass-scale tissue culture plantlets for farmers yet. B. Owour

Ans. No because far too expensive. We use node explants or rooted cuttings.

Table 3. Seed collection report

Location:
Adjacent to gate leading into primary industry reserve, off boaman road. 6 km SE off Charleville. Queensland

Sketchmap



Collection No. ...SM **218**-242...
Species: ...*Acacia* ***aneura....***
Country: **...Australia...**
Province: **...Queensland....**
District: **...Charlsville...**
Latitude: **...26° 25...**
Longitude: ...146° 17...
Elevation: ...300m...
Topography: ...Flat/Hilly...
Slope: ...steep/medium/gentle...
Soil: ...Deep/Shallow/intermediate..
Drainage: **...Good on sandy soil...**
Stoniness: **...Very little...**
Texture: **...Medium red sandy...**
pH: ...Acid/neutral/alkaline...**4.5...**
Rainfall: Mean annual: ...500mm...;
Wet months: **...January...**
Dry months: **...August...**

Temperature: Mean annual: ...20°C...; Mean max: ...28°C...;
Mean min: ...13°C; Frost: ...7... days/year

Stand: Natural: Groups/open Thin/dense
Young / **middle-aged** / old

Plantation: Age......years Height......m Diameter.....**cm**
Original source......................

Associated species: ...*Eucalyptus populnea, Cassia artemisioides*.............

Form: Boles: Single/multiple Straight/fair/poor

Crowns: Flat/narrow/average/wide

Seed crop: Light/medium/heavy

Seed collection: No. of trees ...25...; Minimum distance apart: ...20...m; Kg:...1480

Remarks: **...Long handle pruning saw and shears used for collection**...................

Date of collection:...**12.11.1981**

Officer in Charge: S. Midgley

Studies on the microsymbionts

- Isoenzyme analysis and identification of *Frankia* and *Rhizobium* by DNA markers
- Proteinases involved in the growth cycle of *Frankia.*

Studies on the host plant-symbiotic micro-organism interactions

- *Biochemical aspects:*

  Biochemical identification and the role of cell wall compounds in the infection process by *Frankia.*

- *Molecular aspects:*

  Genetic transformation of genes of the plant involved in the *Casuarina-Frankia* symbiosis.

- *Ecophysiological aspects:*

  Studies on nutritional factors (phosphorus and micronutrients) controlling the functioning of the *Acacia* symbiosis. Role of siderophores.

  Studies on *in situ* N2 fixation by *Acacia mangium* in relation to clone-*Bradyrhizobium* interactions.

  Factors involved in aerial nodulation of *Casuarina.*

New technologies to improve the productivity of the host plant

(Research focused mainly on *Acacia mangium, Faidherbia albida* and partly on *Casuarina)*

- Clone selection. Tissue culture methods
- Genetic transformation of the host plant using *Agrobacterium rhizogenes* and *A. tumefaciens* and gene-coated particle bombardment
- Development of vectors for gene expression in actinorhizal plants.

CATIE'S ACTIVITIES IN GERMPLASM CONSERVATION OF MPT SPECIES IN CENTRAL AMERICA

Rodolfo Salazar *
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The type of land holdings, the farm production systems used and the socioeconomic situation of most Central American smallholders, have led to the widespread utilization of multipurpose tree species (MPTS). Consequently, since 1956, the staff of the Tropical Agricultural Center for Research and Education (CATIE) in Turrialba, Costa Rica, has been studying agroforestry and silvopastoral systems used by farmers.

Most initial agrof orestry studies were carried out to understand the relationship between crops, animals and trees and the role of trees in the farming systems.

Smallholders in the region utilize forest trees mainly as shade trees in perennial crops (such as in coffee and cocoa plantations) and in pasture lands, and with annual crops. Trees are also grown as horticultural crop supports, living fences, windbreaks, or as boundary line-plantings along field borders or roads. Apart from the benefits for which the trees were planted with the crop, the farmers use them to produce fuelwood, poles (for rural construction and agricultural uses), lumber and sometimes fodder. Trees are not traditionally planted to protect or improve soil conditions. Most traditional MPTS are local species, including:

- *Alnus acuminata, Cordia alliodora, Cupressus lusitanica, Erythrina poeppigiana, Gliricidia sepium, Guazuma ulmifolia, Inga edulis, Pinus caribaea* var. *hondurensis* and *Pinus oocarpa.*

During the past decade, agroforestry research at CATIE has concentrated on analyzing the effect of MPTS on the production of coffee, cocoa, corn, beans, pasture and other crops. Research activities have also included management of protein banks and the evaluation of total biomass production.

During this period, more than 120 species elimination trails were established, utilizing more than 150 local and introduced MPTS, to identify the best species for the Pacific and Central regions of Central America. Twenty five priority species were identified for the region, including some of the species traditionally used.

A major obstacle to tree planting in the region is the lack of seeds of good genetic quality. In order to solve this problem, CATIE has been working on provenance and progeny evaluation and selection, selection of plus trees and the establishment of seed stands, provenance seed stands and seed orchards. CATIE has also been involved in germplasm conservation for priority species. These research activities have been carried out on small and medium-sized holdings, as a way to promote tree planting on such farms.

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Table 1. Seed production areas (ha) of MPT species, in Central America

Species	Costa Rica	Guatemala	Panama	Honduras	El Salvador	Total
Acacia indica				0.1		0,1
Acacia mangium	0.1		0.3			0,4
Alnus acuminata		2.0				2,0
Azadirachla indica				0,2		0,2
Bombacopsis quinatum				0,4		0,4
Caesalpinia velutina		2,1				2,1
Cassia siamea				0,2		0,2
Cupressus lusitanica	3,6	1,0			1,0	5,6
Eucalyptus camaldulensis		1.0		0,9	2,5	4,4
Eucalyptus cilriodora				0,1	7,0	7,1
Eucalyptus deglupta	1,0			0,8		1,8
Eucalptus grandis	0,1					0,1
Eucalyptus saligna	0,4					0,4
Eucalyptus tereticornis		0,6				0,6
Gliricidia sepium				1,0		1,0
Gmelina arborea	6,8	0,5	3,0	1,1	3,9	15.2
Leucaena glauca				0,9		0,9
Leucaena leucocephala		1,1		0,1	2,5	3,7
Pinus caribaea		36,0	5,4			41,4
Tectona grandis	1,3	2,0	2,0	2,4	4,5	12,2

Table 2. Provenance trials ofMPTS established in the Central America region

Species	GUA	HON	ELS	NIC	COS	PAN
Acacia mangium	1	2	1		4	2
Albizia guachapele					1	
Alnus acuminata					1	
Araucaria hunsteinii				1	1	
Bombacopsis quinata					2	
Calliandra calothyrsus		1			3	
Casuarina cunninghamiana					2	
Casuarina equisetifolia	1					4
Cedrela odorata					1	
Cordia alliodora					8	
Cupressus lusitanica	1				3	
Eucalyptus camaldulensis	2	2	2		1	3
Eucalyptus grandis					1	
Eucalyptus saligna		1	4		5	
Eucalyptus tereticornis	1		1			
Eucalyptus urophylla				3		
Gliricidia sepium	6	2	1	1	2	
Gmelina arborea	1	2	1	2	3	
Guazuma ulmifolia	1				1	
lnga spp		2			2	
Leucaena leucocephala		2		6	2	1
Pinus caribaea	2				16	
Pinus oocarpa					8	
Pinus tecunumanii					8	
Swietenia macrophylla					2	
Tectona grandis				1	2	
Vochysia hondurensis					3	

* Local species

The promotion of MPT planting during the last few years has increased the seed demand substantially, such that there is a shortfall in seed of the quality needed. Taking into account existing plantations of native tree species and small plots of introduced species, a methodology was developed to select and manage small seed production areas. These now satisfy part of the demand for better quality seeds. Table 1 presents a summary of the seed production areas for 20 species established to date.

More than 150 provenance trials have been established in Central America with 27 MPTS (local and introduced priority species). Seed samples have been supplied by CSIRO, DANIDA, CAMCORE, OFI and from local collections. The preliminary results of these investigations are already being used (Table 2).

In order to conserve invaluable germplasm of priority MPT species, CATIE has been identifying and selecting, in their natural distribution, plus trees of 14 species. These collections are being used in progeny tests, seed orchards, clonal seed orchards and germplasm banks (Table 3). Most species being studied at this level present a high risk of germplasm erosion and a few of them are exotic species for which there is limited availability of high quality seed. For the first time the region has some high quality seed production areas but this action needs to be reinforced throughout the whole region and for all MPT species of current and future importance.

Table 3. Gene conservation activities for MPT species of CATIE, in Central America

Species	No. plus trees selected	Conservation	Progeny tests	Seed orchards	Vegetative propagation
Acacia mangium	-	X	_	_	X
Albizia guachapele	54	X	1	1	X
Alnus acuminata	52	X	1	1	X
Araucaria hunsteinii	-	X	-	-	X
Bombacopsis quinata	117	X	1	1	X
Cedrela odorata	31	X	1	-	X
Cordia alliodora	73	X	5	5	X
Cupressus lusitanica	45	X	2	1	-
Eucalyptus deglupta	55	X	4	5	X
Eucalyptus camaldulensis	-	-	-	2	
Eucalyptus grandis	-	X	1	2	-
Eucalyptus saligna	-	-	1	-	-
Eucalyptus urophylla	-	X	-	-	-
Gliricidia sepium	177		2		
Leucaena leucocephala	24		2		
Erythrina spp	65				X
Gmelina arborea	65	X	8	8	X
, (20) *Inga spp*					
Pinus caribaea	-	X	4	-	-
Pinus oocarpa	-	X	2	-	-
Pinus tecunumanii	15	X	5	2	—
Swietenia macrophylla	36	X	2	_	X
Vochysia hondurensis	61	X	3	3	X

All germplasm conservation activities are being established *ex-situ,* due to the difficulties and insecurity of *in-situ* conservation.

Vegetative propagation techniques are being used to establish clonal seed orchards and germplasm banks, as well as clonal plantations derived from juvenile material.

In the last two years, techniques and experiences of germplasm evaluation and gene conservation have been transferred to national institutions through short courses on tree improvement during field days and in-service trainings. These activities will be refined and repeated in future years.

At the end of 1992 CATIE will be implementing the Project "Central American tree seed network and CATIE tree seed centre" funded by DANIDA. The main activities of this project are research and management of seeds of MPTs and reinforcement of national seed banks of the region.

Most of these materials are being used by students in their research activities. Preliminary findings of some of these results have been already published. All of the field information from germplasm evaluations is being stored and is available in the CATIE data base known as MIRA (Management Information for Tree Resources).

Discussion

1. Ques. Has CATIE done tissue culture work with MPTs? R. Schultze-Kraf t

Ans. No only with crops

2. Ques. Do you undertake investigations to determine the genetic variation of the exotic species in your conservation stands? J. Albrecht

Ans. We only undertake progeny trials and even here we have difficulty getting material.

3. Ques. Do you know anything about the deal between the U.S. company Merck and the Costa Rican government about the right to exploit plant genetic resources? Hans Muhs

4 Comment Merck has an agreement with INBIO to pay for chemical exploration rights. A royalty payment will be made for any drugs developed as a result. Dr Dan Janzen and "bare-foot" taxonomists are involved. J. Burley.

5. Ques. The presentation reflected development of MPTs rather than agroforestry systems research. Is this the true situation at CATIE? C. Lascano

Ans. There are two groups at CATIE. One group works on developing MPTs (seed, vegetative material, evaluation of provenance on a regional basis). Another group works on agroforestry research in Central America.

FRAMEWORK FOR GENETIC RESOURCES IN WEST AFRICA: THE SAHELIAN FOREST SEED AND TREE IMPROVEMENT PROGRAM RFSP/CILSS

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Introduction

Since 1986, governments of CILSS countries have developed a Regional Forest Seed and Tree Improvement Programme (RFSP). This has been achieved in collaboration with international institutions, especially FAO, IUFRO, UNSO together with bilateral donors *viz* France, Netherlands And Denmark. CILSS is an acronym meaning Permanent Interstate Committee for Drought Control in the Sahel and countries involved are Burkina Faso, Cape Verde Islands, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal and Chad.

The problem to be solved is the lack of functional national institutes and the weakness of cooperation between the countries in this region of Africa (Ouedraogo, 1988). For many countries the procurement of seeds in sufficient quantities and in good quality, at a time when they are needed, constitutes a bottleneck for their afforestation programmes.

Tree improvement can provide the basis for important gains in production in both forestry and agroforestry. For this reason, it seems logical for a selection and tree improvement programme to consider the potential genetic resources of the whole CILSS region rather than to be limited to one particular country which may only represent a small portion of this area (CILSS/FAO, IUFRO, 1989).

The present situation is that some institutes in some of the CILSS countries have already initiated national programmes which have already made a significant impact on seed procurement at national level (Burkina Faso, Senegal, and to a lesser extent Niger). These national efforts need to be recognized and reinforced.

In some countries, tree seed activities have recently started with the support of development projects. These do not as yet constitute fully functional tree seed centres due to their very limited production, storage and distribution capacities (Niger, Mauritania, Cape Verde Islands, and Mali). In other countries the procurement of seed for reforestation and agroforestry programmes is not organized at a national level, causing problems in satisfying demands for tree seed within those countries.

Finally, at the regional level, the cooperation between the countries in the CILSS region is weak and needs to be promoted and developed.

To improve this situation the RFSP/CILSS propose to develop in the next 5 years:

- a national forest seed and tree improvement programme (NFSP) for each country which will consist of setting up or reinforcing an existing seed centre and in starting a tree improvement programme.
- a cooperative program including all CILSS countries in Sahelian forest genetic resources. These new developments should lead to the following results (see Table 1)

Table 1. Expected situation after RFSP first phase (5 years)

Countries	Seed Production (kg\5 years)	Tree Improvement Provenance trial (ha)	Genetic Conservation *Ex situ* (ha)	*In situ* (ha)
Burkina Faso	12500	150	50	500
Cape Verde I.	5000	100	20	500
Gambia	3000	50	20	500
Guinea Bissau	9000	20	20	500
Mali	6000	100	40	500
Mauritania	4500	**S0**	20	
Niger	5000	70	20	500
Senegal	10000	110	25	500
Chad	4000	50	20	500
TOTAL	59500	730	235	4000

Table 2. The development sequence of activities in RFSP/CILSS from 1986-1992

1.	Definition of Research Priorities Identification of Regional Project	IUFRO/FAO Nairobi 1986,1987
2.	Collaboration between Countries 1st CILSS Regional Seminar	CILSS - Ouagadougou Oct. 1986
3.	CILSS Minister's Council Government Engagement	CILSS - N'Djamena Jan. 1988
4.	FAO-Subregional Project on MPT	FAO - Djibouti Jan. 1988
5.	Formulation of National Projects and Regional Component	FAO/CILSS/IUFRO Nov. 1988-Oct. 1989
6.	2nd CILSS Regional Seminar	FAO/CILSS/IUFRO Oct. 1989
7.	Donor Round Table	FAO/CILSS/IUFRO Nov. 1989
8.	Formulation Transitory Phase	CILSS/IUFRO Jan. 1990
9.	Revision of Project Doc/ According to Donors' Needs	CILSS/UNSO Aug. 1990 FAO/NLAug. 1991
10.	1 st Regional Workshop Training Program	CILSS/FRANCE Jan. 1991
11.	Set up of the Transitory Phase	FAO/CILSS May 1992

Objectives and functions of RFSP

The RFSP is composed of nine National Forest Seeds Projects (NFSPs) and a Regional Support and Coordination Component (CILSS/FAO/IUFRO 1988).

National projects

All the physical activities related to seed production and distribution will be implemented in the countries through the following objectives:

- to ensure sufficient seed procurement for national afforestation programmes;
- to improve and conserve forest (and agroforestry) genetic resources. The main activities to be carried out are:
- setting up / strengthening of national centres;
- seed stands and production areas, collection, handling, quality control, storage, distribution;
- variability studies, exploration and delimitation of provenance and seed zones;
- tree improvement (and genetic conservation); provenance trials, progeny tests, seed orchards, etc.

Regional project

The Regional Support and Coordination Component is designed to assist countries in the implementation of National projects. This assistance shall be provided in form of:

- Training - high priority (by way of regional workshops, regional courses, *ad hoc* assistance mission, study tours);
- Technical and scientific support (through aid missions)
- Harmonization and coordination of methodologies and techniques (by regional workshop);
- Dissemination of information between the countries and cooperation with other regional bilateral and international programs (by promoting the dissemination of research results, stimulating Sahelian and non Sahelian experience - newsletter or bulletin, etc).
- Unrestricted availability and exchange of plant material for scientific purposes (import-export control, legal regulation, quarantine procedures).

During the next five years, the regional project will work in two main directions:

- assistance to set up and develop national capacities (establishment of seed centre and training of personnel).
- regional coordination (standardization, coordination of regional programmes).

During the next phases, the importance of these two directions will be relatively inverse i.e. priority will be given to promote and maintain cooperation between countries (CILSS/FAO/IUFRO, 1989).

Strategies

Lists of Priority Species

During the consultation between the countries (IUFRO Nairobi I & II workshops, and CILSS/FAO/IUFRO missions in the countries, some lists of priority, important and secondary species have been elaborated for each country. For each species, priority has been given to:

- the appropriate strategies such as exploration, tree improvement and conservation planned at national level;
- the representation of these species in the national afforestation programmes.

There has been a strong focus on multipurpose trees and the following three groupings of species has importance to the CILSS region. They are:

Group 1: Species of regional interest for tree improvement and genetic conservation activities. These species represent a large interest for at least 5 countries are *viz: Faidherbia albida, Acacia nilotica var tomentosa, Acacia Senegal, Eucalyptus camaldulensis, Parkia biglobosa, Prosopis juliflora.*

Group 2: Species of regional interest for genetic resources conservation viz: *Acacia raddiana, Adansonia digitata, Balanites aegyptiaca, Borassus aethiopum, Hyphaena thebaica, Pterocarpus erinaceus, Pterocarpus lucens.*

Group 3: Species of national interest for 1 to 5 countries (non exhaustive list) *viz: Azadirachta indica, Khaya senegalensis, Ziziphus mauritiana, Acacia holosericea* group, *Anogeissus leiocarpus, Butyrospermum paradoxum, Gmelina arborea, Leucaena leucocephala, Parkinsonia aculeata, Prosopis africana, Sclerocarya birrea, Tamarindus indica.*

Strategy for Evaluation of Forest/Agroforestry Genetic Resources in the Framework of RFSP/CILSS

The strategy proposed is summarised as -

Inter-population variability studies

- **International provenance trials:** with one provenance per iso-ecologic zone; 2-3 provenances per country, multi-station trial.
- **National provenance trials:** to test the provenances to be selected for distribution.

After 5-7 years the first results from field trials coupled with electrophoresis and ecophysiological studies) should provide good information on the distribution of the inter-population variability. This should lead to a more efficient exploration of their genetic resources.

Intra-population variability studies

- progeny-tests: heritability studies.

These test will be established only in some countries, e.g. Burkina Faso and Senegal.

- eventually, complementary electrophoresis and ecophysiological studies.

Clonal trials

- clonal-tests: evaluation of individual variability.

Expertise needed for Regional Component of RFSP/CILSS

For the regional component, 3 full time experts are needed (2 experts for 5 years, 1 expert for 3 years).

The expertise will be completed by consultancies provided from international and specialized institutes.

- **1 expert in exploration:** distribution areas of species, provenance zones, seed stands, seed collections;
- **1 expert in seed problems:** organization of seed centres handling, quality control, storage and distribution;
- **1 expert in tree improvement:** selection, evaluation and conservation.

Collaboration

Cooperation with FAO

The cooperation with FAO was initiated in the IUFRO meetings at Nairobi in 1986 and 1987. Since 1988, this collaboration has become possible through the sub-regional project "Development of Genetic Resources of Multipurpose Trees and Shrubs" (GCP/RAF/234/FRA). FAO/IUFRO and CILSS agreed to harness their efforts in the formulation of the national and regional project documents.

Recently again, through the same project, FAO has provided support to the transitory phase of RFSP/CILSS. This assistance consists in recruiting a consultant, as a Sahelian coordinator, for the RFSP with the following mandate:

- to follow up the national projects for which donor funding has been obtained or is in process of being obtained. Eventually the consultant should undertake complementary studies if needed by the countries or donors.
- to formulate a regional project which can integrate the contributions of several donors: Denmark, France and Netherlands, etc.

- maintain contacts with countries and donors.
- to organize a donor round table meeting at the end of 1992 to start the program in 1993.
- to follow up, contribute and share experience with any initiative on forest seed and tree improvement in the region.

Cooperation with ICRAF

The need for ICRAF to satisfy its needs of seed for agroforestry species seems obvious. However the ICRAF initiative must avoid as much as possible duplication, with RFSP/CILSS and NFSPs. It is necessary to continue the discussions to eliminate the risks of any friction and misunderstanding at national/regional levels.

CILSS appreciates and encourages the dialogue already established with ICRAF through SALWA, reference to the collaboration developed with the Institut du Sahel/Bamako, and contacts with RFSP staff base in SEE/CILSS Headquarters. The main recommendation addressed to ICRAF is to look for appropriate mechanisms to support and assist the existing national and regional programs, so that they will be able to carry out their tasks - bolster rather than marginalize their role.

Cooperation with IBPGR

IBPGR has some technical expertise in areas such as *ex situ* conservation and seed storage and could give some input to some specific aspects of RFSP. Future cooperation topics can be discussed and developed.

Cooperation with other regional programs

The RFSP/CILSS expects to start to develop cooperation with IGADD, SADCC, etc., other countries in Africa and outside Africa, through existing and future national and regional programs. This inter-regional cooperation will ensure harmonization of methodologies and transfer of information and genetic material between sub-regions with largely similar ecological conditions. Additionally, some countries, e.g. Sudan, situated in Eastern Africa, and a member of IGADD, have environmental conditions closely related to those of West African countries.

Financing

- Transitory phase: supported by FAO project "GCP/RAF/234/FRA".
  The regional component document project submitted to UNSO, NL.

- Burkina Faso: Forest seed centre well established and functional.
  Donor: The Netherlands.

- Senegal:
  Activities previously carried out on seed collection, handling, storage, and tree improvement were supported by France (CIRAD/CTFT, ORSTOM) and IDRC. The National Forest Seed Program which is in the process of being approved, will be financed by the Netherlands through FAO.

- Cape Verde Islands, Mali, Mauritania, Niger and Chad.
- A set of 5 national project documents and regional component to be financed through UNDP. It seems that some donors will probably finance some projects through bilateral procedures.
- The transitory phase supported by FAO has to develop initiatives and contracts to achieve the financing of national and regional projects.

Conclusion

The implementation of the RFSP/CILSS programme started with an introductory phase. It is an encouraging approach for the development of forest genetic resources in the Sahelian region.

The main objective of the RFSP/CILSS regional framework is to strengthen national capabilities through institution building and training, supported by the free flow of information and genetic material, and exchange of know-how and experience.

It is expected that this regional programme will generate, over the next five years, some research networks (probably based on the IUFRO working parties). The RFSP is considered an efficient instrument for the promotion and the development of multipurpose tree for agroforestry.

Discussion

1. Ques. Isn't *Eucalyptus* an MPT? J. Brouard

Ans. Lets discuss later in Working Groups. Yes some eucalypts are MPTs.

2. Ques. What type of co-operation does your project have with the "green-belt" movement which 1 believe started here in Kenya. Hans Muhs

Ans. No co-operation at present.

3. Comment More emphasis should be given in your project to indigenous fruit trees e.g. *Zizyphus mauritiana* and *Tamarindus indica.* L. Sitaubi

AUSTRALIAN TREE SEED CENTRE: A POSITION PAPER FOR THE ICRAF MPT GERMPLASM RESOURCE CENTRE CONSULTATION

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Introduction

It is estimated that Australian tree and shrub species now constitute more than 40% of all trees planted in tropical areas of the world. They are used for everything from commercial timber and pulp through to soil stabilisation and honey production. The Australian Tree Seed Centre (ATSC) is entering its fourth decade as a focus for the collection and evaluation of Australian tree and shrub germplasm. From a request in the early 1960's by FAO to the Australian Government for a *Eucalyptus* seed and information centre, the ATSC has grown to include a wide range of multipurpose trees of Australian origin and now holds about 20,000 accessions comprising 800 species from several thousand collection sites. Eucalypts make up about half the species in the collection while multipurpose genera represented include *Acacia, Casuarina, Grevillea, Melaleuca, Sesbania* and *Terminalia.* Most accessions come from natural populations but the Centre is managing an expanding range of seed orchards.

The Centre is 90% self funded from specialised grants, training activities, sale of seed and information. Staff numbers rise from about 15 to 20 during peak collection periods.

Past and present activities

Germplasm Collection and Documentation

Over the last 5 years, an average of 40 person-months per year have been spent in the collection and documentation of tree and shrub seed. Collections have taken place across all Australian States and in the neighbouring countries of Indonesia and Papua New Guinea and many of these collections have been carried out in collaboration with scientists from other countries. Collections from wild populations are most common and trees are selected for genetic representation. Minimum standards for numbers and separation of parent trees are strictly enforced. Seed of an increasing number of collections is available by individual mother trees.

The collection plan is dynamic and responsive to the demands of clients and sponsors. Major seed collection plans are prepared every two years.

All seedlots meet minimum standards for documentation including those purchased from other collectors. Minimum requirements are: seed collected from natural stands (unless specified), location of collection (including latitude, longitude and altitude), number of trees in collection, minimum spacing of 100m between trees and a minimum standard for seed cleanliness. For ATSC collections additional documentation includes, soil data, associate vegetation information, tree descriptions, phenological data, photographs and botanical specimens.

Germplasm Evaluation

The ATSC is fortunate to have a home within a larger research organisation, the CSIRO Division of Forestry, with associated access to a broad range of research results and advice across a variety of scientific disciplines. The Centre maintains a modest research program associated with the seed orchard program and isoenzyme evaluation of several key species. In addition to in-house evaluation activities the ATSC contributes to Divisional research programs in silviculture, genetic variation, breeding systems, floral biology, climatic analysis and micro-propagation.

Specific projects include:

1. planning, coordination and review of international provenance trials *(Acacia aneura, A. auriculiformis, A. mangium, Eucalyptus camaldulensis, E. grandis, E. tereticornis, E. urophylla,* arid zone species, *Grevillea robusta)*

1. isoenzyme studies of E. *urophylla, A. holosericea, A. mangium* (collaboration with FRIM), *A melanoxylon* (collaboration with ANU), *Casuarina equisetifolia and Grevillea robusta.*

3. seedling morphology studies of *A. auriculiformis, E. urophylla, E. pellita*

4. assessment of non-wood products including fodder, human food, essential oils and soil amelioration.

5. genetic improvement and breeding strategy work with *A. auriculiformis, A. mangium, A. mearnsii, A. aulacocarpa,* E. *grandis, E. globulus, E. camaldulensis, E. urophylla, E. pellita* and *Grevillea robusta*

6. screening of Australian rainforest species for recalcitrance

7. assessment of fungal contaminants in stored seed

8. seed supply to the ACIAR forestry program in Asia and East Africa

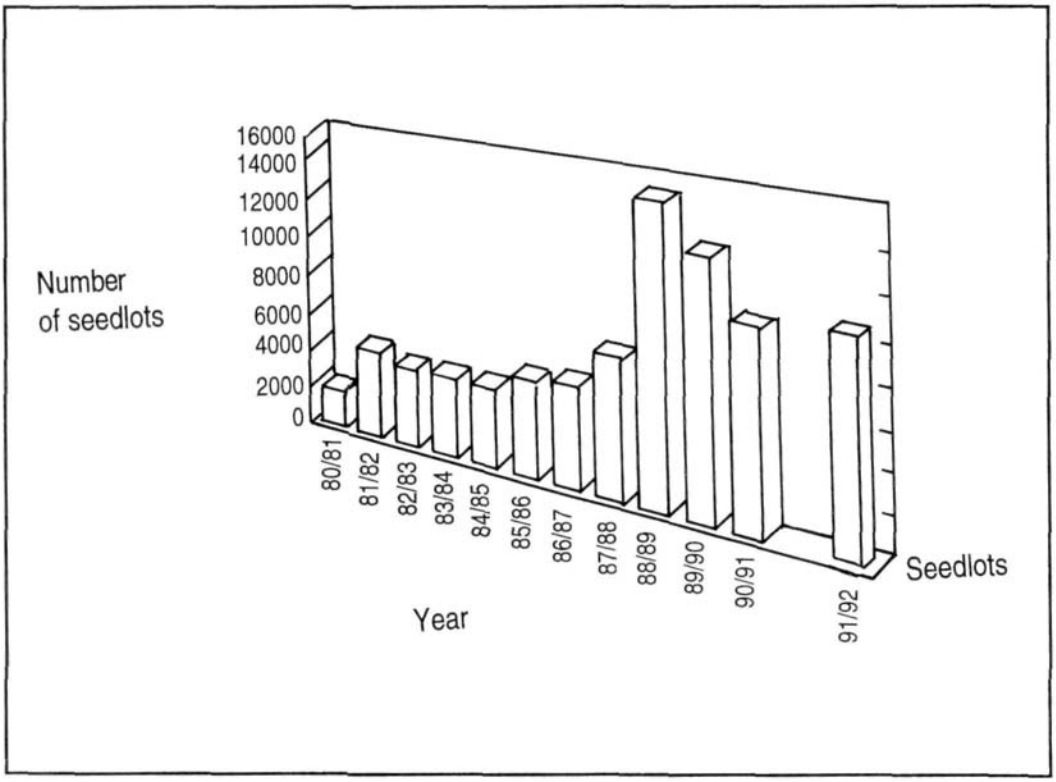
Through this last activity, CSIRO Division of Forestry is evaluating a very broad range of genotypes in the field. Bilateral collaborative agreements with China, Thailand, Laos, Kenya, Zimbabwe and Pakistan have resulted in the establishment of more than 200 species provenance and progeny trials of more than 150 species. These include species for industrial forestry, agro-forestry and planting on degraded land.

The ATSC maintains seed orchards of *A. auriculiformis, A. mangium, A. aulacocarpa, E. grandis* and E. *urophylla.* These orchards provide a base for breeding and evaluation work as well as being *ex-situ* conservation areas.

Germplasm Dispatch

Figure 1 gives the trend in seed dispatch by numbers of seedlots over the last 12 years. The gradual increase was brought about through increasing interest in individual parent tree collections. The sudden increase in 88/89 reflects a number of range wide collaborative collections of eucalypts and acacias. All seedlots are dispatched with passport data including collection location, number of parent trees and viability. Further information is available on request.

Figure 1. Number of seedlots dispatched in financial years 1980/81 to 1991/92



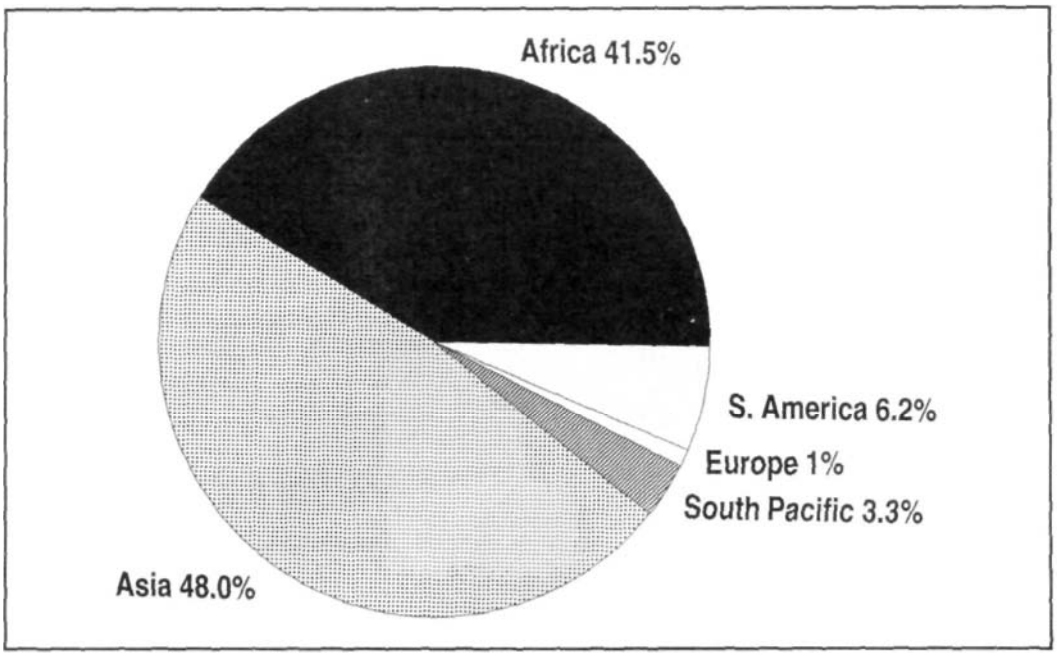
Seedlots are distributed to all parts of the world and Figure 2 gives a breakdown of seed dispatches for 1991 by regions of the world. The proportions given change somewhat from year to year reflecting changing interest by donor agencies or private forest companies.

Germplasm Conservation

The ATSC maintains an active germplasm collection with minimal emphasis on conservation *per se*. Many of the species processed maintain viability for 10 years or longer without special storage regimes. Most of the source areas for seed collection are contained within some form of public land which, in Australia, provides some level of protection from destruction. Some provenances are under threat, ironically, sometimes from seed collection.

Through the seed orchard program, *ex-situ* conservation stands have been established in addition to the breeding populations. At this stage of development the orchards represent a wide range of families from natural populations of the species. Genetic resources will be conserved within the orchards, and through conservation stands and associated block plantings.

Figure 2. Seed dispatches for 1991 to different regions of the world



A program to evaluate long term storage using cryogenic techniques has commenced with preliminary tests on the effects of liquid nitrogen storage on viability of a range of species.

Information supply

The other key role of the ATSC is the supply of technical information to accompany seedlots and to assist in species and provenance selection. Numerous books and publications have been produced and the ATSC is developing computer based decision support systems to assist in site evaluation and seedlot selection and species/provenance suitability.

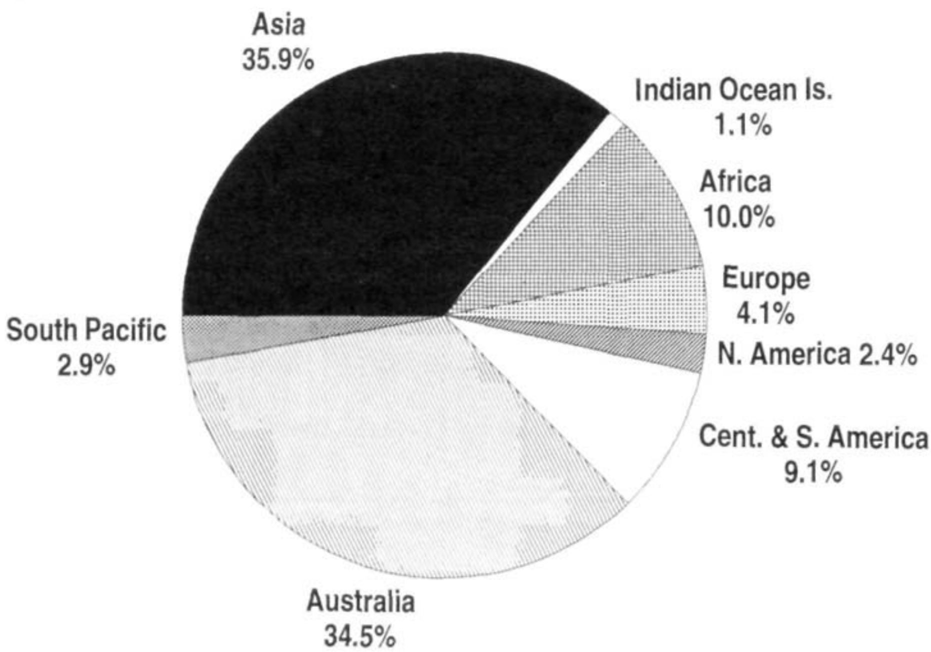
Training

Training by the ATSC is accomplished at three levels: workshops and seminars within and outside Australia, individual training in seed technology and professional attachments. The training workshops have been focussed on a number of priority areas including nursery techniques, x-ray radiography, tree breeding and improvement.

The profession attachment program is an attempt to allow scientists currently in a management role some time and resources to evaluate and communicate results of experimental work which would otherwise remain in raw form. The program has resulted in three excellent reports on phenology in Thailand, eucalypt provenance performance in Mozambique and acacia performance in Malaysia. All scientists involved came from management positions which interrupted their research programs.

More than 120 people have taken part in the training programs and Figure 3 gives a breakdown of recipients by continent.

Figure 3. Origin of ATSC trainees 1985-1991



Future activities and plans

Germplasm collection and evaluation

The ATSC will continue to collect seed from wild populations of Australian (and related) woody flora. It is expected that a greater part of our germplasm activities will be associated with improved genetic material from the seed orchards. The first commercial seed crop from the A *auriculiformis* orchard is expected in a couple of months. Controlled breeding programs will proceed within the orchards as they flower. Early work will look at improving the form of vigorous families and the vigour of good form families.

Although the Division of Forestry already has a strong program in mycorrhiza for eucalypts, the Centre will be paying greater attention to mycorrhizal, frankia and rhizobium root symbionts in up-coming collection programs. Future seed collection programs (casuarina, *Paraserianthes* and arid zone acacias) will collaborate with laboratories capable of isolating pure strains from field material in a form suitable for dispatch with seed.

The ATSC will proceed with programs to evaluate the potential of acacia seed as a human food resource, evaluation of casuarina provenances through isoenzymes and field trials and genetic evaluation of other eucalypts and acacias.

Methods used by the ATSC for collection and evaluation of Australian native flora should provide a model for similar development in other countries. The ATSC is keen to build links with other national and regional Centres with a view to passing on and exchanging experience in this area.

Tree improvement

The seed orchard program will bear its first fruit this year and over the next decade the ATSC expects to expand this program to include more species of a multipurpose nature. We expect these orchards to be of greatest value in producing highly out-crossed material with broad genetic base. We would like to collaborate with end users in further development of the orchards since the ATSC does not have a plantation program to support intensive 2nd and 3rd generation selection. The orchards will also become a scientific resource for manipulated crossing, hybrid programs, physiological studies as well as their conservation role.

Conservation

The ATSC is currently evaluating its role as a conservation centre. There is potential to maintain a small, long term store of important provenances and possibly species with restricted distribution. The seed orchard program constitutes an important *ex-situ* conservation resource for several species and will be expanded.

Role of proposed ICRAF Centre

Some points to consider in discussions on the role of ICRAF's MPT-GRC:

1. The crop centres used for comparison in the discussion paper are dealing with a much more limited range of material. The size of the task being set is huge in terms of numbers of species and geographical source and target areas. Is it possible for one centre to make much of an impression given it is starting from scratch?

2. All tasks of the ICRAF MPT-GRC in the initial stages appear to be already covered by existing centres. There is a risk involved in

spreading already limited resources even thinner while ICRAF gets up to speed. How are existing collections to be 'acquired' and 'duplicated'?

3. IBPGR has been carrying out a similar 'clearing house' role for crop plants and will now include some forestry species. What can ICRAF offer beyond this?

4. Given the established role of other centres, is it a wise use of resources to take another centre with very limited prior experience or capability, bring it up to the level of other centres and then encourage it further to enter into tree improvement programs?

5. Existing ICRAF programs and requirements have provided the basis for this proposal. It may be better to meet these requirements in the first instance using existing staff and in collaboration with existing centres before embarking on a major program. Improved seed, as it becomes available, may provide the basis for some other centre in the future.

Collaboration between Centres

The ATSC will collaborate with any other centre provided there are mutually acceptable benefits to all involved. I believe it has substantial experience and expertise to offer in all areas of germplasm collection and evaluation and has had collaborative agreements with several other centres for collection, evaluation, training and database development.

MPT Germplasm Priority Issues

1. Seed quality

2. Documentation of seedlots

3. Quarantine issues including movement, treatment, fumigation

4. Symbiotic organisms

Discussion

1. Ques. Have there been studies in Australia to compare native eucalypt stock with improved material from other countries of the same Australian origin? Is there concern about contamination of native stock? B. Dvorack

Ans. a) variable performance compared with native stock
b) Australia's strict quarantine laws prevent contamination

2. Ques. Do you think that the ATSC may in future operate along the same lines as Camcore whereby you charge membership fee to help you in seed collection? D. Gwaze.

Ans. Yes 1 see us going in that direction.

3. Ques. You said some provenances are threatened with extinction by mostly private seed collectors. What is being done to control this. D. Gwaze.

Ans. Some form of control is going on. However when overseas countries establish their own seed orchards, the demand from native stands will decrease and save these provenances.

4. Comment The role and responsibilities of seed centres in import/export of seeds needs some sort of regulation. To discuss these issues a joint IUFRO/KEFRI/GTZ symposium on legal regulations for forest reproductive material and the role of seed centres will be held in October 1992. J. Albrecht.

THE NITROGEN FIXING TREE ASSOCIATION: RESEARCH STRATEGY RELATIVE TO THE CGIAR

/. Chamberlain
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Introduction

The Nitrogen Fixing Tree Association (NFTA) has a long history of working with scientists and field personnel, located in remote, often overlooked institutions, around the world, to evaluate the performance of nitrogen fixing tree (NFT) germplasm under diverse ecological conditions. The results of these efforts are evident in the remarkable appreciation for and use of NFTs in rural development forestry. Over the past decade, the number of requests for seed and technical information on NFTs has increased extraordinarily. Much of this increased interest can be traced directly to NFTA's efforts to distribute high quality germplasm, materials and knowledge on important nitrogen fixing trees. Making these much needed resources available and affordable to professionals in developing countries is a driving axiom of the Association.

The NFTA is in an excellent position to assist the CGIAR institutions in making multi-purpose tree germplasm and knowledge on the species available to field oriented organizations and the less sophisticated research institutions, around the world. NFTA is best suited to distribute high quality NFT germplasm and the most current information on important species to an impressive network of organizations. The Association bridges the enormous gap that often exists between research institutes and field oriented organizations.

General description of NFTA

NFTA's mission is to encourage and support the improved understanding and use of nitrogen fixing trees (NFTs) to help satisfy the wood product needs of the resource poor in the world. NFTA promotes the wise planting and management of nitrogen fixing trees to conserve soil and water, develop sustainable land-use systems, and safeguard against destruction of the natural environment. Planting NFTs that are appropriate to the climatic and social conditions can improve rural landscapes and the lives of families who depend on that land. The Nitrogen Fixing Tree Association (NFTA), a 501 (c)(3) non-profit organization, was incorporated in Hawaii, USA in 1981.

To achieve its purpose, the NFTA engages in three defined programs of research, communications and outreach. Sharing "State-of-the-Art" information and materials on NFTs to improve tree research and planting programs is NFTA's guiding principle. It serves as a linkage between scientists and farmers and other users of nitrogen fixing tree germplasm and information. NFTA's research program strengthens institutes to improve their abilities to evaluate NFT germplasm for adaptability to diverse climatic conditions. The communication program is an information bridge that shares research findings and translates technical materials into extension documents. The outreach program helps build the technical capabilities of people to improve their tree planting efforts.

NFTA'S worldwide network

NFTA's strength is its vast network of field oriented organizations, and remote, often under-utilized research institutes. Currently, there are over 1400 NFTA associates in approximately 110 countries; sixty percent are in developing countries. A recent survey of NFTA Associates found that over 35% hold positions at universities or research institutes. Twenty-seven percent are affiliated with government agencies, while 22% are employed by private voluntary and non-governmental organizations. NFTA reaches scientists (61%) and extension/training specialists (52%), equally.

NFTA's main clients are organizations that may not have access to international resources. NFTA works to narrow the gap between implementing agencies and research institutes. The organization focusses on working with research institutions to support and strengthen their activities and build their resource base to do better NFT germplasm research. NFTA believes that by strengthening provincial, national and regional research institutions, we can have a greater impact on the development of institutions. At the same time, many implementing agencies (non-governmental organizations, etc.) have the interest and strength to execute valuable research. A major portion of NFTA's network are non-governmental organizations that are examining NFT germplasm on the farms of their constituents. NFTA joins forces with these groups to evaluate NFT germplasm in rural development forestry schemes. The organization draws the research and outreach communities together through publications, workshops and trainings.

Research concentration

NFTA has concentrated its research efforts in three areas: 1) assembling an extensive collection of quality NFT germplasm; 2) evaluation of that germplasm through a global network of scientists and non-governmental organizations, and; 3) communications of research knowledge. NFTA has developed, through its membership, a research program integrated with outreach to serve growers and scientists, worldwide. The provision of high quality germplasm and technical documentation on the trees' qualities and the communication of this knowledge is NFTA's major means of contribution to international MPT germplasm research.

Germplasm Conservation & Preservation

The NFTA Seed Facility is, perhaps, the best collection of nitrogen fixing tree germplasm in the world. NFTA seeks the best available germplasm of outstanding

NFT species. This material is meticulously documented, stored and regularly tested. No seed is distributed from the collection that can not be traced to its origin. Storage facilities are precisely regulated to assure long-term viability. Germplasm is tested annually to assure that research collaborators receive quality materials. The foundation collection includes seed of more than 120 species of NFTs, and when possible multiple accessions of species. The primary purpose of NFTA's collection is distribution for performance evaluation. A portion of newly collected accessions is provided to appropriate long-term storage facilities.

Species Evaluation

NFTA's primary research has been the evaluation of NFT germplasm for adaptability to adverse climatic conditions. This work has been, and continues to be, through its associates. Supporting the work of these professionals serves an important means to evaluate germplasm over a very broad range of conditions.

The *Cooperative Planting Program* (CPP) is a mechanism whereby development workers and scientists can test and evaluate the adaptability of NFT germplasm to local conditions. NFTA requires that collaborators first define the environmental conditions of their planting site. With this minimum data set, NFTA research staff, select a variety of species that appear to be best suited to the conditions described. NFTA then sends, free of charge, research quantities of high quality germplasm, inoculant, technical fact sheets (Highlights), and research guidelines. Participants are expected to follow the research protocol, collect data and share results in the *Nitrogen Fixing Tree Research Reports.*

Over 550 trials have been established in eighty-nine countries. About fifty-five percent are in Asia, 25% in Africa, and 19% in the Americas. Many of these are on-farm trials with non-governmental organizations, volunteer groups, and community groups. Others are located on the research stations of agriculture and forestry colleges and universities. Some are set up with CGIAR research institutes, such as ICRISAT, IITA, and ICRAF. Data from these trials are presented in the *Nitrogen Fixing Tree Research Reports.*

These trials are providing important data for the participants to select for themselves the most appropriate species for local conditions. Based on this data, NFTA assists collaborators to locate and procure large quantities of the desired species.

NFTA has received support to evaluate leucaena species for psyllid resistance. With backing from the MPTS Research Network (formerly F/FRED), NFTA established and maintained international research network trials to evaluate leucaena species. Seed orchards of resistant varieties have been established at five Asian institutes. New methodologies were developed to assess psyllid infestation and damage ratings.

Research communications

NFTA was founded as a communicating body of current knowledge on nitrogen fixing trees. Sharing "State-of-the-Art" information and materials on NFTs to improve tree planting is one of NFTA's guiding principles. This flow of information has evolved from scientists sharing with scientists to increased communications between scientists and field personnel. People who plant and do research on NFTs need accurate, up-to-date information to improve their programs and many professionals in developing countries are hampered by a lack of technical data or a place to publish their work. NFTA designs and markets its publications with these people in mind.

Information Documentation & Distribution

NFTA documents and distributes research findings through regular annual research reports - *Leucaena Research Reports* and the *Nitrogen Fixing Tree Research Reports* — which are compilations of research results on important NFT genera and provide an excellent means for scientists to publish their work. The *Leucaena Research Reports* (LRR) is in its 13th volume, while volume 11 of the *Nitrogen Fixing Tree Research Reports* (NFTRR) is in production. These international publications are distributed to over 1400 Associates.

NFTA seeks world renown professionals to prepare *NFT Species Highlights* and publishes eight annually. Over thirty-five have been published and many are translated into Spanish. These two page fact sheets cover the botany, ecology, silviculture, uses and pests and diseases of important NFTs. They serve to motivate people's interest in important nitrogen fixing trees. The effect of these fact sheets is clearly visible by the tremendous increase in requests for seed of the species.

Proceedings from "State-of-the-Art" workshops on priority genera help relay up to date knowledge on important NFTs. These compilations of research, presented during a NFTA workshop, advance the current knowledge on important genera and help guide future research. Along with the workshop proceedings, NFTA prepares silvicultural manuals that translate research findings into easily understandable documents. They are widely distributed to field personnel to enhance their understanding and use of NFTs.

Finally, NFTA has collected much information on NFTs and maintains a database and resource library of this material. The Association seeks collaborative arrangement with other international organizations to improve these valuable resources.

State-of-the-Art Workshops

NFTA has a long history of organizing and collaborating with other organizations to co-host international workshops on priority NFT genera. Since 1982, NFTA has conducted 7 "State-of-the-Art" (SOTA) workshops and helped organize 6 other meetings. Over 850 professionals have attended the workshops. Workshop topics include *Casuarina,* Perennial *Sesbania, Gliricidia sepium,* Agroforestry Land-Use Systems. The most recent focussed on the "Economic and Financial Analysis of Agroforestry Systems." Support for these international meetings include USAID, IDRC, USDA Forest Service, SID A, as well as the Dutch Government. Collaborators include ACIAR, Desert Development Center, East/West Center, Winrock International (F/FRED) and CATIE.

NFTA's research strategy

NFTA's *modus operandi* will continue to be collaboration with research and implementing agencies to increase their capabilities to evaluate NFT germplasm in rural development forestry schemes. To maximize efficient use of resources, the program will become more focussed and concentrated with fewer organizations. Though, widespread distribution of germplasm and technical materials is still deemed essential, the NFTA will target organizations that have performed well in previous NFTA collaborative research. Strengthening these groups to become models for other in-country organizations will have a greater impact on the research and outreach of nitrogen fixing trees.

Germplasm Collection & Conservation

NFTA will strengthen its germplasm collection to provide seed for distribution and testing, and long-term conservation. NFTA will increase its activities to collect and conserve NFT germplasm, including the soil *rhizobium.* Collaborative arrangements will be made with "sister" organizations to collect and share germplasm, particularly of native nitrogen fixing trees. NFTA will identify species native to the target countries and work with partners to collect and conserve that germplasm, as well as species deemed economically important. Priority also will be given to those species targeted for NFT Highlights. NFTA will provide partners with the necessary training to collect, handle and store the germplasm. Small grants will be made for germplasm collection.

To assure preservation of the biological diversity of countries, a significant portion of the germplasm (seed and *rhizobium)* will remain in the countries in which it is collected. This may be planted as seed production areas or stored for local distribution. In addition, a portion will be offered (at cost) to major storage facilities, such as CGIAR centers or other international germplasm collection centers, that have the capabilities for long term preservation. Proceeds from these sales will remain in the country, with the organizations that collected the germplasm.

The remaining portion will be stored at the NFTA seed facility. Currently, NFTA has seed of over 120 species. Through the conservation efforts of NFTA and its Associates this collection will increase substantially. The primary purpose of the collection is the distribution of high quality NFT germplasm to evaluate species performance. Germplasm from the seed facility is contributed to the Site Adaptability Evaluation trials.

Site Adaptability Evaluation

Screening Trials: Based on the Cooperative Planting Program model, germplasm screening trials will continue to be a major component of NFTA's research. The objective of the screening trials is to test a large number of species for those that are best adapted to local environmental and social conditions. These trials provide individuals, community groups, and scientists the means to test a variety of species for their adaptability to local conditions. Collaborators then select for themselves the most appropriate NFT germplasm to include in tree planting programs or more intensive research. The results of these trials help to guide the more intensive Network Trials, described below.

NFTA will react to requests from potential participants and establish approximately 100 trials annually. Participants are required to provide a minimum data set of the planting site's environmental characteristics. This information allows NFTA staff to pre-select a variety of species that may best be suited for local ecological conditions. The NFTA will contribute to the trials, NFT germplasm (seed and inoculant), research guidelines, and species highlights.

Participants are expected to follow the research protocol and collect data and share trial results through the *Nitrogen Fixing Tree Research Reports*. Annually, a NFTA research staff will visit a sampling of trials (approximately 10%), established the previous year. The purpose of these visits will be to evaluate tree growth, trial implementation and management, and participant performance. The visits also provide an excellent opportunity for NFTA to build the research capabilities of participants. This approach is designed to provide maximum flexibility to the collaborator and improve the reliability of the data.

Network Trials: Working with research and development organizations, network trials will help to refine the measurements generated on the most promising NFT germplasm selected from the screening trials. The primary objective of the network trials is to improve upon the data collected in the screening trials. To initiate the network trials, NFT germplasm will be selected from the data generated by the NFTA Cooperative Planting Program. Germplasm of promising species, identified through the screening trials, will be added to the network trials. Approximately six trials will be established in similar climatic conditions and with similar species.

The target collaborators are research organizations and field oriented organizations with which NFTA has worked successfully, and that exhibit a propensity for exemplary field activities. Participating research institutions will conduct on-station trials to provide benchmark data for comparison with NGO managed trials. NGO participants will establish and maintain on-farm species trials to provide valuable data on the adaptability of germplasm to field conditions and the acceptability of species by local peoples.

All groups will be provided the means to plant, manage and collect data from the trials. Financial support will be needed to train and hire research technicians with participating NGOs. Research grants will be provided to participating research organizations, to supplement their "in-kind' contribution.

NFTA will provide research technicians training in trial management, and data collection. In addition, participants will receive training in data analysis and presentation. NFTA staff will visit all trial collaborators annually to help solve problems, train staff and evaluate germplasm performance.

Research communications

NFTA is firmly committed to the communication of the most current knowledge on nitrogen fixing trees (NFTs) to a worldwide audience of scientists and practitioners. The Association is prepared to work with the CGIAR and associated institutions to this end. The traditional NFTA publications are well founded and present a solid foundation from which to advance peoples' understanding of the importance of NFTs in agroforestry.

Information Documentation & Distribution

Communications of research findings will continue to be a major concern and obligation of the Nitrogen Fixing Tree Association. Three forms of communications will remain the backbone of the program. First, NFTA will continue to publish the regular research reports ~ *Leucaena Research Reports* and *Nitrogen Fixing Tree Research Reports.* These will evolve into reports that include peer reviewed articles, but will remain accessible to scientists in developing countries.

Eight NFT Species Highlights will be published, annually. These two page fact sheets, translate research findings into extension type documents and motivate field project staff to test new species. Their distribution results in significant increases in requests for germplasm. To accommodate this increase in demand, NFTA will seek to parallel production of Highlights with germplasm collection.

Workshop proceedings and silviculture manuals are integral products of NFTA State-of-the-Art (SOTA) workshops. In addition, NFTA will produce Highlights on species that correspond with the SOTA workshops. For example, products from the *Erythrina* workshop will include a proceedings, silvicultural manual and at least 3 species Highlights.

State-of-the-Art Workshops

Traditionally, State-of-the-Art (SOTA) workshops have been hosted with other organization and this focus will continue. The program will organize at least one workshop, annually. Products from the workshop will include the proceedings, silvicultural manuals and a series of Highlights. In 1992, NFTA and CATIE are co-hosting a SOTA workshop on the genus *Erythrina.* The following year (1993), NFTA plans to co-host a workshop on *Dalbergia* with the Institute of Forestry, Pokhara, Nepal. Plans are developing to co-host a workshop on temperate nitrogen fixing trees in 1994 with the Association for Temperate Agroforestry. Topics for additional workshops are developing.

Research training

NFTA's research training will focus on the training of research technicians to manage on-farm research. Research technicians, professionals who manage field trials would benefit greatly from additional training.

Research collaboration

NFTA has worked with the University of Hawaii and other international research institutions on multi-purpose tree research through "in-kind" contributions of labor and seed. The Association will continue to actively seek these types of collaborative arrangements, as its greatest endowment is its network of Associates and field orientation. Through this global web, NFTA can contribute greatly to the research and outreach of the CGIAR and affiliated institutions.

In addition, NFTA has relocated its offices to the NifTAL project facilities. This move was performed to promote a more synergetic relationships between the organizations. NFTA envisions that the multi-purpose tree research and outreach of the two groups will become more supportive and complimentary.

Discussion

1. Ques. You mentioned "state of the art" workshops. Are these genus or species specific? J. Brouard.

Ans. Basically genus specific e.g. *Dalbergia, Erythrina, Albizia,* etc.

2. Ques. Does NFTA have a mechanism for getting feedback of research results from the many trials for which it has provided seed? J. Turnbull.

Ans. This is a problem. There is about a 10% feedback rate from trials. The Leucaena and Nitrogen Fixing Tree Reports do provide a mechanism for the communication of these research results and we encourage collaborators to make use of this communication medium.

3. **Comment** There may be deleterious problems introducing species and microsymbionts to new environments. Hans Muhs.

4. Ques. Do you work on non-nitrogen fixing legumes like many members of the Caesalpinaceae e.g. *Cassia siamea* which is an important tree species for agroforestry. P. Sanchez.

Ans. No.

MICROBIAL SYMBIONTS FOR AGROFORESTRY RESOURCE, TECHNOLOGY, AND DEVELOPMENT ISSUES

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NifTAL, Hawaii
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Introduction

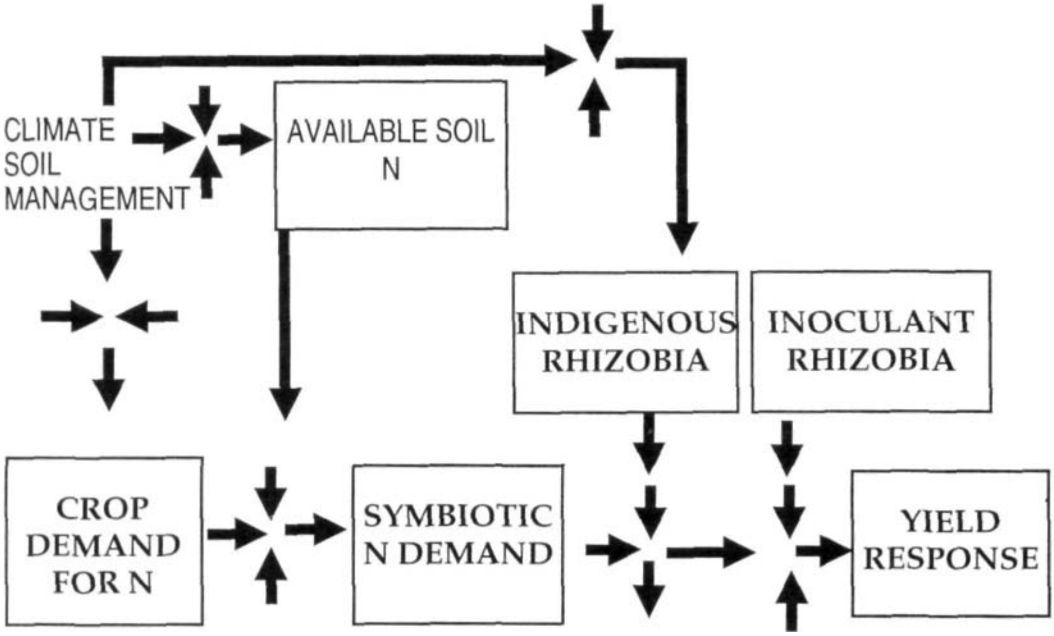
The success of agroforestry species is often linked to the nutritional contributions of soil microbial symbionts. Nitrogen inputs to agroforestry systems via biological nitrogen fixation (BNF) occur primarily through the soil bacteria rhizobia associated with leguminous species, and *Frankia* associated with actinorhizal dependent genera *(Casuarina, Alnus* and *Eleagnus).* Another major group of microsymbionts are the mycorrhizal fungi that enhance their host's ability to assimilate soil nutrients, primarily phosphorus. The vesicular-arbuscular mycorrhizas (VAM) are commonly associated with tropical agroforestry species.

Inoculation of agroforestry species with symbiotic organisms can enhance their growth and survival (Roskoski *et al* 1986; Cornet and Diem 1982; Dela Cruz *et al* 1988; Duhoux and Dommergues 1985; Turk et *al* 1992). It is, therefore, appropriate a Resource Center for Microsymbionts be considered as an integral component of a Multi Purpose Tree Germplasm Resource Center (MPT-GRC).

With the exception of N from BNF, the plant nutrient resource of farmers is essentially fixed if chemical inputs are not supplied. BNF is thus vital to sustaining agricultural productivity and improving marginal soils. Inoculation technologies and production systems are well defined for rhizobial BNF systems. This paper focuses primarily on BNF technologies and resources for legume nitrogen fixing tree (NFT) species; however, many principles elucidated here apply to all BNF symbiotic systems and, to an extent, the VAM symbiosis.

Increasing the capture of BNF through agroforestry requires an integrated approach of research and development. The first step is identifying the agro-ecosystems where improved BNF technology has greatest promise. Research components follow to develop appropriate management and inoculation technology, and to evaluate benefits of BNF to the entire agro-ecosystem. Finally, the integration of technical, human resource, social and commercial components is required to extend improved BNF technology to the field. This paper presents BNF technologies and resources complementary to the MPT-GRC, proposes priority research and development issues, and presents a framework in which symbiotic microbial resources can be integrated into the ICRAF MPT-GRC.

Figure J. A conceptual framework of the factors controlling response to innoculation



Issues and Resources

Response to Inoculation with Microsymbionts

A constraint to adaptation of BNF technology is lack of understanding when, where, and by how much farmers may benefit from inoculation. The response to inoculation has been variable in the few well documented inoculation trials conducted with agroforestry species (Sanginga *et al* 1985, Thies *et al* 1991a).

A conceptual framework of factors controlling response to inoculation is presented in Figure 1 (Singleton *et al* 1992). Inoculation response is site specific. Crop, soil and climate determine yield potential and crop N assimilation requirements. Crop N requirements can be met through the sum of contributions from soil N resources, indigenous rhizobia or rhizobia introduced through inoculation.

Thies *et al* (1991b) developed empirical models predicting legume inoculation response based on measures of 1) indigenous rhizobial population size; 2) soil N availability; and 3) crop yield potential. These types of predictive models can be used to efficiently identify geographic areas and cropping systems where tree legume inoculation is most beneficial. Soil surveys of rhizobial population and N availability can be used to predict impacts from inoculation in many more locations than possible with standard field trials.

Turk *et al* (1992) proposed preliminary models for tree legumes, using six species *(Acacia auriculiformis, A. mangium, A. mearnsii, Leucaena diversifolia, Robinia pseudoacacia, Sesbania grandiflora):*

Yield increase from inoculation (%) $= (155 + 947/m)/x$

Where m = index of available soil N;x = l + Most Probable Number (MPN) estimate of rhizobia in soil at planting.

This model for NFTs, while not field tested, concurs with that of Thies *et al* (1991b) in that the numbers of indigenous microsymbionts in the soil at planting is the major determinant of the inoculation response. When indigenous rhizobial density was less than 50 rhizobia g~ soil, the mean shoot N of these six species in inoculated treatments was 4.75 times greater than in uninoculated treatments, whereas when the indigenous population was greater than 50 rhizobia g" soil, mean total N was only 1.22 times greater in inoculated than uninoculated treatments (Turk *et al* 1992). Management and environmental factors influencing tree yield potential also impact the magnitude of inoculation response. Increasing BNF in agroforestry systems through inoculation is thus inextricably linked with soil microbial and mineral resources, and the genetic yield potential, environmental adaptation, and management of a species.

Microbial Resources in Tropical Soils

Populations of rhizobia vary in tropical soils (Singleton *et al*, 1992). According to Turk's models, 46% of surveyed agricultural soils had deficient populations (100 g^{-1} soil) for NFT's such as *A. auriculiformis*, and 75% were deficient for species (*L. leucocephala, G. sepium, C. calothyrsus)* nodulating with more specific rhizobia (Turk *et al*, 1992). Inoculation in these soils would increase total N assimilation. The paucity of microsymbionts in eroded soils (Habte *et al*, 1988; Habte and El Swaify, 1988) has particular relevance to the need to inoculate agroforestry systems used to rehabilitate degraded lands.

Germplasm Resources for Agroforestry

NifTAL Project maintains more than 1900 rhizobial cultures isolated from 333 hosts, including 400 isolates from trees. NifTAL distributes rhizobial cultures to research laboratories and inoculant producers, and supplies research quantities of inoculant ready for field application. An average of 737 cultures and 1200 inoculant units are distributed per year. Demand for NFT cultures increased from 16% to 43% of the total requests between 1985 and 1990, while NFT inoculant demand increased from 16% to 59% of total. The Nitrogen Fixing Tree Association facilitates distribution by including inoculants with NFT seeds.

Other germplasm sources include the Microbial Resource Centers (MIRCENs) in Nairobi, Kenya and in Bambey, Senegal, the ORSTOM laboratory in Dakar, Senegal, and the BNF Resource Center (BNFRC) in Bangkok, Thailand. MIRCENs and BNFRC can distribute inoculant for tree research. Additional small scale facilities exist in national agricultural research centers such as the College of Forestry at the University of the Philippines. A commercial firm, Medicom in Haiti, markets several tree inoculants to PVO groups using NifTAL germplasm.

Diversity of Rhizobia Nodulating NFT's

Functionally, rhizobia are classified according to effective cross nodulation with host species. Understanding effectiveness groupings is critical to developing inoculant formulations, and using ecological factors such as the occurrence of other legume species as indicators of native rhizobial populations. Rhizobia for

NFT's are poorly characterized, and there are conflicting reports on the specificity of NFT rhizobial associations. Recent work by Turk and Keyser (1992a), has helped to define the rhizobial affinities of ten major NFTs. They found that several species nodulated with a range of rhizobia, but had specific requirements for effective symbioses. The rhizobial requirements for many agroforestry species remain undefined.

Strain Selection

Rhizobial strain selection for trees is in its infancy. Genetic variation in host germplasm resources combined with slow development of nodules and nitrogen fixation in early seeding growth impede systematic screening for superior tree rhizobia (Turk and Keyser 1992b). While important grain legumes number less than ten, agroforesters have identified at least 50 priority species (Brewbaker *et al* 1990). Lack of knowledge of tree effectiveness groupings hamper the progress in strain selection for NFTs in general, though truly superior symbionts are documented for a few important species.

Actinorhizal symbioses are less well studied. The micro-symbionts have been characterized (Baker 1987), and *Frankia* for *Casuarina* and *Alnus* are available through the Yale School of Forestry; however, inoculants are not readily available. *Frankia* inoculant production, quality control and ecological monitoring methods are not well established (see Wheeler *et al* 1991).

Human Resource Development

NifTAL, IAEA, FAO, MIRCENs and other organizations have implemented extensive training programs, primarily in *Rhizobium* technology. NifTAL has increased its focus on extension training and commercial inoculant production. Trained individuals are active in many countries and can assist MPT-GRC network participants. Access is through a NifTAL database.

Inoculant Production Systems, Quality Control, and Distribution

The legume inoculant industry is well developed in many countries. Proven production methodologies make the industry fairly scale neutral. Production units in developing countries range in scale from less than 500 kg inoculant per year (Haiti) to more than 100,000 kg per year (Thailand). Extremely small enterprises are feasible as part of a larger concern. NifTAL is designing a micro-production unit (MPU) suitable for PVO/NGO and other organizations where distribution of inoculant from centralized facilities is not feasible. The MPU requires significant linkage to labs or other production units for sources of germplasm and quality control assurance. Co-production of inoculant within commercial tree nurseries is feasible.

Agroforestry systems generally represent a long term commitment of land resources. Opportunities for inputs are restricted. Ideally, standard protocols for tree nursery production would include the introduction of appropriate microsymbionts to ensure their presence when the trees are outplanted to the field. A major advantage of microbial inoculants for agroforestry programs is their compatibility with nursery operations. Inoculants are easily applied and symbiotic structures monitored within a nursery. Nursery use facilitates the distribution of the inoculant product, and reduces the requirements for extensive promotion of inoculants at the farmer level.

NifTAL is focusing on private enterprise development for BNF products. Most successful enterprises have links with government or international centers such as the BNFRC. Government technologists, regulatory bodies and extension agencies play significant roles providing research and technical assistance, quality assurance, and market development via extension training. Geometric growth in demand for inoculant in Thailand was coincident with sustained extension training (Chanaseni and Kongngoen 1992).

The Economics of Inoculation

In agronomic systems, economic benefit from inoculation is usually confined to measures of increased yield and revenues from the inoculated crop. In agroforestry systems, economic benefit of enhanced BNF is often captured by non-nitrogen fixing crops. Methods for measuring BNF by trees and monitoring its impacts on the ecosystem are difficult and imprecise. These limitations prevent assigning a definite value to BNF in agroforestry systems (Avery, 1991; Wheeler *et al* 1991). This value, along with cost of acquiring fixed N in agroforestry systems, will influence farmer acceptance of improved BNF technologies. Because of their low cost, inoculants are a low risk investment. In most systems, farmers who acquire an additional six to ten kg of nitrogen per ha will justify the marginal costs of inoculation. This figure, while difficult to measure with statistical confidence, is a realistic expectation. Potential returns in soils deficient in indigenous microsymbionts are much higher.

Priority Research and Development Issues for BNF in Agroforestry

Genetic Resources:

1. Strain improvement (traditional and modern methods) for improved tree germplasm, competitiveness, persistence, and survival as inoculant in the distribution network;

2. Cross inoculation/effectiveness groupings;

3. Distribution network of cultures and inoculant to NARs, IARCs, PVO/NGOs, and inoculant producers;

4. Field testing of improved stains;

5. Archiving collection.

Ecology of NFT Symbiotic Microorganisms:

1. Distribution, density, character of populations in lands targeted for agroforestry development;

2. Management and environment influences on native and introduced rhizobia;

3. Improved methodology to predict performance of rhizobia in agro-forestry systems.

Management and Application of BNF Technology in the Field:

1. Methodologies to measure BNF contributions to the system;

2. Management strategies to enhance BNF;

3. Appropriate and effective inoculant application methods.

Human Resource and Market Development:

1. Training in research, technology, quality control, commercial inoculant production and management, extension specialists;

2. Factors influencing farmer acceptance of BNF technology;

3. Economic impacts of developing and implementing BNF technology.

Commercializing BNF Products:

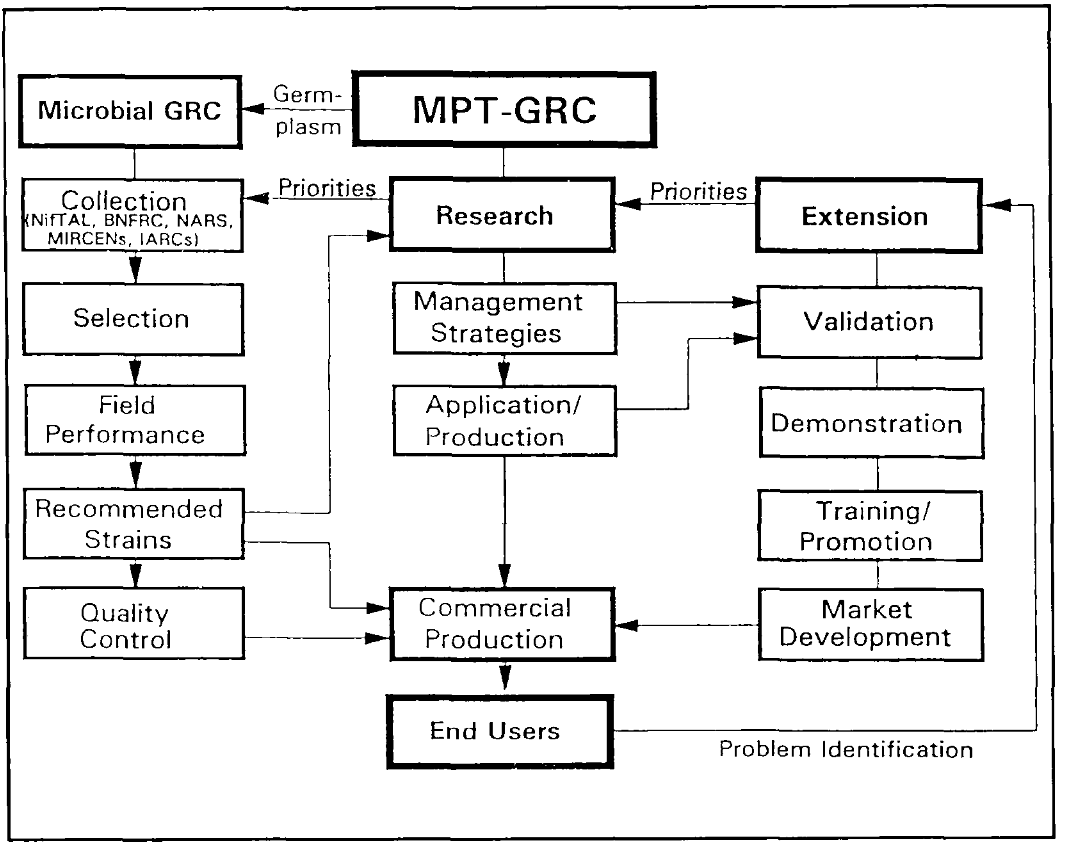
1. Designs appropriate for scale and diversity required by agroforestry systems;

2. Improved manufacturing and distribution systems.

Implementing BNF Technology in Agroforestry Systems Through a Microbial Germplasm Resource Center.

We envisage specific functions for the MGRC, and strong linkages with ICRAF research and network components, national and international centers, and laboratories and firms specializing in symbiotic research and inoculant production (Figure 2). Primary flow of information and problem identification to the MGRC comes from the end users of inoculant products, commercial product developers,

Figure 2. Suggested linkage diagram between MPT-GRC and Microbial GRC, other organisations dealing with rhizobia, and research and development issues.



extension specialists, ICRAF research imperatives, and the MPT-GRC. Germplasm resource development is a primary objective of the MGRC, but only in response to specific needs. Human resource development plays a key role in providing services and technical assistance to the far flung participants in agroforestry research and development projects.

The mission of the MGRC would be: 1) to support research addressing the fundamental gaps in knowledge on the efficacy and nature of microbial symbionts for trees; 2) ensure the productivity and profitability of agroforestry systems are not limited by inadequate microsymbiont resources; and 3) promote the availability of high quality, reasonably priced inoculant for farmers adopting agroforestry technologies.

Microsymbiont inoculants are one of the few cost effective purchased inputs for agricultural production and resource conservation. Exploiting these symbionts is an economically feasible, environmentally sound, and nearly passive technology for resource poor farmers. These unique attributes of symbionts in agroforestry systems warrant the development of a Microbial Germplasm Resource Center as part of the MPT-GRC.

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Discussion

1. **Ques.** What is your experience with salt tolerance of rhizobia strains? H. Jaenicke.

   Ans. Usually plants are less tolerant to salt than rhizobia.

2. **Ques.** Do we really need to inoculate? J. Brouard.

   Ans. Very site dependant.

3. **Ques.** What competition effects are there between improved and indigenous strains? Are exotic strains persistent? J. Hanson.

   Ans. Not enough is known about this competition. Depends on numbers of indigenous rhizobia in soil. Persistence depends upon drought, high temperatures and soil acidity etc.

ACTIVITIES OF THE OXFORD FORESTRY INSTITUTE

/. Burley
O.F.I.
Oxford, United Kingdom

Introduction

My presentation is divided into two main sections. The first section is titled "Genetic resources research and development at the O.F.I." The second section is titled "The Oxford Forestry Institute in relation to the CGIAR" and covers a range of potential contributions by the Oxford Forestry Institute (OFI) to the CGIAR. These two sections include information activities, training and education, network management, policy research and genetic resources research and development. The first section outlines specific activities related to this latter topic as planned by the OFI during a recent policy review.

Genetic resources research and development at the Oxford Forestry Institute

Among all the internationally active national institutions, OFI has the longest experience of exploration, evaluation, conservation and improvement of tropical forest tree species. Thirty years of work on some 40 species has meant that OFI has developed procedures for research and the creation of international networks that have been the model for subsequent work by other organizations. The work of the first 25 years was summarized by Barnes and Burley (1990).

In addition to the traditional stages of population evaluation, the OFI offers advanced capability in the development of tree breeding strategies and populations. OFI's location within the Department of Plant Sciences in the University of Oxford provides close association with plant taxonomists, molecular scientists, biochemists and physiologists. Thus there are opportunities to undertake pure and strategic research supporting the applied research and development programmes of institutions in developing countries and of several multilateral organizations.

In addition to the OFI Director and one University Lecturer, the Tropical Tree Genetic Resources Unit (for brevity the "Genetics Group" at Oxford) consists of 13 scientists (see Table 1) and varying numbers of graduate research students. These persons cover a range of topics and species but work as a coherent and interactive unit constantly seeking to undertake new work, revise their thinking and the accepted theory, and redirect current work to the needs of developing countries.

(A parallel group undertakes research on the ecology, biodiversity and silvicultural management of both tropical and temperate forests.)

Table 1. List of names of OFI staff and current projects

Richard Barnes, Exploration and evaluation of African acacias
Jacqueline Birks, Biometrician
David Boshier, *Cordia* breeding systems
Jeffery Burley, (OFI Director), genetic resource conservation
Andrew Dunsdon, Data processing specialist
Christopher Fagg, Exploration of African acacias
Denis Filer, Database specialist
Colin Hughes, Exploration of Central American legumes
Peter Kanowski, (University Lecturer), breeding strategy
Linda Lockhart, Biochemist
Duncan MacQueen, *Calliandra* exploration
Alan Pottinger, Trials manager
Anthony Simons, *Gliricidia* trials evaluation, reproductive biology and breeding
Janet Stewart, Fodder quality of *Gliricidia*
Brian Styles, Taxonomy of tropical pines and legumes

For each species in turn the group has undertaken the exploration and description of natural sources (and some local land races) together with the determination of the taxonomic status and the extent and pattern of intra-specific genetic variation. These activities have been supported by networks of international collaborative trials, substantial biometrical input, and the development of major database systems and databases themselves for genetic resources research and management.

OFI research strategy

Research at the OFI spans the range from fundamental through strategic to applied topics. Funding is obtained from various sources: the national research councils favour fundamental research; the Overseas Development Administration has traditionally supported applied research but recently has financed strategic topics also; commercial forestry companies tend to support applied research.

The mixture of financial sources and scientific objectives and the placing of the OFI within an academic environment provide an ideal opportunity for a balanced programme. The connections with the applied end of the spectrum identify needs for strategic and pure research and also identify topics and individuals for graduate training programmes. The provision of additional funds through the international systems including CGIAR/CIFOR will permit extensification and intensification of relevant topics.

Objectives

The overall research objective of the group is to study genetic diversity and its control in tropical trees with the aim of providing the scientific basis for germplasm acquisition, conservation, utilization and improvement.

Strategy

This objective requires research in five major scientific areas:-

1. Exploration, collection and taxonomy
2. Reproductive biology and population genetics
3. Evaluation of the extent and pattern of genetic variation
4. Statistical methods and breeding strategy
5. Information systems

Methodology

The methods by which the strategy will be implemented include the following:-

- Survey and acquisition of genetic resources of selected species
- Taxonomic description, using classical, molecular and numeric methods
- Assessment of the extent and pattern of genetic variation in the quantity and quality of products and benefits of selected species through the evaluation of field trials supported by molecular and biochemical information both from the trials and from the natural populations as appropriate
- Definition of floral and fruiting biology, pollination mechanism, and sexual mating systems
- Analysis, interpretation and review of quantitative genetic data and their use
- Formation and review of breeding strategies
- Development of software for recording, managing and reporting taxonomic and genetic resource data
- Distribution of genetic resources as appropriate
- Dissemination of research results through journal articles, manuals and monographs
- Inclusion of designed programmes for research students and post-doctoral attachments
- Provision of specialized training
- Collaboration with other institutions including national and international development agencies and national research organizations

The Oxford Forestry Institute in relation to the CGIAR (particularly ICRAF, IFPRI and CIFOR)

General description of the Oxford Forestry Institute

The Oxford Forestry Institute (formerly the Imperial and later the Commonwealth Forestry Institute) is a semi-autonomous Institute within the Department of Plant Sciences in Oxford University. It has for 60 years provided education and undertaken research in forestry and natural resource management with particular reference to tropical and developing countries.

In formal education its Master's degree course and its M Sc and D Phil research degrees are heavily subscribed by students from developing countries; the education seeks to inculcate the social, political and environmental principles of wise resource use and of decision-making in the face of conflicting pressures on land and varying demands for the services and benefits that can be derived from land. Students have over the years attained senior positions in Governments, international agencies and educational establishments.

For 20 years the Institute has provided non-formal, intensive, professional development courses in research methods, management and social aspects of forestry in developing countries. These three annual courses each train some 25 senior professionals to update their skills and appreciation of modern resource management techniques. Similar courses are also provided each year on demand in developing countries themselves while special professional development courses are arranged for individual professionals from overseas and from various development agencies.

The research of the Institute is undertaken in response to priorities recognized by the quinquennial World Forestry Congress, the quinquennial Commonwealth Forestry Conference, the 4- or 5- yearly Congress of the international Union of Forestry Research Organizations, the triennial review of research of the Overseas Development Administration, and the annual review of the Institute itself. It also takes note of the recommendations of other international and regional meetings of technical departments and donor agencies.

Research has concentrated on several major topics including the following:

Tropical forest ecology, biodiversity, conservation and management. This is one of the principal concerns of agencies, media and the informed public at present and the research of the Institute provides the background information on which decisions can be made concerning the management and conservation of both wet and dry forest types.

Industrial plantation silviculture and improvement. For many developing countries the establishment of plantations is a major contribution to economic development and to the conservation of remaining natural vegetation. Research by the Institute on the variation, breeding, conservation and the technical utilization properties of tropical conifers has become the model of internationally cooperative networks and is analogous to the networks of the CGIAR system for agriculture. A recent estimate indicated that the million pounds sterling invested by ODA in OFI research on tropical pines during the last 20 years should yield a return of some billion pounds by the year 2000 AD if countries continue to plant at the current rate but use the improved material and information developed at Oxford.

Rural development forestry. Although industrial plantations are an appropriate land use in some situations they are not relevant everywhere. The bulk of the wood used in developing countries is used by local populations and individual farmers for subsistence purposes of construction and fuel. There is great interest in the use of trees for multiple products and services including (i) the production of fuel, fodder, food and chemical derivatives, (ii) the improvement of soil holding, soil fertility and water flow moderation, (iii) the improvement of habitats for man, his domestic animals and desired wildlife and (iv) the enhancement of his security by diversifying products and minimizing risks while providing employment and improved welfare. The OFI has established international networks of field experiments with many species, particularly suitable for the drier tropics, that will enable Governmental and Non-Governmental Organizations to extend to rural populations information and material that are suited to their needs. In addition the OFI has undertaken intensive socioeconomic research on the place of trees in rural systems.

Information. The OFI library is recognized as the library of deposit for forestry literature in the western world and receives most of the world's published literature and much "grey" documentation. Many hundreds of visitors come to the library each year often to consult material that is now unobtainable in their own countries. In cooperation with the Commonwealth Agricultural Bureaux International these publications are abstracted in Forestry Abstracts and Forest Product Abstracts which have a world-wide circulation in paper copy and in electronic form through the international database systems such as Lockheed's DIALOG. Recently the OFI and CABI have cooperated in the production of a CD-ROM (Compact Disc - Read only Memory) that contains all the abstracts published since the inception of the service in 1939; this can be instantly interrogated and hard copies of chosen articles can be supplied at cost by the OFI Library.

In addition to formal library information the OFI maintains several, major, computer data bases on the inventory, growth characteristics, technical properties, uses and literature of tropical species. Information from all these sources is compiled and circulated in the form of manuals, monographs and bibliographies.

Management. In addition to its research role *per se,* the Institute is appointed manager of the research strategy area "Forestry and agroforestry" of the UK Government's Overseas Development Administration. In this role it manages some 40 projects in 20 British institutions conducting strategic research in support of bilateral and multilateral assistance programmes. The OFI is also the Resource Centre for Forestry to ODA and in this capacity it contracts to supply a given amount of expertise in consultancies on selected subjects each year.

All of the Institute's 40 professional staff have overseas experience and are available to conduct Institutional and personal consultancies; these cover management of natural resources, research planning, curriculum development, and all stages of the project cycle from identification through preparation and appraisal to monitoring and evaluation.

The Institute is one of the three founding and guiding departments of the University's Environmental Change Unit which seeks to bring together in an inter-disciplinary sense the expertise and facilities of all departments and scientists within the University who are concerned with any aspects of historical, recent, current or future environmental change.

OFI links to other international organizations

The OFI has formal or informal links with the following international organizations either institutionally or through individual staff members:-

CGIAR. The OFI Director has assisted CGIAR/TAC in the preparatory work for the incorporation of ICRAF and CIFOR into the system. He and other members of staff have participated in reviews or advisory sessions for IFPRI, ICRAF, ISNAR and the World Bank.

FAO. One member of OFI's Genetic Section is a member of FAO's Panel of Experts on Forest Genetic Resources and several staff members have acted as consultants to FAO in various countries and topics.

ICRAF. The OFI Director has been a member of a mid-term review team for the consortium of donors and of a separate review by one donor agency. He has also acted as a consultant to ICRAF, assisted in the preparation of its strategy document, co-organized an international conference, and published books and papers for ICRAF. Other members of OFI staff have worked with ICRAF staff in field trials, training courses and conferences. OFI and ICRAF currently conduct joint research on the socio-economic aspects of tree growing by farmers in eastern Africa.

IFPRI. One member of staff, Mr J.E. M. Arnold, has worked with IFPRI on forest policy research and currently supervises a range of research projects funded by four separate donors to investigate social attitudes and incentives for tree planting in rural situations.

ITTO. In addition to undertaking research projects financed through ITTO, the OFI has provided individual and team consultants to assist in the development of ITTO's strategy, the preparation of research projects and conference papers, and the review of ITTO documentation.

IUFRO. The OFI Director is the Vice-President for Programmes of IUFRO and is directly responsible to the Executive Board for the Special Programme for Developing Countries. (He was the consultant to the World Bank and FAO in the preparation of the paper presented to IUFRO Congress in 1981 reviewing the needs for forestry research in developing countries; this paper led on to the Bellagio process, the creation of IUFRO's SPDC, and the CIFOR concept.) Four other members of OFI staff have active roles as officers in IUFRO.

NFTA. The OFI Director is a member of the Board of the Nitrogen Fixing Tree Association and several staff members of OFI participate in that organization's network trials and conferences. Indeed OFI has provided a significant amount of material for NFTA's field trials.

ODA. Although the Overseas Development Administration is a national agency it is listed here because it is concerned with bilateral and multilateral assistance; the OFI is appointed its manager for research and its resource centre for advisory and consultancy work related to forestry and natural resources.

World Bank. In addition to working with various CGIAR organizations, several members of OFI staff have worked as consultants to the World Bank in a range of topics and problems. Recently some six members contributed to the Bank's own policy document.

OFI activities particularly relevant to CGIAR

As planning proceeds for the inclusion of forestry research within the CGIAR system, it is apparent that several activities and facilities of the OFI have relevance; this is particularly the case if the *modus operandi* of CIFOR is likely to lean strongly toward collaborative and contractual research. OFI has expertise, conducts research and has facilities, information resources and training capability in :- forest genetic resources; rural development (including social and agroforestry); inventory, mapping and valuation of natural resources; structural, physical and chemical properties of woody plants and their utilization; ecology and management of tropical land use systems including natural vegetation, plantations and agroforestry mixtures.

The OFI has always worked in a collaborative, network mode and this is exemplified by its work on forest genetic resources. Species are chosen for their potential importance to a number of countries and conditions; their natural ranges are explored and sampled for seed, herbarium specimens, wood and resin specimens and local environmental data. Seeds are distributed with appropriate experimental designs for field trials in a range of conditions and the field trials are assessed comparatively. The combined data are analyzed to determine the extent of habitat-related genetic variation and the genetic correlations between characteristics.

Material of the better seed sources (provenances) is made available for pilot plantations and for the development of breeding populations within each participating country.

Since 1965 the OFI programme has progressed through these various stages for four main groups of species in turn:- tropical pines (largely from Central America but some in Asia) for industrial plantations for timber and paper; tropical central American hardwoods for fine timber plantations; central American multipurpose trees, especially nitrogen-fixing hardwoods for use in rural conditions and semi-arid sites; and African *Acacia* species also for rural development in dry zones. Some 25,000 seedlots of documented provenance have been distributed for over 2,000 trials in 80 countries. The OFI through its staff participation in IUFRO organize international meetings, often with training courses attached, at which field data are presented by national collaborators and by OFI network coordinating scientists. A full account of the extent and international nature of the OFI programme was given by R.D. Barnes and J. Burley (1990).

Potential OFI contributions to the ICRAF, IFPRI and CIFOR process

Without prejudging the CGIAR decisions on the coverage of forestry research, it appears that the OFI has six main potential contributions: -

Information. The OFI has the world's major resource of published information on trees, forests and forestry, much of it in electronic database form, and most available at cost. With appropriate funding the OFI can produce manuals, monographs or bibliographies on species or topics, provide hard copies of original materials, and assist CGIAR and CABI to identify locations for TREE-CD ROM systems throughout the world.

Training. The OFI has a long tradition of formal and informal professional training both in Oxford and overseas in a range of topics, media and languages. Particular emphasis has been given in the past to planning and management in forestry; rural development forestry; forest research methods; and microcomputers in forestry. Courses can be arranged on demand.

Genetic resources. The OFI has the longest experience of international exploration, evaluation, conservation and improvement of tropical forest genetic resources and it holds a large amount of source-certified seed for comparative trials. In addition to the traditional stages of population evaluation it offers advanced capability in the development of tree breeding strategies and populations. Its place in the Plant Sciences Department at Oxford University provides close liaison with molecular scientists and others concerned with the new technologies. With adequate funding it can continue or expand its coverage in terms of number of species, populations or field trials, and in theoretical and strategic research on population genetic structures and conservation methodology.

Policy research. Staff of the OFI through their individual consultancies and institutional research projects have both broad and deep perceptions of the role of policy research in the development of wise resource use. They work closely with other international and national organizations and, with appropriate support, can contribute to collaborative research on policies and institutional issues.

Network management. OFI's *modus operandi* has traditionally been to establish collaborative networks, provide the technical guidance for the management and assessment of experiments, arrange workshop, and complete combined analyses of data (often with graduate students from the participating countries using the data for their thesis work). The size and number of such networks can be increased with additional resources.

ODA *Natural Resources Research Strategy.* As manager of the "Forestry and Agroforestry" strategy area and programme for ODA, the OFI is keen to develop further the collaborative research between UK institutions and those in the CGIAR system. We are prepared to fund suitable projects either wholly or jointly that will be relevant both to the ODA strategy and the programmes of the individual CGIAR institutions.

Reference

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Discussion

1. Ques. You mentioned the importance of finding out more about pollinators. What is currently known for MPTs? J. Hawkes.

Ans. Much more field research needed. Insects, mammals and birds involved depending on species.

2. Comment Agree that taxonomic studies needed especially in the area of close relatives of well-known MPTs. D. Boland

3. Ques. Has O.F.I, thought about other ways of establishing networks based on other models e.g ACIAR, F/FRED. D. Boland.

Ans. Previously O.D.A. hasn't funded networks as such and we are now considering ways of doing so.

KENYA FORESTRY RESEARCH INSTITUTE TREE SEED PROGRAMME

/. A. Oder a
KEFRI
Nairobi, Kenya

Introduction

The Kenya Forest Seed Centre (KFSC) is one of the major technical divisions of the Kenya Forestry Research Institute (KEFRI). The Centre's programme is currently supported by the government of Kenya and the German Government through the German Agency for Technical Cooperations (GTZ). The main function of the centre is to ensure collection and distribution of seeds of trees and shrubs of high genetic and physiological qualities, for planting. The Centres activities are decentralized to seven regional sub-centres (see Fig.l), a strategy that ensures a reasonable degree of ecological and land use considerations in an attempt to cater for tree planting needs country wide.

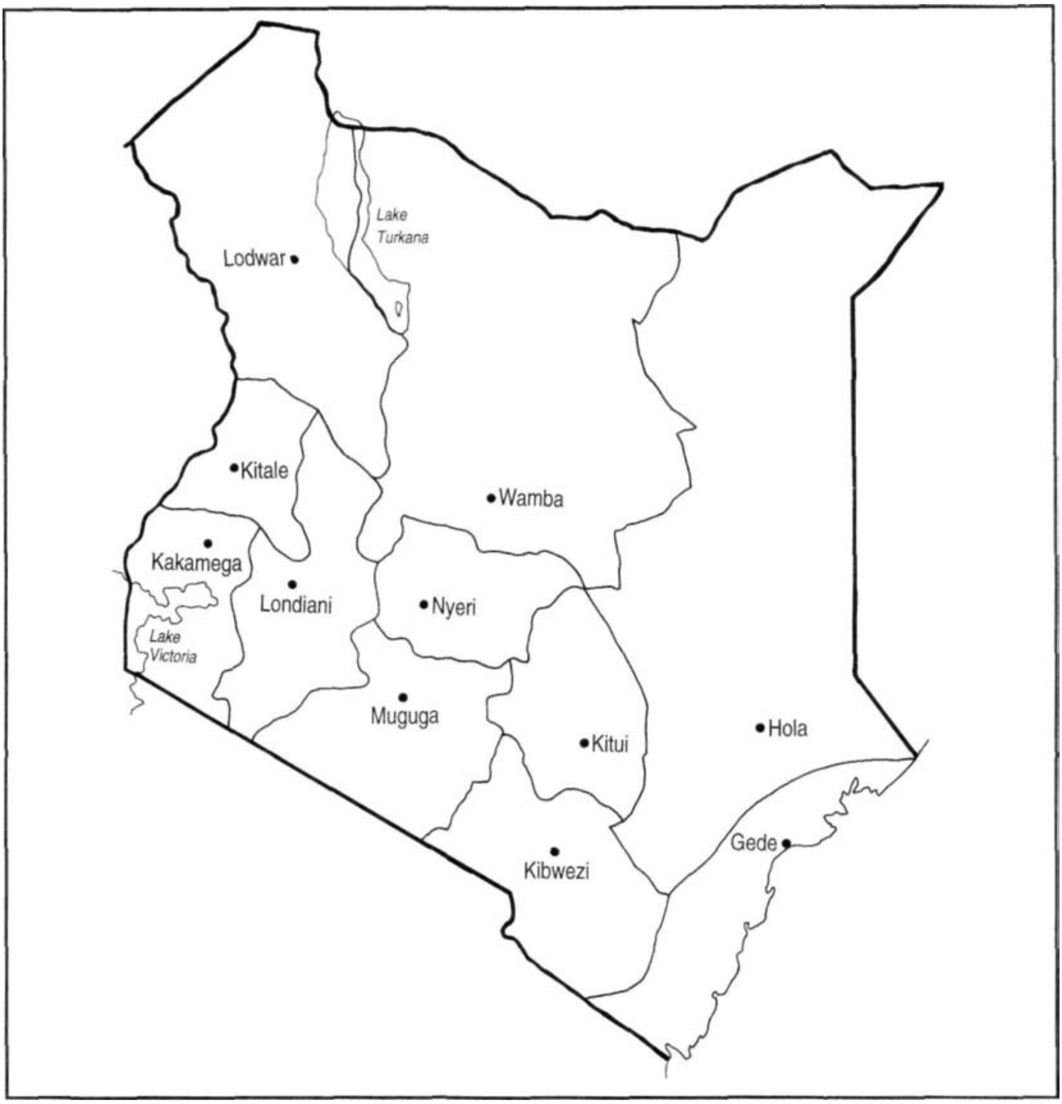
The Centre is also responsible for the development of promoting stability, productivity and genetic diversity in forest and agroforestry systems by ensuring the provision and use of high quality seeds and the protection of seed sources. In addressing this mandate the centre collaborates closely with the forest service, other Government departments, NGOs, research institutions and other divisions of KEFRI. The main facet of the Centre's activities includes:

- Identification and establishment of appropriate seed sources
- Research on production, handling and storage of tree seeds
- Conservation of endangered (indigenous) trees and shrubs species through the establishment of *in situ* and *ex situ* stands of affected sources and long term seed storage
- Identifying suitable provenances
- Developing packages for improving germination of seeds with germination problems including pre-sowing treatments.
- Training on tree seed technology.

With modern facilities for seed collection and a compliment of 150 established staff positions including research officers, foresters, technologists and support staff, the Centre enjoys an effective resource base and capacity for handling documentation, testing and storage of a wide range of tree seeds.

* Paper presented by W. Omondi, O.I.C., Kenya Forestry Seed Centre, KEFRI

Figure 1: Regional seed collection centres and zones



Multipurpose Tree Seed Collection

Prior to the establishment of the Centre, there existed a seed unit within the Silviculture division of Forest Department whose main function was to supply the Department with seeds of the major plantation tree species with emphasis on the exotics. The establishment of the Centre in 1985 meant that the programme expanded to include a wide range of tree and shrub species. The list of clients has also widened and now includes other organizations and farmers that are involved in tree planting and research. Indeed the growing demand for good quality MPTs seed for agroforestry activities has prompted the KFSC to intensify the establishment of seed production stands with improved source identified and site suited seeds, in collaboration with the Agroforestry Division of KEFRI.

Table 1 Seed stands of some popular MPTS established between 1982 and 1992 - a list of species, locations, establishment year and areas planted

Species	**Site\District Establishment**	**Year of (ha)**	**Area**
Acacia mangium	Gede\KiIifi	1988	2.5
Albiziafalcataria	Gede\Bukura	1988	**1**
Calliandra calothyrsus	Kakamega Forest	1991	0.5
Cassia siamea	JiloreYKilifi	1989	1.5
Cassia siamea	Gede\Kilifi	1989	1
Grevillea robusta	Njukiini\Kirinyaga	1992	4
Grevillea robusta	KitaleYTrans-Nzoia	1992	4
Gliricidia sepium	Kakamega Forest	1987	2
Grevillea robusta	Kakamega Forest	1990	2
Grevillea robusta	Naro Moru\yeri	1988	3
Grevillea robusta	Ragati\Nyeri	1988	6
Grevillea robusta	Meru C of Tech\eru	1988	-
Leucaena diversifolia K156	GedeYKilifi	1989	0.5
Leucaena hybrid KX3	Gede\Kilifi	1989	1
Leucaena leucocephala K636	Kibwwezi\Machakos	1989	0.5
Mimosa scabrella	KitaleYTrans-Nzoia	1990	1.5
Parkinsonia aculeata	KibweziVMakueni	1989	0.4
Parkinsonia aculeata	KibweziVMakueni	1987	0.4
Prosopis chilensis	KibweziVMakueni	1987	0.9
Prosopis chilensis	KibweziVMakueni	1987	0.1

Table 2. A summary of seed order and supply for some MPTS at the KFSC in 1991

Species	**Million Seedlings**	
	Quantity ordered	**Quantity supplied**
Albizia gummifera	**0.2**	0.02
Grevillea robusta	**13.2**	1.2
Dovyalis caffra	**7.7**	0.6
Calliandra calothyrsus	**0.6**	0.4
Cassia siamea	**1.5**	1.5
Cassia spectabilis	**0.4**	0.4
Leucaena diversifolia	1.1	1.1
Markhamia lutea	**2.9**	0.9
Melia azedarachta	**0.2**	0.1
Sesbania sesban	**0.3**	0.3
Acacia mangium	**1.2**	1.2
Azadirachta indica	**1.3**	0.03
TOTAL	**30.6**	**7.1**

Consequently the KFSC has changed its strategy of seed production from merely that of availability to that based on demand. This has been brought about by the success and increased adoption of agroforestry as a profitable system of land use in many rural communities. It is also evident that the KFSC has been unable to cope with the sudden surge in demand for many MPT seeds. Currently, the production and supply of seeds of some popular species in high demand such as *Calliandra calothyrsus* and *Grevillea robusta* cannot be met. Consequently, local communities have been left to do their own collection to satisfy their seed requirements. This situation has created a scenario in which a lot of seed is being collected and handled without regard for the basic rules of seed collection.

One of the main reason why the KFSC has been unable to meet the growing demand for the seeds has been due to lack of appropriate seed sources. To alleviate this problem, the Centre has in the last three years established seed stands for the production of improved germplasm (Table 1). Most of these stands are only likely to provide long term solutions to seed availability. The Centre has, therefore adapted a seed purchase system to supplement its own collection efforts to close the gap between the supply demand equation in the short term. Private seed collectors supply seeds of certain species of which the market demand is high enough to guarantee significant returns in sales. Payment for such seeds is made only after assessing and accepting their quality. The seed collector (vendor) would thus ensure proper collection and handling methods.

Training on Seed Collection Techniques and Handling

Training has been adopted as an important strategy for increasing seed collection country wide, and to avoid total dependence on KEFRI as the sole seed supplier. Training courses on seed collection techniques and handling have been designed by the Centre as a means of encouraging and promoting local seed collection. Several organizations dealing with medium to large scale seed collections require training in specific areas of tree seed handling in order to ensure high quality seed provision for planting in Kenya. Some donor-funded projects, such as DANIDA and FINNIDA have taken lead in providing financial resources for training of target groups within their projects. The KFSC intends to continue this programme in future.

Seed Dispatch and Distribution

The KFSC dispatches its seeds directly from the seed store at Muguga. The Centre maintains a stock of 7,500 kg of approximately 200 species in its cold stores at Muguga which has a capacity of 10,000 kg overall. It is estimated that the seeds issued by the Centre in 1991 met 53.4% of the demand. Table 2 summarizes the supply and demand picture for some MPTS supplied in 1991.

Germplasm Evaluation and Multiplication

The provision of appropriate germplasm requires an initial understanding of the growing conditions and the utility of a particular woody species. Selection of the desirable traits and characters is conveniently determined and done by the farmer and the agroforester; while the breeder is concerned with development of populations or clones with superior qualities, etc.

Although the KFSC is not directly involved in the evaluation of germplasm during the breeding and the field trial stages, it plays a major role in the promotion and use of high quality materials. In this regard, the Centre acts as a bridge though which well adapted, high quality germplasm passes to the users while retaining the physiological state and suitability for which they were developed (selected). ICRAF, through its germplasm improvement programme has taken a lead in this direction. KEFRI's silviculture and breeding programmes also conduct species, provenance and progeny trials from which suitable enties are taken up for establishment of seed stands and orchards. In addition, the KFSC has set up seed multiplication units, using improved germplasm.

Although the ideal case should be a situation where only improved germplam is distributed to users, the present practice relies on the use of germplasm from unbred sources because:

- The development, evaluation and multiplication of tree germplasm requires a long time.
- Shortage of trained personnel available for the evaluation and development activities.
- Inadequate resources for the production and distribution of the improved germplasm.

Notwithstanding these bottlenecks the KFSC supplies seeds from unimproved sources only where improved material is lacking. But this short coming is likely to be corrected during the next five years or so.

Germplasm Conservation

The conservation of endangered forest genetic resources is a joint task involving many groups such as the Forest Department, environmentalists, farmers and researchers. According to records available at the Museums of Kenya, about 95 woody plants are considered rare or endangered in Kenya. The KFSC has therefore embarked on a programme of identifying, collecting and etablishing *in situ* conservation stands of some of the affected species.

Prospects for long-term seed storage are being explored but evidently long-term seed storage will only be effectively developed after extensive research work on temperature requirement for given species. Priority for conservation through long-term storage of seeds will however be given to arid, endangered and rare species. The KFSC also collaborates with other research institutions, and participates in germplasm exchange of endanagered, rare or threatened species for the benefit of multiplication and conservation of these germplasm.

Documentation

International regulations demand that all germplasm moving in commerce should be properly and adequately documented. The provision of site appropriate, physiologically sound germplasm also calls for proper documentation especially provision of information on origin, source and usefulness of the planting material.

The KFSC's documentation system (Appendix 1) is designed to store and provide, all relevant information on all germplasm collected and supplied. Following recent computerization, the Centre now enjoys quick and easy retrieval of information for greater client satisfaction. The computer programme incorporates:

- Seed Data Management System

- Seed Zone and Seed Source System
- Phenological Observations and Collection Costs.

Information on all of these systems can be obtained easily and included in the dispatch note and for the general management and planning of the Centre's activities.

Revenue Generation and Sustainability

The present status of tree seed industry in Kenya demand that a slow progression towards commercialization of seeds be undertaken. In order to encourage people to buy the seeds, the prices should be heavily subsidized; the cost of production, packaging and distribution need not be taken into account.

At present the Kenya Forestry Seed Centre operates within the framework of the government accounting policy whereby occasional financial constraints affect the smooth running of the collection activities. In order to recover some of the operational costs, and to merit more allocation of funds from the Treasury, it is imperative that the centre should generate more revenue through the sale of seed. This will ensure sustainability of the supply of high quality tree seeds.

KEFRI has already taken a lead towards seed marketing in order to recover some of the costs incurred during collections, the FD should therefore take it further by use of it's forest stations and extension networks.

The high cost of seed collection, handling and storage is one of the problems which affect seed supply due to the increasing operation costs. In 1991 the centre spent KSh 0.4 million to collect 4,462 kg of seed.

With an average selling price of Ksh 200/kg, the centre could have earned revenue of KSh 892,4000/=. However only about 20% of the seed was sold to private institutions to generate a revenue of Ksh 250,000/=.

The centre has adopted a seed purchase system to supplement its own collection efforts to close the gap between supply and demand. This requires an additional KSh 100,000 annually.

Proposed Collaboration

The Kenya Tree Seed Centre has been recognized as a national reference point for handling seed of woody species. Many organization and research institutions including ICRAF have established close collaboration with the Seed Centre in seed procurement, storage, testing and information documentation, etc.

The seed testing facilities at KFSC will remain a national asset in quality control of germplasm used in national planting programmes, research lots and materials for exports which in most cases has to meet certain standards. This need has been recognized by ICRAF and will remain useful to other organizations. The present arrangement where KFSC and ICRAF are collaborating in seed procurement, storage, testing and dispatch can be improved through forward planning on seed demands, technical support in provision of testing and handling, sharing of facilities and equipment, and in certain cases financial support for urgent collections should be strengthened and maintained.

Establishment of effective collaborative linkages between the facilities at the KFSC and those to be established at ICRAF would greatly strengthen the national and regional capabilities for providing source certified, site relevant and use appropriate MPTS seed on time. Opportunities for realizing complementary/supplementary services, through reciprocal arrangements, employing comparative advantages of each institution should be explored at this early stage.

Appendix 1A list of seeds supplied to ICRAF from 1989 - 1991

Species	**1989**	**1990**	**1991**
Acacia albida	1.00	1.0	
Acacia brevispica	0.25		
Acacia drepanolobium	0.25		
Acacia gerrardii	0.25		
Acacia mellifera	0.25		
Acacia nubica	0.25		
Acacia polyacantha	0.29		
Acacia seyal	0.50		
Acacia xanthophloea	0.3		
Acrocarpus fraxinifolius	0.12	1.25	
Albizia lebbeck	1.54		0.25
Albizia procera	0.02		
Azanza gerckeana	0.10		
Croton megalocarpus	0.65	2.00	
Croton macrostachys	0.02		0.7
Cordia abyssinica	1.1		
Cassia siamea	1.24		
Cassia spectabilis	0.10	.25	
Caesalpina spinosa	0.30		
Dicrostachys cinera	0.01		
Dicrostachys cinera	0.01		
Diospyros abyssinica	0.25		
Dovyalis caffra	0.25		
Entada abyssinica	0.10	0.25	
Erythrina abyssinica	0.25		0.25
Gmelina arborea	0.20	1.00	
Leucaena leucocephala	1.01	-	0.05
Maesopsis eminii	3.75	1.00	0.25
Markhamia lutea	0.10	0.50	1.00
Melia azedarach	1.00	2.00	—
Moringa stenopetala	0.25		
Parkinsonia aculeata	0.12		
Pithecellobium dulce	0.25		
Prosopis chilensis	0.05		
Sesbania sesban	0.65		0.7
Tamarindus indica	0.30	0.6	
Terminalia mentalis	0.10	1.00	
Terminalia prunoides	0.25		
Tipuana tipu	0.15		0.15
Acacia polyacantha	0.10		
Calliandra calothyrsus	0.68		2.00
Grevillea robusta	0.07		
Sesbania grandiflora	0.35		

Species	1989	1990	1991
Vitex keniensis	0.05		
Ziziphus macronata		0.50	-
Ziziphus abyssinica		0.50	-
Casuarina equisetifolia		0.50	-
Tectona grandis		1.00	-
Terminalia catappa		1.00	-
Pinus caribaea		0.4	-
Acacia nilotica		1.00	-
Dombeya goetzenii		2.45	-
Jacaranda mimosifolia		0.05	-
Acacia tortilis		2.00	-
Prosopis juliflordSpallida		2.00	-
Casuarina junghuhniana		0.05	-
Balanites aegyptica		—	0.05
Ziziphus mauritania		-	0.02
Milletia dura		-	0.25
Leucaena diversifolia		-	0.25
Brachychiton acerifolius		-	0.05
Eucalyptus ficifolia		-	0.60
Schinus molle		-	0.70
Faidherbia albida		-	1.00
Brachychiton acerifolius		-	0.50
TOTAL	**18.73**	**22.25**	**8.32**

Discussion

1. Ques. What is the relationship between KEFRI tree seed centre and KARI gene bank? T. Ruredzo.

Ans. Not much although both are part-funded from German aid. KARI does keep some KEFRI seed in base collection.

2. Ques. How do you price seed? J. Brouard.

Ans. Good question. We estimate collection costs as being higher than selling costs and therefore seed is still being subsidized. Seed sold to Kenyan scientists/organisation is cheaper than some seed sold internationally i.e. we charge a premium on this. Seed sold in Kenya is thus heavily subsidized as the government wishes to promote tree planting and keep costs down.

3. Ques. Have you already developed some co-operative activities with seed centres in West Africa e.g. in particular CNSF in Burkina Faso? A. Ouedraogo.

Ans. Two years ago we organised some study tours for some of our staff members. We are hoping to go to the IUFRO meeting on seed problems and look to the future for more concrete co-operation.

4. Ques. In 1991 ICRAF apparently requested seed of 13 million seedlings of *Grevillea robusta.* This is enough to plant 20-30,000 ha. Do you know the purpose of the ICRAF planting? L. Thomson.

Ans. Not known. G. *robusta* seed in very high demand for agroforestry in Kenya and KEFRI. KFSC can't meet demand at present.

FODDER TREE GERMPLASM ACTIVITIES AT ILCA

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Summary

Germplasm evaluation of fodder trees for protein supplementation as animal feeds has been in progress at ILCA for over 12 years. The current state of the germplasm collection, characterization and evaluation is reviewed. The research in progress on breeding systems and *in vitro* culture to support the germplasm activities is also described.

Introduction

The Forage Genetic Resources Section of the International Livestock Centre for Africa (ILCA) is involved with the acquisition, conservation and dissemination of forage species for development of animal feeds. The lack of fodder and poor quality of existing feeds is one of the major constraints to improving livestock productivity in sub-Saharan Africa. ILCA is addressing this constraint through the evaluation of feeds and development of feeding packages for use in livestock production systems by smallholder farmers in sub-Saharan Africa.

Fodder trees are an important animal feed, providing a high quality protein supplement to crop residues and natural pastures, which are the major sources of animal feed in the region. However, the presence of anti-nutritional factors, mainly polyphenols, in many species of fodder trees present problems of intake and protein utilization in the rumen and limit the use of these species as animal feeds. There is a need to select accessions with low anti-nutritional compounds and high agronomic productivity to use in livestock feeding production systems. Although ILCA is primarily interested in their use as fodder, these tree species also have multiple uses, providing shade, fuelwood and poles and showing superior persistence, higher dry-matter yields and better resistance to mismanagement than herbaceous legumes and a capacity *to* retain high-quality foliage under stress conditions.

ILCA's interest in fodder trees began in 1978, when recognizing the importance of browse trees and shrubs, especially in the arid and semi-arid areas, an international symposium was planned for 1980 to assess the current state of knowledge on browse in Africa (Le Houerou, 1980). Research on fodder trees at ILCA began in 1983 and has concentrated on those of known nutritional quality such as *Leucaena, Gliricidia, Calliandra, Cajanus* and *Sesbania.*

Fodder tree germplasm conservation at ILCA

The ILCA genebank began its collection and acquisition of fodder tree germplasm in 1982 and currently holds a varied collection of almost 1700 accessions from over 300 species.

Although many of these species are only represented by few accessions, larger collections of the most promising fodder species are maintained, including *Acacia, Cajanus, Erythrina, Gliricidia, Leucaena* and *Sesbania* (Table 1). A revised catalogue of available germplasm was published in 1991 (Kidest Shenkoru, Hanson and Metz, 1991).

Much of this material has been collected by ILCA or donated to ILCA by other major forage research institutes, particularly the Centro Internacional Agricultura Tropical (CIAT) in Colombia and the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. The collection of *Sesbania* is one of the most comprehensive available and was collected mostly by ILCA with support from the International Development Research Centre (IDRC) and the International Board for Plant Genetic Resources (IBPGR).

ILCA maintains an active genebank for research and distribution of seeds and a base genebank for long-term security storage of original ILCA germplasm collections. Seeds are dried to 5% moisture content in a dehumidified drying room at 20% relative humidity and 15°C and packed in laminated aluminium foil bags for storage in the active genebank at 8°C and in the base genebank at -20°C. All seeds in the active collection are freely available in small quantities to *bona-fide* forage research workers. Distribution is done both directly and through networks, such as the African Feed Resources Network.

Seed multiplication and characterisation

Priority in the genetic resources work has now changed from the collection and acquisition of forage germplasm toward the adequate characterisation and evaluation of the existing collection. Characterisation of germplasm is done whilst plants are in the field for seed increase. Species adaptation is taken into account when selecting the planting sites and sufficient plants of each accession are planted to ensure that the genetic integrity of accessions is maintained.

The germplasm is multiplied at two sites in the Ethiopian Rift Valley. Zwai is the major site due to adequate irrigation facilities. Situated on soils with pH 8 and at an altitude of 1650 m, it is suitable for species which are adapted to sandy alkaline or neutral soils. Species which are better adapted to acid soils are grown under rainfed conditions at Soddo on a site with soil pH 4.5 and at an altitude of 1850 m.

Experiments are in progress on the seed production capacity of *S. sesban* managed at different cutting heights and frequencies. In general, accessions with superior vegetative performance showed inferior reproductive performance. Results will be used to make recommendations on a management system for seed production for use by smallholder farmers where forage production is also important to support livestock.

Evaluation of fodder trees

A wide range of germplasm needs to be evaluated to identify promising accessions adapted to particular environments and with high nutritive values for use as supplementary livestock feed. Evaluation of fodder trees at ILCA is targeted to agro-ecological zones, production systems such as alley farming or intensive feed gardens and livestock nutritional requirements.

A range of germplasm of *Gliricidia* collected in Costa Rica in 1983 has been evaluated in the ILCA humid zone programme at Ibadan on acid soils and with 1200 mm rainfall per year (Sumberg, 1986; Atta-Krah, 1988). Considerable variation in height, coppice regrowth and yield was observed between accessions. *Leucaena* has also been evaluated for adaptation to acid soils in West Africa (Cobbina et al, 1987) and a range of species have been tested for use in alley farming systems (Atta-Krah et *al*, 1986; Sumberg, 1984). *Gliricidia* and *Leucaena* have proved very successful in alley farming and in intensive feed gardens in West Africa (Atta-Krah and Kolawole, 1987; Atta-Krah and Sumberg, 1988) and effects on soil fertility, mulch and fodder production have been closely monitored. Other experiments on soil fertility have also been carried out to assess the effects of effective rhizobia for nitrogen fixation in *Gliricidia* (Atta-Krah, 1987) and *Sesbania.*

Evaluation of species adapted to the highland zone in Ethiopia began in 1985. A large number of accessions of *Leucaena, Sesbania, Chamaecytisus, Cajanus* and *Calliandra* have been screened at Soddo and Debre Zeit in replicated trials to evaluate adaptability to the cool tropics. The results of these trials showed considerable variation between accessions in yield, adaptation and *in vitro* digestibility values.

Further evaluation of a wide range of fodder trees is in progress in the subhumid zones of Nigeria and Kenya, to select promising species for use as supplementation for dairy cattle and small ruminants. The growth of *Gliricidia* accessions in the subhumid zone of West Africa was generally poor compared to the humid zone, possibly due to the hard pan restricting root growth. However, germplasm of *Calliandra, Cajanus* and *Flemingia* grew well at all sites.

Multi-locational evaluation is also possible through the ILCA African Feed Resources Network. A multi-locational trial in semi-arid and sub-humid sites in Kenya, Malawi, Tanzania and Uganda for *S. sesban* and *S. goetzei* showed that there are several promising accessions with high yield and good coppicing ability that can be used for animal feeds.

Evaluation of nutritional quality is important for the use of these fodder trees by animals (Otsyina and Mckell, 1985). The effects of supplementary feeding with *Leucaena* and *Gliricidia* from the alley farming system have been widely studied at ILCA (Reynolds and Adediran, 1987). The nutritive value of promising fodder trees being used to supplement crop residues is being evaluated through laboratory analyses and feeding trials to compare livestock productivity on different species. A range of accessions of *S. sesban* and *S. goetzei* are also being tested to determine if variation exists between accessions in animal response. Research on anti-nutritional factors at ILCA has also shown the variation which exists in the available germplasm and the effects of these compounds on protein metabolism (Reed and Soller, 1987; Reed, 1986; Woodward, 1988).

Research support for germplasm management

Many browse species take several years to produce seeds and may be out-crossing. Therefore, genotypic differences can occur. The use of *in vitro* culture for collection and multiplication can avoid both these problems. *In vitro* culture techniques have been successfully developed from embryo-derived tissues for *S. sesban, Faidherbia albida, Acacia tortilis, Leucaena leucocephala* and *Erythrina brucei.* Experiments to develop field collection techniques in *E. brucei* and *F. albida* were unsuccessful due to the high polyphenolic content of mature tissue. A simple method for transfer of young plantlets from culture tubes to soil was developed using a plastic bag as a humidity chamber. These techniques can be used for rapid clonal propagation of promising genotypes.

Another constraint to the correct management of forage germplasm is the lack of information on breeding systems. This information is essential for the development of appropriate regeneration techniques for germplasm maintenance of selected accessions and for seed production for further utilisation. Earlier work was done at ILCA on flowering and seed production in *Gliricidia* (Sumberg, 1985; Aken'ova and Sumberg, 1986) and currently research on *S. sesban* is in progress to identify a marker for determining the amount of natural out-crossing.

Research on inter-specific relationships between the three woody perennial species of *Sesbania (S. goetzei, S. keniensis* and *S. sesban)* is also in progress. Reciprocal crosses were made in all combinations and some combinations were able to produce viable seeds. Research is continuing to study the cytology and stability of the hybrids and to assess the variation achieved through this genetic recombination between species and its potential for agronomic adaptation and use as animal feeds.

Future activities

Research at ILCA will continue to focus on the collection, conservation, characterization and evaluation of fodder tree germplasm for use as livestock feeds. New species of interest as animal feed and more accessions of promising species will be obtained to broaden the genetic base of the collection. Gaps in terms of species and adaptation will be identified to allow further collection to be targeted. A collaborative agreement is being developed with ICRAF to work on species of mutual interest and to make the best use of scarce resources to address the constraints to utilization of fodder tree germplasm in sub-Saharan Africa.

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Table 1. Major fodder tree germplasm in the ILCA genebank

Genus	Number of accessions	Genus	Number of accessions
Acacia	157	*Faidherbia*	12
Aeschynomene	130	*Flemingia*	6
Albizia	26	*Gliricidia*	89
Cajanus	15	*Leucaena*	174
Calliandra	6	*Prosopis*	13
Codariocalyx	27	*Pseudarthria*	18
Chamaecytisus	38	*Sesbania*	291
Desmanthus	113	*Teline*	13
Erythrina	57		

Discussion

1. Ques. Is ILCA considering the possibility of collaborative research on polyphenols in MPTs? C. Lascano.

Ans. Yes. There are some plans involving ILCA/ICRAF and a German University.

2. Comment There is a terminological problem regarding the general use of the term "MPT" or "fodder tree" when one refers to genera e.g *Aeschynomene*, that include erect growing but often not very woody (and even annual shrubs). It would be useful to develop a definition of "MPT" and make clear to what extent the term may refer to shrubs and subshrubs. R. Schultze-Kraft.

3. Ques. What isolation techniques or buffer zones are you using in your programmes to multiply Sesbania accessions? L. Thomson.

Ans. ILCA is undertaking research to quantify the breeding system of different sesbania species. Meanwhile different accessions are being multiplied using bagging and manipulated pollination and/or natural selfing.

4. Ques. Has ILCA investigated genetic correlations amongst fodder and other traits relevant to agroforestry systems e.g. phenology, growth, etc. J. Weber.

Ans. No. We feel other centres have a comparative advantage here. ILCA will continue to focus on quality and quantity of fodder.

5. Ques. Do you follow certain rules in seed collection and seed multiplication programmes in order to maintain genetic variation? J. Albrecht.

Ans. Yes we do. First we assess size of the natural population and assess. its suitability for collection. Secondly we maintain a minimum of 25 trees per seed multiplication unit. Available land for seed multiplication is a serious constraint for us at ILCA.

MULTIPURPOSE TREE AND SHRUB GERMPLASM EVALUATION AND CONSERVATION AT IITA

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IITA, Ibadan, Nigeria

Summary

IITA (International Institute for Tropical Agriculture) has over the years devoted considerable resources to collecting and evaluating germplasm of crops within its mandate. With increasing need for environmental stability and soil fertility maintenance in the humid and sub-humid tropics, inclusion of leguminous woody species in farming systems has become increasingly important. Research on alley cropping and improved fallow system with various multipurpose tree species (MPT) particularly *Gliricidia sepium* and *Leucaena leucocephala* and shrub species such as *Cajanus cajan* and *Tephrosia Candida* conducted at IITA over the last two decades have shown the potential of these species for sustaining crop production. Realising the values of this genepool, efforts to collect and identify useful species have recently been intensified at IITA in cooperation with ILCA and ICRAF. MPT germplasm evaluation and screening under AFNETA (with coordinating office at IITA) is being undertaken. Germplasm of more than 27 species were distributed to AFNETA investigators for evaluation in 4 different agro-ecological zones in 21 African countries during the past 2 years, a collection of MPT's of over 100 species has been established in arboreta, at IITA Ibadan, Onne (Nigeria) and Mbalmayo (Cameroon) stations. Seed collections of over 100 MPT species have also recently been added to its gene bank as part of a joint IITA/ICRAF/OSU MPT project. This USAID assisted joint project aims at explorations for tropical exotic and indigenous West African MPTS for acid soils in the humid lowlands of West Africa.

Seed storage studies of 12 important MPT species in support of germplasm conservation effort was recently started with interesting results emerging. These studies aim to ensure the development of appropriate long term storage strategy for these species. These joint efforts are important for both IITA and ICRAF on agroforestry research particularly on MPTs development and improvement.

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With the excellent seed storage facility available at IITA and the establishment of the three arboreta, it is desirable to further the cooperation with ICRAF in exploration, evaluation and conservation of MPT species within west Africa. IITA's future plans have called for the need for additional efforts to collect and conserve the genetic resources of indigenous multipurpose tree and shrub species.

Introduction

IITA has over the last two decades devoted considerable resources to collecting, evaluating and conserving germplasm of important food crops (cowpea, rice, yam, cassava, maize, soybean, Bambara groundnut, African yam bean, Lima bean, sweet potato, Taro) and their wild relatives (Ng 1982,1991a). To date the institute has conducted more than 50 plant exploration missions in over 30 countries in Africa for the collection of germplasm of these species. It now holds about 40,000 accessions of these food crops and their wild relatives, which are maintained, documented and preserved at the institute's seed bank, *in vitro* culture laboratory and field gene bank. Though work in collecting, evaluating and conserving agroforestry species at IITA is less elaborate than that for food crop germplasm, IITA places equal importance in its agroforestry germplasm collection.

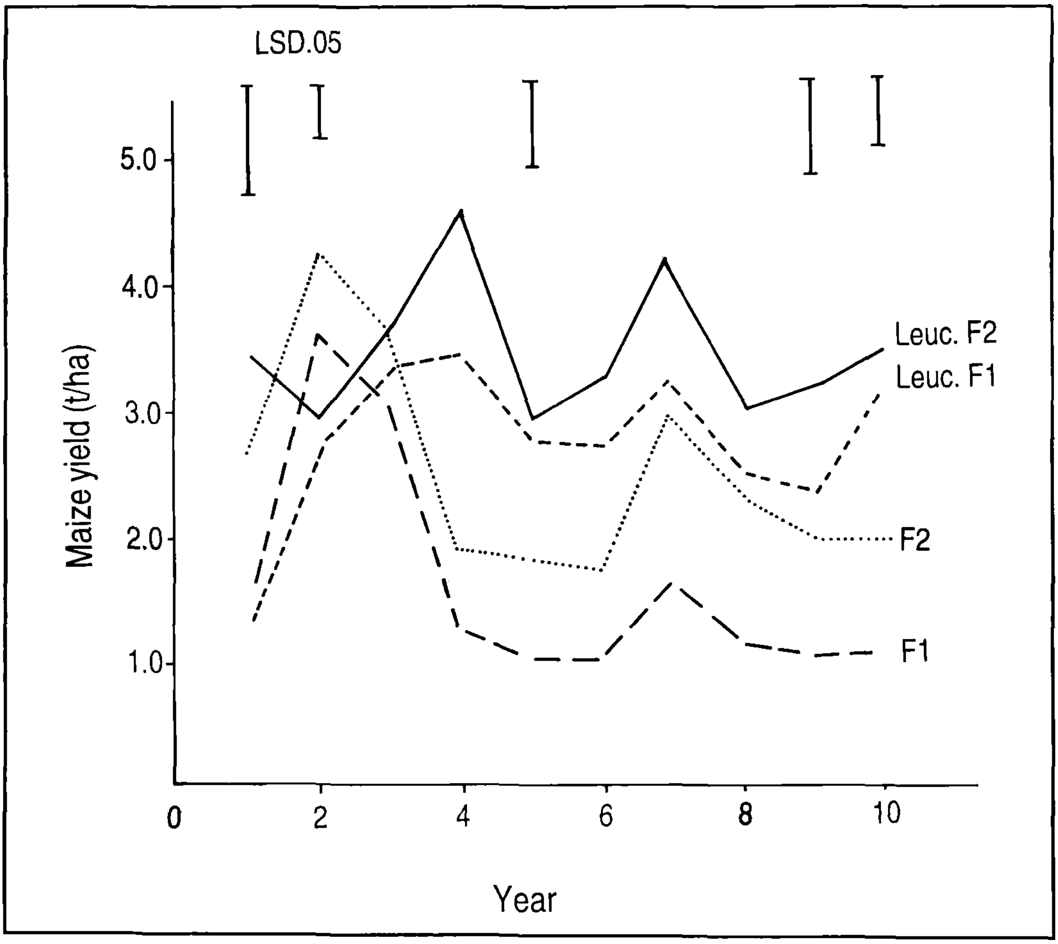
Like many food crops, MPT genetic resources are under the threat of erosion, as a result of deforestation (Soladoye *et al* 1986, Ladipo, *et al* 1990) and other unproductive land-use systems (Kang *et al* 1990) in the lowlands of west Africa. This ecoregion is recognized as a centre of diversity of many important multipurpose tree species, particularly the leguminous species such as the genus *Baphia* (Soladoye 1985). The humid lowlands of west Africa is within the mandate of IITA, and ICRAF. Both centres have collaborated and worked with multipurpose tree germplasm in this region. This paper aims to provide an overview of IITA's past and present activities, with special reference to its collaboration with ICRAF, and its future plans in multipurpose tree and shrub species germplasm collection, evaluation and conservation.

Collecting and evaluating tree and shrub species for use in agroforestry

Since 1970 IITA has invested a large part of its resources in agroforestry research that aims at the development of appropriate technologies for the management of fragile tropical soils and for substituting traditional bush fallow system for sustainable food production in tropical Africa. Over the years many woody species have been collected or assembled and evaluated by IITA's scientists for their potential use in alley cropping system/farming in different ecologies, for weed control or for restoring soil fertility to sustain food production. Several suitable species of trees and shrubs have been identified, including a number of leguminous species, such as *Leucaena leucocephala*, *Gliricidia sepium* and *Calliandra calothyrsus*. These species are suitable for alley farming in the forest-savanna transition zone. Other promising species such as *Acioa barteri*, *Flemingia macrophylla* and *Alchornea cordifolia* that are suitable for alley cropping in the high rainfall region with highly acidic Utisols (Kang *et al* 1984; Kang *et al* 1990; Gichuru *et al* 1990).

Past research work in these areas at IITA has shown the potential benefits to soil fertility and crop production by incorporating multipurpose tree and shrub species in farming systems. This can be seen in the results of a long term alley cropping experimental trials with maize and *Leucaena leucocephala* (Figure 1). Alley cropping of maize with *Leucaena leucocephala* as hedgerow, without N-fertilizer application, gave higher maize yield than sole crop of maize in control plots (with no hedgerow) receiving 45 Kg N. The hedgerows not only are useful for providing prunings for restoring or maintaining soil fertility; they also can provide firewood and staking material for supporting climbing plants such as beans (Rachie 1983) and yams (Wilson and Akapa 1981), and fodder (particularly leguminous species). Woody species such as *Cajanus cajan* and *Tephrosia Candida* have also been found to be useful in planted fallow for soil improvement (Gichuru 1990). Realizing the potential of multipurpose tree and shrub species in sustainable food production,

Figure 1. Longterm effect of alley cropping with L. Leucocephala (Leuc.) and fertilizer application (F) on grain Yield of Maize grown on degraded Alfisol (Fertlizer rate: year 1, FI=0, F2=90N-40P-40K; year 2-3, Fl=45-20-20, F2=90-40-40; Year 4-10, FI=0-I2-25, F2=45-J2-25). (B.T. Kang, unpublished data).



IITA's scientists and their collaborators particularly ICRAF and ILCA continue the search for promising species for each of the different ecologies. Emphasis is now on the identification of indigenous multipurpose tree/shrub species for use in improved fallow and alley farmings particularly for the humid zone.

The Alley Farming Network for Tropical Africa (AFNETA)

Realising the potential of alley farming in sustaining food production, the Alley Farming Network for Tropical Africa (AFNETA) which is supported by IITA, ICRAF, and ILCA with its coordination unit based at IITA, was established in 1989. It's task is to promote and coordinate alley farming research and development within the national agricultural research systems in tropical Africa. This is done through promotion of information exchange, training and collaborative research on alley farming, including testing and evaluating germplasm of multipurpose tree species in different ecologies. During the past two years, AFNETA has distributed germplasm of more than 27 species to its collaborators for evaluation in four different ecologies in 21 countries of sub-saharan Africa (Table 1). More species are expected to be evaluated in the future and appropriate species and varieties suitable for each ecology will be identified and promoted for adoption by farmers.

Collecting and conserving germplasm of Multipurpose Tree (MPT) species

Since the inception of agroforestry research at IITA about twenty years ago, its scientists have collected or assembled many tree and shrub species. Some of these species were maintained, while others were abandoned due to poor performance or discontinuity of research. To preserve and assess the multipurpose tree species, two arboreta were established in 1979 in Nigeria. One was established at the IITA headquarters in Ibadan, characterized by bimodal rainfall with total annual rainfall of 1280mm and non-acid soil. The other was established at IITA substation at Onne, characterized by pseudo bimodal rainfall with total annual precipitation of about 2400mm and acid ultisol. The Ibadan arboretum has more than 40 species consisting of about 60 accessions with maturity already attained by many species. From these trees seeds are regularly gathered for distribution and new collections of seeds being preserved in IITA's gene bank.

A joint IITA/ICRAF/OSU (Oregon State University, Oregon, USA) project on multipurpose trees/shrubs evaluation for agroforestry systems in the humid lowland zone of west Africa was established at IITA in 1990. The main objective of this project is the collection and evaluation of some exotic and indigenous multipurpose tree and shrub species for use in agroforestry. Four plant exploration and collection trips were conducted since the project commenced, and with collections of over 376 accessions of seed samples and several cuttings consisting of about 117 tree/shrub species already collected. The seed collections have now been added to the existing collection in IITA's gene bank (see Table 2). In addition, new collections of multipurpose tree/shrub species of over 100 species have been added to the arboreta, at IITA's station in Ibadan (about 100) and Onne (over 60). A new arboretum has been established at IITA's station Mbalmayo (29) in Cameroon.

The list of the existing seed collections of tree and shrub species presently maintained at IITA's gene bank and arboreta are listed in Table 3. This expanded collection of tree and shrub species seed is a result of the collaboration between IITA and ICRAF on a common goal. The results thus far have proved beneficial to both centres.

Seed Storage Investigations

Storage characteristics of most of the seeds of tree/shrub species coming in from the MPT project explorations are still unclear. Based on past experience and published information (Cromarty *et al* 1982; King and Roberts 1979; Ladipo *et al* 1990; Ng 1991b) it has been possible to classify the seeds into the general groups of recalcitrant and orthodox species.

However, it is desirable to conduct further investigations on the seed storability characteristics of some of those species in order to provide information for appropriate long-term conservation strategy.

Currently, a joint ICRAF/IITA seed storage studies on the following species are being conducted at IITA:

Tetrapleura tetraptera
Millettia thonningii
Lonchocarpus sericeus
Erythrophleum suavolense
Daniella ogea
Millettia grifoniana
Lonchocarpus cyanensis
Pterocarpus milbraedii
Grewia pubescense
Afzelia africana
Afzelia bella
Enterolobium cyclocarpum

Work on some recalcitrant seeds has commenced with substantial results on seeds *oi Acioa barteri* (ICRAF/IITA/OSU, 1992).

Future plans

With the excellent seed storage and laboratory facilities already available at IITA and the establishment of three arboreta at three different IITA field stations, the institute is reasonably well placed in West Africa for the collection, evaluation, distribution and conservation of germplasm of multipurpose tree/shrub species in the region. The existing collections of multipurpose tree/shrub germplasm available at IITA are useful to the current work of both CG centres (IITA, ICRAF and ILCA) and NARS. IITA will continue to maintain and preserve the collection and making it available to researchers according to the current policy of CGIAR on plant genetic resources. It will continue to collaborate with ICRAF in studies involving seed storage.

In its new medium-term (1993-98) plans IITA stresses the need for additional efforts to collect and conserve indigenous food crops which are regularly grown in sub-Saharan Africa but are currently not covered by its existing mandated activities, including MPT species in collaboration with ICRAF, ILCA and IPGRI and other international organizations and African NARS. IITA will pursue activities vigorously in the future. It is desirable for IITA to further the collaboration with ICRAF while continuing the joint initiative of IITA/ICRAF/OSU commenced a year ago. IITA will consider expanding the collection of high potential multipurpose tree/shrub species, as shown in Table 4 in conjunction with relevant centres:

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Table 1. Tree species currently being screened under AFNETA in four agroecological zones in 21 countries in sub-saharan Africa

Agroecological Zones			
Humid	**Sub-humid**	Semi-arid	Highlads
Leucaena leucocephala	*L. leucocephala*	*Faidherbia albida*	*L. diversifolia*
L. diversifolia	*L. diversifolia*	*Acacia Senegal*	*L. leucocephala*
Gliricidia sepium	*G. sepium*	*A. holocericea*	*Calliandra calothyrsus*
Flemingia macrophylla	*F. macrophylla*	*A. tortilis*	*C. siamea*
Tephrosia Candida	*T. Candida*	*A. auriculiformis*	*C. spectabilis*
Calliandra calothyrsus	*Parkia biglobosa*	*A. nilotica*	*Sesbania sesban*
Cassia siamea	*C. siamea*	*Prosopis cineraria*	*Erythrina peopigina*
Cassia spectabilis	*C. spectabilis*	*P. juliflora*	*Grevillea robusta*
Albizia lebbeck	*A. lebbeck*	*P. alba*	
Sesbania sesban	*Acacia auriculiformis*	*Albizia lebbeck*	
Cajanus cajan	*A. mangium*	*G. sepium*	
	Azadirachta indica		
	C. cajan		

Table 2. Tree species germplasm maintained at IITA's genebank

Species	No. of Accession	Species	No. of Accession
Acacia albida (Faidherbia albida)	9	*Casuarina cunninghanni***	
Acacia auriculiformis	1	*Cathormiun alfissimum*	
Acacia melanoxylon	1	*Chrysophyllum albidum**	2
Acacia milotica	5	*Chrysophyllum cainito***	
Acacia polystycha	1	*Cnestis ferruginea*	
Acioa barteri	4	*Cola millenii**	
Adenanthera parvonina	2	*Cylicodiscus gabonensis*	
Afzelia africana	8	*Dacryodes edulis*	
Afzelia bella	4	*Dalbergia albiflora*	
Afzelia bipindensis	1	*Dalbergia lactea*	
Albizia adianthifolia	2	*Dalbergia latifolia*	2
*Albizia caribaea** (A. niopoides)*	5	*Dalbergia saxatilis*	7
Albizia ferruginea	5	*Dalbergia sissoo***	3
Albizia gummifera	1	*Dalbergia spp.*	1
*Albizia lebbeck***	2	*Daniella ogea*	1
Albizia zygia	1	*Daniella oliveri*	i
Alchornea cordifolia	1	*Delonix regia*	1
Annona muricata	1	*Dinnettia tripetala*	1
Anthonotha macrophylla	3	*Detarium microcarpum**	1
*Artocarpus heterophylum***	I	*Dialium guineense*	3
Balanites aegyptiaca	6	*Dichrostachys cinerea*	1
Baphia dewildeana	1	*Distemonanthus benthamianus*	1
Baphia laurifolia	2	*Elaeis guineense*	1
Baphia leptostemma	1	*Entada abyssinica*	1
Baphia nitida	9	*Entada spp.*	5
Baphia pubescens	2	*Entandophragma angolense*	2
Baphia spp.	1	*Enterolobium cyclocarpum***	1
*Bauhinia monandra***	3	*Erythrina senegalensis*	1
*Bauhinia tomentosa***	1	*Erythropheleum suavolenses*	3
Berlinia auriculata	1	*Erythrophleum ivorense*	1
Berlinia grandiflora	1	*Flemingia macrophylla***	2
Blighia sapida	1	*Garcinia kola*	1
Blighia unijugata	1	*Gliricidia sepium*	2
Brachystegia luricoma	3	*Gmelina arborea*	1
Brachystegia kennedyi	2	*Grewia pubescens*	2
*Butyrosvittelaria paradoxa **	1	*Icacina trichantha*	1
Byrsocarpus coecineus	1	*Irvingia gabonensis*	1
Caeselpinia spp.	1	*Lecaniodiscus cupanioides*	1
*Calliandra calothyrsus***	2	*Leucaena leucocephala*	1
Calpocalyx dinklegii	1	*Lonchocarpus cyanenses*	28
Canavalia ensiformis	1	*Lonchocarpus sericeus*	37
Carpolobea alba	1	*Maesobotryia barteri*	I
Cassia alata	1	*Microdemis keamyana*	1
Cassia fistula	2	*Millettia aboensis*	13
Cassia nodosa	1	*Millettia drastica*	1
Cassia oraria	1	*Millettia rhodantha*	1
*Cassia siamea (Senna siamea)***	1	*Millettia spp.*	1
*Cassia siberiana***	2	*Millettia stuhlmanii***	1
*Cassia spectabilis***	2	*Millettia thonnigii*	20

Species	No. of Accession	Species	No. of Accession
Monodora myristica	**1**	*Pycnanthus angolensis*	
*Napoleona imperialis**	3	*Acacia senegalensis*	
Nauclea diderrichii	2	*Samnanea saman (Albizia samans,*	1
Nauclea latifolia		*Stemonocoleus micranthus*	2
Newtonia griffoniana		*Sterculia oblonga*	
Olax subscopioidea		*Sterculia setigera*	
Parkia biglobosa	4	*Sterculia tragacantha*	3
Parkia bicolor		*Strychnos spinosa*	
Peltophorum pterocarpum		*Tabernaemontana pachsiphon*	
*Pentaclethra macrophylla**		*Tamarindus indica*	7
Pericopsis alata		*Terminalia ivorensis*	
Pericopsis laxiflora		*Terminalia spp.*	2
Pisidium guajava		*Terminalia superba*	
Platysepalum violaceum	2	*Tetrapleura tetrapera*	7
Plerocarpus soyauxii		*Treculia africana*	
Prosopis africana	10	*Uvaria chamae*	
Pterocarpus angolense		*Xylia xylocarpa***	
Pterocarpus erinaceus	7	*Xylopia aethiopiaca*	
Pterocarpus osun	10		
Pterocarpus santalinoides	4		
			365

Including collections made by ICRAF/IITA/OSU Project
* Recalcitrant seed
** Exotic

*Table 3. List of tree and shrub species in Ibadan, Onne and Mbalmayo Arboreta**

Species	Family	Species	Family
Ibadan		*Adansonia digitata*	Bombacaceae
		Adenathera panonina	Mimosaceae
Acacia albida	Mimosaceae	*Afzelia africana*	Caesalpiniaceae
(Fadherbia albida)		*Afzelia bella var bella*	Caesalpiniaceae
Acacia auriculifarmis	Mimosaceae	*Afzelia bipindensis*	Caesalpiniaceae
Acacia holocericea	Mimosaceae	*Albizia adianihifolia*	Mimosaceae
Acacia cincinata	Mimosaceae	*Albizia caribaea*	Mimosaceae
Acacia eulocarpa	Mimosaceae	*Albiziafalcataria*	Mimosaceae
Acaciafaluescens	Mimosaceae	*Albizia ferruginea*	Mimosaceae
Acacia flariseus	Mimosaceae	*Albizia gummifera*	Mimosaceae
Acacia lafesens	Mimosaceae	*Albizia lebbeck*	Mimosaceae
Acacia leptocarpa	Mimosaceae	*Albizia zygia*	Mimosaceae
Acacia mangium	Mimosaceae	*Alchornea cordifolia*	Euphorbiaceae
Acacia melanozylon	Mimosaceae	*Anacardium occidentale*	Anacardiaceae
Acacia nilotica	Mimosaceae	*Anthonotha macrophylla*	Leguminosae
Acacia polytycha	Mimosaceae	*Annona muricata*	Annonaceae
Acioa barterii	Rosaceae	*A rtocarpus heterophyllus*	Moraceae

Species	Family	Species	Family
Balanites aegyptiaca	Balanitaceae	*Indigofera macrophylla*	Papilionaceae
Baphia latifolia	Papilionaceae	*Inga endulis*	Mimosaceae
Baphia nitida	Papilionaceae	*Irvingia gabonensis* var excelsa	Irvingaceae
Baphia pubescens	Papilionaceae		
Bauhimia monandra	Caesalpiniaceae	*Irvingia sp.*	Irvingaceae
Bauhimia tomentosa	Caesalpiniaceae	*Lecandiscus cupaniodes*	Sapindaceae
Berlinia grandiflora	Caesalpiniaceae	*Leucaena hybyrid* KX8	Mimosaceae
Blinghia sapida	Sapindaceae	*Leucaena leucocephala*	Mimosaceae
Blingia uniujuglata	Sapindaceae	*Leucaena leucocephala* K38	Mimosaceae
Brachysteria eurycoma	Caesalpiniaceae		
Butyrospermum paradoxa	Sapotaceae	*Leucaena diversifolia*	Mimosaceae
Caesalpinia sp	Caesalpiniaceae	*Leucaena esculenta*	Mimosaceae
Calliandra calothyrsus	Papilionaceae	*Leucaena leucocephala* K584	Mimosaceae
Calliandra portorisensis	Papilionaceae		
Calliandra haenatagabala	Mompsaceae	*Lonchocarpus cynaceus*	Leguminosae
Cassia siamae	Leguminosae	*Lonchocarpus sericeus*	Leguminosae
Cassia fistula	Leguminosae	*Maesobotyria barteri*	Euphorbiaceae
Cassia spectabilis	Leguminosae	*Millettia aboensis*	Papilionaceae
Cassia oraria	Leguminosae	*Millettia drastica*	Papilionaceae
Cassia nodosa	Leguminosae	*Millettia grifonianus*	Papilionaceae
Casuarina cunanighanii	Casuarinaceae	*Millettia sp*	Papilionaceae
Ceiba pantandra	Bombacaceae	*Millettia stuhlmannii*	Papilionaceae
Chrysophyilum albidum	Sapotaceae	*Millettia thonningii*	Papilionaceae
Chrysophyllum cainito	Sapotaceae	*Millettia thonningii* (Nsukka)	Papilionaceae
Cola millenii	Steruliaceae		
Cola parchycarpa	Steruliaceae	*Moringa oleifera*	Mimosaceae
Cordia alliodora	Boraginaceae	*Morus alba*	Moraceae
Dacryodes echitis	Burseraceae	*Napoleona imperalis*	Annonaceae
Dalbergia lactea	Papilionaceae	*Napoleona imperalis* (Benin)	Annonaceae
Dalbergia latifolia	Papilionaceae		
Dalbergia albiflora	Papilionaceae	*Nauclea didderrichi*	Rubiaceae
Dalbergia sissoo	Papilionaceae	*Nauclea latifolia*	Rubiaceae
Daniel la ogea	Caesalpiniaceae	*Newbouldia leavis*	Bignoniaceae
Daniellia oliveri	Caesalpiniaceae	*Parkia bicolor*	Mimosaceae
Delonix regia	Leguminosae	*Parkia biglobosa*	Mimosaceae
Dialium guineense	Caesalpiniaceae	*Peltophyorum pterocarpum*	Triuridacaea
Dialium guineense (Owerii)	Caesalpiniaceae		
		Pericopsis alata	Papilionaceae
Dipteryx odorata	Papilionaceae	*Pericopsis landiflora*	Papilionaceae
Elaeis guineansis	Palmae	*Persea americana*	Lauraceae
Entanda abyssinica	Mimosaceae	*Pinus caribea*	Pinaceae
Enterologium cyclocarpuni	Mimosaceae	*Pithecellobium dulce*	Mimosaceae
Erythrophyllum suavolense	Caesalpiniaceae	*Platysepalum violaceum*	Papilionaceae
Erythrina senegalensis (white flower)	Leguminosae	*Plerocarppus soyauxi*	Papilionaceae
		Prosopis africana	Mimosaceae
Erythrina pospigama (red flower)	Leguminosae	*Psidium guajava* (Red)	Muyrtaceae
		Pterocarpus mildbraedii	Papilionaceae
Gliricidia sepium	Papilionaceae	*Pterocarpus osun*	Papilionaceae
Gmelina arborea	Verbanaceae	*Pterocarpus santalinoides* (Moniya)	Papilionaceae
Grewia pubescens	Tiliaceae		
Holarrhenafloribunda	Apocynaceae	*Pterocarpus santalinoides* (Ugheli)	Papilionaceae

Species	Family
Raphia hookeri	Palmae
Samanea saman	
Spondias mombin	Anarcadiaceae
Stemonocolus micranthus	Caesalpiniaceae
Tamarindus indica	Caesalpiniaceae
Terminalia ivorensi	Combretaceae
Terminalia superba	Combretaceae
Tetrapleura tretraptera	Mimosaceae
Treculia africana	Moraceae
Triplochiton scleroxylon	Sterculiaceae
Uvaria chatnae	Annonaceae
Xylia xylocarpa	Mimosaceae
Xylopia aethiopiaca	Annonaceae
Onne	
Acacia albida	Mimosaceae
Acacia mangium	Mimosaceae
Acacia barterii	Rosaceae
Adenanthera parvonina	Leguminosae
Afzelia africana	Caesalpiniaceae
Afzelia bipinacensis	Caesalpiniaceae
Afzelia bella	Caesalpiniaceae
Albizia carribea	Mimosaceae
A Ibizia ferruginea	Mimosaceae
Albizia gummifera	Mimosaceae
Albizia lebbeck	Mimosaceae
Alchornea cordifolia	Euphorbiaceae
Anthonatha macrophylla	Caesalpiniaceae
Balanites aegyptica	Balanitaceae
Baphia pubecense	Papilionaceae
Baulhlmla monandra	Caesalpiniaceae
Berlinia grandiflora	Caesalpiniaceae
Caesalpinea sp	Caesalpiniaceae
Cassia spectabilis	Mimosaceae
Chrysophyllum albidum	Sapotaceae
Cola pachycarpa	Sterculiaceae
Dacryodes edulis	Burseraceae
Dalbergia latifolia	Papilionaceae
Dalbergia sissoo	Papilionaceae
Daniella ogea	Caesalpiniaceae
Dialium guineensis	Caesalpiniaceae
Dipteryx odorata	Papilionaceae
Elaeis guineensis	Palmae
Enterolobium cyclocarpum	Mimosaceae
Erythropleum suaveolens	Caesalpiniaceae
Gmelina arborea	Verbenaceae
Grewia pubescens	Tiliaceae
Inga eduvlis	Mimosaceae
lrvingia gabonensis var gabonensis	Irvingaceae
Leucaena leucocephala	Minisaceae
Lonchocarpus sericeus	Leguminosae
Lonchocarpus cynaceus	Leguminosae
Lophira alata	Ochnaceae
Maesobotrya barteri (stump)	Euphorbiaceae
Melicia excelsa	Moraceae
Microdesmis spp	Euphorbiaceae
Millettia rhondata	Papilionaceae
Millettia aboensis	Papilionaceae
Millettia griffonanus	Papilionaceae
Millettia stuhlmannii	Papilionaceae
Millettia thonningii (Nsukka)	Papilionaceae
Millettia thonningii (Ibadan)	Papilionaceae
Monodora tenuifolia	Annonaceae
Morus alba	Moraceae
Napoleona imperialis	Annonaceae
Nauclea didderrichi	Rubiaceae
Parkia bicolor	Mimosaceae
Parkia biglobosa	Mimosaceae
Pericopsis alata	Papilionaceae
Pinus caribea	Pinaceae
Piptadeniastrum africanum	Mimosaceae
Pithecelobium dulce	Mimosaceae
Platysepalum violeceum	Papilionaceae
Prosopis africana	Mimosaceae
Psidium guajava	Myrtaceae
Pterocarpus santalinoides (Ibadan)	Papilionaceae
Pterocarpus erinaceus	Pterocarpus
Pterocarpus osun	Papilionaceae
Pterocarpus santalinoides	Papilionaceae
Sesbania pachycarpa	Papilionaceae
Stemonocoleus micranthus	Caesalpiniaceae
Tamarindus indica	Caesalpiniaceae
Terminalia ivorensis	Combretaceae
Terminalia superba	Combretaceae
Tetrapleura tetraptera	Mimosaceae
Treculia africana	Moraceae
Triplochiton scleroxylon	Sterculiaceae
Xylia xyclocarpa	Mimosaceae
Xylopia aethiopiaca	Annonaceae
Mbalmayo	
Acacia albida (Faidherbia albida)	Mimosaceae
Acacia auriculiformis	Mimosaceae
Acacia mangium	Mimosaceae
Acioa barterii	Rosaceae

Species	Family	Species	Family
Adansonia digitata	Bombacaeae	*Gliricidia sepium*	Papilionaceae
Afzelia africana	Caesalpiniaceae	*Gmelina arborea*	Verbanaceae
Alchofnea cordifolia	Euphorbiaceae	*Hum crepitans*	Euphorbiaceae
Arthocarpus communnis	Moraceae	*Indigofera sp*	Papilionaceae
Bauhimia tomentosa	Caesalpiniaceae	*Irvingia gabonensis*	Irvingaceae
Cassia siamea (Senna siamea)	Leguminosae	*Lonchocarpus sericeus*	Leguminosae
		Lonchocarpus cynaceus	Leguminosae
Cassia spectabilis	Leguminosae	*Mangifera indica*	Leguminosae
Caesalpinia sp	Caesalpiniaceae	*Millettia thonningii*	Papilionaceae
Citrus medica	Rutaceae	*Millettia laurentii* (Mbalmayo)	Papilionaceae
Dacryodes edulis	Burseraceae		
Dalbergia sissoo	Papilionaceae	*Millettia laurentii* (Nkolbisoon)	Papilionaceae
Entandophragma utile	Miliaceae		
Enterolobium cyclocarputr	Mimosaceae	*Persea americana*	Lauraceae
Erythrophleum suaveolense	Caesalpiniaceae	*Psidium guajava*	Myrtaceae
		Prosopis africana	Mimosaceae
Flemingia macrophylla	Leguminosae	*Pterocarpus santalinoides*	Papilionaceae
		Terminalia ivorensis	Combretaceae

Table 4. High potential MPTs in the humid lowlands of West Africa. These include both native and exotic species

Uses	Species/Genus
(1) Soil improving species (legumes and non legumes)	*Albizia* *Pterocarpus* *Millettia* *Pentaclethra* *Leucaena* *Acioa* *Gliricidia* *Cajanus* *Calliandra*
(2) Fruit, Vegetable and foods	*Irvingia* *Dacryodes* *Vernonia*

Discussion

1. Ques. Do you include provenances in your species comparison trials? J. Burley.

Ans. Populations of some species are collected to represent a particular ecological type e.g. acid soil. Yes we do include several provenances of some species.

2. Comment Follow-up to previous question. Provenances are also involved in ecoregional evaluations.

3. Ques. Your diagram indicating how IITA could collaborate with ICRAF suggests a one-way flow from West Africa into IITA. Does IITA plan to co-operate with other established seed centres in West Africa Sahel e.g. ICRISAT, CNSF in Burkina Faso? J. Weber.

Ans. Yes collaboration will depend on storage facilities in national/regional programmes in the Sahel. I am not entirely familiar with their capabilities.

4. Ques. a)What level of feedback do you achieve from your network?
b)Does *Cajanus cajan* require more collection or did you mean acquisition. R. Schultze-Kraft.

Ans. a) No feedback from network yet. Network quite new.

b) We believe further collection is required.

5. Ques. Do you collaborate with other seed centres? J. Albrecht.

Ans. Yes NFTA has sent seed samples.

* Including collections made by ICRAF/IITA/OSU Project

MULTIPURPOSE TREES AND SHRUBS AT CIAT

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Introduction

Trees and shrubs are used in many tropical areas as shade for perennial crops, as a source of fuelwood, and as feed for domestic animals. Among the different genera of trees and shrubs, there has been considerable interest in N2-fixing legumes. This is because of their potential use as a protein source for ruminants and as an efficient nutrient-cycling component in integrated crop-livestock systems.

In tropical America most research on leguminous trees and shrubs has been confined to a few genera (e.g. *Leucaena, Gliricidia, Erythrina)* that only grow well in soils of moderate acidity with low levels of exchangeable aluminum (Perdomo 1991). As a consequence, CIAT's Tropical Forages Program (TFP) accepted the responsibility to develop woody forage germplasm for the acid infertile soils in the lowlands and mid-altitude hillsides of tropical America (CIAT in the 1990s and Beyond: A Strategic Plan). Specifically, the TFP will concentrate its efforts on developing N2-fixing leguminous trees and shrubs with forage value and ability to contribute to soil conservation and enhancement in different farming systems.

In this paper we summarize our current research activities and findings with woody leguminous species. We also outline future plans for multipurpose trees and shrubs (MPTS) germplasm acquisition, evaluation, conservation, distribution, and utilization in production systems.

Current activities with MPTs

Germplasm available

In the early 1980s CIAT's former Tropical Pastures Program began acquiring leguminous shrubs through exchange and collections in Southeast Asia

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(Pattanavibul and Schultze-Kraft 1985, Schultze-Kraft *et al* 1989). CIAT now has a limited collection of woody legumes comprising 1229 entries, representing 34 genera and 122 species. Table 1 summarizes MPTS germplasm conserved in the Genetic Resources Unit (GRU) and its origin.

Germplasm agronomic evaluation

Regional agronomists of the TFP are screening a considerable part of the collection of shrubby legumes for adaptation to edaphic, climatic and biotic factors in the savannas of Colombia and Brazil, the humid tropics of Peru and the Philippines, and the hillsides of Central America (Table 2). The evaluation includes an assessment of site adaptation, forage yield and quality, seed production potential, and rhizobium requirements.

Shrubby legumes such as, *Calliandra grandiflora, Cratylia argentea,* and *Flemingia macrophylla* have yielded significantly more dry matter than species like *Gliricidia sepium, Erythrina poeppigiana, Leucaena leucocephala,* when grown in acid soils with high Al saturation (Perdomo 1991).

Variation in seed production potential of MPTS adapted to acid soils has been observed among and within species. In Pucallpa, Peru seed production of 10 accessions of F. *macrophylla* varied from 4 to 20 g/plant. Similar variation in seed production was also recorded in *Tadehagi* sp. and *Desmodium velutinum* (CIAT, unpublished results).

Using a simple need-to-inoculate test in undisturbed soil cores, some shrubby legume species have been found to respond to specific rhizobium strains under acid soil conditions. As a consequence, there is a recommended rhizobium strain list for a number of shrubby legumes adapted to acid soils (e.g., C. *argentea, F. macrophylla, Codariocalyx gyroides).*

Germplasm quality evaluation

In the limited collection of shrubby legumes under evaluation in acid soils of tropical America, a large variation in quality has been observed among species. Some of the leguminous shrubs adapted to acid soils have high tannin levels, which are associated with low rumen protein degradability and low dry matter digestibility. On the other hand, there are shrubby legumes adapted to acid soils and low in tannins that have protein levels and digestibility coefficients similar to those found in *Leucaena, Erythrina,* and *Gliricidia* (CIAT, unpublished results).

The negative effect of high tannin levels in shrubby legumes has been measured in terms of palatability. While the palatability of shrubby legumes high in tannins (e.g. C. *grandiflora* and *Phyllodium)* was very low, some species, such as *Desmodium velutinum* and *Cratylia argentea,* had palatability ratings similar to E. *poeppigiana, G. sepium,* and L. *leucocephala* (Perdomo 1991).

Variation in forage quality within species has also been observed with shrubby legumes adapted to acid soils. With 22 accessions of F. *macrophylla* grown in the Llanos of Colombia, tannin level ranged from 3 to 12% and digestibility from 9 to 36%. A large variation in protein, *in vitro* digestibility, and tannin levels has also been observed among accessions of *Codariocalyx gyroides, Cratylia argentea, Desmodium velutinum,* and *Tadehagi* spp. (CIAT, unpublished results).

Summary of present activities

Work up to now has allowed us to identify species of shrubby legumes adapted to acid soils, some of which (e.g., *C. argentea)* appear to be productive and to have good forage value, due to low tannin levels. With other species high in tannins (e.g., *F. macrophylla),* we have found variation in yield and quality among accessions, thus making it possible to select genotypes with acceptable forage values.

Future activities with MPTS

Acquisition of MPTS

The CIAT collection of MPTS with adaptation to acid soils is limited. Therefore, we will acquire selected germplasm with acid-soil adaptation potential through exchange with institutions such as ICRAF, ILCA, CSIRO, NFTA, CATIE, CENARGEN, OFI, and others. Collections of MPTS germplasm already identified as promising, such as *C. argentea, D. velutinum* and *Flemingia* spp., will be increased through exchange and collection, when possible. We will supplement strategic acquisition of new germplasm of still unknown value by collection efforts, in collaboration with national and international institutions. We will give high priority to indigenous woody legume species in acid soils of tropical America (e.g., the Cerrados of Brazil).

Evaluation of MPTS

The Germplasm Specialist of the TFP, in collaboration with the GRU, will characterize unknown MPTS germplasm. This characterization will include a description of plant morphology and phenology, which will help to design the subsequent screening process.

TFP regional agronomists will evaluate MPTS germplasm at all major TFP screening sites within CIAT's mandate agroecosystems in tropical America, with priority for hillsides and forest margins. In addition, selected MPTS species and accessions will be evaluated in different locations within regions by existing networks in Latin America (RIEPT), West Africa (RABAOC), and Southeast Asia (SEAFRAD).

The minimum screening criteria for MPTS will include: adaptation to abiotic/biotic factors, ease of propagation, rhizobium requirement, edible forage yield, quality of edible forage, and soil improvement capacity (i.e., nitrogen fixation, and litter decomposition characteristics). When necessary, the TFP will adjust or develop appropriate methodologies for agronomic evaluation, assessment of nutritional quality and antiquality factors present, and soil enhancement capacity of MPTS.

CIAT's Agroecosystems Programs (AEPs) will be responsible for research on utilization and management of selected MPTS in farming systems, but in collaboration with the TFP. This collaborative effort will provide feedback to the TFP for acquiring new MPTS germplasm and for including relevant selection criteria in the evaluation process.

MPTS germplasm in the Genetic Resources Unit

CIAT's GRU is responsible for characterizing, conserving, and distributing forage germplasm. Physical facilities for germplasm conservation for short- and long-term storage are adequate to handle future MPTS germplasm in the form of seed. We foresee, however, that for multiplication, storage, and distribution of MPTS species that take several years to produce seed, and that may be outcrossing or have recalcitrant seed (i.e., *Inga),* we will have to rely on *in vitro* techniques. CIAT has successfully developed *in vitro* techniques for cassava germplasm. The techniques include conservation of about 5,000 clones in slow-growth conditions, pathogen eliminations by meristem culture and thermotherapy, and *in vitro* system for international germplasm exchange (Roca *et a!* 1989). CIAT's previous experience in cassava will be valuable for the application of *in vitro* methods for MPTS germplasm. We are seeking complementary funds to adapt or develop *in vitro* techniques for forage germplasm, including MPTS.

We conduct quarantine procedures for incoming germplasm in collaboration with Colombian authorities (ICA). We will work on the development of new techniques and methodologies for a speedy quarantine procedure for forage germplasm exchange. We also plan to deposit a duplicate base collection of leguminous MPTS species in a collaborating germplasm bank, such as ICRAF's.

Database for MPTS germplasm

CIAT's computerized database on forage species will be expanded to include information on MPTS. Information to be stored and made interactively available to CIAT scientists and researchers in other international centers and NARIs includes: passport data, morphoagronomic and quality attributes, regional evaluation performance, rhizobium strains, short- and long-term seed inventories, seed multiplication events, herbarium documentation, and international shipments.

The GRU, in collaboration with the TFP, will elaborate catalogues/diskettes on MPTS germplasm that will include passport data and other relevant information.

Conclusion

The TFP's development of leguminous trees and shrubs for acid soils will be an important contribution to CIAT's new activities on natural resource management and will complement ICRAF's activities on MPT. Specifically, we foresee that the proposed Multipurpose Tree Germplasm Resource Centre of ICRAF will be a source of MPTS germplasm for research and development activities in tropical areas. This resource centre can also play an important role as depositary of duplicate MPTS base collections and in the development of guidelines for characterization, evaluation and conservation of "key" MPTS species.

CIAT would be eventually prepared to assume global germplasm responsibilities for leguminous MPTS adapted to acid soils and with forage potential derived from the TFP efforts. This will take time and additional resources. It is imperative to initiate an interinstitutional dialogue leading to the definition of germplasm responsibilities the various institutions are willing to assume so as to avoid duplication and maximize relevance and effectivenes.

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Table 1. Origin of the collection of leguminous MPTS species in CIAT's tropical forage germplasm bank (number of accessions as of 1992)

Genus and species	Origin				
	Tropical America	SE Asia	Africa	Other	Total
*Codariocalyx spp**	0	34	0	1	35
Cratylia argentea	14	0	0	0	14
Dendrolobium spp.	0	41	0	0	41
Desmodium spp.	86	122	6	0	214
Erythrina spp.	23	0	*1*	35	60
Flemingia spp.	2	83	*2*	6	93
Galactia spp.	55	0	0	0	55
Leucaena spp.	150	4	0	39	193
Mimosa spp.	36	0	0	1	37
Phyllodium spp.	1	104	0	0	105
Sesbania spp.	18	0	2')	6	53
Tadehagi spp.*	0	76	0	0	76
Other genera	168	58	3	24	253
Total	553	522	42	112	1229

[1] Genera marked with * are subshrubs; [2] *Desmodium cajanifolium, ramosissimum, velutinum;* [3] *Galactia glaucescens, jussiaeana.*

Other genera and species include: *Acacia, Aeschynomene, Albizia, Ateleia, Bauhinia, Cajanus cajan, Calliandra, Cassia, Chamaecytisus, Crotalaria, Dalea, Enterolobium, Gliricidia, Indigofera sujfruticosa, Moghania, Pachecoa, Paraserianthes, Parkinsonia, Parosela, Piptadenia, Pipladeniopsis, Podocarpium, Prosopis, Rhynchosia schomburgkii, Schyzolobium, Senna, Tephrosia sinapou, Uraria picta, Zapoleca,* and *Zornia.*

Table 2. Number of accessions of leguminous MPTS germplasm under evaluation at major screening sites of CIAT's Tropical Forages Program

Genus and species	Savannas Llanos Colombia	Savannas Cerrados Brazil	Humid tropics Peru	Central America Costa Rica	Humid tropics Philippines
Cajanus cajan	0	0	10	0	2
Codariocalyx spp. *	27	26	30	5	0
Cratylia argentea	11	11	II	12	2
Dendrolobium spp.	25	2	11	0	0
Desmodium velutinum	95	68	85	21	10
Flemingia spp.	59	13	11	1	6
Leucaena spp.	0	0	21	34	0
Sesbania spp.	0	20	32	3	0
*Tadehagi spp**	40	5	10	3	0
Other genera	6	0	12	9	0
Total	263	145	233	90	20

Genera and species marked with * are subshrubs.

Other genera include: *Acacia, Albizia, Bauhinia, Calliandra, Clitoria, Desmanthus, Erythrina, Phyllodium,* and *Uraria.*

Discussion

1. Ques. You mentioned research on plant quarantine issues at CIAT. Do you foresee future difficulties for international exchange of germplasm. B. Dvorack.

Ans. *In vitro* techniques are being developed as a storage method and can also be used for transfers.

2. Comment Regarding quarantine procedures. IBPGR and FAO are working on quarantine procedures and have already issued technical guidelines for the safe exchange/movement of genetic material. It will be appropriate to issue some guidelines together with CIAT and ICRAF for the exchange of MPT germplasm to avoid spread of pathogens and diseases. F. Attere.

3. Ques. Is there scope in CIAT to evaluate trees and shrubs which have low forage value but have high tolerance of acid soils? Many Australian nitrogen fixing trees and shrubs are in this category. J. Turnbull.

Ans. Maybe but forage production is the major requirement for farmers.

4. Ques. a) What value if any, do S. American sesbanias have on acid soils? b) Has CIAT considered use of MPT legumes in acid soil grasslands simply as a device to improve grass quality and yield without in fact serving directly as fodder. J. Brewbaker.

Ans. a) Sesbania most unlikely as a priority species because as far as is known no S. American species are adapted to acid soils. R. Schultz-Kraft.
b) Agree with prospects for grass fodder improvement via use of trees. R. Schultze-Kraft. CIAT has discussed this issue but feels farmers adoption likely to be low. C. Lascano.

5. Ques. Do you have scientists working on understanding the basic processes at the tree/crop interface who provide feedback to fine-tune the tree selection criteria? Without this basic understanding selection criteria may be rather location specific. P. Cooper.

Ans. Yes. Nutrient cycling research in pastures (5-6 scientists in the savannah region. Will expand to hillsides and forest margins. Agree that work is essential to define selection criteria.

FOREST GENE CONSERVATION AND GERMPLASM DEVELOPMENT: STRATEGIES PROPOSED FOR THE CENTER FOR INTERNATIONAL FORESTRY RESEARCH

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Introduction

The expansion of forestry research in the tropics has been the subject of international discussions since it was highlighted at the XVII IUFRO World Congress in Japan in 1981. Concurrently, the Consultative Group on International Agricultural Research (CGIAR) recognised natural resource management as a target for its research. In 1991 CGIAR decided to expand and restructure its research system in terms of research themes and approach, and to incorporate additional centres to conduct forestry and agroforestry research..

The International Council for Research in Agroforestry (ICRAF) has now joined the CGIAR system as the focal point for agroforestry research and has adopted a global mandate. The CGIAR is in the process of establishing a new entity to cater for forestry, the Center for International Forestry Research (CIFOR).

The first meeting of CIFOR's Board of Trustees will be in July 1992 and it is anticipated that the Director-General of the Center will be appointed by the end of 1992. An outline for a strategic plan for CIFOR has been prepared for consideration by the CIFOR Board and a draft strategic plan will be presented to the CGIAR in November 1992. The outline plan has been prepared by the Australian Centre for International Agricultural Research (ACIAR) on the basis of the discussions and conclusions of a series of IUFRO workshops and other major meetings such as Bellagio II (1988); seminars on research needs and capabilities in Latin and Central America and Africa, advice from Asia through FAO/FORSPA and ITTO and a series of commissioned thematic papers.

The outline draft strategic plan for CIFOR includes four Research Programs, one of which is Germplasm conservation, genetic improvement for plantation establishment and management of natural forests'. A CIFOR thematic paper 'Germplasm conservation, forest genetics and tree improvement' was compiled from a position paper prepared by ACIAR and subsequent comments by internationally recognised genetic resource specialists. The following paper is based on the outline draft strategic plan and the CIFOR thematic paper.

Background

Major land use systems in which trees have a conspicuous role are natural forests, agroforestry systems and plantations. These systems and their genetic resources are managed to varying degrees for conservation, for production or both.

The amount of attention which conservation is receiving is rapidly increasing. The conservation of biodiversity will be reviewed in detail at the United Nations Conference on Environment and Development (UNCED) international conference in Brazil in 1992 . The amount of research on complex conservation issues, undertaken by institutions other than those supported by CGIAR, may well increase as a result.

Genetic conservation is an integral component of strategies in use for the improvement of cultivated tree species. The number of species in cultivation is small in relation to the number of tree species in the world, and the number of species for which effective improvement programs are in place is smaller still. Thus only a small fraction of trees are known in detail and are subject to very active conservation. Most tree improvement work undertaken so far has been on temperate species for industrial use.

In developing countries over 2000 million people, the majority in rural areas, and small rural industries, use wood as their primary energy source; more than 80% of wood consumed in these countries is used as fuelwood and charcoal. Continuing supply of this crucial commodity is increasingly dependent on planting. The success and returns from investment in planting is greatly influenced by the choice of species, the selection of well- adapted provenances and the level of inbreeding in the planted material.

Whilst conservation and improvement of the genetic resources of trees is inevitably a geographically dispersed activity in which national and regional research centres will have a critical role, there is potentially a secondary complementary role for an institution such as CIFOR with a broad geographic mandate. This mandate will be shared with other institutions such as FAO, IBPGR and ICRAF. The scale of the task to be undertaken is so large in relation to available resources that there is no sound basis for concern that wasteful duplication will occur, but there is clearly a requirement for relevant institutions to operate in collaboration, and to utilise their comparative advantages in a complementary manner.

Whilst in some areas of forest research there is very clear separation between research and the operational activity in which the results of the research are applied, tree improvement activities form a continuum from strategic research (eg. biotechnology) to management operations such as seed production of useful species. The distribution of activities between research' groups and operational agencies is thus somewhat arbitrary, and an optimal result will only be obtained if there is a close collaboration between the groups in question.

Over the last decade a number of international working groups (eg. IUFRO's SPDC meetings at Kandy and elsewhere, Bellagio II, CGIAR's TAC, and FORSPA) have considered research priorities and concluded that aspects of the management of genetic resources deserve support.

The US National Academy of Science published the conclusions of its Forest Genetic Resources Working Group in 1991, identifying four areas in which research could assist the conservation and management of forest genetic resources.

- studies of patterns of genetic variation in tree populations
- improved inventories of forest trees
- elucidation of the distribution and structure of genetic variation, especially in tropical trees
- effects of global climatic change and pollution on forest tree species

Considerations

Efforts to collect, conserve in genebanks and manage the genetic resources of trees **ex situ** are very limited. There will remain a much greater need for **in situ** conservation of forest germplasm, than for agricultural crop plants. It is unfortunate that many tropical forest trees produce recalcitrant seed, and that little or nothing is known of their breeding systems and genetic variation. In some circumstances, however, **ex situ** methods of long-term germplasm conservation through seed, pollen, or tissue storage *will* be important, and will be essential adjuncts on the one hand to the working collections for tree improvement, and on the other to ensure preservation of segments of diversity under threat of genetic depletion or destruction.

Rapid expansion of tree planting to provide fuelwood, rural income, shelter and other benefits has created a large demand for seed of well-adapted, vigorous trees. Often problems of seed supply and cost result in sub- optimal material being used. This detracts not only from the success of and returns from the initial planting, but may make the subsequent introduction of more suitable material quite difficult. Successful planting of high-yielding trees potentially assists the conservation of natural vegetation by shifting the production focus from natural forests to plantations. There is thus real urgency to raise the quality of seed or vegetative propagules available to a high level as quickly as possible.

The vigour of some tree species can be significantly assisted by effective microbial symbionts involved in nitrogen fixation and nutrient uptake. The importance of using selected symbionts has frequently received scant attention in either research or practice. Inoculation of planting stock with selected microorganisms provides an opportunity to improve survival and enhance yields, at low cost, on nutritionally-poor or highly degraded lands.

The selection of effective microorganisms and the development of appropriate inoculation techniques in parallel with a tree improvement program should ensure greater efficiency in tree planting activities.

Techniques for addressing many of the research and operational tasks arising in pursuit of genetic conservation, improvement and utilisation have evolved rapidly in the last decade and will no doubt continue to improve. CIFOR has an opportunity to foster application of these techniques to selected species, and to enhance training of and cooperation among scientists from national research institutions. Such opportunities are already being pursued through regional networks, eg. the multipurpose tree research network in Asia and the Pacific.

Potential for CIFOR activity

Given the intended small size of CIFOR and the current preferences of CGIAR donors, CIFOR will initially concentrate on subtropical and tropical regions while noting that there are substantial needs for strategic research in other regions.

CIFOR is particularly conscious of the importance of using comparative advantage, for example by working with existing institutions that are already contributing to the Center's strategic goals and itself undertaking research in critical areas not already adequately serviced. Recognising that few of the major problems of tropical forestry can be studied from a single (headquarters) location, CIFOR will operate primarily in a highly decentralised manner, through partnerships and contractual arrangements with executing institutions in developing and industrialised countries. A number of established institutions in the world already effectively undertake germplasm conservation and development work. CIFOR's contribution lies in providing the strategic research support essential to the successful implementation of seed programs, and may therefore elect to have work undertaken in collaboration with these bodies. This approach has several attractive features, not least being the promptness with which effective action could be initiated: the urgency of improving planting stock has already been mentioned; the urgency of providing an improved basis for **in situ** conservation is also great, and further the two areas are related. There is wide agreement that the training of staff of national institutions will be very important, a task in which established centres can assist greatly.

The extent of CIFOR activity in genetic conservation and development research will depend on the financial resources available but it is likely that projects will be undertaken within two complementary 'programs' -

Gene conservation and management

Both conservation strategies and technologies are required. A particular technical problem is the large fraction of tropical species which produces recalcitrant seed. It is anticipated that there will be great scope for collaboration with FAO, IBPGR, ICRAF and other international, regional and national institutions.

Goal:
To assist conservation and utilisation of forest genetic resources through research on patterns of genetic variation and mating systems in populations of tropical trees, and by incorporating the results of these studies in relevant conservation strategies.

Objectives:

(1) Develop strategies and management practices for genetic resource conservation, both **in situ** and **ex situ,** in the process drawing on results of studies of genetic diversity and reproductive biology of forest trees.

(2) Develop databases which contribute to efficient strategic planning and management of research and selected operational activities relevant to the conservation and use of forest genetic resources.

Germplasm development

Although a number of existing programs operate in this area, there is good evidence that significant further gains can be achieved. Work would be undertaken with regard to existing international (FAO, IBPGR), regional (F/FRED, CSIRO, CTFT etc.) and national activities. The program' would be pursued in four ways.

(i) Woody germplasm collection and distribution.

Goal:
To increase the benefits of trees to communities by improving the availability of appropriate germplasm.

Objectives:

(1) Support national and regional institutions to undertake germplasm collections of internationally-significant tree species to broaden the genetic resource base available to tree breeders.

(2) Further development and rapid adoption of appropriate scientific standards and efficient techniques for field collection, processing, maintenance and documentation of germplasm to ensure that both the germplasm itself and the accompanying data are of high quality.

(3) Improve the storage technology for, and distribution of tree germplasm, and minimise the risks from disease and insects associated with its international transfer.

(ii) Evaluation of species and provenances

Goal:
To increase the availability of high-priority forest products and community incomes by identifying productive forest taxa.

Objectives:

(1) Strengthen national and regional capability to develop productive woody germplasm.

(2) Improve availability and use of methodologies for rapid screening and evaluation of species and provenances.

(3) Identify productive woody germplasm for the rehabilitation of degraded lands.

(iii) Enhancement of tree productivity by breeding

Goal:
To increase community benefits, especially in lesser developed countries in the tropics, by improving the productivity of key tree species (ie. species already known to be productive, or with high potential) by breeding.

Objective:
(1) Increase yield potential of selected tree species by assisting national and regional tree breeding programs.

(iv) Enhancement of tree productivity through use of selected symbiotic microorganisms

Goal:
To increase community benefits, especially in lesser developed countries in the tropics, by improving the productivity of trees through inoculation with selected microorganisms.

Objectives:
(1) Increase yield potential of particular combinations of tree species and sites by improving understanding of, and availability of effective symbiotic microorganisms.

Current CIFOR activities

It is not intended that CIFOR begin research activities until they can be approved by its Board and Director-General. However,in preparation for starting activity in this area, CIFOR in collaboration with IBPGR has contracted two consultants to prepare reports on research needs for the conservation and utilisation of genetic resources of woody species; to identify institutions with the capacity to contribute to research in this area; to assemble information on significant collections of woody germplasm; and to establish a data base on the current state of these genetic resources and associated activities. The consultants will seek close cooperation with ICRAF, FAO, regional and national centres gathering information and assessing critical research needs.

Conclusions

There has been strong support at international meetings over almost a decade for an enhanced international effort to conserve and develop forest genetic resources, and especially those of the tropics. Both the conservation and production aspects of this task are urgent.

CIFOR can have a valuable catalytic role in this large task, complementing efforts of existing national, regional and international institutions.

A consultative and cooperative approach will be essential to optimise the returns from any enhanced international investment.

Good organisational and conceptual frameworks for new activities are available.

Acknowledgements

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Discussion

1. Ques. Your presentation focused mostly on plantation forestry. Does CIFOR plan to work on natural forests? E. Bonkoungou.

Ans. Yes most certainly.

2. Ques. Please clarify if CIFOR only works in Asia? How does CIFOR plan to interact with private forestry companies? B. Dvorack.

Ans. CIFORs mandate is global. CIFOR has much to gain (especially funding wise) through collaboration with private companies for specific projects.

3. Ques. What is the status of CIFOR discussions of forest product research other than wood e.g. fruit, nut, medicines. J. Brewbaker.

Ans. Minor role now.

IBPGR AND DOCUMENTATION OF GENETIC RESOURCES IN RELATION TO MULTIPURPOSE TREE GERMPLASM

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Introduction

The need for accurate and timely information on plant genetic resources is well understood and the documentation of genetic resources for many collections of agricultural species has increased dramatically in the last few years. Burley and Carlowitz (1984) provided a reference to 14 existing databases relevant to multipurpose trees (MPT). This number has probably grown to some degree since that time. This is evident from the publication of the "Multipurpose tree and shrub seed directory" (1986), the "Multipurpose trees and shrubs -sources of seeds and inoculants" (1991), through the descriptions of various tree seed bank databases that included MPT species given in the "Report of the IBPGR forest genetic resources workshop" (1991), and the FAO "Forest Genetic Resources Information Number 18" (1990). The International Council for Research in Agroforestry (ICRAF) provided a very comprehensive discussion paper on the establishment of a MPT germplasm resources centre (GRC). It was interesting to note from this document (page 4), that of the 10 aims and functions of the MPT-GRC given, 2-7 and 10 require a documentation component. The purpose of this talk is to provide an overall idea of what responsibilities may exist in the area of MPT germplasm documentation and information management for ICRAF and to present guidelines for information management in a germplasm resources centre (GRC) based on an extrapolation of the International Board for Plant Genetic Resources (IBPGR) work with agricultural species. In addition, a brief overview will be given of:

- The similarities of the data and information needs for agricultural and MPT species;
- IBPGR's role as a primary focal point for plant genetic resources information and documentation;
- and ICRAF and its intended role with the GRC and genetic resources documentation needs and responsibilities.

Genetic resources information for agricultural species

Since its inception, IBPGR has given strong support to the adequate management of plant genetic resources information. This includes not only germplasm sample-specific data, but also data of relevance to genetic resources work on a global scale. Included in the latter are:

- Summary data on the institutes and collections that maintain and/or use genetic resources in each country;
- Documentation Methodology and Application Specialist Documentation, Information and Training Group
- All data relating to IBPGR-sponsored collecting missions;
- A genetic resources profile for each country with a genetic resources programme;
- and current information on all people that have been trained by IBPGR.

However, the most important types of information for the running of a germplasm collection are sample-specific. Although the descriptors for plant morphology are specific to a particular crop, many descriptors in the categories set out below have wide applicability. These data are needed for an adequate understanding of how, where and for what purpose the germplasm sample can be maintained and used. IBPGR has developed descriptors lists for many crops in consultation with the relevant international specialists. Most descriptor lists include the following categories of data:

A. Passport

Passport descriptors include those that are used for accession identification and all data recorded by the germplasm collectors. These include provenance and detailed collection site characteristics.

B. Characterization

These descriptors describe characters that are highly heritable, can be easily seen by the naked eye and are equally expressed in all environments. Documentation of these characters is generally the responsibility of germplasm collection curators.

C. Preliminary evaluation

These traits may not be equally expressed in all environments, may be more difficult to score than characterization descriptors, but have been determined to have been important to score for collection management and use by a consensus of users of the particular crop. Even though environmentally influenced, non-replicated trial data are generally used for genetic resources collections.

D. Further evaluation

These traits are also generally not equally expressed in all environments and usually require replicated trials (possibly over years and locations) for an adequate understanding of the genetic attributes of the accession. The scoring of these descriptors is generally not the responsibility of the curator, but rather breeders and other users of the germplasm.

E. Management

These descriptors include those needed for the short and long-term management of germplasm maintained as seed (in a cold storage room), *in vitro* material or field collections. Included are descriptors necessary for the multiplication and regeneration of germplasm samples.

Due to its recently expanded involvement in the documentation of certain woody species, IBPGR has begun to see an increase and in some cases a reclassification in the types of data that need to be maintained by certain genetic resources collections. This has been especially true with IBPGR's interaction with coconut genetic resources. It was determined at a recent meeting on coconut genetic resources data (19-22 May, Montpellier, France) that the types of descriptors required for adequate management, use and exchange of genetic resources do not always fit into the definitions given above. This included moving some of the descriptors that have normally been considered as evaluation to characterization because of the usefulness of these traits to the selection and description of coconut germplasm.

Genetic resources information for MPT and forestry germplasm

Biological differences between MPT and forest tree germplasm and crop plants will affect the types and extent of information needed for the documentation of their genetic resources. Many tree species:

(i) have a long juvenile period which increases the amount of time needed for regeneration or multiplication (if it is possible) and the time needed for breeding for adaptability for environmental conditions different from those under which they were originally found;

(ii) Have recalcitrant seeds that preclude long term storage and *ex situ* conservation in seed banks;

(iii) Differ in their reproductive biology and breeding system;

(iv) Germplasm can or will be used without further improvement. This is in contrast to many agricultural species that are relatively rapidly improved. Also, in contrast to agricultural crops, there are usually a large number of potentially useful species that may have application for planting in one or more environments, for use by one or more systems, and/or for several purposes.

Specific documentation needs for MPTs will depend on how it is planned to conserve and utilize their germplasm. These needs are broadly similar to agricultural species and may include: identification of the species to test; determination of the appropriate methods of exploration and evaluation; and how and where to locate suitable sources of germplasm when the appropriate species and population are known (Burley and Carlowitz 1984).

The types of information that are relevant for the conservation and use of MPT have also been described by Burley and Carlowitz (1984) and include:

(i) observed or measured data collected during the exploration phase;

(ii) anecdotal information on the uses and characters of trees in the natural range and as exotics;

(iii) measured data on sites and trees in evaluation trials (including passport information);

(iv) information on activities of donors of germplasm, recipients and research agencies.

The extent of information needed, the specific descriptors and the importance of certain of these data may be quite different when agricultural species and MPT species are compared. In general, the extent of information on the accession's provenance, specifically the climatic and soil conditions, can be used for selection of germplasm, establishment in another location, regeneration and multiplication. For species that have extremely long juvenile periods, those for which the seed is not easily obtained and for forest species, the provenance and locality data may indicate the area of the *in situ* stand where the germplasm is found. The use of this germplasm is based on the details of the site compared with those of the site in which the germplasm is thought to be beneficial. In many cases, MPT and forest tree germplasm is not improved to any great extent before it utilized. Also, the data that is collected on the collection site, characteristics of the trees and what they are used for may be all that is known for a number of years about the germplasm sample and is used for the selection of the germplasm for use in other areas.

IBPGR and genetic resources information

IBPGR has a major role in the documentation of agricultural species genetic resources at the global level. It is reasonable to assume, that since ICRAF is now within the CGIAR and will probably act as a "first point of contact for enquiries on MPT germplasm", then some of these roles will be similar. This will, however, depend on the extent to which IBPGR and CIFOR will be involved with MPT and forest genetic resources documentation work. A brief discussion on IBPGR's role may provide a basis for planning for ICRAF.

IBPGR has been dedicated to the management of genetic resources information since its inception. It is a focal point for agricultural species genetic resources data and information on a global level. Activities have included support to national programmes for the development of documentation aspects of their genetic resources programmes, development and dissemination of standards for data collection and exchange (including crop descriptor lists, hardware and software procurement and guidelines on information exchange), compilation and dissemination of data relevant to the global genetic resources community (directories, etc.) and documentation training.

Since the development and implementation of the crop network concept, the documentation programme has provided direction for the documentation activities within these networks. These include: the establishment and compilation of central crop databases, exchange of information among the network participants, development and dissemination of specific descriptors lists for crop characterization, assistance in the exchange of data within the network, and support for the development of specific software for use at collections for data management and exchange. In addition, the documentation programme has also provided data management, computer, and other documentation-related support to it's research staff. Computer operation and planning for the Institute are also the responsibility of the documentation programme.

Joint documentation activities between the commodity related IARCs and IBPGR have spanned across many different areas. IBPGR and the IARCs have published and will continue to publish descriptor lists for the many crops held by these Centres. Currently descriptors for *Sorghum*, pearl millet, groundnut, chickpea, *Capsicum*, pigeonpea are in preparation with the appropriate IARCs. Descriptor lists for sweet potato and maize have been published jointly with CIP and CIMMYT, respectively. Support for the compilation of central crop databases and software development at CIMMYT and INIBAP was provided in the context of crop networks for maize and *Musa*.

ICRAF as a commodity centre

The establishment of a genetic resources programme for MPT species at ICRAF, will considerably broaden the responsibilities and duties of the Centre as a whole. This will increase the amount of information required by the Centre both for its own activities and to service other genetic resources programmes in the region.

Information systems for accession-specific genetic resources data and seed distribution are in wide use. Various additional descriptors should be developed based on other collection's experiences and using descriptors that have proven useful for MPT species. It is recommended that from the outset, ICRAF maintain the following types of data on each accession:

Passport. The descriptors describe characters that are used to identify individual accessions, selected on the basis of experiences of establishing other collections, original collection data, and what is known about the maintenance and use of the germplasm.

Characterization and preliminary evaluation. The descriptors in this category will have to be developed for many of the MPT species of interest to ICRAF.

Development, publication and distribution of such descriptor lists is a potential area of collaboration between ICRAF and IBPGR.

Evaluation. For a breeding programme, it is necessary to maintain this type of information. The GRC should be able to maintain this type of data when provided by users of ICRAF-supplied germplasm.

Management. The number of descriptors that are needed in this category will depend on the manner in which the germplasm is maintained (seed, field genebank, *in vitro*, etc.), the regeneration and multiplication difficulties that are expected and those that are unknown due to an inadequate knowledge of the species. It is possible that quite a large number of descriptors will be needed.

Distribution. For many MPT species the descriptors needed in this category are already known (FAO 1990). Because the GRC will provide this service soon after its establishment, it is necessary to determine the descriptors that are needed as soon as possible.

In anticipation of acting as a primary point of contact and providing an expanded information service to its clients and collaborators, the ICRAF GRC should also either have access to or maintain data related to the following areas:

Germplasm **collecting missions.** Summary information on the collecting missions that are sponsored by relevant MPT programmes throughout the world.

Details of MPT collections. These include summary information on the details of known MPT germplasm collections. The descriptors that are important include: the institute's name and address, the type of maintenance for the material, genus and species names, the type of collection (base, active), duplication status of the material, the availability of the material, number of accessions and basic geographical distribution data.

IBPGR maintains similar information and using the names of MPT species given by Burley and Carlowitz (1984) and MacDicken and Mehl (1990), IBPGR now has 2,211 species records from 251 different institutions that maintain MPT germplasm. These records represent 792 different species and 102,276 accessions. There may be accessions represented more than once in this total.

Details on institutes involved with MPT germplasm. These might include the structure of the programmes, contacts for information, their involvement with MPT germplasm activities, and past, present and future research activities.

Information management

Software

To manage even some of the data elements suggested above, it is advisable that a database management system be selected with long-term expectations in mind. The capabilities of the selected software should include the ability to construct a truly relational model to minimize duplication of data and speed performance (Oracle, Paradox). In addition, file import and export capabilities should allow for the easy reading and writing of data in a range of formats to facilitate exchange between ICRAF and its collaborators. It should not be difficult to develop applications for use with the DBMS and to provide a flexible design for user interfaces. There should be a single copy of the database to check all changes entered into it.

The actual design of software will need to be based on a clear formulation of the objectives of the GRC, and should allow for expansion and change. As the GRC develops, it will be necessary to modify the information system, both for accession-specific and other types of information. The user interface should be logically and simply designed and the system should be thoroughly documented when completed. All prospective users of the system in the GRC should be trained in its use.

To facilitate the data flow from germplasm collecting missions, a specific piece of software should be developed for collectors. This software should provide a data entry form and data verification routines to minimize errors. Germplasm collectors should be trained to enter their data into this system.

Hardware

The selected hardware for the GRC will depend on the organization of the computer functions at ICRAF. However, it may be desirable for the GRC to acquire personal computers with large hard disks (greater than 300 Mb) and 80386 microprocessors (as a minimum configuration). If possible, these PCs should be able to communicate with each other either through a local area network (LAN) or less sophisticated communication protocol. A LAN would ease the amount of disk space that is needed on the individual PCs and enable the use of a shared database. Printers can be used to print out bar codes. Bar code readers for sample identification are recommended for implementation at an early stage.

Personnel

It is important for ICRAF to have a capable manager for its genetic resources documentation. This person should be able to work effectively with breeders as well as understand genetic resources and information management. The analysis of the problem of system design should be determined by this individual, the head of the GRC and others. At the outset, 1-2 computer programmers will be needed to effectively design and implement the system. Two to three full-time people will be required for data entry.

Conclusions

The importance of effective data management needs to be recognized, especially for organizations that are in the process of establishing a new unit or branch. ICRAF needs to develop an information way of thinking for its GRC. This will need to be backed up through the dedication of resources such as personnel and funding. ICRAF should also utilize existing information about the operations of other MPT collections, learning from the mistakes and building on the strong points of these units.

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Discussion

1. Ques. Does IBPGR deal with models to predict species distribution and growth? T. Vercoe.

Ans. IBPGR is involved with some models, particularly in conjunction with GIS systems, but only in the early stages of development.

TREE IMPROVEMENT PROGRAMME OF THE MULTIPURPOSE TREE SPECIES RESEARCH NETWORK

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Introduction

The 8th World Forestry Congress in Jakarta in 1978 stressed the need to augment forest resources with multipurpose tree species (MPTS) to provide continuing supplies of tree products for household use and income in rural areas. Active participation by rural folk in tree growing was the focus of new strategy.

Following the 1978 Congress and an FAO paper on Forestry Research Needs in Developing Countries (FAO 1980), the International Union of Forestry Research Organizations (IUFRO) Congress in Japan adopted a resolution to review and promote forestry research activities in developing countries. As a result, IUFRO organized a regional workshop on increasing productivity of Multipurpose Tree Species (MPTS) in Kandy, Sri Lanka in 1984. Priority species were selected and research activities were identified (Shea and Carlson 1984).

As a result of that meeting, the Forestry/Fuelwood Research and Development (F/Fred) Project was established. F/FRED was funded by the United States Agency for International Development (USAID) and administered under a cooperative agreement by Winrock International. This project has been instrumental in setting up the MPTS Research Network in Asia (MacDicken *et ah* 1990).

The MPTs Research Network

The 10-year F/FRED project began 1985. It was designed to help scientists cooperatively address the needs of small farmers for fuelwood and other tree products. The MPTs Research Network was established as part of this project, which also funds part of ICRAF's East African AFRENA program. Presently, the MPTs Network has over 20 participating institutions in 11 countries in the Pacific and South and Southeast Asia. Mechanisms for network development include scientific and organizational meetings, cooperative research projects, long and short-term training, travel grants, publications and small research grants. A number of other donor organizations have collaborated in supporting network activities.

The MPTs Research Network is built upon national-level networks formalised by MPTs research meetings held annually by participating countries. These meetings provide opportunities for discussion of MPTs research issues; provide national level links to the regional research network; monitor and evaluate on-going F/FRED-funded research projects; develop a prioritized list of MPTs-related research topics; and select representatives (a social scientist and a biological scientist) to serve on the MPTs Research Network Research Committee.

A number of countries have initiated national level research programs on MPTs. Indonesia, Malaysia, Philippines, Sri Lanka and Thailand have established formal National MPTs Research Committees.

The MPTs Research Network is guided by a Research Committee and a Steering Committee. The Research Committee consists of two representatives from each participating country who are selected at the national MPTs research meeting. The committee recommends network research direction, priorities, and standard methodologies. The Steering Committee advises on policies and strategies, promotes programs and activities, and reviews Research Committee recommendations. The Steering Committee is made up of three members elected by the Research Committee and four permanent positions. The permanent positions include the Chair of the Research Committee, the ranking Asian member of IUFRO, the FAO Regional Forestry Officer for Asia and the Pacific, and the Dean of the Faculty of Forestry at Kasetsart University, the institution that hosts the Network Secretariat.

Network germplasm evaluation and improvement activities

Management *x* species *x* genotype trials

F/FRED has supported a series of multilocation network trials in the humid/sub-humid and arid/semi-arid zones of South and Southeast Asia. The trials have not only provided a focus for network development but have also helped improve and standardise methods used in MPTs research. The trials incorporate the following features:

- Common design and standard methodology,
- Common minimum data set,
- Common germplasm,
- Thoroughly described soils and climate at each site,
- Data exchange and professional interaction among participants,
- Intersite combined analysis of data.

The first set of trials, in the humid and subhumid zones was established in 1987 at sites in Indonesia, Malaysia, Philippines, Republic of China (Taiwan) and Thailand. The trial design, developed by the collaborating scientist, compared two genotypes each of three species *(Acacia auriculiformis, A. mangium* and *Leucaena diversifolia)* under three management practices.

In the arid and semi-arid zones, trials were established at 10 sites in India, Nepal, Pakistan, and Sri Lanka with *Dalbergia sisso* and *Eucalyptus camaduknsis* in the semi-arid zone and *Prosopis pallida* and *P. cineraria* were in the arid zone trials. *Acacia nilotica* was included in both trials and each cooperator was asked to select an additional species.

Germplasm collection and improvement

- *Acacia spp.* In collaboration with the Division of Forestry and Forest Products, Commonwealth Scientific and Industrial Research Organization (CSIRO), the F/FRED Project has partially supported seed collection expeditions for *A. auriculiformis* and *A. mangium.* These collections provided the first range-wide provenance collection of A. *auriculiformis* for use in tree improvement programs.

One of these was a series of international provenance trials for *A. auriculiformis* which the F/FRED Project co-sponsored with the Australian Centre for International Agricultural Research (ACIAR), the German Agency for Technical Cooperation (GTZ) and the Finnish International Development Agency (FINNIDA). A total of ten cooperators from China, Indonesia, Malaysia, Sri Lanka, Taiwan, Thailand and Zimbabwe participated, with 25 provenances being evaluated. The trials are now about 2.5 years old and the data are being compiled for combined analysis, which is being undertaken jointly by F/FRED and CSIRO. An annotated bibliography on *A. auriculiformis* has been published.

A lot of past and ongoing work on the acacias is funded by national and donor institutions other than F/FRED. We have convened a Consultative Group on Research and Development of Acacias (COGREDA) to inventory these activities and their outputs. At annual meetings, COGREDA reviews existing research, defines future priority areas, and formulates strategies for their promotion. About 20 scientists working on various aspects of acacias from the Southeast Asia region participate.

A. mangium is one of the most widely planted and researched tropical acacias, especially in the humid/subhumid regions of Asia. Research conducted on this species has generated a considerable amount of information in proceedings, research reports and journals, and in the grey literature. In collaboration with COGREDA scientists, F/FRED will synthesize this information in a state-of-the-art book on the species.

- *Casuarina equisetifolia.* In 1990-91, the CSIRO Division of Forestry Research supported range-wide collections of about 50 geographic and land races of *Casuarina equisetifolia* from 13 different countries. The F/FRED Project has supported the establishment and management of provenance trials of these accessions in 5 countries within its MPTs Research Network. The trials will evaluate 25 of the seedlots using a standardized randomised complete block design with 4 replicates. Data will be exchanged through the MPTSys, the F/FRED micro-computer information and decision support system.

- *Dalbergia sissoo.* Thirteen bulked provenances of Dalbergia sissoo were collected by the Pakistan Forest Institute (Pakistan) and the Forest Research Division (Nepal) as part of a regional research plan developed by the MPTs Network in 1989. Five provenance trials (randomized complete block, 4 replications) were planted in 1990-1991 in India, Pakistan, and Nepal. Transport and handling of the seed was a major constraint, and as a result, several provenances failed to germinate at some of the sites. In all, 8 provenances were established at the Nepal trials, and 13 were established at the Pakistan and India trials. An annotated bibliography of the species was also published.

- *Azadirachta indica.* Neem *(Azadirachta indica)* was identified as a priority species by the MPTs Research Committee during the 1991 meeting. Work has begun this year with limited provenance collections in Thailand and India. Several research projects in these two countries on ontogeny, phenology, and seed handling are underway. Material collected in Thailand will be outplanted this year in progeny trials in two locations. Collaborative linkages have been made with the Centre Technique Forestier Tropical (CTFT, France) to handle germplasm exchange with Africa and to perform isozymatic studies of population genetics. A consultancy on neem improvement is planned in Bangkok for late 1992, and major germplasm collection efforts will begin in 1993.
- *Artocarpus heterophyllus.* Jackfruit *(Artocarpus heterophyllus)* is a quintessential multipurpose tree. Work began in 1991 on the identification of major uses and tree breeding objectives. Presently, work on propagation and clonal techniques is underway. A consultancy will be convened in early 1993 to discuss germplasm exchange, a process that is severely constrained by the recalcitrant nature of the seed and the difficulty in transporting vegetative clones.

Constraints to network affectivity in tree improvement work

Sustainability

All networks in Asia are externally funded on soft money. Inevitably, the question of network sustainability arises. Phase II of F-FRED is scheduled to end in April, 1995, and it is not clear at this time exactly what the mandate of a Phase III will emphasize. It is important to begin dialogue with third parties that can sustain and coordinate field trials still under way in 1995 in the event F/FRED's successor takes on other mandates.

Conflicts with National Priorities and Donor Policies

Several countries in the network have not been effective network participants because of lack of interest by key Ministries not necessarily linked to forestry research. Also, several countries have unique social and environmental conditions that make it more desirable to establish networks within the country than establish external linkages.

Because F/FRED is USAID-funded, we do not operate in Indonesia, Burma, and China. Although we expect authorization for China and Indochina in the near future, this restriction has limited our overall effectivity.

Seed Transfer and Storage

The ASEAN/Canada Tree Seed Centre in Muak Lek, Thailand, has assisted F/FRED considerably by handling short-term storage. However, there is crucial need to strengthen and formalize linkages between quarantine facilities in the countries where we work. It would be simpler to have network participants exchange seed directly as part of network tree improvement activities.

Because many MPTs have short-lived orthodox and recalcitrant seeds, there is a need to study how best to handle and transport such germplasm. This need exceeds the financial capabilities of F/FRED at present.

Linkages with ICRAFs MPT-GRC

F/FRED welcomes the establishment of ICRAF's MPT-GRC. The establishment of this facility is long overdue. The following are possible areas of collaboration:

- Sustainability. F/FRED and MPT-GRC should co-design mutually advantageous programs so that sustainability is ensured in the event of a different F/FRED Phase III mandate.
- Outreach. MPT-GRC and F/FRED can work together to deliver network trials in countries where F/FRED does not operate.
- Seed exchange. MPT-GRC should strive to improve linkages between quarantine facilities and researchers in Asia, in the same manner and spirit as agriculturally-oriented CGIAR institutes.
- Research. MPT-GRC should conduct and/or sponsor research on handling, transport and storage of important short-lived MPTs seed. F/FRED can assist in the identification of priority species.

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Discussion

1. Ques. Your F/FRED networks appear to have good links with forestry type organizations in Asia. Do you have similar good links with agricultural organizations in Asia given that we are dealing with trees on farms? D. Boland

Yes we do. This has been fostered through the small grants programme where we can target agriculturalists.

To what extent does F/FRED support the network trials financially? R. Schultze-Kraft.

Initially 100%. Meanwhile cost-sharing by participating institutions is increasing.

Would you care to comment on the sustainability of your forest researchers with whom your network operates? J. Brewbaker.

Basically two problems. The first is mobility of scientists and hence we lose them from the network. The second is the concern of junior scientists to have less voice *vis* a *vis* older scientists more closely involved in the organisation of network collaboration.

SADCC TREE SEED CENTRE NETWORK PROJECT

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Summary

The SADCC Tree Seed Centre Network (TSCN) Project is a regional institutional strengthening project in Southern Africa funded by the Canadian International Development Agency (CIDA). The project includes all ten SADCC countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe.

The goal is to achieve a sufficient supply of high quality tree seeds of a diversity of species. The project aims to achieve this goal through the strengthening of national tree seed centres.

Forestry Canada has been contracted as executing agency to implement this project. It will place a number of staff in the field. A field project manager and training coordinator have been hired in Canada. They will be joined by a locally hired administrative assistant, to constitute a project secretariat to be based in Harare, Zimbabwe.

Four technical specialists (specialists in tree seed technology or related fields) will be contracted to assist a sub-group of two or three countries each in the implementation of the project. These will be decentralized and based in: Maseru, Lesotho; Maputo, Mozambique; Windhoek, Namibia; and Kitwe, Zambia. In the interests of sustainability, as much of the long-term education and short-term training will be carried out in the region, specific sub-projects will be contracted out to local NGOs, universities, national tree seed centres or the private sector, and three of the technical specialists will be hired in the region.

The proposed MPT-GRC could collaborate with the SADCC-TSCN project through joint seed collection exercises and training workshops, and conservation, testing and multiplication of Southern African MPT germplasm.

SADCC Tree Seed Centre Network Project

Goal and purpose

The project goal is to provide a sufficient supply of tree seed of appropriate quality and species to the SADCC region.

The project purpose is to improve existing national capacity in tree seed production to the SADCC region.

General description

The Canadian contribution to the project will be two-facetted: to provide support to the network of the Tree Seed Centres in the region, and to assist in strengthening them. The role of the Canadian Executing Agency (CEA) is to coordinate the project inputs, including training, technical assistance, facilities and equipment, and to provide advice.

Countries are responsible for running their own centres. The CEA will provide a Field Project Manager (FPM), four Technical Specialists (TSs - tree seed specialists) and a Training Coordinator (TC) to the region to carry out these tasks. They will work closely with the National Tree Seed Centres (NTSCs). The technical specialists will have complementary specialities, and each will be primarily responsible for a sub-group of countries. Specialists from Canada and the region will be contracted to assist in implementation of the project, as required and approved by the Project Board.

It is the intent of the project to deliver some intangible (skills upgrading and better established SADCC networking) and tangible (equipment and buildings) items. The inputs will be provided in stages over a period of six years, with training, including language training and WID training, provided as a first step (after a training needs survey), as well as support to the network through meetings and the provision of communications facilities. The upgrading of skills involves two distinct thrusts: offering a number of university graduate and undergraduate courses identified on request, and based on needs; and improving skills through short-term courses, workshops and practical attachments.

Another part of the project will be to train NTSC managers to continuously assess and respond to the needs of tree seed consumers through the analysis of user surveys and other socio-economic studies. The results of these surveys will guide seed collection activities. Training will be provided in the use of standard computer equipment and software packages to assist in a common data management system.

The first six years will serve to lay the groundwork for development of the NTSCs by ascertaining needs, providing trained personnel and setting up a network throughout the region. The experience of the first phase will determine SADCC and CIDA involvement in subsequent phases up to a maximum of fifteen years.

Implementation strategy

The basic philosophy guiding this project is that:

a) technologies introduced must be locally adaptable and acceptable;

b) the current strengths of those individual SADCC States NTSCs that are more advanced should be used to assist less well developed NTSCs;

c) those SADCC States which wish to participate must demonstrate a willingness to provide local inputs and qualified human resources to the extent possible, show consideration of the required upstream and downstream interventions, and provide a budget for operation and maintenance of NTSCs;

d) the project must have an economic and environmental focus, with particular consideration being given to the needs of the community;

e) upstream linkages (to research) and downstream linkages (to extension) must be fostered. Linkages should also be made with other projects and agencies, particularly in relation to those affecting tree seed use;

f) the project should result in long-term and sustainable economic and social development of participating countries forestry sectors. In order to achieve this, the project will hire staff from the region, use regional educational, non-governmental, and consulting agencies where feasible, and will encourage NTSCs to operate as profit centres.

While Forestry Canada has been selected as CEA to manage day to day operations of the project, the Project Board will be responsible for approving their Inception Report, Training Plan, Work Plan and subsequent annual work plans, and for ensuring that the plans are carried out. All SADCC countries shall participate directly in the Project Board and the Project Technical Committee. Although the project funding and the assignment of specialists to particular countries will vary according to need and the priority setting for activities within the SADCC states, each country representative is entitled to an equal voice.

It is not practical to provide management, technical assistance and physical installations to all ten countries at once. Therefore, while all countries will participate in regional networking activities as from the first quarter, the four technical specialists (TSs) will be engaged and deployed in a phased manner.

- It is expected that the first technical specialist (TS1) will begin work in Quarter 3 (Q 3: April-June 1993), the second (TS2) in Q 4, TS3 in Q 5, and TS4 in Q 6.

The NEWS sub-grouping has been adopted to facilitate project delivery. The SADCC region is divided in North, East, West and South sub-groups on the basis of physical proximity, ease of transport and communications, and ecological similarity. The NEWS sub-groupings are:

North: Tanzania, Zambia, Malawi - TS1 Kitwe, Zambia;
East: Zimbabwe, Mozambique, Swaziland - TS2 Maputo, Mozambique;
West: Angola, Namibia - TS3 Windhoek, Namibia;
South: Botswana and Lesotho - TS4 Maseru, Lesotho.

The project will have a small centrally-placed secretariat consisting of the Field Project Manager (FPM), the Training Coordinator (TC), and an Administrative Assistant (AA). The secretariat will be based in Harare, Zimbabwe.

In order to permit the exchange of seeds for experimental and trade purposes, the SADCC countries should begin discussions on the lowering of internal trade barriers. This could occur through the leadership of the SADCC Regional Gene Bank (SRGB) in Lusaka, Zambia. Such harmonization of phytosanitary regulations would facilitate seed exchanges and the development of sub-regional specialization.

Host governments must provide sufficient and capable personnel to the NTSCs, and when there is a shortfall in staffing, should permit the introduction of short term expatriate personnel. Some allowance must be made for attrition in identifying staff for training. Governments need to provide basic infrastructure to the project, and should fulfill their contractual obligations in terms of timely inputs. This project is meant to aid the integration process of these SADCC countries and not to become a drain on very limited skilled personnel, infrastructure and funds. Therefore it is of the utmost importance to forge linkages with other projects that have an influence on seed demand or availability.

In order to develop a functioning network, it is of prime importance that the communication process be clearly identified, supported and enhanced as necessary. A long-term model for networking will be developed that should prove beneficial to participating states.

Beneficiaries

The direct beneficiaries of this project will be the existing or proposed national tree seed centres. Other agencies involved in tree seed activities, and local or regional NGOs and educational institutions will also be given the opportunity to participate in the project through participation in training and networking, or through contracted sub-projects.

The indirect beneficiaries will be the diversity of tree seed consumers. These will benefit through an improved supply of better quality seed of a wide variety of tree species. Ultimately, it is expected that multiplier effects will be felt nationally and regionally through the improved supply of tree or forest products from private industries, government forest departments, small and large land holders and agriculturists, and both rural and urban populations.

Special considerations in the formulation of the SADCC Project

Development philosophy

The project aims to assist in the sustainable development of forestry in the region. In order to do this, as much of the managerial component will be delegated to forestry professionals from the region. Thus, three of the technical specialists will be hired from the region, and they will have the opportunity to broaden their managerial and technical skills in tree seed technology, procurement and marketing. In order to make this opportunity more broadly available, these technical specialists will only be hired on two-year contracts. A different set of individuals will be contracted for the second two-year period, and so on. This should ensure that the benefits of secondment to the project are spread more equitably among countries among the region.

In the same vein, local educational institutions will be favoured for long term training (Diploma, BSc and MSc training).

It is believed that regional networking will only continue after external project funding ceases if it is in the mutual interest of the cooperating partners. Hence, the project will encourage specialization, and intra-regional trade in tree seeds.

A fully stocked national tree seed centre is not a good measure of success of this project. Tree seeds have to be used. It is the aim of this project to instil a good sense of the upstream linkages to research (seed of which tree species to collect, tree improvement, cost and market studies) and downstream linkages to extension. It is also imperative that tree seed centre managers collect seed of those species that will actually be in demand from consumers. This then requires that TSC managers be broad-minded in their outlook, and that they develop skills beyond seed research or seed technology to encompass marketing, basic tree improvement, fruit tree technology and project management.

In order to empower local organizations and to broaden their skills and outlook, this project will aim to sub-contract and devolve responsibility as much as possible to local NGOs, universities and colleges, consulting firms and individuals, and to the staff of existing tree seed centres. This does not mean that the management team abdicates its responsibility for the implementation of this project, but rather that it will assist the regional agents in the successful execution of specific tasks and sub-projects.

Pressures on forestry

There are three sources of pressure on forestry which require special consideration:

a) Fuelwood crisis

The demand for fuelwood around urban areas is quite high locally, and this has resulted in serious deforestation problems around densely populated areas.

b) Declining soil fertility and environmental degradation

There is a growing awareness of the importance of declining soil fertility, shortage of browse and fodder, and disturbance of water catchment and other protection forests. This is stimulating an increased interest in agroforestry systems as potential sustainable methods of land management. The availability of seeds of indigenous and exotic multi-purpose trees is a constraint to widespread adoption of agroforestry systems.

c) Strong interest in indigenous species

A strong interest in indigenous trees has developed over the past decade. This is in response to a greater appreciation of the value of non-timber forest products e.g. food, medicines, cordage, fencing and so on. This interest is developing at the same time as the general public becomes aware of the rapid erosion of the natural forest resource through conversion of woodlands to agriculture, industrial forest land, urbanisation, overgrazing and excessive fuelwood gathering. In the SADCC region which counts several thousand tree species, very few species have been studied to any great extent, and fewer still are actually planted. There is a strong case to be made for the exploration of indigenous genetic resources. The study, collection and distribution of seeds of indigenous species can be profitably conducted by many institutions in concert.

Involvement of women

Women are the targeted beneficiaries of many forestry development projects, since it is they who are traditionally responsible for fuelwood gathering and collection of other minor forest produce. Women are also the principal agricultural labourers, food providers and care givers in rural family structures in the region. Yet, women are not strongly represented in traditional male-dominated forestry circles in the region. Thus they have often been identified by men as the ultimate beneficiaries of forestry development projects, while not having been consulted, or not having been given the opportunity to participate in project planning, management and implementation supposedly designed for their benefit.

Project staff will be given extensive gender sensitivity training. A target of 50% women's participation has been set for all training and management positions in this project.

Cost recovery

In the interests of sustainability of NTSC operations, the project will encourage, wherever possible, the adoption of a cost-recovery or profit basis. This does not mean that Governments should not subsidize tree seed sales, but that this should be done in the full knowledge of the true costs. If NTSCs are required to subsidize seed sales, then Governments should be asked to pay for the cost of the subsidy. NTSCs cannot sustain their activities without some form of cost recovery.

Research

This project has taken a practical seed supply approach. Supportive research will be conducted when it better enables the realization of this seed supply objective, or when it can lead to the more effective use of tree seed. The project will maintain close links to national and regional research organizations and projects.

Discussion

1. Ques. Two questions, Firstly your network; has it developed shared responsibilities with the SADCC-RGB.? Secondly are you trying to ease seed distribution and avoid problems like over and under collection as you mentioned in your presentation?. F. Kwesiga.

Ans. We believe that the SADCC-RGB could help us with issues such as policy, plant health and archiving. Costs of collection of expensive high quality seed could perhaps be shared by the network centres.

2. Comment I foresee potential for good co-operation with CILSS / SADCC since there are a lot of similarities between the networks e.g. requirements, species, strategies to adopt etc. However I would like to point out that networking still needs to be developed in the IGADD countries (eastern subsaharan countries). A. Ouedraogo.

3. **Comment** Sustainability and conflict with national policies call for consultation with national centres and national programmes. All concerns must be addressed if we are to facilitate good relations at a later date. A. F. Attere.

POTENTIAL FOR COLLABORATION BETWEEN THE SADCC REGIONAL GENE BANK AND THE ICRAF MPT-GRC

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Introduction

The Southern African Development Coordination Conference (SADCC) region is a grouping of eight countries which lie between 1° and 31°S *viz.* Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe. The region has six distinct agroecological zones. This reinforces the case for regional cooperation in agricultural and related research activities.

The SADCC region is rich in indigenous wild and domestic plants which are utilized for food, fodder, medicine, timber and fuelwood. It is a reservoir of wild crop relatives (Rhoades, 1991) and parts of it are global centres of plant diversity (IUCN, 1990). Some of these natural resources are threatened by genetic erosion due to the introduction of high yielding uniform varieties, over-exploitation of forests, other development programmes and poor environmental management.

In 1986, the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR) and the International Board for Plant Genetic Resources (IBPGR) held a consultation in Lusaka, Zambia on Plant Genetic Resources in SADCC countries. In response to the recommendations of the consultation (IBPGR, 1986), the SADCC member states launched a long term programme, the SADCC Regional Gene Bank for Plant Genetic Resources (SRGB), to coordinate all activities in plant genetic resources in the SADCC region. The Scandinavian countries jointly committed themselves to initially support the programme financially for 20 years. The SACCAR was appointed Implementing Agency and the Nordic Gene Bank (NGB) Executing Agency. Technical assistance is provided by the IPGRI and other IARCS.

Germplasm exploration has been carried out in the SADCC countries since the late 1970's. Even so, there are wide differences in the level of activities, resources and personnel between the countries and wide gaps exist in the collections especially in wild species including multipurpose trees (MPTs). The SRGB programme welcomes collaboration between the ICRAF-Genetic Resources Centre (ICRAF-GRC) and its Crop Working Groups (CWGs) such as; agroforestry, forest trees, fodder and forage, under utilized plants, medicinal plants.

The SADCC Regional Genebank (SRGB) Programme

The SRGB is a regional network based on National Plant Genetic Resources Centres (NPGRCs). Each SADCC member State has a National Plant Genetic Resources Committee (NPGRCom.) which coordinates plant genetic resources (PGR) activities at the national level through the establishment of National Plant Genetic Resources Centre (NPGRC) and a National Crop Working Groups (NCWGs) to focus on specific species or groups of species.

Some of the members of the NCWGs will form Regional Crop Working Groups (RCWGs) which will play the same role as NCWGs at the Regional level. The NPGRComs are also responsible for the development of National Plant Genetic Resources Plans of Action (NPGRPA). The Chairmen of the NPGRComs are members of the SRGB Board, of which the Director of SACCAR is the Chairman. The NPGRCs are national counterparts to SRGB.

SRGB objectives

The objectives of the SRGB are to:

- "Establish over a 20-year period a SADCC Regional Gene Bank and network of local germplasm programmes to support plant research in the region;
- Conserve indigenous plant genetic resources and crop genetic resources; and
- Train plant genetic resources personnel for the region" (SIDA, 1989).

The SRGB contributes to the region by training specialists in plant genetic resources, developing national plant genetic resources programmes, and preventing erosion and loss of plant genetic resources through exploration, collection, preservation and management. The SRGB ensures the documentation and compilation of catalogues of the region's plant genetic resources and promotes utilization of plant germplasm through workshops, seminars and publications. SRGB also facilitates the availability of exotic plant germplasm for breeding and crop improvement research through exchange with other genebanks and other sources. The regional genebank ensures that international scientific standards are maintained in the genetic resources activities of the region through training, workshops, dissemination of information to NPGRCs and regional scientists and through collaboration with IARCs and other centres of excellence. The SRGB network provides a forum for exchange of scientific as well as cultural experience.

Major functions of National Plant Genetic Resources Centres (NPGRCs)

The SRGB programme recognizes the comparative advantage of the NPGRCs for organizing exploration and collecting expeditions and for characterizing, evaluating, rejuvenating and multiplying germplasm in environments which are similar to or near the original collection sites. Short or medium term collections will be kept by the NPGRCs to ensure utilization at the national level by plant breeders and other interested scientists. NPGRCs will handle the *in situ* and *"inter-situ"* conservation (nature reserves and field gene banks, respectively) in collaboration with the SRGB as well as work in close collaboration with national plant breeding institutions and other *bona fide* users for effective utilization of plant genetic resources.

National crop working groups (NCWGs) composed of specialized scientists in each SADCC member state recommend necessary activities and procedures for the genetic resources requirements of specific groups of species.These scientists and those in the RCWGs liaise with SRGB to set priorities and meet periodically with their counterparts in other member states to exchange information.

MPT Genetic Resources activities in the SADCC region

Germplasm collection

The only major MPT collection mission carried out in the SADCC region is the IBPGR/ILCA/Winrock International-Tanzanian collection of *Sesbania* spp. (Mengistu, personal communications). In their Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL), the Kew Seed Bank has collected in Angola, Botswana, Namibia and Swaziland. A few MPT samples were also collected in the SADCC region in the late 1970's. In 1991 SRGB and IBPGR co-sponsored the collection of forage species in Lesotho and Namibia. The collections include several MPTs.

During the next phase of the SRGB programme, 1993-96, SRGB will encourage the relevant CWGs to organize exploration missions. The ICRAF-GRC, will be encouraged to collaborate with SRGB and the NPGRCs to organize and carry out MPT germplasm collections in the SADCC region. Research in alternative methods for field collection of vegetative material, such as minimum facility *in vitro* collection methods, will be encouraged. Full collaboration with the IARCs will be invaluable in the development of such techniques.

Conservation

The optimum conditions for long term storage of most tree species are not yet clearly defined. Most of these species are considered recalcitrant. Through the relevant CWGs, and in collaboration with the ICRAF-GRC and IBPGR, the SRGB programme will encourage research to address these problems. Again, the SRGB recognizes the comparative advantage of the IARCs in conducting and coordinating strategic research and will collaborate with them to establish the optimum conditions for seed storage and to develop alternative *in vitro* culture solutions.

SRGB will collaborate with the ICRAF and the NPGRCs in identifying potential *in situ* conservation reserves. Here, SRGB has the comparative advantage to approach the governments of the SADCC member states whilst experts in forestry will be able to identify potential sites during exploration activities.

Multiplication and rejuvenation

Germination tests of samples which were left in the SADCC member States by early collectors have shown that most of the material is no longer viable due to poor storage conditions and poor management. This includes several MPTs. The SRGB programme will trace the genebanks in which original collections are stored and request for samples as soon as the NPGRCs are ready to multiply the material. The NPGRCs will multiply the samples in environments which are close or similar to the original collection sites. The CWGs will be responsible for coordinating the multiplication of the material. The IARCs in collaboration with SRGB and CWGs will ensure that the required scientific standards are kept to retain the genetic base of the samples.

Characterization and evaluation

The utilization of germplasm can only be realized after it is characterized. This is especially important for MPTs where selection from original collections can lead to a potential crop. The SRGB recognizes that the expertise for characterization and evaluation is in the IARCs and the CWGs. Collaboration will be encouraged for the characterization of all material that will be under multiplication. The SRGB will collaborate with IBPGR, SADCC/ICRAF and the relevant CWGs to produce descriptors for indigenous MPT species and to give guidelines for characterization and evaluation.

Documentation and Information

The SRGB is developing databases to hold information on the collections held by the network and their management. Databases are also being developed for the plant genetic resources inventory (PGRI) of the SADCC region which will hold information on the flora of the region, nomenclature, known uses etc. Collaboration with IARCs will be required for identifying species-specific descriptors. This is especially important for indigenous germplasm including MPTs which have not yet been covered by IBPGR descriptors. Collaboration will also be very important to ensure that vital characters for utilization are not neglected during characterization.

Opportunities for SRGB collaboration with the ICRAF-GRC

The conservation and promotion of utilization of the plant heritage of the SADCC region is a formidable task which calls for well coordinated collaboration with other institutions. The SRGB therefore welcomes IARCs and other centres of excellence to carry out PGR activities in the SADCC region. The ICRAF-GRC and SRGB should take a leading role in organizing MPT genetic resources activities in the SADCC region. The two institutions should collaborate fully (with the NPGRCs as the national focal points) in the SADCC region in MPT genetic resources activities to ensure maximum effect and avoid duplication of efforts.

The SRGB is especially interested in collaboration in training, collection, characterization, evaluation, promotion of utilization and information on MPT genetic resources. The SRGB would also like collaboration with the ICRAF-GRC in conducting research in the handling of MPT germplasm and to produce guidelines for long term storage of indigenous species. The two institutions should also play a leading role in conducting strategic research in biotechnology. The development of minimum facility techniques for *in vitro* collection, multiplication and conservation will speed up technology transfer to national programmes.

Conclusion

The proposed ICRAF-GRC complements SRGB activities. ICRAF-GRC and the SRGB network should closely collaborate in MPT genetic resources activities in the SADCC region and avoid duplication of efforts. The comparative advantage of ICRAF-GRC in conducting strategic research in MPT genetic resources should be fully exploited.

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Discussion

1. Ques. Is there need to increase the scope and skills available in the SADACC-RGB? D. Gwaze.

Ans. Staff at SADCC-RGB will not increase as we have financial constraints to staff levels. This means that our staff must identify expertise from outside the RGB to help.

2. Ques. **I** refer to the budget mentioned in your presentation. Was it a planned or pledged budget? Quat Ng.

Ans. Donors are to contribute U.S.$20 million for infrastructure and personnel development. Member countries are to contribute the rest to bring the total to U.S.$34 million over 20 years. SIDA have helped national programmes with other basic needs to facilitate their participation.

MPT GERMPLASM CONSERVATION AND MANAGEMENT IN THE PHILIPPINES

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Introduction

The Philippine forest resources have dwindled rapidly in recent years. The majority of the Filipino people are aware of the extent that our natural forest are being destroyed daily but few people recognize that as our forests disappear, so do their genetic resources. Furthermore, few appreciate the serious consequences attendant to the loss of such germplasm.

At the University of the Philippines at Los Ban'os (UPLB), the concern for MPT germplasm conservation and management has recently been given emphasis. There is great recognition for the need to come up with a sound and unified program on MPT germplasm. A number of activities have been and are currently being undertaken, but these efforts have thus far been largely isolated and fragmented.

UPLB and MPT Germplasm

The UPLB College of Forestry is located at the foot of the 4,244-hectare Makiling Forest Reserve. With its rich flora, this forest reserve possesses vast potentials for tree germplasm conservation and management studies. No less than 200 hectares of the forest is home to the Makiling Botanic Gardens (MBG). The MBG, and the Makiling Forest Reserve in general, is a huge repository of tree germplasm, including many MPTS or species with MPTS potential. Plantations of MPTS, as well as provenance and species trials have been established. With its Living Collections program, the MBG hopes to intensify its collection of germplasm of forest trees including MPT.

In 1976, the National Plant Genetic Resources Laboratory was established as a component unit of the Institute of Plant Breeding of UPLB. Its specific functions are to systematically collect, introduce, conserve, and maintain a germplasm bank of important crops. While its current priority is on agricultural crops, it can

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accommodate in its various programs the multi- purpose trees which are, after all, important components of upland farming systems in the Philippines.

In 1989, the Agroforestry Seeds Information Clearing House (AFSICH) was created. Based at the College of Agriculture, the project was intended to facilitate information exchange on agroforestry seed sources, availability, technology and related matters among practitioners, government and non-government organizations through correspondence, publications, training and applied research. To date, the project has accumulated a significant amount of information on seed sourcing and distribution of MPTS.

The latest boost to MPT germplasm was the creation of the UPLB Agroforestry Program (UAP) on 12 March, 1991. The UAP has a basic mission of promoting ecological stability and alleviating poverty in the country through the application of sustainable agroforestry systems. It would like to institutionalize a university wide program on agroforestry science and technology geared towards the development of agroforestry professionals and the production of appropriate agroforestry technologies.

Like any other agroforestry project, the UAP is very much involved with MPT, and will continue to be so in the coming years. The project greatly recognizes the urgent need of conserving and managing MPT germplasm knowing full well that the development of improved varieties of such tree crops, as well as enhancing the adaptive mechanisms of these species to changing environment largely hinge on the availability of a large range within species variation.

Cognizant of the above, UAP has initially established a small research and demonstration area featuring among others, a germplasm collection of species, both indigenous and exotic, for hedgerow and other purposes. To date there are eleven (11) species planted namely: *Cassia spectabilis, Piliostigma malabaricum, Leucaena leucocephala, L. diversifolia, Sesbania grandiflora, S. sesban, Moringa oleifera, Acacia villosa, Dismantus virgatus, Flemingia congesta and Desmodium renzonii.* This will further be expanded as other materials are acquired.

Also planned is a project on Planting Material Production in Agroforestry which aims to provide ready sources of planting materials of MPT commonly used in agroforestry. Through this activity, the UAP hopes to establish and manage seed production areas and clonal orchards of MPT. Part of the project will be the UAP-Farmer Collaborative Seed Production/Collection and the Seed Bank/Seed Storage Project. When implemented, these projects will undoubtedly contribute to the budding efforts on MPT germplasm conservation and management in the country.

The UPLB Agroforestry Program hopes to bring to the fore the urgency of coming up with a national program for MPTS germplasm conservation and management in the Philippines. Given the opportunity and support, UAP can play an active role in its planning and implementation.

Some issues and considerations

The rapid and continuing loss of forests in the Philippines has been a grave concern for many years. The extent to which this may have caused the erosion of germplasm of MPTS is not known, but it is the general belief that if the destruction remains unabated, the genetic diversity of MPTS in the country and elsewhere will suffer. This may result to the poor adaptation of the species to changing environments and/or the creation of a big barrier to the development of improved varieties of the species.

In addressing this worldwide crisis of decline in the variability of MPTS, a number of issues will need to be given considerable attention:

Collection of basic information on important MPT

The need is urgent to intensify efforts geared towards ascertaining distribution of MPT and determining the extent of variation within species. The conservation of intraspecific variation of species can thus be effectively planned and implemented. In a larger scope, the conservation of germplasm can effectively be carried out given this information.

Information to be gathered should not only be confined to botanical aspects, but should also consider farmer's practices as regards the species. The farmer's propensity to select the best trees from his crops, or the continuing exposures of indigenous/tribal people to urban culture may have a reinforcing effect on germplasm erosion.

Development of priority list of MPTS

While the MPTS have been identified in our respective countries, there is a need to prioritize them in terms of their germplasm status. This way, those facing the greatest risk of germplasm erosion will be the first to be addressed.

Need for MPT germplasm conservation

Efforts should be made to improve public awareness of the necessity to conserve germplasm. It is recommended that MPTS germplasm conservation and multiplication should be considered as key component of community based forest development activities. People should be informed of the great complementarity between MPT germplasm conservation and multiplication and food production as well as the provision of other basic needs. Forest conservation programs should amplify the concept and the need for conserving genetic resources of MPTS.

Efforts must also be exerted to bridge the communication gap between proponents of MPTS germplasm and the government decision-makers.

Logistical support for MPT germplasm collection, dispatch, evaluation, conservation, multiplication and documentation

Funds for the conduct of research and other productive endeavors related to MPTS germplasm should be generated. Research and development institutions in forestry and agroforestry alike should be encouraged to prioritize for funding those project proposals designed to address problems and technology constraints on MPTS germplasm.

In rural development activities, concepts should aim at reconciling the perceived needs and aspirations of the local population residing near potential stands/sources of germplasm and the benefits that can be derived from efforts at conserving and multiplying genetic resources. In other words, the conservation and protection of germplasm stands must consider providing long and short term benefits to people who live near them. Efforts must be made to institute certain programs which are compensatory in nature to insure that communities will not be penalized by the existence of germplasm stands nearby.

Dearth of trained personnel for MPTS germplasm collection, dispatch, evaluation, conservation, multiplication and documentation

Training and education on the different aspects of MPTS germplasm management, particularly on *in situ* and *ex situ* conservation should be given adequate attention.

Development of In Situ and Ex Situ programs for MPTS

For the prioritized MPTS, these programs must immediately be undertaken. Long term *in situ* management plans for important MPTS should be developed. Likewise, complementary *ex situ* conservation and management of pollen, seed, tissue culture and other forms of reproduction material should be developed. MPTS *ex situ* plantations can serve as living seed banks, as evaluation stands, or both.

Intensified research and development efforts on MPT germplasm

In addition to increased botanical surveys for genetic diversity and distribution, R & D should be accelerated and expanded in scope to accommodate a far greater number of MPTS. Research in tropical MPTS should focus on the pattern of genetic variation in tree populations, accurate inventory of MPTS, long term storage of MPT germplasm, effects of global climatic change (e.g. global warming), acid rain and pollution, crossability patterns and mating systems, and reproductive biology. These are essential prerequisites in the design and implementation of *in situ* and *ex situ* conservation stands.

Regional/Global networking

The continuous erosion of genetic resources of MPTS is not a local problem but an international concern. Hence, the global problem of MPT germplasm depletion should be confronted by a global strategy, one which will encourage, enhance or provide guidance to national and regional institutions to carry on with works on MPT germplasm. A global network should be established which will facilitate interaction among national and regional programs, information exchange, training, fund sourcing, etc. The same network can come up with standardized procedures for MPT germplasm collection, dispatch, evaluation, conservation, multiplication and documentation.

It is in this context that the ICRAF MPT-GRC, as an international center under CGIAR, should take the lead.

Discussion

1. Comment Just a word about idealism in any MPT improvement programme. We must be practical and be careful. Goals should be narrow and long range to be successful. J. Brewbaker

EMBRAPA GERMPLASM EXPLORATION AND ACTIVITIES

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Introduction

EMBRAPA is the organization in charge of agriculture, livestock and forest research, at federal government level, in Brazil. Its headquarters is located in Brasilia, -DF, but there are several Research Centres distributed throughout Brazilian territory. Centra Nacional de Pesquisa de Florestas CNPFlorestas (the National Centre for Forest Research) is responsible for coordination, promotion and execution of forest research at EMBRAPA level. To carry out this task, CNPFlorestas develops its activities in association with local State Governments, private companies and other EMBRAPA National Centres, such as CENARGEN - Genetic Resources and Biotechnology Centre and Regional Centres located in Amazonia Region, Cerrado Region and Semi-Arid Region.

CNPFlorestas, located near Curitiba, PR (Southern Region of Brazilian) started its activities in 1978, first as a Regional Centre and after 1984 as a National Centre. Since 1978, MPTS have received special attention from EMBRAPA.

In the Southern Region, for instance, more than one hundred forest tree species are being studied and some of them, such as "bracatinga" *(Mimosa scabrella* Beth) has proved to be an excellent MPT. Information on natural distribution, silviculture and use of this species is already available. Seeds were collected and sent to Costa Rica and Hawaii by CNPFlorestas. A recent study aiming economic strategies for "bracatinga agroforestry systems (BETTERS, 1991), indicated an optimal rotation at seven years and "bracatinga" with corn and beans as the best economic option when compared with "bracatinga", "bracatinga" and corn, and "bracatinga" with beans. More studies are needed in relation to genetic variation, breeding and conservation of genetic variability.

Research on agroforestry systems is one of EMBRAPA's priority activities for Amazonia Region. Excellent results have been obtained using consortium involving rubber tree, coffee, cocoa, banana, black pepper, Brazil nut, *Cordia goeldiana, Theobroma grandiflorum, Bactris gasipaes,* combining with farming crops. Agroforestry systems with MPTS have been used traditionally by the native people (Indians) to cope with the complexity of the ecosystem, due to the interdependence of climate (hot and humid), poor soil quality and the high biodiversity of microorganisms, animals and plant species. Farming of cleared forest sites following "modern techniques" has not always shown good results. Almost one third of seventeen million ha of pasture is now degraded and unproductive

(Serrao, cited by Lopes & Guilherme, 1991). According to Van Tomme & Peixoto, cited by Tomaselli (1989), more than 80% of wood harvested in the Amazonian forest are from less than 50 forest tree species, among more than 3000 forest tree species known. It shows the necessity of more research on MPT germplasm collection, evaluation, conservation and use.

Consortium of forestry and livestock activities is one of the best options for land use in the Brazilian Semi-Arid Region (RIBASKI), 1991). MPTS such as from the genus *Prosopis, Leucaena, Mimosa* and *Manihot* have been used in this region.

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Discussion

1. Ques. How accessible are genetic resources from private companies in your networks in Brazil? T. Vercoe.

Ans. Everyone in the network has access to genetic material. Breeding programmes within companies are more complicated. Genetic conservation material within private companies is no problem. Improved material is property of individual companies and access is negotiable.

2. Ques. Accessibility both outside and within? T. Vercoe.

Ans. Yes both, but access easier within.

3. **Ques.** Which activities should be ICRAF's main focus in South America? R. Salazar.

Ans. ICRAF should focus on humid lowlands.

4. Ques. Embrapa actively collects some unusual species such as peach palm. Is Embrapa willing to share this germplasm and collaborate in its characterisation. R. Schultze-Kraft.

5. Comment ICRAF is in discussion with Embrapa on this issue. No problem with ICRAF and Embrapa sharing germplasm within Brazil but sharing outside more difficult. F. Owino.

LEUCAENA GERMPLASM AND GENETIC IMPROVEMENT AN UPDATE

fames L. Brewbaker
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Introduction

Important progress has been made in breeding and in knowledge of the genetics of the genus Leucaena since my review paper for the 10th anniversary of ICRAF (Brewbaker, 1987). This progress increasingly involves national research programs throughout the tropics, although they are rarely funded adequately to the need (as we perceive it). The newly enlarged role of ICRAF as a participant and coordinator in MPT research internationally is thus most welcome, with the proviso that funding be expanded and not diluted.

Leucaena is an MPT genus that no longer needs introduction to agroforesters. None of us consider it miraculous, but few of us can choose to ignore it. However, this is an age of truly miraculous genetic events that promise to recreate human, animal and plant germplasm in ways heretofore impossible. Leucaena must be at the forefront of exploratory research to apply this biotechnology in the service of the growers and the public who benefit from agroforestry. This paper is a brief update of germplasm and genetic improvement research in the past decade.

Status of the genus leucaena

No well-studied tropical plant genus can remain taxonomically static for long, and thus it has been with *Leucaena.* This mimosoid genus was variously described as having 50 or more species at the time we initiated provenance evaluations just 30 years ago in Hawaii. The most common species was then called *L. glauca.* Most of those species became synonyms through herbarium and common-garden research. I currently recognize 13 species (Table 1). Authorities like Colin Hughes (OFI) and Charles Sorensson (UH) would add to these *L. multicapitula* (2n = 52), an arboreal relative of *L. trichodes* in Panama. Another unknown highland taxon in our studies is L. sp. shown by Sorensson to be 2n - 112.

Subspecific variation is rampant in the genus, and is perhaps more important to the field botanist than to the experiment station breeder. The classic variation is that of distinct shrubby and arboreal variants, as in *L. leucocephala* (Lam.) de Wit (referred to here as LEUC), that appear to have evolved independently to a large extent. Hughes and Sorensson recognize such variants at subspecific level in *collinsii, diversifolia* (2n, 4n), *esculenta, lanceolata,* and *shannoni.* The relatively simple inheritance of this arboreal trait gives a dynamic form of ecologic versatility to each of these species. The arboreal types of *lanceolata, shannoni* and *trichodes* (= *multi-capitula)* are all most promising for grower use. These arboreal types grow to 15-20m in 3-4 years and flower in 1-2 years, ideal "molding clay" for plant breeders.

Hybridization among leucaena species

Largely through the Herculean efforts of Charles Sorensson, the genus *Leucaena* is now the most thoroughly intercrossed of trees. Of the 240 possible crosses among 16 taxa (including 2n and 4n DIV, *L. multicapitula,* and the 2n - 112 "L. sp."), Sorensson (in press) is currently publishing that over 232 crosses have been completed by him and other students in my team over the years. Among these, at least 140 crosses have produced seed, and 90 hybrids grown, 50 have flowered and many are fertile. The four polyploid taxa cross with great ease, while cross-fertility is less among diploids and between diploid and polyploid taxa.

We conclude that the genus *Leucaena* is one large breeding base, and that species evaluation has been largely through geographical and ecological isolation. It offers a great array of phenotypes as options for future genetic improvement. Table 2 is taken from Brewbaker and Sorensson (1990), and gives pollen fertility of hybrids that had flowered. Twelve hybrids (marked with *) were fully seedless. The abbreviations of species names in this table will be used in the following discussions.

All future genetic improvement must contend with the options presented in Table 2 for gene transfer among the species. Our current emphasis is to hybridise species differing in traits as edaphic and climatic adaptability, pest tolerance, and wood and fodder properties. A most significant rangewide collection of *Leucaena spp.* is that of Hughes at Oxford Forest Institute, that should offer expanded range and use for the leucaenas. The Hawaii collection embraces a little over one thousand accessions, all having been grown and characterized, of which about half are of the species *L. leucocephala.*

Leucaena genome analysis

The breeder's first concern is phenotypic diversity, but a concern that follows closely is the degree of heritability of that diversity. Most significant phenotypic variation is of course quantitative and environmentally sensitive. Major studies are underway in Hawaii and Taiwan of many such traits in leucaena, but they are only the tip of the iceberg. Similarly, a few monogenic loci are now known in the genus, but a serious genome analysis is called for within this decade, if funds can be obtained to support it. Only recently was the first gene identified in sugarcane, a tropical polyploid genus similar to leucaena. In a short time, genome analysis was expanded to include maps of the 20 cane chromosomes of sugarcane based on RFLPs drawn from maize. An important current extension of this knowledge is to QTL (quantitative trait linkage) with reasonable promise of accelerating breeding progress in tree species.

Isozymes have provided most of the 15 loci we now recognize in leucaena. Weiguo Sun in my lab has identified over 100 polymorphisms involving Krebs and glycolytic pathway enzymes. Most species can now be identified by specific bands. The common and giant leucaenas can thus be identified and the prospective parentage of polyploid species such as LEUC are more evident through these analyses. We now recognize 10 isozymic loci, again only the tip of the iceberg that promises to emerge in the next few years.

The "common" LEUC is a vigorous seedy shrub that migrated from Mexico in the 16th century throughout the tropics. We can now verify that it is a single, highly homozygous, self-pollinated variety, based on Sun's isozymic analyses that show virtually no genetic variation in 30 isozymes in 79 accessions from 40 countries. In contrast, the LEUC accessions from Latin America are quite polymorphic.

The S or incompatibility locus identified by Pan (1989) is one of the most significant in this genus. All diploid species are self-sterile through S allele action, while most of the tetraploids (LEUC, DIV4, and L. sp. of Sorensson) are fully self-fertile. An interesting exception is the self-sterile polyploid, *L. pallida,* that Pan has shown to be an amphiploid of DIV2 and ESCU. This has become our most important source of resistance to the psyllid, and the self-sterility thus characterizes many plants in advanced breeding generations.

Psyllids

The psyllid insect, *Heteropsylla cubana,* is due to arrive on the African continent this decade. It has moved steadily from Lain America through the Pacific (1984) and SE Asia (1986) to S. Asia (1989) and to the Mascarenes (1991). Common LEUC is very susceptible to the insect, and defoliation during its first season can be quite dramatic. Despite the bad press, however, I have never seen a leucaena killed by psyllids. In all regions, and notably in Latin America itself, the insect has become much less important with time. Many regions of Asia now report no damage, possibly due largely to insect predation. Psyllid damage can be great, however, on susceptible hedges harvested regularly for fodder or green manure, and on tree seedlings during establishment. Resistant lines are clearly to be preferred.

Most L. spp. are partially or highly resistant to the psyllid. Resistance has been bred into two major hybrid populations:

KX2 — derived from PALL x LEUC (high resistance)
KX3 - derived from DIV4 x LEUC (low resistance)

Both populations also carry the cold tolerance of the highland parents. The KX2 population is recommended for fodder use where psyllids are serious (available early in 1993 from fourth generation of recurrent selection in Hawaii). Highly tolerant LEUC accessions include K420, K584 and K636, of which the latter is now widespread as a highly productive arboreal type. All DIV and PALL accessions show tolerance, and some exceptionally resistant lines are parents of newer hybrids.

Environmental adaptability

Cold and acid tolerance lead the list of targets for expanding the adaptability of LEUC. Most L. spp. are cold tolerant, however, and genes for tolerance work well in the immediate KX2 and KX3 hybrids. These prove superior in fodder yield to the non-recurrent parent, and vastly superior to LEUC in cold tolerance. However, varieties of DIV2 and DIV4 are often very attractive for highland wood production. Among these are valuable new germplasm from Sumatra, Queensland and Taiwan. Frost tolerance characterizes only the yellow-flowered shrub, *L. retusa,* so its hybrids with LEUC (Table 2) are now of great interest. Surprisingly, the best American market for leucaena is for K636 as fodder in south Texas, where frosts kill it annually to the ground.

Tolerance of high aluminum saturation evidently does not exist in the genus *Leucaena,* and performance is equally poor on acid manganous oxisols below pH5. The high requirement of leucaenas for calcium is probably involved. Continuing exploration by OFI's Colin Hughes, Taiwan's Fuh-Jiunn Pan (Pan and Brewbaker 1988) and our staff will focus on Latin American regions of soil acidity. Alternative biotech approaches deserve similar exploration, e.g. through gene transfer from the closely-related acacias.

Major efforts have been made in Hawaii to produce seedless leucaenas (Brewbaker and Sorensson 1990), since the genus is almost a grain legume in its insistence on high seed production. This diversion of energy from wood and fodder production is undesirable, and the accompanying weediness makes us a target for less than amiable critics. Of the 12 seedless species hybrids (all are triploids), two have been chosen for large scale seed production, using cloned diploid parents as females in isolated stands. The triploid trees are very attractive and we expect ongoing yield trials will show wood yield gains from this diversion of fixed carbon.

High quality is a requisite for fodder legumes, and most of the tropical ones evolved with clever devices to avoid being eaten. Mimosine in leucaena is an example, an amino acid that greatly limits leucaena's use by non-ruminants and man. Mimosine's distribution (dry matter concentrations) in leucaena accessions and species is distinctly bimodal, around means of 2.2 and 4.5% of dry matter. Several accessions of LEUC from Colombia are in the lower group, and breeding is underway to provide high yielding fodder lines at this level. High biotech opportunities for suppressing mimosine synthesis with antisense DNA are under consideration.

Role of proposed ICRAF Center

It may be argued that almost all trees have multiple purposes, but *Leucaena* is arguably a genuine MPT genus. Together with other NFTA genera such as *Gliricidia* and *Sesbania,* it deserves full attention of the proposed ICRAF germplasm center. The major field collections of leucaena exist with UH, OFI and CSIRO, and the major CGIAR germplasm collections are those of ILCA and CIAT. To these can be added many seed units throughout the world often with local accessions of the single "common" genotype of LEUC, together with introductions from those mentioned.

I view these collections as of two types, typical for example of my maize germplasm Foundation seed and Breeders' seed. The CG germplasm centers naturally focus on Foundation seedstocks, to be maintained, characterized, distributed. However, breeders' seed-lots of new, psyllid and cold-tolerant leucaenas, could also be held by the center on an interim basis.

Self-pollinated leucaenas (LEUC, DIV4) are easily handled, increased and distributed as foundation seeds. The self-sterile species and breeders populations present much greater challenges to seedsmen and germplasm centers. Both the self-fertile and self-sterile types are commercially attractive, with homogeneity emphasised for plantation trees and diversity for small-farm fodder and green manure. I cannot overemphasize the importance of supportive basic research. The first big step in leucaenas, from Common to Giant LEUC, was an easy one. The next steps will be much harder, and require solid knowledge of the breeding system, genetics, adaptabilities and qualities of germplasm.

In the near future, it is important that ICRAF and other African institutions be prepared for the arrival of the leucaena psyllid, now in the Mascarenes. Major foundation seedlots from Hawaii and other institutions should become part of the ICRAF gene bank, while smaller breeders' seedlots might temporarily be held for use in the MPT genetic improvement network trials throughout Africa by ICRAF, ILCA, IITA, NARS and others.

In a long-range perspective, ICRAF may best play a coordinative role that serves to stimulate AF applied research globally. This would involve the provision of many Foundation seedstocks of leucaena to researchers, but ensuring that only the superior germplasm for any ecosystem and use are channeled into farmer demonstrations and seed orchards.

Collaborators in leucaena improvement program, U. Hawaii

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Mike Austin, PhD student, Agronomy, UH
Wei Guo Sun, PhD student, Horticulture, UH
Robert Wheeler, PhD student, Forestry, Purdue Univ.
Nicholas Dudley, Seedsman, Hawaiian Sugar Planters' Ass'n
Fuh-Jiunn Pan, Forester, Taiwan Forestry Research Institute
Jim Chamberlain, Acting President, Nitrogen Fixing Tree Ass'n

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Table 1. Widely recognized Leucaena species.

Species	Abbrev.	Somatic Number	Breeding System	Author	Date
L. collinsii	COLL	56*	SI	Britton and Rose	1928
L. diversifolia	DIV2,4	52,104	SL,SF	Bentham	1842
L. esculenta	ESCU	52*	SI	(Moc & Sesse) Benth	1875
L- greggii	GREG	56	SI	S Watson	1888
L. lanceolata	LANC	52	SI	S Watson	1886
L. leucocephala	LEUC	104	SI-	(Lam.) de Wit	1842
L. macrophylla	MACR	52*	SI	Bentham	1844
L. pallida	PALL	104	SI	Britton and Rose	1928
L. pulverulenta	PULV	56	SI	(Schlecht) Benth	1842
L.retusa	RETU	56	SI	Bentham	1852
L. salvadorensis	SALV	56	SI	Standley	1928
L. shannoni	SHAN	52	SI	Donn. Smith	
L. trichodes	TRIC56*	52	SI	(Jacq.) Benthl928	1842

1842* Some variability exists among chromosome counts.
SI = Self-incompatible; SF = Self-fertile.
Alternate spellings: *L. shannonii.*
Proposed additional species, *L. multicapitula* (or "multicapitulata"), 2n = 52, SI;
L. sp., 2n = 112, SF.

Table 2. Flowering status and Fl pollen stainability of verified leucaena species hybrids.

Species	CO	D4	D2	ES	GR	LA	LE	MA	PA	PU	RE	SA	SH	TR
COLL						98								
DIV4						8*	95		87			NF	15*	
DIV2	97	13		NF		89	31			NF			97	
ESCU							9*						40*	
GREG														
LANC	NF		96									NF	96	
LEUC	NF	85		6*		13*			69	**54**	**43**		30*	36*
MACR			98			98								NF
PALL		69					58							
PULV	NF	5*				NF	65				NF		NF	
RETU	64*	77*			14	NF	NF	20	86	nf			51*	
SALV						NF								
SHAN	NF		NF	NF		94			NF		70*	NF		
TRIC			NF			88								

NF = Non-flowering (up to 1992)
* = Seedless hybrids

THE ACTIVITIES OF THE REGIONAL SEED CENTRE (ZIMBABWE)

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Introduction

The project was started in 1984 and funded by the International Development Research Centre IDRC, Canada. The project was initiated as a result of problems of acquiring seed in large quantities and seed of known origin in Southern and Eastern African countries. There were also problems in lack of storage facilities and trained personnel in seed technology. These problems affected afforestation initiatives and research activities in the region. In the region we grow or are interested in the same species and our problems are similar. Therefore the establishment of the Regional Seed Centre was an important development. Zimbabwe was chosen as the host country of the Regional Seed Centre as it had a well advanced tree breeding programme and an already established national seed centre. This resulted in Zimbabwe expanding its existing national centre for the acquisition, testing, storage and distribution of authenticated forest tree seed for research and development purposes to the region.

Membership was open to any countries in the Southern and Eastern African countries. The member countries of the Regional Seed Centre are Zimbabwe, Botswana, Kenya, Malawi, Madagascar, Rwanda, Swaziland, Tanzania, Uganda and Zambia.

Objectives

The overall objective of the Regional Seed Centre is to provide Zimbabwe, Botswana, Kenya, Malawi, Madagascar, Rwanda, Swaziland, Tanzania, Uganda and Zambia with access to sources of certified forest tree seed for research and development purposes. Techniques will be developed for collecting, processing, storing, testing and distributing quality seed. The sharing of information on species performance and seed technology, and the training of staff are some of the specific objectives.

Seed Procurement

By collection from natural stands

One of the most important aims has been to identify, make recommendations and record existing seed sources /stands /production areas in the country and to establish resource conservation stands for seed production. This has also been extended to MPT seed as we are also considering maintaining the trials as seed stands. In fact we have recommended seed to be collected from our trails e.g. *Acacia holosericea* at Chesa Forest Research Station which was planted as part of the Australian Centre for International Agricultural Research (ACIAR) project.

A large amount of indigenous tree seed of a wide range of species is now in stock. Expeditions for seed collections of some of our indigenous MPTs *viz* African acacias require careful timing of collections and information on correct seeding times is still not at hand. Information on seasonal flowering periodicity and fluctuations in seed production also needs reviewing.

All seeds of Zimbabwean indigenous tree species that have been planted in trials involving researchers at F.R.C. were collected by the Regional Seed Centre, e.g. in a collaborative project to look at fuelwood production in fragile ecosystems of Zimbabwe, seed of *Colophospermum mopane, Combretum apiculatum, Acacia karroo* and *A. tortilis* were collected in the Zambesi Valley, Chiredzi, Matopos and Kadoma areas.

Interest in indigenous tree species has increased over the past years and the seed centre has selected certain trees as having higher priority for collections according to demand for planting and ex-situ conservation. The following is a list of indigenous tree species which have been given priority in collections:

Acacia albida
Acacia karroo
Acacia sieberana
Acacia tortilis
Afzelia quanzensis
Azanza garckeana
Baikiaea plurijuga
Bauhinia thonningii
Bivinia jarlbertii
Brachystegia spiciformis
Colophospermum mopane
Combretum apiculatum
Combretum zeyheri
Dichrostachys cineria
Diospyros mespiliformis
Entandrophragma caudatum
Guibortia coleosperma
Khaya nyasica
Kigelia africana
Kirkia acuminata
Pericopsis angolensis
Pterocarpus angolensis
Sclerocarya birrea
Terminalia sericea
Warbugia salutaris

By collection from established seed stands

Seed for commercial purposes is collected from clonal seed orchards, seedling seed orchards, breeding seedling orchards and commercial plantations. Established seed stands are available for the pines and eucalypts which have a breeding program.

By exchange and purchase

Seed for MPT research procured from other tree seed centres or forestry research institutes is received mainly as free issues or by exchange. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) Tree Seed Centre supplies us with some seed of Australian species for research purposes. We also have a seed exchange programme with the Oxford Forestry Research Institute (OFI). We have received a number of Central American species through OFI and we have supplied them with some local acacias. Small research seed lots are also acquired by purchase from other countries e.g. seed of *Azadirachta indica* was purchased from India.

Testing of Seed

Two samples of pure seed drawn from each seed lot are submitted to the Government Department of Research and Specialist Services and to the R.S.C. laboratory respectively for germination tests. Results are always compared and in most cases are found to tally. However if the discrepancies are greater than the given degree of tolerance a re-test for that particular seed lot is carried out.

Routine tests are performed on all commercial seedlots which are mainly pines and eucalypts. Testing of indigenous tree seeds requires research in pre-treatment methods which is carried out on a continuous basis.

Documentation and Storage of Seed

When cleaning is completed, each seedlot is allocated with a stock number and a storage bin number. Information with regard to date of collection, mass in stock, mass reserved, effective germination factor, provenance and location of each seedlot is always recorded and entered into the computer.

Small quantities are usually stored in two cold-rooms maintained at temperatures of 4°C and 12°C respectively. However, large quantities for commercial purposes are stored in large plastic bags and bins under ordinary room temperature due to a shortage of cold room space. However, this problem will be overcome with the completion of a new cold room at the end of July 1992.

Collection of forest tree seed is expensive and it is preferable to collect only in a year of abundant seed production. This has necessitated on-going research in phenology studies of indigenous trees. This offers much greater freedom of action in the choice of stands and trees as well as the possibility of obtaining more seed for a given cost. The seed centre has developed seed storage facilities to maintain viability for short periods e.g. until seed is retrieved for evaluation trials or routine planting. Research seedlots are usually stored in long storage facilities since planting dates may not be certain. Long term storage is also necessary for germplasm conservation of certain indigenous species. This should be easily facilitated by use of facilities at the SADCC Regional Gene Bank based in Zambia.

The centre stores both othodox and recalcitrant seed. Most of the important species for re-afforestation programmes in Zimbabwe are orthodox and the seed requires cold and dry storage conditions. Small research seedlots are stored in a cold room set at 12°C. Storage facilities for recalcitrant seed which if dried to a low moisture content and kept under low temperature conditions lose viability have not yet been fully developed. The other class of seed handled is hard-coated othodox seeds. The seeds maintain viability over long periods without strict requirements of temperature, moisture and relative humidity. This class includes most of the tropical leguminous MPT species. Most of the indigenous species stored are also in this class. The hard seed-coat of *Acacia, Afzelia, Brachystegia* and *Piliostigma* prevents desiccation of the endosperm to some extent, and therefore seed of this species is stored at room temperatures.

In the absence of researched methods of storage for a given species, those that are used for its closest taxonomic relative are applied.

Seed Distribution

There is considerable enthusiasm by international bodies, government and non-governmental organisations, and individuals to plant trees on degraded sites, in rural areas for non-industrial purposes. The seed centre has developed capabilities to procure and distribute a wide range of species, and stores enough seed to meet most planned planting targets. The centre has problems in meeting impromptu orders, especially for indigenous tree seed.

In 1989, a tree seed questionnaire was circulated to forest departments, forest research institutions and individuals in various countries and within to seek information on the species required for planting in evaluation trials, agroforestry, timber, fuelwood and conservation stands. The responses were not fully representative of species required by different countries or organisations. However, they indicated that tree seeds were in demand for various non-industrial purposes for example agroforestry, silvo-pastoral systems, fuelwood and conservation.

To this end, the centre distributed small seedlots for research and development purposes to many organisations in different countries. This requires detailed documentation of seed information, e.g. parent tree description, location, soil description, latitude, longitude, annual rainfall, date of collection and viability during collections. Database programmes were developed by the Research Division's Biometrics section, to handle this information.

Since its inception the centre has distributed a wide range of species. There has been a strong increase in demand for MPT species notably *Acacia albida.* Table 1 shows the number of research seedlots distributed both internationally and locally from 1988 to 1990. Table 2 shows the research seed presently in stock.

The Regional Seed Centre also distributes commercial seedlots to both local and international organisations and companies for their planting programmes. Table 3 summarises the commercial seed distribution between 1988 and 1991, and Table 4 shows commercial seed presently in stock.

Last year's financial revenue from seed sales was US$124,000.00 for external sales and Z$35,000.00 for internal sales.

Research Activities

Conservation

The Centre, in a collaborative effort with the National Herbarium of Zimbabwe, has conducted a study to locate individuals of, and develop a conservation strategy for *Warburgia salutaris,* a very important medicinal tree in Zimbabwe. The centre is also engaged in an *ex-situ* conservation project of indigenous trees which is funded by SAREC, a Swedish donor agency.

Table 1. Number of research seedlots distributed from 1988-1991

Species	Number of seed lots		
	1988	**1989**	**1990**
Pinus	447	107	250
Eucalyptus	289	811	74
Acacia indigenous)	619	342	84
Acacia (exotic)	111	26	14
Other (indigenous)	72	33	79
Other (exotic)	71	34	52
TOTAL	**873**	**623**	**653**

Table 2. Number of species, seedlots and weight of seed for research purposes presently in stock

Genus	Species	Seedlots	Weight (Kg)
Pinus	35	1700	140
Eucalyptus	100	1700	300
Acacia (exotic)	80	450	20
Acacia (indigenous)	10	400	150
Other (exotic)	160	350	20
Other (indigenous)	40	200	300

A gazetted list of endangered tree species in Zimbabwe is available, and efforts will be made to collect seed of such species and store it at the SADCC Regional Gene Bank facilities, in Zambia but some will be kept at the centre ready for distribution.

Other units at the Research Centre carry out species and provenance trials. In terms of multipurpose tree species over 100 Australian, 30 Central American and 40 African species have been evaluated in several ecological zones around Zimbabwe.

Table 3. Weight of commercial seed distributed between 1988 to 1991

Species	**Kg**			
	1988	**1989**	**1990**	**1991**
Pinus	1227	998	754	826
Eucalyptus	414	445	450	342
Others	318	253	**71**	210
TOTAL	**1959**	**1696**	**1275**	**1378**

Table 4. Number of species, seedlots and weight of seed for commercial purposes presently in stock

Genus	Species	Seedlots	Weight (Kg)
Pinus	6	1365	3200
Eucalyptus	10	120	2780
Acacia (exotic)	2	8	40
Acacia (indigenous)	3	17	25
Other (exotic)	5	9	30
Other (indigenous)	4	22	230

Information and advisory

Apart from selling seed the Centre provides advice on species to plant on particular sites and, nursery, planting and maintenance techniques.

A number of publications have been written especially on seed pre-treatment. A seed brochure is nearly ready for publication. This should increase our seed sales to a large extent.

Training courses on seed collection were held during the project period and also seminars to exchange information.

Suggestions for the role of the ICRAF MPT-GRC

The ICRAF MPT-GRC can collaborate with other MPT Centres through collection of germplasm to which other MPT centres have no access. This ICRAF Centre has an advantage over other centres which do not have access to foreign currency to purchase MPT seed from seed centres in other continents, e.g. Asia. The ICRAF centre should be advised not to collect germplasm in the SADCC region as this is already covered by the SRGB, thereby avoiding duplication of services. If individual SADCC countries want to collect MPT seed for storage at either the SRGB or ICRAF MPT-GRC, the later should provide funds if not available to the individual SADCC country's seed centre. Likewise the ICRAF Centre should provide funds at request, to any other national seed centre to collect MPT seed if the individual centres have no funds to do so. This new international centre should be able to supply seed of MPTs to any individual national seed centre when seed is required for planting. Failure to do so may result in other countries not collaborating with the ICRAF centre. The most important point is that the centre should not duplicate services in any region to avoid conflict of interest.

PART B

FINAL REPORT OF WORKING GROUPS

Introduction

The meeting divided into three working groups (WGs) for discussions. The titles of each, plus names of Chairpersons and Rapporteurs are as follows:-

WG1 Conservation strategy and germplasm management in MPT-GRC
Chairperson J. Hanson; Rapporteur B. Ditlevsen

WG2 Research and service related priorities in MPT-GRC
Chairperson R. Schultze-Kraft; Rapporteur J. Turnbull

WG3 NARs collaboration with MPT-GRC of ICRAF
Chairperson T. Ruredzo; Rapporteur O. Souvannavong

The following pages include summary reports of these working groups plus reports of plenary discussions.

REPORT OF WORKING GROUP 1:- CONSERVATION STRATEGY AND GERMPLASM MANAGEMENT IN MPT-GRC

Collection strategy

R : All seed collections should be organized in consultation with other experienced Institutions or Organizations. Such Institutions could be National Centres or Regional/International Centres or Organizations.

- It is particularly important to include national centres in the collections

R: ICRAF should strengthen the national centre's capacity to participate in collection of MPT germplasm, through training and other support.

- to be able to develop a collection strategy, information will be needed about:
    1) previous collections of MPT species (collection intensity, coverage of the natural distribution etc.)
    2) species characteristics such as genetic variation and reproductive system.

R* = recommendation

- surveys may be needed before collections are initiated.

R: ICRAF should develop a collection strategy for MPT's including species priorities variations in the species, collection intensities etc. in collaboration with participating institutions and centres.

Conservation

- ICRAF's participation in practical *in situ* conservation activities would not be possible
- ICRAF could keep information about *in situ* conservation areas of MPT species of interest to ICRAF.
- Compilation of complete information on *in situ* conservation areas would however be the responsibility of FAO, IBPGR, IUCN, UNEP, UNESCO and others.

R: ICRAF should however recommend and encourage specific areas to be conserved *in situ* by national programmes for species of interest

R: ICRAF should concentrate its activities in *ex situ* conservation.
- the method(s) applied will depend on the species.
- it is important that ICRAF concentrate on conservation activities that supplement these available at the national centres so as not to weaken national and regional efforts.

R: ICRAF should concentrate on base collections, i.e. long term storage for species of interest.

- germplasm from "own" collections will be included and possibly also collections from other centres and organisations.
- improved material of priority species may be included in cases where it takes a long time to reconstitute the improved material.
- the collections of endangered species should be of sufficient size, to allow for further research on the germplasm stored.

R: ICRAF should hold "safety" duplicate base collections of material from other centres where required and "safety" duplications of ICRAF's own base collections should be stored in other centres.

R: MPT species difficult to store should be maintained in field gene banks in national programmes.

R: ICRAF should assist in development of field gene bank designs and supply information on reproductive biology etc. of species of interest to assist national programmes on the establishment of the gene banks.

R: ICRAF should concentrate its conservation activities on MPT species having a wide distribution (covering many countries) and/or on species that are not included in national programmes and that are of interest to ICRAF.
- ICRAF's role in keeping "Working Collections/Active Collections" was discussed. There were different opinions in the group. Some felt that

such working collections should be kept at national centres while others found it more convenient/practical that ICRAF kept and distributed seed from its own germplasm bank. The group agreed on, the following recommendations:

R: ICRAF should concentrate its activities to research samples. Handling of commercial quantities as well as mass production of improved seed will be the responsibilities of the national and regional centres.

R: ICRAF should be the focal point (clearing house) for seed requests for the research programmes, and those of its collaborating partners.

R: In cases, where seed cannot easily be achieved directly from national centres, ICRAF will keep working collections for the research programmes.

R: Information on base collections will be kept at IBPGR as well as at ICRAF.

Storage facilities

R: ICRAF should study recommendations given by FAO/IBPGR on storage conditions and monitoring for maintenance of germplasm and make appropriate decisions on facilities depending on needs and resources.

Documentation, data management and information systems

- CIFOR/FAO/IBPGR/ICRAF and other centres are collaborating on germplasm documentation for woody species.

R: An initial "minimum set" of descriptors for all MPT species should be developed by ICRAF in agreement with collaborators on MPT species. These descriptors may be expanded for certain species.

R: ICRAF should be the focal point for MPT information and make an overview of MPT germplasm at ICRAF and at other centres.

- An IBPGR/CIFOR/ICRAF/FAO Consultation that includes Information Management and Documentation is planned for November 1992.

R: ICRAF should take this opportunity to clarify respective roles in information management and documentation.

R: ICRAF should analyse existing seed bank management systems before choosing/developing a system for the MPT-GRC.

Staffing

- In planning the staffing of the MPT-GRC it is important to identify priority functions at the centre. In view of the restricted number of positions, staff with wide experience are preferred.

R: The following three functions subject areas should be given priority:

- A documentation/information specialist
- A seed technologist
- A seed collection specialist with knowledge in the fields of taxonomy, ecology, species diversity and/or tree breeding.

R: Additional functions/positions should be addressed through collaboration within ICRAF and other centres or should be filled through deputation of staff to ICRAF.

Other issues

R: ICRAF should (through its extension contacts) encourage the use of seed/germplasm of high genetic quality.

R: ICRAF should concentrate its activities to research samples. Handling of commercial quantities as well as mass production of improved seed will be. the responsibilities of the national and regional centres.

Plenary discussion of W.G. 1

1. Ques. What does wording "seed of high genetic quality imply"? Hans Muhs

Ans. Agreed to change wording to "well documented seed and germplasm".

2. Ques. Some concern about small research quantities *vis a vis* a responsibility for ICRAF to produce larger quantities of seed. C. Lascano

Ans. Mass production not envisaged. ICRAF should act as a catalyst for NARs to produce large amounts. B. Ditlevsen

3. Ques. Why only one collector recommended? D. Gwaze

Ans. Collaboration with other groups should be actively explored. B. Ditlevsen

4. Comment B. Duguma believed that the report was too restrictive on commercial quantities of seed.

5. Comment J. Chamberlain said that there was a need to define priority areas in service-related research areas. This generated a lot of discussion and led to agreement that seed requests not able to be handled by ICRAF should be redirected to Centres that can.

6. Comment Prof. Hawkes indicated that wording in report "ICRAF Working Collections" should be altered to "ICRAF active collections". Change agreed upon by participants.

7. Comment P. Sanchez supports collaboration with other centres.

8. **Comment** Q. Ng believed that there was too much bias towards seed collection *vis a vis* germplasm collection.

REPORT OF WORKING GROUP 2:- RESEARCH AND SERVICE RELATED PRIORITIES IN MPT-GRC

Goal

The GRC should be in a position to supply seed samples of MPTs for research to all bonafide Scientists and Institutions who request it. While the seed will be primarily for selection and breeding, it should be available to other researchers.

After consultation with NARS and other institutions the GRC should prepare a list of priority species with justification for their priority status. There should be provision for the review of priority species periodically.

Germplasm acquisition, characterisation and conservation

- Regarding priority species, GRC should undertake collections in close collaboration with NARS, and arrange acquisition from existing collections.
- Regarding other species, the Centre should play a coordinating and catalytic role in the acquisition (including collecting) of germplasm.
- GRC should have a responsibility for the characterization of priority species. It should also consult with clients (breeders etc) on germplasm requirements and traits for characterisation. It should develop appropriate methodologies as required.
- The Centre would take global responsibility for the maintenance of a base collection of the priority species.

Service Functions

- *Seed supply:* it was considered that the GRC should be in a position to supply seed of priority species for research. This should extend beyond the ICRAF networks.
- *Microsymbionts:* the supply of *Rhizobium* and other microsymbionts is an important service function. The activities of GRC should be limited to acquisition, selection, strain maintenance, and the application of existing technologies of inoculant production and distribution. The Centre should have a role in determining the necessity for inoculation and the formulation of inoculants.

The GRC should maintain links with specialist institutes conducting research on symbiotic micro-organism.

- *Information and Documentation:* arrangements should be made for the acquisition, storage and distribution of information related to the germplasm for which the GRC has responsibilities.

  Linkages, including feed back mechanisms, with the CGIAR centres, NARS and other ICRAF programs should be clarified.

- *Germplasm Health:* high standards of seed health are a must for an international germplasm distribution centre. The centre should have appropriate capacity to deal with pathological and entomological problems.

Research to Support Service Functions

As a general principle research conducted within the GRC will be focused on solving problems associated with the service function of the centre.

- *Genetic Studies:* the Centre should conduct research on the reproductive biology, breeding systems and genetic diversity to the extent necessary to support its germplasm acquisition and characterisation of priority species. It should not undertake more classical tree breeding activities.

The group considered the GRC should have the capacity to apply existing technologies, such as isozyme analysis, as tools to support its genetic studies and other service functions. It was not considered appropriate for the Centre to be involved at this stage in more advanced biotechnologies e.g. RAPDs.

- *Seed Accessions:* the GRC should take responsibility for applying, and if necessary, developing methods to determine the correct identity of its germplasm (e.g biochemical techniques).

- *Characterisation:* in consultation with MPT breeders, the centre should develop guidelines for the characterisation of MPT germplasm so that promising material is used effectively in agroforestry systems research.
- *Seed Studies:* research on seed germination, handling and storage should be undertaken to overcome problems experienced with germplasm use and conservation within the GRC. The scope and level of this research will be dependent on the characteristics of the priority species.

Staffing

The group consider the following staffing arrangements are appropriate:

Officer in charge:	a scientist with management skills
Assistant to O/C:	possibly with data management skills
Plant Explorers:	up to 4 persons with responsibilities for field collections and characterisation of collected germplasm. (There was divergence of opinion in the group on whether the explorers be located at HQ or outposted).
Seed Technologist:	appropriately qualified scientist to undertake research associated with seed testing, handling and storage
Population Geneticist:	a scientist to undertake genetic diversity, reproductive biology and breeding systems research.
Microsymbiont Technician:	Routine microsymbiont activities could be carried out by trained technician. It could be desirable for this work to be undertaken under the supervision of a scientist with microbiological skills, possibly a secondment from outside ICRAF.

Seed Health Technician: this person would handle routine seed health and quarantine activities. GRC should explore arrangements for the attachment of a local quarantine service official. It should also arrange for close collaboration i.e supervision of the technician by qualified pathologists/entomologists elsewhere in ICRAF.

Laboratory Facilities

- There are not specified but should be commensurate with the service and supporting research functions

- A specialized tissue culture laboratory was not considered appropriate at this stage, although tissue culture facilities may be developed elsewhere in ICRAF.

Name of Centre

- There was a suggestion that the GRC should be known simply as the Germplasm Centre. There was no consensus on this matter.

Plenary discussion of W.G. 2

1. Comment Hans Muhs raised several issues in relation to

a) name of Centre and use of the word "Resource" and what this word implies.
b) environmental issues related to movement of germplasm off-site and effects on natural ecosystems by the introduced germplasm.
c) Wide range of legal issues related to germplasm e.g international rules, plant property protection for improved material, sovereign rights etc.

P. Sanchez responded that ICRAF plans to appoint an agroecologist in Programme 1 to look at *ex ante* effects of ICRAF activities. For legal issues ICRAF will be guided by *CG* and IBPGR in particular. A much broader issue than just ICRAF.

2. Ques. What does the group mean by the need to present a list of species for collection? J. Brouard

Ans.

a) Species selection driven from grass-roots level within ecoregionally based programmes. F. Owino

b) Species list should be presented by ICRAF but list should not be "frozen" thus allowing charges in direction if needed. J. Turnbull.

c) By naming species of interest to ICRAF it avoids duplication by others. It also allows ICRAF in plan collection programmes long-term and refine the MPT-GRC research programme according to needs. D. Boland.

3. Comment Paul Singleton stressed the potential service role of the MPT-GRC for microsymbionts. Research not so critical initially. Main activities to focus on training, distribution of rhizobia, strain characterisation etc.

4. Comment Prof. Hawkes recommended that ICRAF must give greater emphasis to collaboration and that this should be reflected in any documents.

5. Comment Carlos Lascano indicated that the ICRAF proposal as presented to the Consultation was weak in the area of linkages between the MPT-GRC and other research programmes (outside Programme 2) within ICRAF.

6. Ques. Why no mention of vegetative storage? J. Hanson

Ans. Target species need to be refined first. R. Schultz-Kraft.

REPORT OF WORKING GROUP 3:- NARS COLLABORATION WITH MPT-GRC OF ICRAF

Introduction

The Working Group recognizes that there is a need for ICRAF to have a MPT-GRC. The working group stresses the importance for the MPT-GRC to collaborate with and strengthen national and regional capacities.

Networks

- ICRAF should identify national, regional and international networks and centres worldwide working on MPT Germplasm research. ICRAF should capitalize on the networks strength and alleviate weaknesses.
- ICRAF should facilitate efficient communication and collaboration between national, regional and international MPT Germplasm research networks/centres.
- Establishment of networks should also be considered on species (or group of species) basis within ecozones.
- ICRAF should consider sub-contracting biotechnological work with relevant centres of excellence.

Training

ICRAF should collaborate in assessing the needs for training in the MPT field at general, specific and practical levels in the 3 regions and collaborate with other institutions to provide appropriate training. This should be achieved by co-organising or co-sponsoring training activities.

Field collections

The target species of ICRAF programme should be selected in collaboration with national, regional and international institutions.

For research field collections ICRAF should collaborate with national, regional and international organisations having appropriate expertise. Co-organising, co-sponsoring or contracting may be envisaged, the most efficient and cost-effective solution being chosen in each particular operation.

When national expertise is not available, ICRAF should undertake the field collections with national staff, taking this opportunity to provide training on prospection/collection methods.

Staffing

Start small.

Staffing in the MPT-GRC should progressively expand only after a felt need is identified in collaboration with its research partners.

Plenary discussion of W.G. 3

1. Comment P. Cooper indicated that the main clients of the MPT-GRC were ICRAF staff and collaborators but also other researchers upon request. ICRAF will be actively collaborating with NARs.

2. Comment J. Weber indicated that ICRAF should establish networks for particular species within ecozones globally. This was supported by O. Souvannavong.

3. Comment Hans Muhs indicated that ICRAF should build strong links with a wide range of Institutions world-wide. Consultancies on special issues could also be arranged. Also recommended a kind of advisory board (internationally recruited) to help guide activities and avoid mistakes.

4. Comment Jean Hanson indicated that one of ICRAFs major strengths is that it has worked actively in the past with national programmes and this good track record should be maintained.

5. Comment Jim Brewbaker drew attention to the potential need to financially support NARs. T.J. Ruredzo mentioned that this was discussed in the W.G. 3 meeting and that collaboration with NARs inevitably involves financial inputs.

PART C

LIST OF NAMES AND ADDRESSES OF PARTICIPANTS TO THE MPT-GRC CONSULTATION 2-5 JUNE 1992 - LIST DIVIDED INTO NON-ICRAF AND ICRAF PARTICIPANTS

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