

Leucaena Research in the Asian-Pacific Region

**Proceedings of a workshop held
in Singapore, 23-26 November 1982**

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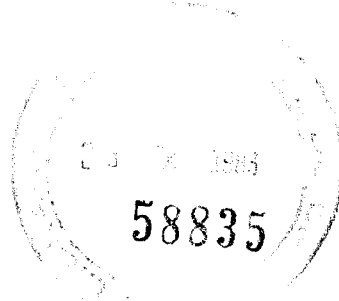
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Leucaena Research in the Asian–Pacific Region

**Proceedings of a Workshop Held in Singapore, 23–26
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Abstract

Because of *Leucaena leucocephala*'s multiple uses as forage, fuelwood, poles, green manure, etc., this fast-growing, nitrogen-fixing tree has been the subject of much research in the last decade. The results have clarified the capabilities of the plant as well as its limitations. One main constraint to cultivation in vast areas of Latin America and Southeast Asia has been *leucaena*'s inability to survive on acidic, aluminum-saturated soils. At low pH, the aluminum complexes with calcium, which is essential for good growth. Trials have shown that some varieties of *L. diversifolia* can make use of the calcium from the complexes and that crosses between these varieties and *L. leucocephala* perform well on acidic soils. The main constraint to use of *leucaena* as a forage derives from the plant's content of mimosine, a toxic, nonprotein amino acid. Although *leucaena* has proved to be a highly nutritious animal feed, the mimosine and its breakdown product, DHP (3-hydroxy-4[1H]pyridone), have caused toxicity among animals fed high levels of leaf meal. Scientists now have evidence that the mimosine is converted into DHP when brought into contact with an enzyme contained in some of the plant's cells harbouring mimosine. This finding needs follow up; it suggests that simple processing, such as chopping fresh leaves, will convert all the mimosine into the less-toxic DHP. Elsewhere, researchers have found that DHP can be metabolized by anaerobic microorganisms that have been found in the guts of ruminants in countries like Indonesia. They have successfully transferred the microorganisms to animals in Australia where toxicity from DHP has deterred graziers from using *leucaena* as forage. Other research has defined optimal approaches to breeding and genetic improvement of *leucaena*; characteristics of rhizobia that effectively provide the plant with nitrogen-fixing ability; biomass production under widely different soil conditions; effects on fish, poultry, cattle, goats, and sheep fed *leucaena* leaf meal; management and cultural practices for both large-scale and smallholder operations; etc. The results are the subject of this publication, which comprises 30 papers from researchers in the Asian-Pacific Region.

Résumé

Leucaena leucocephala a fait l'objet de nombreuses recherches au cours de la dernière décennie, cet arbre légumineux fixateur d'azote et de croissance rapide ayant de nombreux usages comme fourrage, combustible, poteau, engrais vert, etc. Ces études ont permis d'en délimiter les fonctions. L'un des facteurs limitants de sa culture dans de vastes régions de l'Amérique latine et de l'Asie du Sud-Est est l'incapacité de *Leucaena* de survivre dans des sols acides, saturés d'aluminium. Dans le cas d'un faible pH l'aluminium complexe le calcium, essentiel à une croissance régulière. Des essais ont démontré que certaines variétés de *L. diversifolia* peuvent utiliser le calcium présent dans les complexes et que les croisements entre ces variétés et *L. leucocephala* prospèrent dans des sols acides. Le principal obstacle à l'utilisation de *Leucaena* comme fourrage est sa teneur en mimosine, acide aminé non protéique toxique. Bien que ce fourrage soit hautement nutritif, la mimosine et DHP (3-hydroxy-4[1H]pyridone) ont provoqué des cas de toxicité chez les animaux consommant de grandes quantités de farine de feuilles. Les scientifiques ont découvert que la mimosine se décompose en DHP lorsqu'elle entre en contact avec une enzyme contenue dans certaines cellules où elle est présente. Cette découverte a permis de déterminer des moyens simples de neutraliser cette substance toxique, tel que le hachage des feuilles vertes qui décompose la mimosine en DHP moins toxique. Ailleurs, des chercheurs ont trouvé que le DHP peut être métabolisé par des microorganismes anaérobiques présents dans l'intestin des ruminants dans certains pays comme l'Indonésie. Ils ont réussi à transférer ces microorganismes à des animaux en Australie où les pasteurs refusent l'emploi du fourrage de *Leucaena* à cause de la toxicité de DHP. D'autres recherches préconisent une approche optimale: de la sélection et de l'amélioration génétique de *Leucaena*; des caractères des rhizobiums qui assurent la fonction de la fixation d'azote chez la plante-hôte; de la production de bio-masse dans diverses conditions de sols très variés; des effets des rations de farine de feuilles sur les poissons, les volailles, le bétail, les chèvres et les moutons; de la gestion et des pratiques culturelles des

opérations des petites et des grandes exploitations, etc. Tous ces résultats sont détaillés dans la présente brochure qui contient trente communications exposées par des chercheurs de la région du Pacifique asiatique.

Resumen

Debido a los múltiples usos de la *Leucaena leucocephala* como forraje, combustible, madera, abono, etc., este árbol, de rápido crecimiento y habilidad para fijar el nitrógeno, ha sido objeto de abundante investigación en la última década. Los resultados han aclarado las capacidades de la planta, así como sus limitaciones. Uno de los problemas para su cultivo en vastas áreas de Latinoamérica y el Sudeste Asiático ha sido su incapacidad para sobrevivir en suelos ácidos, saturados de aluminio. A niveles bajos de pH, el aluminio forma complejos con el calcio que es esencial para un buen crecimiento. Las pruebas han mostrado que algunas variedades de *L. diversifolia* pueden usar el calcio de los complejos y que los cruces entre estas variedades y la *L. leucocephala* se desempeñan bien en suelos ácidos. El principal inconveniente para usar la leucaena como forraje proviene de su contenido de mimosina, un aminoácido tóxico no proteínico. Aunque la leucaena ha probado ser un alimento animal altamente nutritivo, la mimosina y su producto de descomposición, el DHP (3-hydroxy-4[1H]pyridone), han causado toxicidad entre los animales alimentados con altos niveles de harina de follaje. Los científicos tienen ahora evidencia de que la mimosina se convierte en DHP cuando entra en contacto con una enzima que se encuentra en algunas células de la planta que contienen mimosina. Este hallazgo necesita seguimiento, pero sugiere que un simple procesamiento, como picar las hojas frescas, convierte toda la mimosina en el menos tóxico DHP. En otras partes, los investigadores han encontrado que el DHP puede ser metabolizado por microorganismos anaeróbicos que han sido hallados en el intestino de rumiantes en países como Indonesia. Ellos han traspasado con éxito los microorganismos a animales en Australia donde la toxicidad del DHP ha impedido que los ganaderos empleen la leucaena como forraje. Otras investigaciones han definido los enfoques óptimos para el fitomejoramiento de la leucaena, las características de la rizobia que efectivamente dotará a la planta de la habilidad de fijar nitrógeno, la producción de biomasa bajo condiciones edáficas ampliamente distintas, los efectos sobre los peces, las aves, el ganado, las cabras y las ovejas alimentadas con harina de hoja de leucaena, las prácticas culturales y de manejo para las actividades a gran escala o del pequeño agricultor, etc. Los resultados son el tema de esta publicación que abarca 30 trabajos de investigadores en la región Asiopacífica.

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The Miracle Tree: Reality or Myth?

Michael D. Benge¹ Science and Technology Bureau, Office of Forestry Environment and Natural Resources, Agency for International Development (AID), Washington, D.C., USA

Research in forestry is 40 years behind that of agriculture, although tissue-culture techniques are a promising tool to speed up forestry research. No matter how fruitful are the findings of research; however, without adequate agronomic inputs, only marginal production will be obtained from trees planted on agriculturally marginal lands. Most of the tree planting (to include leucaena) in the developing countries will take place on agriculturally marginal lands. Demands for increased agricultural production to feed growing populations dictate that arable lands be used for sustained cropping. What people tend to forget is that marginal lands that will not sustain continued cultivation with agricultural crops will not sustain continued cropping with trees either. Trees require fertilizer, water, soil amendment, site preparation, etc. to reach maximum production and sustained yield. This is true of all trees, including leucaena despite its reputation as a miracle tree.

La recherche forestière est en retard de 40 ans sur la recherche agronomique, bien que la technique des cultures de tissus semble être un instrument prometteur pour atteindre des résultats plus rapides. Cependant, si fructueuses que se révèlent les observations des spécialistes, sans une contribution adéquate de l'agronomie, on ne pourra attendre qu'une production marginale des plantations d'arbres en terrains impropres à l'agriculture. Dans les pays en développement, la plupart des plantations (incluant Leucaena), s'effectueront dans des sols de ce genre. Dans ces pays, en effet, l'urgence d'accroître la production agricole pour nourrir des populations de plus en plus nombreuses oblige à consacrer les terres arables à une production agricole soutenue. Ce que l'on a tendance à oublier c'est

que les terres marginales, que l'on ne peut cultiver régulièrement pour en retirer des récoltes soutenues, sont elles-mêmes impropres à entretenir des cultures arbustives permanentes. Les arbres cultivés ont également besoin d'engrais, d'eau, d'amendements du sol, de préparation du terrain pour atteindre un rendement satisfaisant et soutenu. Cette réalité est vraie pour tous les arbres, y compris Leucaena, malgré la réputation qu'on lui a faite d'arbre miracle.

La investigación forestal está 40 años atrás de la agrícola, aunque las técnicas de cultivo de tejidos son un instrumento promisorio para acelerarla. Sin embargo, no importa cuán fructíferos sean los hallazgos de la investigación, sin insumos agronómicos adecuados, la producción de los árboles plantados en tierras agrícolas marginales, será marginal. La mayor parte de la plantación de árboles (para incluir leucaena) en los países en desarrollo tendrá lugar en tierras agrícolas marginales. Las demandas de una producción agrícola aumentada para alimentar las crecientes poblaciones exigen que las tierras cultivables sean usadas para el cultivo sostenido. Lo que la gente tiende a olvidar es que las tierras marginales que no pueden sostener la siembra continua con cultivos agrícolas tampoco podrán sostener la siembra continua de árboles. Los árboles requieren abonos, agua, preparación de suelo, lote, etc. para alcanzar la máxima producción y rendimiento sostenido. Esto es válido para todos los árboles, incluyendo la leucaena a pesar de su reputación como árbol milagroso.

Before asking whether leucaena is a miracle tree, perhaps one should first ask whether other "miracle" crops, such as rice, really were miraculous. On close examination, for instance, IR8 wasn't a miracle rice but a high-yielding variety having certain desirable genetic characteristics, developed at a time when a major aim in development was to increase food production in the Third World. If there were a miracle, it was the scientific input into germ-plasm collection, testing, evaluation, selection, breeding, and development of management practices. However, to obtain the high yields, farmers must apply large amounts of fertilizers, pesticides, labour, etc.

Like the IR8 rice, giant leucaena (Salvador type, common varieties being K8, K28, and K67) was timely, appearing just when the devastating effects of deforestation first came to public attention. As Noel Vietmeyer of the National Academy of Sciences said, "Truly leucaena was a tree whose time had come." This fast-growing, multipurpose, leguminous tree came along when a miracle was needed. Deforestation was taking place so rapidly that

¹ These views are mine and not necessarily those of AID.

little hope was seen in countering it with traditional forest trees, which take many years to mature and are often incompatible with agriculture. *Leucaena* — and later other fast-growing, nitrogen-fixing trees — offered a light at the end of the tunnel. Hundreds of millions of dollars are now being spent on reforestation and related activities by development and donor agencies, multilateral lending institutions, private voluntary agencies, and governments in developing countries. Much of the reforestation is being done with fast-growing trees such as *leucaena*, but much of the money is wasted because of the lack of technical information, which, when available, has not been widely disseminated.

In many of these projects, *leucaena* has grown well, adding to its reputation as a miracle tree. However, its credibility has been seriously damaged by poor performance in many areas. For some: "the wonder ceases" (Halos 1980). Perhaps, through enthusiasm, *leucaena*'s advocates have overstated the case, and expectations far exceed the genetic capabilities of the present germ-plasm base.

Researchers are working from a limited germ-plasm base from a collection made by James Brewbaker and his associates in Hawaii. Because of genetic uniformity, specific varieties of *leucaena* are susceptible to disease outbreaks such as affected potatoes and corn in the past. *Leucaena* is largely self-pollinating; however, there is some outcrossing if the crop is not maintained in isolation (R.J. Jones, personal communication). Perhaps the outcrossing is a blessing because, with the rapid proliferation of *leucaena*, it reduces the potential danger of epiphytotics. With the blessing, another problem has been inherited — varietal impurity — often resulting in unpredictable growth. If *leucaena* is to continue to be a solution to any development problems, its genetic improvement must be given high priority. The miracle rice had a distinct advantage because scientists had a wealth of domesticated varieties with which to work. However, the giant *leucaenas* are little more than "wildlings." The last intensive genetic improvement of the species was by the pre- and postcolonial Mexicans (Nahautl and Mixtec-Zapotec cultures) who selected *leucaena* for superior pod and seed size (Perez-Guerrero, in press).

Traditional foresters, when asked to explain growth differences of certain species of trees planted on the same site, all too often attempt to pass them off as a result of microsite

differences. Rather, these growth differences could be a result of genetic variation caused by outcrossings of nondomesticated species.

Tissue culture, used in the generic sense of the term, is a biotechnique that is proving to be a valuable tool in tree improvement. The private sector is developing super trees (conifers), using tissue culture to clone trees that grow quickly, have superior form, and exhibit improved tolerances. These cloned trees are used for the establishment of seed orchards. Much of this work is closely guarded corporate secrets (Durzan 1979).

Recently, scientists (Venketeswaran and Romano 1982) at the University of Houston have reported the successful cloning, regeneration, and rooting of *leucaena*. This breakthrough has tremendous potential for the genetic improvement of *leucaena* and may help alleviate many of its limitations, such as insect problems, intolerance to saline soils, limited tolerance to acidic soils, etc. Tissue culture provides a relatively inexpensive method of screening thousands of samples of plant material within a small laboratory within a short time. It does away with the costly method of screening by outplanting, which may take years to provide improved varieties. Tissue culture also provides a more controlled atmosphere in which to screen plants. For example, cultured material from various genetic sources could be challenged with different levels of salts in a test for the best tolerance. Also, mutations might spontaneously occur or be induced through tissue culture, creating valuable new phenotypes (Nabors 1976).

Tissue culture is an excellent method of cloning trees that express superior or desired characteristics for the relatively rapid establishment of seed orchards of self-pollinating super trees. I have received reports of single super trees evolving from a stand of trees in which the rest of the trees were not spectacular. Professor Azad Osman (personal communication), University of Mauritius, reported that from one lot of K156 *leucaena* seed sent to him by Brewbaker last year one superior tree emerged from several hundred he planted. All of the trees expressed good growth and were relatively uniform except for one tree, which was outstanding. It was taller than the others; it grew more vigorously; and it developed more and larger leaves than did the others. Aart Van Wingerden (personal communication), Operation Double Harvest — Haiti, reported similar experience with K8. He planted more than 500

seedlings on a difficult site that had low fertility. All of the trees grew well, but one developed "head and shoulders" above the others. Are these specific hybrids, chance crosses, mutants, or tetraploids? No one knows. But these superior trees could be cloned through tissue culture and multiplied to create seed orchards of outstanding trees. The potential is there.

Tissue culture can also be used to develop disease- and insect-resistant varieties as well as plants that are more tolerant to pesticides. Peter Felker (personal communication), Texas A&I University, reported extensive insect damage to leucaena in south Texas, Brazil, and Argentina. Twig girdlers (*Oncideres pustulata* in Texas and *O. saga* in South America) have virtually wiped out some plantings of leucaena, and in one instance a single insect cut down a 3-m tree (Texas size).

A. Kretschmer and R. Bullok (personal communication), Agriculture Research Station, Fort Pierce, Florida, reported that the caterpillars (*Ithome lassula*), larvae of a micro Lepidoptera (moth), are destroying the cannonballs (florets) of leucaena in Florida before they have a chance to mature. As a result, the trees do not set seed. They believe that the insects may also retard growth and reduce yield. Whether all varieties are susceptible to attack is uncertain. Common and Beattie (1982) reported similar findings in northern Queensland, Australia, and, in Bogor, Indonesia. Similar findings have been reported in Puma, India. Bullok has also observed a problem of psillids (sapsuckers) attacking young developing foliage, the effect of which is dieback and retarded growth. I (1979) made a similar observation at Semarang, central Java, Indonesia.

On the brighter side, Pat Dugan (personal communication), AID, Philippines², reported that Bobok Sawmill Company, Benguet Province, has, over the last few years, been able to increase the altitude tolerance of giant leucaena by several hundred metres by incrementally planting the crop up the side of a mountain; this report, however, needs verification.

Research in forestry is 40 years behind that of agriculture (Durzan 1979). Without adequate agronomic inputs, only marginal production will be obtained from trees planted on agriculturally marginal lands, and, unfortunately, most of the tree planting in the develop-

ing countries in the future will take place on agriculturally marginal lands. Demands for increased agricultural production to feed growing populations dictate that lands suited for sustained agricultural production be used for such. If these agriculturally marginal lands will not sustain agricultural production, neither will they sustain the continued cropping of trees.

In this respect, trees are no different from any other crop (such as corn) requiring fertilizer, water, soil amendment, site preparation, etc. to produce maximum and sustained yields. If trees are cropped on a short-term rotation, such as proposed for dendrothermal projects (generation of electricity with wood-fueled steam plants), nutrients mined from the soil will have to be replaced if high yields are to be sustained. Even though leucaena and other leguminous trees fix nitrogen, they need phosphorus for maximum growth. There are other nutrients whose absence will limit leucaena and other tree growth (Benge and Curran 1976). It is reported that adequate levels of molybdenum are necessary for maximum efficiency of nitrogen production by *Rhizobium*, and some research indicates that nitrogen utilization may be linked to phosphorus availability (Allen and Duzan 1982). However, Mike Dow (personal communication) of the National Academy of Sciences recently told me that scientists in the Congo reported to him that, when they applied phosphate to leucaena plantings, growth was depressed. They theorized that the phosphate is complexing with some other trace element, such as molybdenum, such that the uptake is limited. Inadequate amounts of boron also can reduce tree growth (Ladrach 1980).

Little is known about the association of mycorrhizal fungi with leucaena (and with most other trees). Mycorrhizal fungi facilitate the uptake of phosphorus and other nutrients and can transform unavailable forms of fixed phosphorus into forms available for plant uptake. They also increase the efficiency of fertilizer utilization, reducing application costs (Johnson and Menge 1982). Research has shown that, in the absence of mycorrhiza, growth of leucaena (Bob Davis, personal communication) and other trees is reduced, and many trees will not grow unless inoculated.

Most of the agriculturally marginal lands in Asia, especially those dominated by *Imperata cylindrica*, are deficient in phosphorus, and what little is present is in a form unavailable to leucaena. Mycorrhiza can transform this un-

² Now consulting for the World Bank.

available form of phosphorus into available forms; however, the strains of mycorrhiza associated with trees may be absent from these lands (John Gordon, personal communication).

Without adequate amounts of phosphorus, trees will grow poorly on these lands, and continuous cropping with sustained yield will be impossible. This fact became evident with the poor yields of leucaena grown on *Imperata* lands by Mabuhay Agro-forestry Corporation and a Japanese firm in Illegan, Mindanao, Philippines. Concern over this phenomenon has been expressed in response to the optimistic forecasts of leucaena yields from similar lands set aside in the Philippines for dendrothermal projects.

Peter Felker (personal communication) is

planning pioneer research on mycorrhizal association with leucaena and its effect on phosphorus utilization. He will start his research, working with six cultivars of mycorrhiza from a collection from Purdue University, in cooperation with J.A. Menge of the University of California at Riverside. According to Felker, Menge has recently successfully isolated mycorrhiza from mesquite.

In conclusion, unless leucaena (and every other fast-growing, nitrogen-fixing tree) is treated as an agricultural crop, with emphasis being placed on genetic improvement, breeding, nutrient needs, pest control, proper management techniques, etc., it will cease to be regarded as a miracle tree and become a marginal tree on marginal land — a tree whose time has passed.