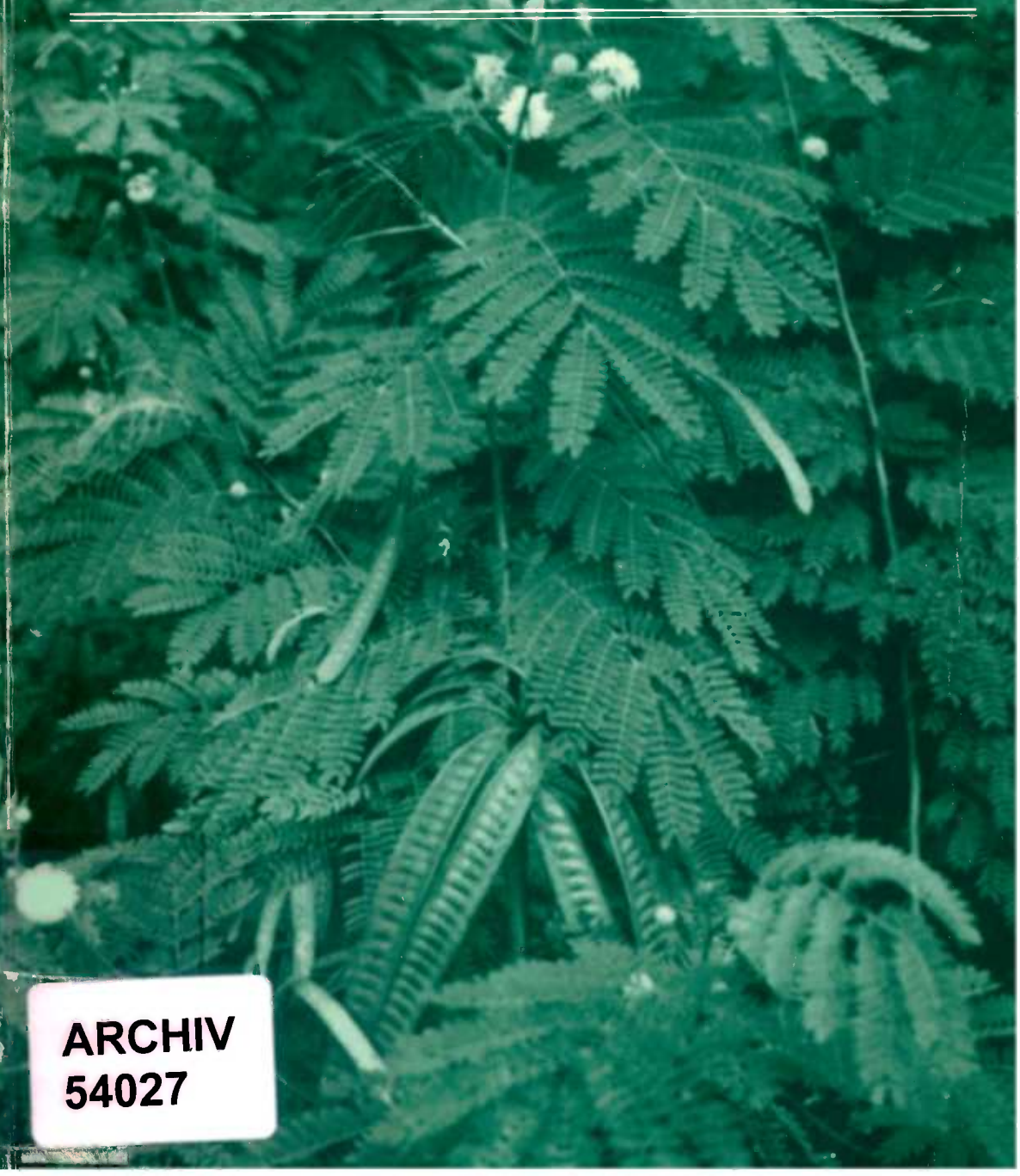
IDRC-21

Leucaena Research in the Asian-Pacific Region

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



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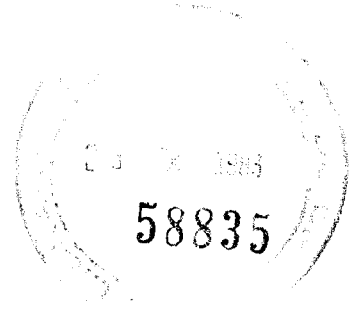

Leucaena Research in the Asian–Pacific Region

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

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

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 culturales 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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Contents

Leucaena for Erosion Control and Green Manure in Sikka

Viator Parera *Agriculture Service, Sikka District, Maumere, Flores, Indonesia*

Sikka district, on the island of Flores, Indonesia, is small, densely populated, dry, and eroded. Since 1973, its people have successfully planted lamtoro (Leucaena leucocephala) *for erosion control and green manure. Lamtoro biasa is a local term used for the Hawaiian-type leucaena. The local people plant this type to create hedgerows for terraces to control erosion. The Hawaiian giants are planted in the flat areas of bench terraces. More than 2.0 × 10⁴ ha of hilly lands are already terraced, and more than 2 million Hawaiian giants have been planted. On these terraced lands, perennial crops, such as cocoa, cloves, pepper, etc., are being grown, and BIMAS, the national food crops intensification program, is providing improved varieties of upland rice and corn to farmers who plant leucaena. The successful results so far reflect leucaena's ability to meet the farmers' needs and to become a* Tanaman Rakyat *(people's plant), a* Tanaman Pelopor *(pioneer plant), and a* Tanaman Perdagangan *(cash crop).*

Le district de Sikka, dans l'île de Florès, est peu étendu mais fortement peuplé et les terres sont arides et érodées. Depuis 1973, ses habitants ont planté avec succès le lamtoro (Leucaena leucocephala) *pour combattre l'érosion et comme engrais vert. Lamtoro biasa est un terme local désignant le* Leucaena *de type hawaiien. Les indigènes s'en servent comme haies pour les terrasses aménagées contre l'érosion. Les géants hawaiiens sont plantés dans les parties planes des terrasses en gradin. Plus de 2,0 × 10⁴ ha de collines sont déjà aménagés en terrasses et plus de 2 millions de géants hawaiiens y ont été plantés. Ces terrains portent des récoltes permanentes de cacao, de girofliers, piments, etc, et BIMAS, le programme national d'intensification des cultures vivrières, foumit des variétés améliorées de riz et de maïs pour terres hautes aux cultivateurs qui plantent des* Leucaena. *Les succès obtenus jusqu'ici témoignent des possibilités qu'offre* Leucaena *de répondre aux besoins des cultivateurs, en devenant pour eux une* Tanaman Rakyat *(plante du peuple), une* Tanaman Pelopor *(plante pionnière) et une* Tanaman Perdagangan *(culture de rapport).*

El distrito de Sikka, en la isla de Flores, Indonesia, es pequeño, densamente poblado, seco y erosionado. Desde 1973 su gente ha sembrado con éxito lamtoro (Leucaena leucocephala) *para controlar la erosión y producir abono verde. El lamtoro biasa es un término que designa la leucaena de tipo hawaiano. La población local siembra ese tipo en hileras para formar terrazas contra la erosión. Las gigantescas plantas hawaianas son sembradas en las áreas planas de las terrazas. Más de 2,0 × 10⁴ ha de colinas están ya en terrazas, y más de 2 millones de estos árboles han sido sembrados. En estas terrazas se siembran cultivos perennes como el cacao, el clavo, la pimienta, etc., y el BIMAS, programa nacional de intensificación de cultivos alimenticios, proporciona variedades mejoradas de arroz alto y maíz a los agricultores que siembran leucaena. Los resultados exitosos hasta ahora reflejan la capacidad de la leucaena para hacer frente a las necesidades de los agricultores y convertirse en una* Tanaman Rakyat *(planta popular), una* Tanaman Pelopor *(planta pionera) y una* Tanaman Perdangangan *(cultivo de efectivo).*

Sikka district on the island of Flores, is one of the smallest (1670 km²), most densely populated (120 people/km²), and driest (954 mm rainfall on the north coast, 1192 mm on the south coast, and 1500 mm in the mountains) districts in the province of Nusa Tenggara Timur in the southeastern part of Indonesia. Metzner (1976: 103–105) described some important details about this district:

- A stratum of volcanic ash and tuff several hundred meters thick covers this area. Water courses have cut deeply into this volcanic rubble, so that only 20 per cent of the area has a slope of less than 10 per cent. Flat surfaces are therefore rare.
- Irrespective of the regional differences in annual rainfall distribution, all parts of Sikka suffer from acute water shortage during the dry season which seriously affects cultivation since no technical irrigation is possible. Only those plants with deep roots can survive on the sandy soil during the dry season, in spite of the fact that some of the hill soils are quite fertile.

Agriculture production is thus set quite narrow limits by this long dry season and by the rugged terrain. Only 20 per cent of Sikka's total area is used for cultivation. Dry farming predominates with crop rotation in a short cycle of three to four years of cultivation with an equal period of fallow, even on fields with more than 30 per cent of slope.

The area has been described as including 13 620 ha good for upland rice, secondary crops, and perennial crops; 46 810 ha highly restricted for upland rice and secondary crops, good for perennial and forage crops; and 79 720 ha of land that is not good for agriculture: very thin upper horizon and very stony, only good for forestry and certain trees. Thus, erosion control (Ten Dam 1950) is essential. Bench terraces were introduced in 1966, but, because of the hard work in setting them up and the lack of immediate payoffs, the population was reluctant to adopt them.

Starting in 1971, planting trials with the Hawaiian type of leucaena (lamtoro biasa) were successful in controlling erosion and led to planting on a larger scale in 1973.

In 1978, the Hawaiian giants, lamtoro gung (agung = the great) as they are named in Indonesia, were introduced. Now, more than 2 $\times$ 10^4 ha of hills are terraced with lamtoro biasa and more than 2 million lamtoro gung trees have been planted in Sikka.

BIMAS, the national food crops intensification program, operated by the District Agriculture Service, was introduced in Sikka in 1974. This program makes available, on a credit basis, improved varieties of upland rice and corn as well as fertilizers and insecticides. A local regulation stipulated that only farmers who planted leucaena on their land could take advantage of the national program. Local authorities reasoned that the leucaena would halt runoff and ensure that the fertilizer would not be washed away along with the precious topsoils.

Perennial crops, such as cocoa, cloves, pepper, etc., were planted on the terraced lands and worked not only as a component for the successful cultivation of leucaena but also as an integral part of the permanent agriculture based on leucaena (Prussner 1981).

A new development has since taken place. Bench terraces, the construction of which was practically abandoned when indirect terraces were created by leucaena hedgerows, are again being constructed. Now, the bench terraces are supplemented with rows of Hawaiian-type leucaena grown along the edge of the terraces and Hawaiian giants planted in the flat areas. This arrangement has proved very effective in erosion control. The flat surface of the bench terraces slows the flow of water; the hedgerows arrest the overflow; and the Hawaiian giants with their deep taproots improve percolation through the hard layers.

An old poem describes well the concept:

> Uma puang naha nora tuang (forest must be on the upper side); uma erit di naha nora tuang (forest must also be on the lower side); uma lorang naha nora blepeng[1] (blepengs[1] must be in the centre).

The effectiveness of leucaena in reducing water runoff is determined by the layout and timeliness of planting, which must be done on the contour and just before the short rainy season (~4 months long). The Hawaiian-type seeds are sown on raised beds, whereas the Hawaiian giants are grown first in plastic bags and then planted out.

The first step in creating hedgerows for erosion control is to establish the contour lines. For this purpose, a water level of an A-frame is used. Then, the weeds have to be eliminated, and raised beds of 20 cm $\times$ 10 cm constructed. The next steps are to level the beds and form a shallow furrow with a stick; then the seeds can be sown in the furrow. Depending on the slope of the land, 70–100 kg seeds/ha will be planted 3–5 m apart, i.e., 1 kg seeds for a single row 25–30 m long.

Many have asked why so many seeds are used. The reasons are that:

- The seeds used at the beginning of the project to initiate leucaena were imported and exhibited poor germination.
- The aim is to obtain a solid network of vegetation, not individually grown stems.

No special seed treatment is practiced. Sowing is done in October, at the hottest time of the year, and the hard coats of the seeds have enough time to be cracked by the hot sun before the first rain, and they sprout easily. The early establishment reduces the possible negative effects of the heavy rains in January and February; however, to reduce risks to the young plants, farmers sometimes place bamboo, small trunks, or folded coconut leaves on the underside of the beds and secure them to the ground.

If the rainy season starts before planting has been done, then the beds have to be protected, covered with banana stems. As legumes such as Bei/Fai (*Albizia chinensis*), Luma (*Sesbania grandiflora*), Bue (*Phaseolus radiatus*), Wuek (*Cayanus cayan*), Heo (*Psopocarpus tetragonolobus*), etc., are found and planted almost everywhere in Sikka, the leucaena seed

[1] Simple terraces made from bamboo, small trunks, or folded coconut leaves laid and secured horizontally across the slopes.

is not inoculated with rhizobia. This system of sowing seeds on prepared beds gives better results than the traditional system practiced since the Dutch colonial times.

Many people also have asked why the Hawaiian giant seeds are not used for hedgerows. The reasons are that:

- Seeds for the giants are in short supply, even though the variety is already growing in Sikka;
- Sikka's volcanic ash soil, which is highly vulnerable to erosion, seems to be best protected by a solid network of vegetation provided by bundles of small, tough Hawaiian-type stems; and
- Pruning of the low Hawaiian-type leucaena is now once every 5–6 weeks but would probably have to be more often with the giant types.

The periodic pruning of the hedgerows (at 75–80 cm) prevents them from becoming weeds — a development that made them unacceptable to farmers in the past. Pruning should be done only after the plants are more than a year old. In many cases, poor performance of hedgerows can be traced to too-early pruning. In burned-over areas, the regrowth of leucaena can be stimulated by pruning.

Although not many farmers in Sikka intentionally use the pruned leucaena leaves as green manure for their crops, most of them throw the leaves around the places they have just pruned and the effects are the same, the upperside of the terraces benefiting from the practice (Metzner 1976).

The presence of the evergreen leucaena hedgerows also improves the ecoclimate—microclimate. Some farmers have recognized the changes and have begun cultivating crops, such as peppers, cocoyams, etc.

In areas where upland rice, corn, and cassava are planted together, the cassava is left in the ground after the other two crops are harvested. The farmers have found that if they do not prune the hedgerows again until after the cassava is harvested, the increased shade improves the cassava root yields. The leucaena also seems to have a beneficial effect on growth and production of the fruits from the coconut trees.

The green manure that is provided by the pruning of leucaena is beneficial but not sufficient to maintain soil fertility. It is a good supplement to inorganic fertilizer available to farmers through the BIMAS program. The

Bench terraces incorporate giant leucaena on the flat.

Hawaiian giants have to be coppiced or pruned when food crops are planted among them so they do not excessively shade the interplanted crops.

The traditional practice of the farmers in the central and western parts of Sikka is to break the branches of young *A. chinensis* and *S. grandiflora* plants and leave them hanging on the trees. The leaves wither and fall gradually among the young upland rice and corn plants. This practice, thus, was adapted to the leucaena giants in a system of girdling the trunks. Before the planting of upland rice and corn, the trunks of the trees are girdled in a ring 20 cm wide, 1.5 m above the ground. Within a couple of months, all the leaves fall. New sprouts emerge at the lower part of the girdled area of the trunks, but only two or three sprouts should be left to grow. In Tana Ai of the eastern part of Sikka where leucaena planting has been difficult and slash-and-burn cultivation is still practiced, this system is showing some promise of adoption. The leucaena leaves decay quickly, and there are no trunks or branches remaining on the fields to be burned. In the past, burning has been practiced not so much to obtain fertile ash as to eliminate the trunks, branches, and leaves left from land-clearing operations.

Another effect of leucaena that has impressed the farmers is the emergence of earthworms after the 1st year of leucaena establishment. Earthworms to these farmers, with their background as shifting cultivators, are identified with fertile soil.

Conclusion

The introduction of leucaena to the agricultural system of Sikka is a practical application in line with Dioscoro L. Umali's request: "Help us to build production systems that are not carbon copies of those in industrialized countries. Our need is for models that are simple, based on indigenous sources and techniques native to the soil." The successful results so far reflect leucaena's ability to meet the farmers' needs and to become:

- A *Tanaman Rakyat* (people's plant) because, with only the simple techniques and capabilities possessed by the farmers, it can be planted and managed to produce profitable yields.
- A *Tanaman Pelopor* (pioneer plant) that enhances conditions for the introduction of improved agriculture techniques by its ability to rehabilitate soil, control erosion, and improve the ecoclimate.
- A *Tanaman Perdagangan* (cash crop) because the sale of seeds of the Hawaiian giant has already provided good income, and fast-growing Hawaiian giants provide leaves and wood that can be used in animal feed and charcoal, both of which promise to become commodities with a profitable future.