

**LEUCNET**

# LEUCNET: The leucaena research and development network

## Background

LEUCNET is a network of scientists and institutions who share common interest in improving the productivity and utility of leucaena by growers. The concept was considered and endorsed at the workshop reported in these Proceedings. Workshop participants strongly supported the formation of the Network to facilitate coordination and communication of leucaena improvement among scientists, extension workers and farmers. An interim Coordinator and a Steering Committee were appointed on 30 January 1994, and are listed in Appendix 1.

## Introduction

The genus *Leucaena* Benthham contains 16 or 17 species of N-fixing tree legumes indigenous to the Americas (Table 1). It appears to have been used by man for several millennia, and continues to be conserved and cultivated by farmers from Texas to Peru. From this region, one species (*Leucaena leucocephala* (Lam.) de Wit) has spread to most countries of the tropical world. It is also the most widely planted species and is known colloquially as leucaena.

**Table 1.** Leucaena species and characteristics (after Brewbaker and Sorensson 1993).

No.	Species	2n	Biomass	Psyllid tolerance	Elevation Range (m)	Mature height and DBH	
						(m)	(cm)
1	<i>L. collinsi</i>	52, 56	med	high	400-800	15	20
2	<i>L. cuspida</i>	-	v. low	-	1800-2000	5	5
3	<i>L. diversifolia</i>	52	high	high	700-2500	17	17
	<i>L. diversifolia</i>	104	high	med	500-1500	20	30
4	<i>L. esculenta</i>	52	med	high	700-2000	15	27
5	<i>L. sp. 'glossy'</i>	112	v. low	med	1900-2400	7	15
6	<i>L. greggi</i>	56	low	med	1200-1800	7	13
7	<i>L. lanceolata</i>	52	med	low	0-800	13	25
8	<i>L. leucocephala</i>	104	high	low	0-900	20	40
9	<i>L. macrophylla</i>	52	low	med	400-1500	8	13
10	<i>L. multicapitula</i>	52?	med	low	0-200	17	50
11	<i>L. pallida</i>	104	high	high	1500-2100	13	15
12	<i>L. pulverulenta</i>	56	med	low	0-1500	20	35
13	<i>L. retusa</i>	56	low	high	500-1400	5	5
14	<i>L. salvadorensis</i>	56	med	med	200-800	20	50
15	<i>L. shannonii</i>	52, 56	med	med	0-900	15	30
16	<i>L. trichodes</i>	52	low	low	0-600	12	17

Leucaena has demonstrated a wide environmental adaptation and a great variety of uses. It possesses a combination of attributes, perhaps without parallel in other species.

The limitations of leucaena are now better understood and include susceptibility to the psyllid insect pest (*Heteropsylla cubana*), lack of adaptation to cool temperatures or frost, and lack of tolerance to strongly acid or waterlogged soils. The damaging effect of the psyllid, in particular, has halted promotion and new plantings in many regions. Without new strategies to tackle these limitations, the great expectations predicted for leucaena during the 1970s and 1980s will not be realised.

There is general recognition that the present germplasm used around the world is very narrowly based on one species (*L. leucocephala*), a self-fertilised polyploid with low genetic diversity. The huge areas of leucaena naturalised globally represent only a small fraction of the genetic resources available in the leucaena genus.

There are strong reasons to re-examine the leucaena genus and to develop some of the lesser-known species for the benefit of the farming systems and rural communities of the tropical world. Many of these species have characteristics which are potentially very useful to agriculture.

Resources available for agricultural research and development are declining worldwide while ease and desirability of cooperation are increasing. The benefits of integrated and collaborative effort are increasingly recognised and encouraged. Research administrators and donors rightly stress the importance of closer linkages between researchers, extension workers and rural communities. New research initiatives which lack effective links with farmers often lack credibility.

There is a need to integrate the global efforts of leucaena R & D workers for mutual benefit and enhanced effectiveness. LEUCNET (an acronym for Leucaena Network) has been proposed and developed as a loosely structured network of all those interested in leucaena to achieve this aim.

### **Objectives of LEUCNET**

The general objective of LEUCNET is to provide a structure to enhance collaboration and communication between scientific, communication and extension groups working on research, development and promotion of leucaena for the benefit of rural communities around the world. The Network will not direct the research endeavours of members but will facilitate cooperation among groups and individuals in the network. The specific objectives of LEUCNET are to:-

Provide a cooperative network structure to more effectively integrate the efforts of the many individuals and groups around the world working on aspects of leucaena R & D. It will facilitate communication of research results and activities among participants of the network. It will provide feed-back and two-way communication between research groups and growers on important issues faced by farmers introducing leucaena into their farming and forestry systems.

Foster cooperative research projects within the LEUCNET framework that exploit the lesser-known species and hybrids of leucaena.

Ensure more efficient use of decreasing resources for leucaena improvement at a time when international research funds are limited but new developments offer exciting new possibilities.

Provide a structure for ensuring the flow of outputs from research projects to the end-user, the farmer. This should broaden the appeal of research proposals with a disciplinary focus and make them easier to justify in terms of relevance to global leucaena R & D.

### **Coordination and Communication in LEUCNET**

The interim Liaison Coordinator will take responsibility for establishing a sound and ongoing network. The Coordinator will be required, with support from the members of the Steering Committee, to seek a more permanent arrangement for the continuing function and expansion of LEUCNET activities. This may require modest physical and financial support from an appropriate institution to set up a small office for the administration and promotion of LEUCNET activities.

The permanent Coordinator might be assisted by a number of Regional Coordinators representing Southeast Asia, Africa, Europe and North America, South Asia, Central and South America and Australasia.

An important aim of LEUCNET is effective communication among members. Communications should report the R & D activities of members, stimulate and catalyse collaborative projects among members, and ensure the promotion of new germplasm and new management recommendations to extension workers and farmers. Communication will ensure both improved leucaena production where it is already grown and expansion to new areas.

It is envisaged that communication would initially be among members of LEUCNET, some 200-400 people. Wider distribution may be desirable at a later date.

To meet these needs, four types of publication were envisaged:

**Newsletter.** During the first year of LEUCNET, an inexpensive newsletter format will be adopted to inform members of relevant issues. In view of the 83 or so existing newsletters of relevance to foresters and agroforesters, it may be possible to combine LEUCNET communication with an existing newsletter (e.g. with a one page insert) with little delay and at low cost. Use could be made of these newsletters to publicise the formation of LEUCNET.

The LEUCNET Newsletter should ensure information is brought to the attention of members on such matters as: communication of research results; new initiatives in leucaena R & D; achievements of members and groups; forthcoming conferences and workshops; and highlights of workshops and conferences.

**Technical Reports.** These could take a number of forms, viz. catalogue of international germplasm availability; catalogue of insect pests and diseases with colour plates for field workers; annotated bibliography of leucaena research articles; revival of the journal *Leucaena Research Reports*.

**Manual.** 'How to' manuals on topics of practical significance such as revision of the leucaena forage, wood production and use manuals.

**Highlights.** These would be directed at leucaena extension workers and farmers, and would be one page communiques aimed at specific issues. Examples include: leucaena for cool regions; leucaena for chickens; leucaena for wood, etc.

A logo will be created as a symbol of all LEUCNET related activities. Other communication issues might include the provision of training courses, workshops and field days; translation of existing information to other languages; and publicity for LEUCNET activities.

### **Collection, Conservation and Breeding of Germplasm**

The genetic resources of genus *Leucaena* have been more thoroughly explored and collected than other tropical woody legume genera. All major species are well represented in three major germplasm collections. These are located at CSIRO Division of Tropical Crops and Pastures in Brisbane, University of Hawaii, and at Oxford Forestry Institute at the University of Oxford. Other collections are held at CIAT in Colombia, ICRAF in Kenya and at ILCA in Ethiopia. Further collections are therefore not a high priority at present.

Given the severe degradation of native populations of leucaena, germplasm needs to be protected in situ to conserve native populations. Despite large germplasm collections, adequate measures have not been put in place for genetic conservation.

A major need is for expanded evaluation of the germplasm in these collections. Evaluation will provide a sound basis for prioritising material for seed increase and for identifying genetic material for core collections. However, a coordinated approach is now needed to evaluate, rationalise, select and deploy material from these collections. An integrated germplasm catalogue is urgently needed to avoid continued confusion over their content and identification systems. Sound guidelines are required for the rational use of these collections.

The potential for genetic gain through breeding has been clearly demonstrated in leucaena, primarily through species hybridisation. More than 90% of the possible combinations have been tested. Many of the hybrids now growing have potential commercial importance. Population improvement through selection should also be a core activity in evaluation and seed orchard research. A basic need is for methods of vegetative propagation to permit full exploitation of hybrids.

Priority issues that need to be addressed by LEUCNET include:

A World Leucaena Germplasm Catalogue which summarises seed quantities held in international seed banks and provides minimal passport data for users. This catalogue would need to be periodically updated with new germplasm additions and new information such as performance and quality data.

The identification of major gene diversity groups (about 40) among the known leucaena taxa to be placed as core collections in permanent seed storage in 2-5 banks. A subset of these groups needs to be selected and seed increased for R & D work. A basic and applied research program on seed orchards, both in situ and ex situ, needs to be conducted with linkages to seed producers.

Expansion of breeding activities to develop new cultivars which optimise combinations of high quality and high yield for forage and wood. Methods for induction of tetraploids are needed to facilitate gene transfer to commercial species. Simple guidelines should be developed for genetic advance and maintenance of heterosis in provenances from lesser-known diploid species.

Refinement of clonal methods to permit large-scale production of hybrids including seedless triploids.

Support for Latin American farmers and organisations to protect and maintain native species in cultivated or semi-natural stands. Policy guidelines are required for the promotion of gene conservation in situ in Latin America.

### **Germplasm Trials and Seed Production**

A central platform of LEUCNET will be germplasm evaluation trials. These will be coordinated by the Oxford Forestry Institute (OFI) and will comprise three main trial types:

[a] Species/provenance/hybrid evaluation trials

These multi-location germplasm trials will initially form the main collaborative activities of LEUCNET. The trials will include representative germplasm from most major gene diversity groups in leucaena based on the OFI collection but including germplasm from other sources as available, such as key University of Hawaii (UH) populations and hybrids, and CSIRO accessions.

[b] Complete foundation collection trials

This would involve unreplicated within site observation of the complete OFI seed collection, with additional seed supplied of significant lines from UH, CSIRO and other collections. These trials would be established at a few sites only because of the large number of entries and the large resource input involved.

[c] Provenance/progeny trials of *L. diversifolia*

A smaller set of *L. diversifolia* trials is planned to examine the diversity in this important species.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Identification of the main ecological zones to be included in the multisite germplasm trials. It was recommended that these should include:

- a) Highland tropical
- b) Lowland tropical (humid)
- c) Lowland tropical (semi-arid)
- d) Subtropical

Within these zones, sites should be selected with a range of characteristics including soils of low pH and fertility. Site descriptions will be required which provide comprehensive standardised information on soils and climate.

Suitable collaborators need to be identified. Collaborators representing the main agroecological sites will not need to be solicited as most national institutions requesting participation in the trials are located on or have access to representative sites in the above zones. Collaborators will be required to develop a plan to show how useful material will be distributed to end users.

Regional coordinators need to be appointed to oversee sites in geographical regions. There will be too many sites for adequate supervision and assistance to be supplied from OFI. Regional coordinators would assist with trial management and data collection and analysis in their region with direction from OFI. They would visit sites in their region at least annually and help maintain the enthusiasm of the collaborators. They would need to be funded for travel and other costs.

A full set of germplasm should be assembled by OFI in conjunction with other institutions such as CSIRO and UH. Germplasm and rhizobium will be distributed by OFI possibly as early as mid-1994.

Simple robust trial designs need to be developed which can be modified to accommodate regional priorities. However, where possible, standardisation of design, management and measurement is desirable to enable comparison and analysis of results across the range of sites. It is desirable that data sheet design can be modified to suit local requirements. Species of local significance should be incorporated into the design as controls.

Two basic trial designs are recommended for (a) wood production, and for (b) forage production. Measurements should include not only biomass (wood and foliage) but also observations on survival, early growth, insect and disease attack.

Results will be collated by OFI and disseminated to collaborators and others via the LEUCNET publications.

Elite germplasm will be identified for selection, seed increase and dissemination to national programs. LEUCNET will provide technical support for adaptive and participatory research.

### **Strategic Benchmark Research Programs**

At the Workshop, a survey of priorities for strategic benchmark research on leucaena was conducted among the 58 participants from 19 countries representing all major tropical geographical regions of the world. The results of this survey are summarised in Table 2.

Eight key priorities areas for R & D focus were identified. These were considered by workshop participants and key issues and recommendations identified for each of the priority areas as described below.

#### **Acid soil tolerance**

Currently, the cultivation of *L. leucocephala* is limited to alkaline, neutral and mildly acid soils of the world and it generally performs poorly on the severely acid soils (pH < 5.0) of Latin and South America and Asia. Acid tolerance in leucaena would greatly extend the range of adaptation of this valuable genus.

In general, it is thought unlikely that leucaena species can be found for strongly acid soils (pH < 4.0). However, there are many examples of the biotic adaptation of important crop species being extended well beyond their original environmental range through selection and breeding. This is a costly and long-term activity and it may be more appropriate to examine other MPT genera for strongly acid soils.

Since little is known about the adaptation and genetic variation in leucaena species for acid soils, this aspect needs to be explored before a definitive judgement can be made concerning prospects for developing an acid tolerant leucaena.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Screening of accessions on acid soils to explore the range of variation among leucaena provenances and accessions. An assessment needs to be made of the potential for developing truly acid tolerant leucaenas.

A detailed review of acid tolerance in leucaena.

Table 2. Leucaena R & D priorities: values in columns show priority ratings as percentages out of 100 for each region).

Region	Africa [4] <sup>1</sup>	America [5]	Australia [12]	Asia [18]	Global [5]	Overall Average [44]
<b>1. Limitation</b>						
<b>Environmental</b>	<b>57</b>	<b>40</b>	<b>34</b>	<b>45</b>	<b>35</b>	<b>41</b>
(a) Cool/Frost	6	14	9	2	4	6
(b) Acid soils	22	10	3	9	9	9
(c) Psyllids	8	0	15	17	8	13
(d) Other	21	16	7	17	14	13
<b>Agronomic</b>	<b>9</b>	<b>21</b>	<b>13</b>	<b>11</b>	<b>28</b>	<b>15</b>
(a) Establishment	5	15	8	6	9	7
(b) Seed production	3	5	4	4	12	5
(c) Other	1	1	1	1	7	3
<b>Management</b>	<b>11</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>6</b>	<b>10</b>
(a) Farming systems	9	5	5	6	0	5
(b) Other	2	7	6	4	6	5
<b>Forage Quality</b>	<b>14</b>	<b>15</b>	<b>32</b>	<b>10</b>	<b>10</b>	<b>17</b>
(a) Animal production	7	5	10	5	0	6
(b) Tannins	6	6	15	1	7	6
(c) Other	1	4	7	4	3	5
<b>Wood Utilisation</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>10</b>	<b>2</b>	<b>6</b>
<b>Adoption</b>	<b>5</b>	<b>8</b>	<b>8</b>	<b>14</b>	<b>19</b>	<b>11</b>
<b>TOTAL</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>2. Germplasm interest</b>						
<i>L. leucocephala</i>	28	39	43	41	37	40
Other <i>Leucaena</i> spp.	38	42	34	30	39	34
Leucaena hybrids	23	21	22	20	18	20
Seedless triploids	11	0	1	10	6	6
<b>TOTAL</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

<sup>1</sup> Number of respondents

## Cold and frost tolerance

Some leucaena species thrive in subtropical (occasional frosts) and highland tropics (cool temperatures). Good cold tolerance exists within *Leucaena* germplasm and there is considerable genetic variability among provenances, particularly in *L. pallida* and *L. diversifolia*. However, few data are available on cold and frost tolerance of leucaena species other than *L. leucocephala* which ceases growth at around 15°C. Frosts will defoliate plants and kill above ground stem growth although they will usually regrow from the crown in the following season.

Overall, the prospects for finding cold and frost tolerant *Leucaena* species are higher than those for finding *Leucaena* species for strongly acid soils.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Characterisation of species, provenances and hybrids for adaptation to cold temperature and frosts. This can be achieved through the multi-location trials using an extended set of likely germplasm. Testing of the mechanisms of cold and frost tolerance are recommended at sites with appropriate resources.

Assessment of the nutritive value of cold tolerant species other than *L. leucocephala*. Such species may be inferior to the well tested *L. leucocephala* in feeding value for livestock.

## Psyllids and other pests and diseases

There are reports from many regions that the damage caused by psyllids is now less severe than when psyllids first appeared and psyllid-tolerant varieties and hybrids are now in wide evaluation. However, there is potential danger from a resurgence of *Heteropsylla cubana* and from the appearance of other pests which may also feed on *Leucaena* species. The University of Hawaii leucaena psyllid trials demonstrated resistance in many accessions and species. However, more work remains to be done.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Continued study of the variability in genetic resistance among provenances within *Leucaena* species.

An expanded breeding, backcrossing, and selection program for psyllid tolerant populations high in nutritive value. There are indications that resistant germplasm may be inferior in nutritive value and this must be thoroughly researched.

An understanding of the genetic control and mechanisms of resistance to psyllids. This aspect requires research to accelerate efforts to breed psyllid resistance.

Release of effective enemies/predators of psyllids in countries where such predators are absent. This should be done with due regard for quarantine requirements.

Production of a catalogue which describes and illustrates the diseases and insect pests of leucaena. The catalogue would be distributed to leucaena field workers around the world for easy identification of pests.

Continuing studies on the native pests and diseases of leucaenas in Latin America to help prevent future occurrences similar to the psyllid problem.

Development of quarantine guidelines for the safe movement of seed to prevent spread of pests such as bruchid beetle larvae, other pests and diseases. This may require research on seedpathogen associations.

## Establishment

In extensive systems, leucaena establishment is a continuing problem. However, solutions to many of the causes of poor establishment are known from prior research and the problem is really one of technology transfer. It is acknowledged that there is a need for local information (e.g. on fertilizer rates etc.) but these are not seen as major research problems.



In developing countries the main establishment problems relate to techniques of raising seedlings and to weed control.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Study of potential for achieving faster seedling growth by more effective exploitation of rhizobial and mycorrhizal symbioses.

Investigation of root/shoot ratios and root morphology in new leucaena provenances and hybrids and the role of root characteristics in seedling establishment.

Screening of selective herbicides for weed control in young leucaena stands.

Standardised procedures to assess and maintain seed quality.

## **Propagation**

There is great interest in vegetative propagation methods to facilitate wide scale plantings of elite genotypes and the production of hybrid seed. However, production of rooted cuttings has been inconsistent and may lead to poor root system development. Grafting procedures are straightforward but labour intensive. There is a number of potential problems with seed production of cross-pollinated species of leucaena.

Priority issues and recommendations that need to be addressed by LEUCNET include:

A simple, effective and consistent method of vegetative propagation with emphasis on cuttings and grafts for micro-propagation.

A thorough study of the influence of propagation method on root system development as influenced by soil types.

Improved seed production from studies of pollination biology, pollinating insects, flower synchronisation, and tree spacing and dwarfing methods to promote ease of seed harvest, especially of hybrid seed.

## **Forage quality**

The psyllid plague and the poor performance of *L. leucocephala* outside its ecological range has focused attention on other species and hybrids in the *Leucaena* genus as sources of psyllid resistant and environmentally adapted (cool and acid soil tolerant) plants. However, these other species and hybrids are largely untested for forage productivity and animal production potential.

Agronomic testing of new species and hybrids must be accompanied by evaluation of animal responses to leucaena feeding in different farming and production systems. *Leucaena leucocephala* has proven quality as a forage and is the benchmark species for comparisons.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Measurement of animal production potential of the new psyllid tolerant and cold tolerant species (*L. diversifolia*, *L. pallida* etc). The palatability and nutritional constraints on these species as both a supplement and sole feed for ruminants require study.

Assessment of variation in chemical composition, palatability and quality (in vitro digestibility) in relation to environment and plant genotype.

Elucidation of the biological and nutritional significance of variable tannin levels in *Leucaena* species and hybrids.

Elimination of mimosine toxicity in ruminants where this is still a problem by use of DHP-degrading bacteria (*S. jonesii*).

Exploration and identification of other bacteria to degrade potentially harmful secondary plant metabolites eg. tannins.

## **Farming systems research**

There is a continuing role for multipurpose tree legumes, such as leucaena, in tropical farming systems to address the problems of land degradation, productivity decline and the instability of current systems.

Leucaena is appropriate for use in this role because it produces fuelwood, fodder and timber and has a service role in soil fertility improvement and slope stabilisation.

In the past there have been difficulties with adoption of the results from farming systems research in general and from systems involving leucaena in particular. For example, there has been a poor record of transfer or extension of alley cropping technology to end users. There has been little research into markets and the socio-economic implications of new MPT systems have often not been taken into account.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Identification of systems where leucaena may be used. This may involve substitution for currently used species, eg. replacing *Eucalyptus* with *Leucaena* spp. where appropriate.

Evaluation of markets for leucaena products or end use. The commodity should be vertically integrated into the market.

Evaluation of improved fallow systems with leucaena.

Investigation of methods for reclaiming degraded/underutilised lands such as the extensive *Imperata* grasslands of Asia and the Pacific with MPTs such as leucaena.

Evaluation of the new species of leucaena as a nurse or support tree for high value timber species and obligate shade species eg. vanilla.

## **Wood quality**

Leucaena species are widely preferred, managed and sometimes cultivated in Mexico and Central America for wood production. MPT species for wood use are also valued in Asia and Africa. However, there is little published wood quality information on *Leucaena* species other than *L. leucocephala*, which is generally described as being strong, of medium hardwood density, easy to work and producing an attractive finish.

Leucaena wood has a wide range of uses from traditional small scale use by village farmers to large scale industrial use for pulp and generation of energy. Its principal value will continue as a source of wood products for small-scale rural use.

Priority issues and recommendations that need to be addressed by LEUCNET include:

Study of the comparative wood quality of all leucaena species for fuelwood and other uses. Other species than *L. leucocephala* are preferred for wood uses in the native range of leucaenas. Notably *L. salvadorensis*, *L. collinsii* spp *collinsii*, *L. collinsii* spp *zacapana* and *L. sp nov* 1. are considered superior in terms of durability, strength and fuelwood characteristics.

Establishment of guidelines for plantation management, spacing, pruning and thinning, and harvest cycle for superior leucaena genotypes for wood.

## **Participatory Research and Grower Adoption**

Participants recognised that lack of attention to participatory research and poor grower adoption has limited development of leucaena. The workshop gave high priority to increased rates of adoption. It is anticipated that closer collaboration between social and biological scientists and farmers will develop through collaboration on the issues raised below.

A better understanding of the issues which affect adoption of leucaena will lead to improved uptake of existing and new technologies.

Priority issues and recommendations that need to be addressed by LEUCNET include:

A better understanding of the needs of leucaena users, particularly those with long-term experience. An understanding of the social and economic factors which have importance in determining patterns of use is required. A better understanding of social (eg. seasonal labour availability, land tenure rights) and economic factors (eg. markets, finance) is an essential first step in improving adoption and uptake of research results.

Development of 'on farm' as well as 'on station' research programs and involvement of farmers in the early stages of programs. Adaptive research should be undertaken with farmer participation in design, and the research should be market driven and where possible focus on smallholders.

Increasing awareness and understanding by leucaena researchers of the methods developed by social scientists to facilitate participatory research with farmers.

Education of the extension workers and national researchers in proven technologies relating to leucaena and other MPTs. This could prevent unnecessary failure of projects and loss of farmer confidence.

Application of techniques such as rapid rural appraisal (RRA), and participatory rural appraisal (PRA) in selected areas where leucaena is already used or where 'on farm research' has been established.

Wider dissemination of information on techniques used in RRA and PRA to leucaena researchers through LEUCNET. RRA and PRA exercises need to be considered where introduction of leucaena to new areas is proposed. Information gathering exercises need to have standardised approaches so that the results obtained can be of general benefit to leucaena users.