

Leucaena Research in the Asian-Pacific Region

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

Leucaena Research in the Asian-Pacific Region

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Leucaena Research in the Asian – Pacific Region

**Proceedings of a Workshop Held in Singapore, 23 – 26
November 1982**

*Organized by the Nitrogen Fixing Tree Association and the
International Development Research Centre*

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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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A Farmer's Practical Guide for Giant *Leucaena* (Lamtoro Gung)

Kenneth A. Prussner¹ US Agency for International Development (AID), Jakarta, Indonesia

The adaptability and multiple uses of lamtoro gung (giant varieties of *Leucaena leucocephala*) give it a comparative advantage over other species in large areas of Indonesia where the dry season lasts longer than 3 months. For this reason, the Provincial Development Program is designing and testing cropping systems based on leucaena. Two August 1982 meetings — Lamtoro Gung Workshop and the National Lamtoro Seminar I — provided a forum for exchange of research results and field information on the legume, and participants emphasized the farmers' need for practical information to guide the field implementation of projects including lamtoro gung. A table of crop-management recommendations was drawn up. This table, accompanied by written explanations, provides extension workers and progressive farmers with technical information that can be easily adapted to local conditions. The recommendations for planting and cultural practices are based on the intended use — main purpose — of the crop. The idea is that farmers will choose one of six possible main purposes and follow the procedures recommended for that purpose. Although the recommendations are designed to maximize the primary product, they also allow for secondary products.

L'adaptabilité et les usages multiples auxquels elles se prêtent confèrent aux variétés géantes de *Leucaena leucocephala* (lamtoro gung) un avantage sur d'autres espèces dans de vastes régions de l'Indonésie où la saison sèche dure plus de 3 mois. C'est pourquoi le Programme de développement provincial étudie et fait l'essai de systèmes culturaux à base de *Leucaena*. Deux réunions, en août 1982 (Colloque sur le lamtoro gung et Séminaire national lamtoro) ont servi de tribune pour la publication des

résultats obtenus et pour un échange d'informations sur cet arbre de la famille des légumineuses. Les participants ont insisté sur la nécessité de fournir aux cultivateurs des directives pratiques pour la réalisation de divers projets incluant le lamtoro gung. Une table de recommandations a été rédigée pour les pratiques à suivre, accompagnée d'explications écrites destinées aux responsables de la vulgarisation et aux exploitants de fermes modèles, et que ceux-ci pourront adapter aisément aux situations locales. Les recommandations sur la plantation et les pratiques culturales ont été conçues en fonction de l'utilisation prévue (l'objectif principal) de la récolte. Les cultivateurs se voient offrir un choix de six objectifs principaux éventuels avec, pour chacun d'eux, les méthodes recommandées pour les réaliser. Bien que s'attachant surtout à maximaliser le produit primaire, ces recommandations tiennent compte également des produits secondaires.

La adaptabilidad y los múltiples usos del lamtoro gung (variedades gigantes de *Leucaena leucocephala*) le dan una ventaja comparativa sobre otras especies en grandes áreas de Indonesia donde la estación seca se prolonga por más de 3 meses. Por esta razón, el programa de desarrollo provincial se ocupa en diseñar y probar sistemas de cultivo basados en leucaena. Dos reuniones sobre el lamtoro celebradas en agosto de 1982 proveyeron un foro para el intercambio de resultados investigativos e información de campo sobre la leguminosa, y los participantes hicieron énfasis en la necesidad de los agricultores de una información práctica que guiara la implantación en el campo de los proyectos que incluyen el lamtoro gung. Se elaboró un cuadro de recomendaciones sobre el manejo del cultivo. Este cuadro, acompañado por explicaciones escritas, proporciona a los extensionistas y agricultores una información técnica que pueden fácilmente adaptar a las condiciones locales. Las recomendaciones para las prácticas culturales y de plantío se basan en el uso pretendido —propósito principal del cultivo. La idea es que los agricultores escojan uno de seis posibles propósitos principales y sigan los procedimientos recomendados para ése. Aunque las recomendaciones se diseñan para maximizar el producto primario también sirven para productos secundarios.

Lamtoro gung (*leucaena* varieties with K designations as well as Peru and Cunningham) has generated widespread interest in Indonesia. Many government and nongovernment institutions are implementing research and field activities incorporating the legume, and two important national meetings on the subject were held in 1982. The first was the Lamtoro Gung Workshop, 19–21 August, sponsored by the Ministry of Home Affairs and jointly opened by three ministers (Home Af-

¹ The views expressed in this paper are mine and not necessarily those of AID—Indonesia.

fairs, Environment, and Agriculture). This workshop focused on five provinces — East Nusa Tenggara, West Nusa Tenggara, East Java, Central Java, and the Special Province of Yogyakarta — in which leucaena projects have been launched. The farming practices in these areas are similar, based on rainfed cultivation of small parcels of poor, hilly soils in climates with a dry season that lasts longer than 3 months. Leucaena provided farmers the opportunity to generate income while reducing erosion and improving soil fertility. The results of the workshop were sent to all national, provincial, and district administrators and heads of technical agencies.

The second was the National Lamtoro Seminar I, 23–25 August, which was hosted by the Agency for Research and Application of Technology (BPPT). The organizers of this meeting received 52 abstracts, from researchers and field implementors, of which 41 were selected for presentation. Thus, individuals from all over Indonesia were able to share their research and field experience, and the information presented is not only of general importance for Indonesia but also of international interest. It covers leucaena's uses as fodder for ruminant livestock, hedgerows for reducing erosion, and fermented seed cake

(*tempe* in Indonesia) for food. It also features leucaena varieties suitable at various altitudes from sea level to 1500 m and on acid soils (pH 5.5)

Both national meetings demonstrated that many people and institutions in diverse locations of Indonesia are researching and implementing projects that include leucaena for the purpose of direct use by farmers. Efforts include the development of leucaena-based cropping systems by the Provincial Development Program (PDP); the promotion of hedgerows to reduce erosion in Sikka District; energy research and leaf-production field trials assisted by BPPT; and varietal trials at various altitudes and on acid soils by the Ministry of Agriculture in North Sumatra Province.

PDP's efforts to develop cropping systems for small farmers in East Nusa Tenggara (NTT) Province deserve special mention, especially the work of Roberto Monserrat, PDP agricultural adviser who has cooperated with the Central Research and Development Institute of Food Crops of the Agency for Agricultural Research and Development (Department of Agriculture) and various NTT provincial and local administrative and technical services. During the past 3 years, the focus has been field-station plots and farmers' fields. During



East Nusa Tenggara during the dry season, which will continue another 2 months or more.

1982–83, demonstration plots will be established in 65 villages.

The two national meetings emphasized that leucaena is attractive to farmers because of its ability to generate income and reduce erosion while allowing them to produce food crops. Although this sounds relatively straightforward, the farmers do need to learn new cultural practices for the crop. For example, one farmer who planted leucaena, eventually ripped out 4-m tall trees from his fence row because his food crop yielded comparatively less near the trees than in the middle of the field. He believed that the roots of the leucaena were the problem. Neither the farmer nor the extension worker promoting the use of leucaena realized that the shade, not the roots of the trees, was the problem. Instead of destroying the trees, the farmer needed to coppice them for leaf production at the beginning of the food-crop planting season. He needed to be made aware that he could produce green manure and forage from the trees while producing a healthy food crop. This example is typical of what happens when not enough basic information is available to farmers and extension workers. It prompted the preparation of a list of management recommendations (Table 1), which were attached to the final report of the Lamtoro Gung Workshop.

Explanations of the Recommendations

The Lamtoro Gung Workshop was based on reports of field experiences that were primarily aimed at:

- Increasing farmers' incomes on small areas of land, while
- Improving the environment through erosion control and soil amendment.

These were the guiding principles for the management recommendations as well. Possible large-scale applications (energy plantations, silvipasture systems, and monoculture reforestation) were not addressed.

The recommendations were based on the intended use — main purpose — of the crop. Six possible main purposes were drawn up, and planting procedures and cultural practices that would maximize each one were listed. Farmers can choose the purpose that best suits their needs and follow the practices recommended for that purpose. The technical information has been synthesized from research trials and field-implementation reports from

Indonesia as well as other countries. Nevertheless, the recommendations must be adapted to local conditions.

Before continuing with more detailed explanations, I think some general comments are needed. The term, lamtoro gung, is used for varieties having the K designators such as K6 (Peru), K8, K28, K67, etc. Also included is one variety, Cunningham, released by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Townsville, Australia. Uses for the varieties most common in Indonesia are:

- K8, K28, and K67: firewood and poles. These varieties have fewer and higher branches (except when coppiced) than other varieties, and coppicing causes a substantial increase in branching and leaf production so that K8 and K28 forage yield is similar to Peru and Cunningham.
- Peru and Cunningham: leaf production for animal feed and green manure. These varieties, without coppicing, have more and lower branches than the other K varieties.

Some general points need to be emphasized in the use of the management recommendations (Table 1):

- One main purpose for each location must be selected before planting is done;
- Cultural practices directly relate to the main purpose;
- The planting system depends also on the main purpose and on the cultural practices;
- Leaves and young stems can constitute 100% of the diet of ruminant animals to be fattened for slaughter. Most efficient weight gain is obtained, however, with 40% lamtoro gung leaves and 60% roughage such as grass, straw, or crop wastes;
- Leaves and young stems can make up 30% of the diet of ruminant breeding stock with no ill effects;
- Leaves and young stems can be 5–10% of the diet of chickens, pigs, and rabbits with no ill effects;
- Plant growth is less vigorous at elevations above 500 m, in soils below pH 6, in waterlogged soils, and in saline soils;
- Germination rates can be improved by scarification of the seeds;
- Plant growth is enhanced by atmospheric nitrogen fixation, which is assisted by inoculation of seeds with soil taken from

Table 1. Management recommendations for smallholders growing leucaena in Indonesia.

Planting		Cultural practices			Primary product ^b	Secondary products ^b
Slope	Spacing	Material	Population (seed required)	0-12 months ^a	Older than 12 months	
				Main purpose: Trees for seed		
Slope 0-5%	3 m × 3 m	Seeds, seedlings	1111/ha (0.25 kg/ha)	Continue to harvest seed until tree becomes too tall or rainy season begins		Firewood plus leaves for animal feed when trees are cut
Slope 5-50%	2 m × 5 m	Seeds, seedlings	1000/ha (0.22 kg/ha)			
				Main purpose: Conservation, reducing erosion		
Slope 0-15%	Double rows: 25 cm × 5 m	Seeds	16000/ha (3.6 kg/ha)	A food crop that does not excessively shade the leucaena is planted between the double rows	Replace dead plants; coppice product if diameter is >3 cm	Leaves (5-10 t/ha by fresh weight) for green manure (growing season) or animal feed
Slope >15%	Double rows: 25 cm × 2 m 10 cm × 2 m	Seeds	40000/ha (8.9 kg/ha) 100000/ha (22.25 kg/ha)	A food crop that does not excessively shade the leucaena is planted between the double rows	Replace dead plants; coppice for secondary product if diameter is 3 cm	Leaves (10-20 t/ha by fresh weight)
Terrace	Raised bed: 0.5 cm × 10 m	Seeds, seedlings, stumps	2000/ha (0.4 kg/ha)	Interplanted food crop	Replace dead plants; coppice/induce leaf shed if diameter is >3 cm	Leaves (no measurement of production yet)
Home garden	Bench: 1 m × 2 m 25 cm in the row	Seeds, seedlings, stumps	5000/ha (1.0 kg/ha) 400/100 m (90 g/100 m)	Interplanted food crop Interplanted food crop	Replace dead plants; coppice/induce leaf shed if diameter is >3 cm Replace dead plants; coppice product if diameter is >3 cm	Leaves (no measurement of production yet) Leaves, firewood, food (no measurement of production yet)
	Individual 2 m × 3 m	Seeds, seedlings, stumps	17/100 m ² (3.6 g/100 m ²)	Interplanted food crop	Replace dead plants; coppice/induce leaf shed for green manure if diameter is 3 cm	Leaves, firewood, food (no measurement of production yet)

Fence	0.75–1 m	Seeds, seedlings, stumps	100–133/100 m (22–30 g/100 m)	Main purpose: Leaves for animal feed Coppice every 3 months during the rainy season, every 4 months during the dry season	Leaves from two coppiced trees/day for each head of cattle being fattened	Firewood, green manure
Field	1 m × 1 m	Seeds, seedlings, stumps	10000/ha (2.2 kg/ha)	Coppice when trunk is 3 cm in diameter, 7.0–1 m above ground	Feed for 2–3 head of cattle/ha	Firewood, green manure
Field	1 m × 2 m	Seeds, seedlings, stumps	5000/ha (1.1 kg/ha)	Main purpose: Firewood Do not cut	Firewood (20 m ³ /ha after 2 years)	Leaves (when tree is cut)
Fence	1–1.5 m	Seeds, seedlings, stumps	67–100/100 m (15–22 g/100 m)	Do not cut	Firewood (20 m ³ /ha after 2 years)	Leaves (when tree is cut)
Community	2 m × 3 m	Seeds, seedlings, stumps	1666/ha (0.37 kg/ha)	Do not cut	Firewood (20 m ³ /ha after 2 years)	Leaves (when tree is cut)
Slope	0–15%	Seeds	13333–32000/ha (3.0–7.1 kg/ha)	Main purpose: Trees for shade Do not cut	Shade for other cash crops (coffee, cocoa)	Reduced erosion, green manure, animal feed
Slope	0–15%	Seeds	16000/ha (3.6 kg/ha)	Main purpose: Green manure Do not cut	Leaves (5–10 t/ha by fresh weight)	Leaves for animal feed once during the season

^a For all the main purposes, the leucaena requires weed control and protection from fire and animals in the 1st year. Only the additional measures have been listed in this column.

^b Both primary and secondary products are for trees older than 12 months unless otherwise indicated.

beneath vigorously growing lamtoro trees or with commercial inoculum, when available, immediately before planting so that the sun does not kill the live bacteria;

- Plants can be frequently coppiced but will have a longer, more productive, life if stems are 3 cm (the width of a thumb) in diameter before the first cutting; cut at the height of 0.3–1 m; and allowed to regrow for 3 months in the rainy season and 4 months in the dry season.

Definitions of Categories in the Management Recommendations

Main purpose

Lamtoro gung may be used as a permanent or temporary component of cropping systems. It may be interplanted in hedgerows, alley cropped, planted as a border, or grown as an individual plant with other crops. It stabilizes and improves soil fertility. It has potential to produce a variety of products, but it can serve only one main purpose at a time. For example, the most leaves are produced when the tree is frequently coppiced and, hence, does not continuously produce seeds. If both seeds and leaves are desired from one plant, the production of both will be lower than it would be when only one product (i.e., seeds or leaves) is regularly harvested.

Planting

Each main purpose has a recommended spacing for effective production of the desired product, be it seeds, leaves, firewood, or erosion control. However, variations in soil and climate conditions at a particular site require slight adjustments for maximal productivity. Choice of planting method is dependent on factors such as seasonal availability of labour, germination percentage, cost of seeds, etc. The three methods (direct seeding, transplanting of seedlings, and stump planting) have differing requirements.

The choice of a method for demonstration plots must be consistent with local farmer capabilities. For example, the selection of the main purpose “conservation, reducing erosion” means that tens of thousands of plants per hectare will be planted. Because of the large number of plants, the farmer will probably choose direct seeding, especially if he or she already has seeds. The cost considerations and ease of implementation offset the lower germination rates to be expected with direct

seeding. Farmers can consult local extension workers for assistance.

The density of plants is calculated from the spacing at planting and the assumption that 100% of the seeds will grow. The required amount of seeds (~15 000 seeds/kg) is based on the recommended plant density for each main purpose and the estimated survival rate from germination to 6 months. The percentage used for calculation for each planting method is: seed (direct) 30%, stump 50%, and seedling 60%.

Cultural practices

Lamtoro gung appears to grow very slowly the first 3 months after germination, as most of the plant's energy is spent in putting down a strong taproot. During the 1st year's growth, including the dry season, lamtoro gung must be protected primarily from the shade of faster-growing plants (weeds), fire, and grazing livestock. After the 1st year, cultural practices and expected products relate to the chosen main purpose. For example, if the main purpose is for animal feed, the plants should be coppiced every 3 months in the rainy season and every 4 months in the dry season. Another example: if the main purpose is green manure, lamtoro gung 3 cm in diameter should be coppiced 1 week before the food crop is planted and the cuttings immediately incorporated into the soil for maximum nutrient benefit.

Although application of phosphate fertilizer will enhance establishment, it is not recommended because output is to be maximized with minimum inputs and low risks to farmers living in a subsistence or limited cash economy.

Primary and secondary products

The primary product is the one that fulfills the main purpose and for which the planting system and cultural practices have been designed. The secondary products are those that are possible with the planting system and cultural practices required for the yield of the primary product.

Achieving the Main Purpose

Trees for seed

Seed trees should be allowed to grow until either the seed pods become too high to harvest easily or the third rainy season begins, whichever comes first. Then they should be cut to 1.5 m high, with only three sprouts (spaced evenly around the trunk) being allowed to grow back.

Seeds should not be harvested in the rainy season because of increased prevalence of pathogens and insects. Regrowth will be rapid in the rainy season, and seeds will be ready to be harvested at the beginning of the succeeding dry season. The fruiting season is usually long and continuous. Pods should be harvested when mature (yellow) and not overly mature (dark brown) because, with age, the seed coats harden and insect-disease damage increases. Mornings and evenings are preferred times of the day for harvesting so that the seeds lost through pods' shattering are minimized.

Seeds for storage should be immediately separated from the pods, cleaned, and sundried for 3 days. The seeds should be dry when stored, and airtight containers should be used for storage. Farmers commonly dust stored seeds with wood ash (1 part sifted ash to 2–4 parts seeds) to deter insects and pathogens.

Conservation, reducing erosion

To reduce erosion and increase soil fertility, one must save the topsoil. Planting leucaena is an effective way of doing this, and it has advantages for secondary products. For example, coppicing the plants and applying the leaves to the soil can provide nutrients for interplanted food crops. The four recommended systems are: for slopes 0–15% not terraced; for slopes greater than 15% not terraced; for existing terraces that need improvement, and for home gardens. In all these systems, the cultural practices are similar. That is, during the 1st year, the lamtoro gung should be:

- Planted on raised ridges or beds, especially in the first three systems;
- Planted just before the rainy season; and
- Protected from too much shade, weeds, fire, and animals.

After the leucaena becomes established, the timing, frequency, and height of coppicing depend on the types and ages of the crops to be interplanted with it. For example, if there are food crops, the important general principle is that lamtoro gung must not excessively shade the interplanted food crops.

The primary product is erosion control, but the secondary products deserve special attention, and the timing of cultural practices is important. If food crops are to be interplanted with leucaena, the steps would be:

- 1 week before planting the food crop, coppice the lamtoro gung 0.3–1 m above

ground so that lamtoro gung does not shade out the food crop;

- Incorporate the leaves immediately into the soil because the nutrient contribution of the cuttings as green manure is greater than when incorporated later;
- 1 month after the food crop is planted, coppice the lamtoro gung again and apply on the soil surface as green manure;
- Each time lamtoro gung is coppiced, cut a little higher on the plant so that more branching takes place and, therefore, more production of leaves; and
- During the dry season, when crops are not interplanted, coppice only one time for use as animal feed.

Green manure can be obtained by the shedding method, which reduces labour considerably. In this method, one girdles or removes a 20-cm wide strip of bark on the trunk 1.5 m above ground. Within 1 month, the leaves dry and fall. Shoots grow back from the portion of the trunk below the girdled area. Only three shoots should be allowed to grow.

These are some general principles and cultural practices for the four conservation, reducing-erosion systems. Some of the differences among the systems are:

- For slopes of 0–15% not terraced: seeds and seedlings are planted along the contour of the hill in double rows, with 40 cm between the two rows and 10 cm between plants in the row. The distance between two double rows is 5 m.
- For slopes greater than 15% not terraced: seeds or seedlings are planted along the contour of the hill in double rows, with 40 cm between the two rows and 5 cm between plants in the row. The distance between two double rows is 2 m.
- For existing terraces: when landholdings are very small, lamtoro gung is planted on the terrace not only to provide green manure for interplanted crops and animal feed in the dry season but also to allow the taproots to loosen the soil, improve water infiltration, and reduce runoff.
- For home gardens: leucaena may be an individual plant, intercropped or used as a fence in humid and drought-prone areas. The advantage in dry areas is that the taproots penetrate the soil to find water and bring plant nutrients closer to the surface where other plants can use them.

Leaves for animal feed

There are two suggested planting systems to be used with the cut-and-carry harvesting system for penned animals. These are:

- Fence: lamtoro gung is planted as a living fence. The principle is to make the land more productive, but it does not restrict access of animals;
- Field: lamtoro gung is planted in a field to produce animal feed as the primary product.

For fattening of ruminant animals, the leaves are most effective if they constitute about 40% of the total ration. Research results obtained by the government of Indonesia, at the Livestock Research Centre, Ciawi, West Java, and field experiences from East Nusa Tenggara show that leaves have no toxic effect even when fed as 100% of the ration for fattening ruminants. This finding has particular implications for the dry season when other feeds are unavailable.

Firewood

There are three suggested planting systems for a primary product of firewood:

- Field: lamtoro is planted in a field to produce firewood as the primary product.
- Fence: lamtoro is planted as a fence around the home garden, along the road, etc.
- Community forest: lamtoro is planted on selected community lands reserved for the planting of firewood as the primary product.

All three of the above systems will produce firewood as the primary product as well as produce leaves for animal feed or green manure as a secondary product at the time the trees are cut.

Trees for shade

When the main purpose is to provide shade on slopes 0–50% or steeper, seeds or seedlings are planted along the contour of the hill in double rows, 40 cm between the rows and 25 cm between the plants in the row. The trees will be thinned to suit the shade requirements

of the interplanted crop. The distance between two double rows is from 2.5 m to 6 m, depending on the planting distance for the crops to be shaded and the steepness of the slope. Only tree crops should be grown on the steep slopes.

Green manure

The recommended method to produce green manure as the primary product is to plant lamtoro gung in double rows, with the distance between the rows 40 cm and 25 cm between plants in the row. There are two green manuring methods: coppicing and the induction of shedding.

Research in the Philippines has demonstrated that:

- The effect of lamtoro gung as green manure for corn is the same as that from NPK fertilizer applied at the rate of 90/40/40 kg/ha; and
- Rainfed upland rice (IR36 variety) when provided with lamtoro gung as green manure yielded as well as can be expected from NPK-fertilized plots (80/30/30 kg/ha).

Conclusions

The management recommendations evolved because of field-implementation needs and the unavailability of practical materials for field use. The scope and the organization of the recommendations, according to main purpose, reflects the farmers' situation in the areas of the five provinces where lamtoro gung is being actively promoted. Thousands of hectares of land supporting tens of thousands of people were planted to lamtoro gung even without technical guides. It is hoped that the main purposes of the management recommendations will be further developed for farmers' use.

I recognize that the recommendations are only a first attempt to organize information into a format for field use, and I solicit specific constructive suggestions.