PN-AAJ-944

Leucaena leucocephala:
a tree that "Defies the Woodcutter"

Office of Agriculture
Development Support Bureau
Agency for International Development
Washington, D.C. 20523

June 1, 1981

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From seedling to tree in six years. Leucaena leucocephala is one of the fastest growing legumenous trees known.

Leucaena at 6 months (left), 1½ years (middle) and 10 years (right). The 6 month old trees are 6 meters high (20 feet).

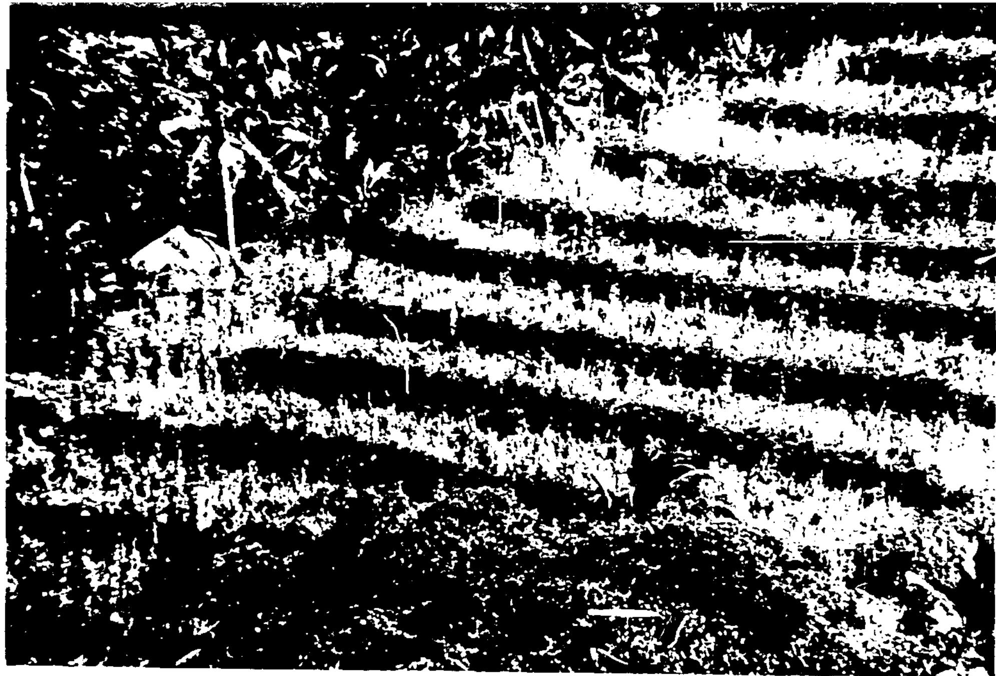
Leucaena leucocephala, an excellent feed for livestock: it can be planted and managed in a variety of systems, such as in balanced pasture-forage systems [above], or in hedgeroes to control erosion in fields, or as a windbreak, fence or boundry marker around the house or field [below].

In the seasonally dry tropics, there are vast scattered areas where recurring dry seasons preclude shallow-rooted perennial forage grasses and pasture legumes. For these areas, an excellent management system is Leucaena planted at a spacing of 1 m. by 1 m. and allowed to grow until it reaches a 10 cm (4 in.) base diameter, or approximately 1½ years, before cutting back. The trees are then cut to a stump height of 1 m. and allowed to coppice [regrow (above left)]. The foilage is then cut every three months. The 1½ year period before cutting allows the growth of a long taproot. This enables Leucaena to maintain a high rate of production even during the critical dry season months [above right] when other forage sources have dried up and become unpalatable.

The abundant-lush growth of Leucaena, harvested in a cut-and-carry system [above], is fed to and relished by tethered livestock [below].

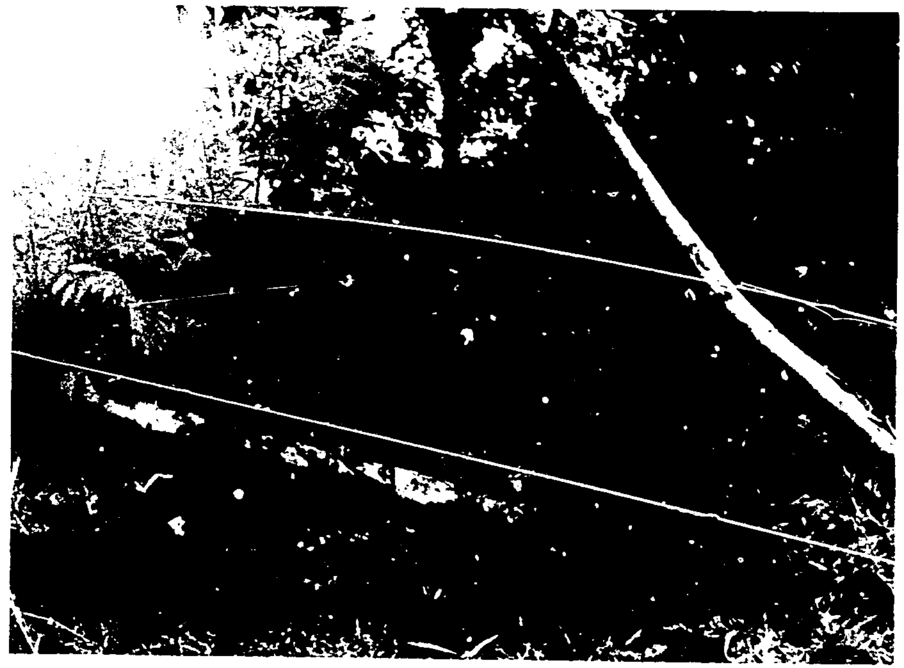
Leucaena is a most versitile and multi-purpose tree which can be used for shade for the home [previous page upper left], as a windbreak [upper left], as a firebreak [upper right], and as a erosion control barrier [lower right].

Leucaena is an excellent source of firewood when planted around the house, as a covercrop for fallow fields or in woodlots. When cut, it readily coppices (upper left), providing an abundant and renewable source of wood (lower right).



Densely planted in contour strips and continually cut back, it will remain as a hedgerow [lower right, previous page] and the leaves can be applied as a nutrient-rich green fertilizer, thus increasing yields of inter-crops [upper left and right].

It is excellent as a cover-crop for hillside rotational cropping systems or as a nurse crop for trees interplanted in the cover-crop [lower left]; or used as a fertilizer-hedgerow planted around trees [lower right].



Leucaena "Defies the Woodcutter"

Leucaena is excellent for reclaiming infertile and unproductive man-made grass savannahs, comprised of grasses such as Imperata cylindrica [above], which can be converted into productive agro-forestation systems in which coffee and other food crops can be grown [lower right]. Leucaena is only one of several multi-purpose legumenous trees with excellent potential for use in agro-forestation systems and are identified in the National Academy of Science publication, "Tropical Legumes: Resources for the Future" [Washington, D.C., 1979].

OPERATION DOUBLE HARVEST
Port-au-Prince, HAITI
Leucaena leucocephala
10 inches in circumference
in 51 weeks

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

Dear Sir or Madame:

Please excuse any delay in answering your request for information pertaining to the purchase of seed. There are few reliable sources of seed of the GIANT varieties of Leucaena leucocephala. The price may vary from one place to the other, depending upon labor and shipping costs and the quality of seeds. I generally recommend three sources, two in the U.S. and one in the Philippines.

Maryland: Tree Seeds International
2402 Esther Court
Silver Spring, MD 20910
ATTN: Dr. Fariyal Sheriff

Hawaii: Dr. Linden Burzell
Lowe Inc.
P.O. Box 131
Kahuku, Hawaii 96731

Philippines: Philipinas Plant Center
P.O. Box 3350
Manila, Philippines
ATTN: Miss Belen H. Abreu

Tree Seeds International specializes in planting materials for agro-forestry. Their Leucaena seeds come from growers in the Caribbean, who keep their seed orchards for the different varieties well separated from each other and cull the orchard trees to select for optimum form, growth rate and varietal characteristics. The Maryland firm grades the seeds for density, and so has a range of prices, currently about $8 to $25 per kilogram (2.2 pounds).

Seeds from Hawaii are somewhat higher in price, because of the high cost of labor there. The current price is about $45 per pound. However, Lowe Inc. indicates that the seeds are inspected and their characteristics verified by the University of Hawaii.

Seeds from the Philipinas Plant Center in Manila were priced at $15 per kilo at the time of my last communication with them. Air freight costs to the U.S. average approximately $5.00 per kilo. However, delivery is often delayed. The seeds are said to have been verified by the University of the Philippines at Los Banos.

To my knowledge, Tree Seeds International is the only group that is selecting seeds for optimum form, growth rate and varietal characteristics.

I generally recommend three varieties, K-8, K-28 and K-67, all of which are dual purpose, wood and forage. None of the varieties have been researched extensively to establish their specific growth differences. The K-8 variety is a sparce seed producer and may produce a little more wood, however, this has not been verified. The K-28 variety produces more seed than the K-8, but not as much as the K-67. The K-67 variety is a prolific seeder, therefore, it is excellent for programs which are large in scope and where a large amount of seed is needed. The K-67 variety may branch more than the other varieties. Another variety, the Peru (Cunningham), is often recommended as a good forage plant, but it will not produce large volumes of wood since it has bushy growth characteristics. In appropriate management systems, K-8, K-28 and K-67 varieties can equal the forage yield of Peru (Cunningham). However, these varieties will grow into trees if unmanaged.

Leucaena seeds must be scarified to obtain maximum and uniform germination. Common methods are hot water, chemical and mechanical. however, the simplest is scarification by hot water. The easiest way to scarify by hot water is to:

> Heat water to boiling point, remove from the heat and allow to cool for 1-2 minutes (instant coffee temperature). Place the seed in a container and pour the hot water over the seed; the volume of water should be twice the volume of the seed. Stir the seeds so that they are uniformly treated, allow the water to cool and soak the seeds overnight.

Nitrogen fixing bacteria, Rhizobium, live in symbiotic relationship with Leucaena, fixing nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena as well as other plants. Not all soils contain the correct strain nor the necessary amount of Rhizobium to insure the proper inoculation and growth of Leucaena. The Leucaena seeds should, therefore, be inoculated before planting. Leucaena generally grows in neutral or alkaline soils and an acid-exuding strain of Rhizobium (31A3) is associated commonly with the plant. The Commonwealth Scientific and Industrial Organization (CSIRO) in Australia has developed a strain of Rhizobium (CB81), reported to be alkaline-exuding thus enabling Leucaena to grow in more acidic soils. In requesting Rhizobium strains, it is desirable to specify both the plant (Leucaena) and the pH of the soil in which it is to be grown.

Small quantities of the inoculum, CB81, may be obtained for research purposes from CSIRO, Davies Laboratory, Private Mail Bag P.O., Townsville, Queensland, Australia. Commercial and small quantities of 31A3 may be obtained from J. Burton, Nitragin Corp. 3101 West Custer Ave., Milwaukee, Wisconsin 53209, U.S.A. Small experimental samples of CB81 and 31A3 inoculums as well as information and training in Rhizobium production can be obtained from the University of Hawaii NifTAL Project, P.O. Box "O", Paia, Hawaii, 96779, U.S.A. Rhizobium inoculants are inexpensive.

The Rhizobium should be stored at temperatures ranging from 0° to 7° Centigrade or 32° to 45° Fahrenheit, approximately the temperature of a refrigerator. The seeds are easily inoculated after scarification by sprinkling the damp seeds with a light coating of inoculum.

Leucaena requires adequate levels of phosphate, potash and sulfur. High levels of magnesium and low calcium content in surface soils may cause a retardation in the growth of Leucaena. Adequate levels of available trace elements, molybdenum and cobalt, are necessary for maximum efficiency of the nitrogen fixing bacteria, therefore, it is important that sufficient levels of these elements are available in soil in which Leucaena is to be grown. A soil test should be made on the site selected for the establishment of Leucaena prior to planting to determine the appropriate fertilizer that will be required to gain maximum growth.

Usually, government clearances must be obtained prior to importing seeds or inoculum. If clearances for the inoculum are difficult to obtain, perhaps an arrangement can be made with the host country's soils bureau laboratory or with a college or university's soils laboratory to produce the amount needed. NifTAL, Hawaii might assist in this matter. They follow accepted sanitation precautions when shipping Rhizobium cultures.

Thank you for your interest in Leucaena. I would be pleased to learn of the results of your experimental trials.

Sincerely,

Michael D. Benge

Michael D. Benge
DS/AGR, Agro-forestation
Rm. 420-B, SA-18

Leucaena, A Tree That Defies The Woodcutter

The most urgent task that faces mankind today is to solve the problems of hunger and malnutrition by methods that do not overburden stocks of nonrenewable resources such as oil and minerals and that do not impoverish the environment.

The long-ignored Leucaena leucocephala may offer a breakthrough in the solution of the growing worldwide firewood crisis. As Erik Eckholm (Natural History, Oct. 1975) states in his timely article "The firewood crisis," "the most profound ecological challenge of the twentieth century is the growing demand and subsequent worldwide shortage of firewood. Even if we produce enough food to feed the world's population, there won't be enough firewood to cook it."

A study by Denis Hayes of the World Watch Institute revealed that "Two years ago the world appeared to have three energy alternatives on which to build a substanable post-petroleum world: coal, nuclear power, and solar energy. Today we have one clear-cut option: the sun."

The late English economist E.F. Schumacher in his epic book Small is beautiful summed mankind's problems today as:

> "Since fossil fuels, the mainstay of the 'modern system' have ceased to be cheap and may soon cease to be plentiful, many people are becoming interested in solar energy. They

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* Article by Michael D. Benge, Development Support Bureau, Agency for International Development, Department of State, Washington, D.C. 20523.

are looking for all sorts of wonderful man-made contrivances to collect solar energy. I am not sure that they always appreciate the fact that a most marvelous, three dimensional, incredibly efficient contrivance already exists, more wonderful than anything man can make -- the TREE. Agriculture collects it three-dimensionally. This surely is the wave of the future."

The growing concern toward the ecological problems of denudation, dwindling wood supplies, and crop production has inspired a group of scientists such as Dr. James Brewbaker of the University of Hawaii to search for plants that might offer solutions. That search led to the "rediscovery" of a long ignored legumenous plant species, Leucaena leucocephala. The National Research Council of Washington, D.C., has recently published a report* on this most versatile legume. Leucaena is an arborescent legume belonging to the Mimosaceae family. It is closely related to Acacia, Albezzia, Mimosa, and Prosopis. Leucaena is widely used in the tropics as a shade plant; for erosion control; for fuel; and as a browsing crop. GIANT varieties of this species are among the fastest-growing trees and the most efficient converters of solar energy in the tropics.

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*Leucaena: Promising Foreage and Tree Crop for the Tropics, available without charge from the Commission on International Relations (JH 215), National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Press copies are available from the Office of Information, National Academy of Sciences, 2101 Constitution Avenue, N.W. Washington, D.C. 20418, U.S.A.

Leucaena is from Central America. The Maya and Zapotec civilizations spread some of its varieties throughout the region thousands of years ago. Leucaena as an intercrop has been theorized to have been a principal source of nitrogen fertilizer for the staple food of both civilizations, corn. Leucaena was so important to their agriculture that it was recorded in their pictographs. Mexico's fifth largest state, Oaxaca, derived its name from a preColombian word "huaxin," meaning "the place where Leucaena grows."

The Spanish first introduced Leucaena to Southeast Asia and the South Pacific as horse feed on the galleons in the 1800's. In Hawaii, Leucaena is known as "koa haole," a foreign or haole version of their lovely koa tree (Acacia koa). For purposes of identification the University of Hawaii labels the different varieties with a prefix of "K" (for koa) and a number.

Botanists first recorded Giant varieties of Leucaena in Central America in 1910, and named them Leucaena Salvadorensis. But until recently, this fast growing versatile plant species was largely ignored or taken for granted, and its actual value and potential overlooked.

GIANT varieties of Leucaena grow to 20 meters (m) in height and 25 centimeters (cm) in diameter in 5 years.

The common variety of Leucaena is slower growing than the GIANT varieties yet produce a high volume of wood when densely grown. The common Leucaena has been recorded as yielding 88 cu m of stacked wood per hectare (ha) in 1 year: 125 cu m in 2 years; and 130 cu m in 3 years. Albizzia falcata, sometimes referred to as the miracle tree, produces 39 cu m of wood/year. The density of the wood of this species is less than that of Leucaena and it is planted at wider spacing for pulping wood. The density of Leucaena has been recorded as 0.75 (a comparison to the density of water, i.e. 1 cu m of H_2O = 1 mt), compared to a medium-light hardwood; Albizzia is about 40% lighter. Yields of Giant Leucaena have been estimated to exceed those of the common varieties by from 100 to 200%, although at a young age (3 years) its wood is of a lower density, 0.55.

The heating value of some Leucaena species ranges as high as 16,000 BTUs per kg, approximately 35% of that of natural gas. The production costs (in the developing countries) of a quantity of Leucaena that would give an equivalent heating value to natural gas would only be about 18%. It is also an excellent raw material for making charcoal.

Although the wood of the Salvador types of Leucaena is short fibered, it pulps satisfactorily, producing both paper-grade and dissolving pulps. The pulp yield is also quite high, 50 to 52%. "Kraft" pulp from Leucaena can be used in printing and writing paper and would be well suited for blends with long-fibered pulp. The dissolving pulp can also be used for rayon and cellophane production.

Giant Leucaena wood, properly cured, is an attractive low-cost wood, useful for making furniture; parquet flooring; studding; crating material; poles; posts; rafters; and excellent props for bananas. It can also be made into a good quality cardboard product as well as attractive and sturdy waffle board, chip board, and pressed board (hardboard or fiber board) for low-cost housing materials.

As a forage crop, Leucaena has yielded as high as 20 metric tons (m.t.) of dry matter per hectare (ha) per year. Alfalfa yields more green forage than Leucaena but the forage value of the two are about equal. The nutritive value of green and dry Leucaena forage is equal or superior to that of alfalfa. Leucaena is equivalent or superior to alfalfa in digestibility and is markedly superior to alfalfa in percentage of protein (the green leaves generally exceed 25% crude protein). The content of total digestible nutrients (TDN) is comparable and Leucaena contains almost twice as much vitamin A and carotene as alfalfa. Dry Leucaena contains almost four times as much total protein as napier grass.

In Australia cattle fed on a diet of 100% Leucaena gain up to 1 kilogram per animal per day in weight . They can be fed at this level for about 4 months.

The pelletized leaves of Leucaena are in high demand as an animal feed mix, and are exported to Japan and Europe.

Leucaena, rich in protein, is not only an excellent forage for animals but it is also eaten by humans. In Asia and Latin America, the slightly bitter leaves are added to soups, eaten fresh in salads, and dipped in sauces eaten as a side dish. The flowers and the young seed pods are also eaten in salads and the young pods are eaten both fresh and cooked. The young seeds are palatable and eaten as a vegetable much like mung beans, and are pulverized and made into dried bean cakes. Mature beans are roasted and used as a coffee substitute. In Thailand, children pluck the tender young leaves from the hedges and relish them as one would candy.

Despite the heralded success story of the "green revolution," the new agriculture technology has reached only 10 to 15% of the world's 3 billion farmers. Those increases in production resulted mostly from the industrialization of agriculture, which involves large fuel subsidies, sophisticated chemical control, and highly domesticated plant varieties. Maximizing yield without regard to other consequences is producing serious environmental and social backlashes. A doubling of crop yields requires a tenfold increase in fertilizer, pesticide, and horsepower -- inputs that subsistence farmers can hardly afford. Furthermore, some chemical fertilizers increase the soil acidity. Susan De Marco and Susan Sechler of the Agrobusiness Accountability Project cited that studies conducted by Barry Commoner and Associates at Washington University found that over a 20-year period a five-fold increase in the chemical fertilizer requirements was needed just to sustain previous yield levels.

The value of Leucaena to maintain soil fertility was documented in Indonesia as early as 1900. In 1975, Anacleto Guevarra, at the University of Hawaii, researched the actual chemical fertilizer equivalent of the "Hawaiian Giants," applied as a green manure crop. He found that the fertilizer equivalent of one hectare of GIANT Leucaena harvested over 1 year was estimated as more than 500 kilograms (kg) of nitrogen (N), 200 kg of phosphate (P), and 500 kg of potash (K). Alfalfa will add only about 300 kg N/ha per year and clover, 100 to 200 kg/N ha.

In 1976, Guevarra experimented with the intercropping of Leucaena with corn and with applying Leucaena as a green mulch.

In those field trials, he obtained corn yields of 9 mt/occupied ha of a single-cross field hybrid variety (H610). Single rows of Leucaena were established 91 days before corn was planted. Just before the planting of the corn, the Leucaena was cut, chopped, and incorporated into the soil. It was subsequently cut and applied as side dressing at 41 and 92 days.

Guevarra's experiment was not unique. In 1953 at the Alabang Soil Conservation project, Alabang, Rizal, Philippines a less productive common variety of Leucaena was intercropped with a local variety of corn, Pangasinan yellow flint, under conditions similar to those found among the hilly land corn farmers throughout the Philippines. The land where the experiment was conducted was severely eroded and devoid of organic matter. In some parts of the experimental area adobe stones were exposed and the top soil was completely removed. The area had a slope of 25% (a drop of 2.5 m every 10 m).

Paired rows (bunds) of Leucaena spaced 10 cm betwe the rows were planted on the contour of the experimental field. The distance from one pair of rows to the next was 1 m. When the Leucaena was about 1 m high it was cut back leaving stumps 35 cm high. The trimmings were allowed to decompose between the rows. Sometimes the cuttings were turned under and incorporated in the soil. The cutting frequency was from 1 1/2 to 2 months apart. Continuous interplanting of corn was made throughout a period of four years.

The continuous addition of Leucaena as a green manure increased the yield of the corn by over 380%. Erosion of the experimental plot under this modified form of cropping, was less than 2.5% of the erosion on the control plot.

In 1976 the national yield of corn in the Philippines averaged about 800 kg/ha. In the Visayas region, where per capita consumption of corn is highest, yields were only 650 kg/ha. Those people, as well as millions of marginal corn farmers in Latin America and elsewhere who cannot afford to purchase chemical fertilizers, could afford farming systems that incorporated Leucaena.

The people in Naalad, a village in the Visayan Islands, Philippines have used a local variety of Leucaena in a modified terracing system for erosion control, fertilizer, fuel, and animal feed since 1896. Naalad farmers are some of the most prosperous in the area.

George Borgstrom, in the July 1976 issue of Smithsonian wrote that:

> "In the course of Man's quest for food, more than half of the world's forest cover has vanished, large areas of grasslands have been plowed, and major groundwater reserves irreversibly drawn down. Forest and pasture lands have been squeezed down to wholly inadequate levels.

Erosion, desertification, waterlogging and salination have destroyed much tilled land and are jeopardizing still more. Irrigation reservoirs are filling with silt at ten times the anticipated rate. Such problems are equally grave in numerous other countries that should be labeled biologically overdeveloped rather than designated underdeveloped.

Despite impressive post war advances in yields per acre, 40 to 60 percent of the world food production increase has come from expanded acreage. To accomodate future billions, half of the now remaining forests will have to be cut down and much surviving grassland will give way to plow. These prognostications jibe poorly with ambitious plans for expanded forest production, not least of all in the poor world where 80 percent is used for firewood. Most of the remaining accessible forests lie in the humid tropical zone, on land poorly suited for intensive agriculture."

Aurelio Peccei of the Club of Rome warns that the tropical rain forests are being destroyed at a rate of 20 ha/minute.

<u>Leucaena</u> has been known throughout the tropics since the late 1800's as a shade tree for commee, vanilla, quinine, cacao, and tea; as a companion-fertilizer crop; for protection against wind erosion on certain soils; and as a nurse-fertilizer plant for fruit and forest trees. In Indonesia, teak plantings, intercropped with <u>Leucaena</u>, outgrew pure stands by almost 100%.

In the tropics, forest removal decreases the land's ability to hold and recycle nutrients in the face of high year-round temperatures and periods of leaching rainfall. Most minerals available in the tropical ecosystems are tied up in dead and living organic systems. The levels of available minerals that are free in the soil are always low. Mycorrhiza, which is abundant in the surface litter and thin humus of the forest floor, is believed to be capable of digesting dead organic litter and passing minerals and food substances through the hyphae to living root cells. In this manner, little soluble mineral leaks into the soil where it can be leached away. Many trees will not grow without mycorrhizal fungal symbionts.

Leucaena has a vigorous taproot and limited lateral branches that angle downward. Roots are commonly as deep as the tree is tall. With its deep-growing root system, Leucaena can obtain nutrients from soil strata that are not accessable to most other plants. Surrounding the roots of Leucaena are masses of mychorrhizae that can metabolize "unavailable" phosphorous and other minerals. These minerals are taken up by the mychorrhizal mass and then slowly released to the plant.

Symbiotic nitrogen-fixing bacteria also draw or "fix" nitrogen from the air and store it in bacterial clusters on the Leucaena roots. The plant then transfers minerals and nitrogen to its leaves. The constant leaf drop provides a rich organic litter, making the plant an efficient recycler of those nutrients and a constant, readily available source of free fertilizer. Leucaena can thus be compared with a pump -- it pumps nutrients from the deep soil strata to the surface soil.

Organic materials -- humus and soil organisms that live in the soil -- play an essential role in preserving the soil structure and fertility needed for productive farming. Organic matter holds the soil in place when rain falls and wind blows and reduces the wasteful, polluting runoff of applied chemical nutrients, thus increasing the efficiency of their use.

The population explosion is accelerating forest devastation. Until industry can absorb the unemployed and population is checked, migration to upland areas will continue in man's quest for arable land.

Excessive and irresponsible logging coupled with the quest for more agricultural land are two main causes of denudation in many areas of the world. In many lesser-developed countries, industrialization and massive use of motorized vehicles demand huge oil importations which causes an imbalance of trade. Many feel that this is easily remedied by exporting what seems to be a never-ending supply of natural resources such as lumber and logs. The damage that has been done, more often than not, is realized too late.

Swidden agriculturists, often referred to as slash-and-burn cultivators or fire-farmers, are another problem. In many countries they have been declared illegal occupiers of forest lands. They often bear the brunt of the blame for denudation. A convenient scapegoat, slash-and-burn cultivators can be separated into two groups -- sedentary and traditional. The sedentary cultivator is usually a migrant who has left the lowlands for the mountainside, either in search of land for cultivation or to flee social pressures. He usually tries to farm the hillsides with cultivation practices used in the lowlands, farming the same land year after year without crop rotation and making little or no organic or chemical inputs. This damages the soil structure and causes erosion. He soon finds that he needs more land, which he gains by cutting more forested areas. The "traditional" slash-and-burn cultivator is generally a cultural minority, who has, over the years, realized the relationship between forest regrowth and soil fertility. Those people's shifting cycle is usually from 2 to 4 years and they refarm fallow fields that had grown to second- or third-growth timber after a period of years. If one closely studies their practices in some areas, he finds that many practice natural erosion control and reforestation methods. For example, certain groups in New Guinea reforest with Casuarina, a nitrogen-fixing, nonleguminous tree. In the Philippines, the Ikalahans plant broom straw and windrow crop residues on the contour as an erosion-prevention measure. Those practices, inherent in their traditional systems, disappear as lowlanders compete for their land and laws are passed preventing their natural rotational patterns. Subsequently, the soils are soon lain waste, depleted, and taken over by noxious grasses and weeds -- the slash-and-burn cultivators forced from their lands and thus deprived of their means of livelihood. Are they to blame or are we, as technocrats who have offered them no alternatives? "Hunger is not the tragedy of an empty stomach, it is the tragedy of a human mind and abilities not used."

Dr. Dioscoro L. Umali, Assistant Director General, FAO Regional Office in the Far East, Bangkok, summarized the problem faced by developing countries when he castigated the roles that affluent intellectuals and technicians have played in attacking world hunger and poverty by emphasizing on plantation export crops and sales of modern technology: "Help us to then build production systems that are not carbon copies of those in industrialized countries. Our need is for models that are simple, based on indigenous resources and techniques native to the soil."

J. Sholto Douglas and Robert A. de Jhart, in their book "Forest Farming," wrote that:

> "Vast areas of the world which are at present unproductive or under-productive -- savannahs and virgin grasslands, jungles and marshes, barren uplands and rough

grazings, deserts and farmlands abandoned owing to erosion -- could be brought to life and make more hospitable to human settlement. The know-how exists to make abundant contributions to man's food needs by methods combining scientific and technological research with traditional husbandry. The tool with the greatest potential for feeding men and animals, for regenerating the soil, for restoring water-systems, for controlling floods and droughts, for creating more benevolent microclimates and more comfortable and stimulating living conditions for humanity, is the TREE."

The challenge of finding solutions has stimulated the development of new programs across the world. Cropping systems based on perennial tree crops, cover crops, and proper management procedures offer maximum environmental protection as well as a profitable alternative for the marginal farmer (redundantly termed the "poorest of the poor"), who now cultivates once-forested uplands. In one such system Leucaena leucocephala is planted in contour bands 5 m in width and intercropped in alternating 10 m bands. The Leucaena is cut and applied to the intercropped annual crops as an organic mulch, providing fertilizer that the marginal farmer could not otherwise afford. Such a constant source of fertilizer would eliminate the need for continued shifting agriculture because the trees that the marginal farmer previously slashed and burned for fertilizer would be replaced by Leucaena and would no longer be needed.

In the Philippines, a modified version of this is being tested with the Mangyans, a cultural minority group that inhabits the mountains of Mindoro, an island off the southern Luzon. Their basic staple is "nami," Discorea hispidia, a shade-loving yam, that grows wild under a forest canopy. At the University of the Philippines at Los Baños, (UPLB), Discorea was domestically grown under a normal forest canopy. Test plots of the yam yielded a projected 30 m.t. of tubers/ha. Because of Leucaena's value as a fertilizer plant, Discorea could yield even higher if cropped under a canopy of Leucaena. Cassava, Manihot esculenta, is a root crop that is extensively cultivated throughout the developing countries. Cassava has high nutrient requirements and its continuous cropping rapidly depletes the soil's plant food reserves. On hilly terrain, cassava cultivated without ground cover seriously accelerates soil erosion. In many areas, cassava is planted to produce starch for sizing, clothes starch, and pastes, and for tapioca production. Discorea starch could possibly replace part of the cassava starch used for industrial purposes. In such a manner a forested area could be double cropped with trees and a root crop grown as well; reducing the area planted to the nutrient-demanding, erosion-inducing cassava.

E. F. Schumacher coined the term "intermediate technology" to describe the types of approaches and industries needed in the developing world. "I have named it intermediate technology," he says, "to signify that it is vastly superior to the primative technology of bygone ages but at the same time much simpler, cheaper, and freer than the supertechnology of the rich." Leucaena would surely qualify as intermediate technology.

Despite its many promising characteristics, Leucaena is no panacea. A toxic alkaloid, mimosene, may cause thyroid problems or other harmful side effects when fed over a sustained period in excess of 5-10% of the total diet to nonruminants, and 50% to ruminants. Those symptoms rapidly disappear when the animal's diet is reproportioned. Leucaena is highly desirable as an additive to chicken feed. Its high carotene content intensifies the yellow coloring of the egg yolk.

Leucaena is found at elevations as high as 1,500 m. Higher altitudes usually mean lower temperatures, shorter days (and thus less light), and more acidic soils, conditions that do not enhance Leucaena growth. Leucaena does not normally tolerate waterlogged soils, although strains that grow along canals in Thailand seem to have adapted.

Characteristically, Leucaena does not thrive on highly acidic soils. An acid-producing rhizobium is normally associated with

Leucaena. Tests in Hawaii and the Philippines indicate that Leucaena may adapt to more acidic soils if it is initially established with CB81, an alkaline-producing rhizobium recently developed by the Commonwealth Scientific and Industrial Research Organization of Australia. Leucaena growth may be retarded if planted on soils low in molybdenum and cobalt (which are necessary for bacterial growth); low in potash, phosphorous, and sulphur; and high in magnesium but low in calcium. These deficiencies are easily overcome by pelletizing the seed with necessary nutrients or by later fertilizer applications.

Alfalfa and other similar plants usually require the best and most arable land for their growth -- land that is needed to grow more basic staples in the developing countries. But Leucaena is more persistent and rugged, thriving on the steepest, rockiest slopes where its roots penetrate deep into rock crevices.

Leucaena withstands prolonged drought (22 cm of rain/year), and thrives under 60 to 150 cm of rainfall per year.

Leucaena has few enemies other than man who cuts it down, and monkeys who ravish the young pods. Animals will graze young plants to the ground. The roots sometimes harbor soil fungi and young plants will damp-off in wet soils. Weevils attack the seeds, especially in the wet season or when the seeds are old. This is easily overcome by use of normal plant insecticides.

The problems of denudation and ecosystem inbalance are found throughout the developing countries. Haiti today faces those problems which result in denudation, drought, and hunger. Barren hills betray their denudation for wood as a source of fuel (Time, July 1975).

In Nepal, population pressures have forced farmers to move to less-fertile mountainous areas for more arable land.

Simultaneously, villagers seeking firewood have caused extensive deforestation. Erik Eckholm of the Washington, D.C.-based Worldwatch Institute describes the ecological havoc:

> "Topsoil washing down into India and Bangladesh is now Nepal's most precious export, one for which it receives no compensation. As fertile soils slip away the productive capacity of the hills declines, even while the demand for food grows enerxhorably. The existing population is hard-pressed to find fuel for cooking and heating homes. As nearby sources of wood disappear, villages have to travel hours to find firewood, or they burn cow dung. Since the dung is needed to restore fertility, burning it only exacerbates the dilemma of the people."

A major cause of denudation in the Philippines is the cutting of the forests for fuelwood to feed the furnaces of the tobacco-curing flues. In the Ilocos region of northern Luzon, farmers cut an estimated 8,000 ha or more of trees each year for this purpose. That in turn accelerates erosion and flooding and severely damages crops in the lowlands. Rice in the Ilocos region is rainfed so enough water is available for only one crop of rice per year -- too little even to feed the farmer and his family. He turns to tobacco as a supplemental cash crop. Although tobacco is economically important both for the farmer and the Philippines, cutting down the forests for this nonessential, nonfood crop is a regretable use of good trees. Tobacco farmers are now encouraged to plant the giant varieties of Leucaena to reforest the barren uplands and for a readily available source of renewable energy.

Worldwatch has estimated that more than 6 million ha of the Philippine forests have been destroyed. Every year typhoons rip across the Philippines and other parts of Asia, killing hundreds of people and leaving countless numbers homeless. Important transportation routes and bridges are washed out yearly and entire barrios are submerged by flood waters. In the treeless mountains where vegetables are raised for city dwellers, heavy rains sweep away ill-constructed terraces that have no trees to check erosion. Run-off plunges down the mountain slopes, cutting into the rice fields along the rivers, valleys, and river deltas, leaving the paddy lands inundated with rocks and gravel -- destroyed forever. Modern science has yet to solve the problem of typhoons but rape of the forests can be stopped and barren slopes can be reforestated to reduce the run-off. Billions of dollars of revenue are wasted in destroyed infrastructure, devastated crops and rehabilitation. The floods that cause such havoc result from the mountains being divested of forests.

As oil prices rise, demand for firewood increases. The "firewood crisis" is real, an important part of the energy crisis. As one Indian official put it when questioned about declining forests and the growing firewood crises:

> "Without a rapid reversal of prevailing trends, in fact, India will find itself with a billion people to support and a countryside that is little more than a moonscape. But the politicians, in India and other poor countries, will soon start taking notice, for they will begin to realize that if the people can't find any firewood, they will surely find something else to burn."

It is sad that the teachings of Buddha are not followed. In India, he taught that every good Buddhist should plant and care for one tree at least every 5 years. If the spirit of that teaching were followed today, and every able-bodied Indian planted and maintained one tree per year for 5 years, 200 million more trees would reforest the India countryside.

In the Philippines, despite the fact that most of its 44 million people are Catholic, President Marcos seems to advocate Buddhist teachings. In June of 1977, by "Presidential Decree " under the powers of martial law, he ordered every Filipino more than 10 years old to plant one tree per month for the next 5 years. If martial law can alleviate the ecological disaster that has taken place in the

Philippines -- the denudation of 6 million hectares, a fifth of the total land area -- it will have made a contribution to mankind.

The lack of planting materials is one of the most formidable constraints to reforestation. The ever-present woodcutter also often cuts newly planted trees. In areas suited to its growth, Leucaena may offer an answer to this problem. One tree of some of the giant Leucaena varieties can produce about 20,000 viable seeds/year. Once established, Leucaena regenerates rapidly after cutting with lush regrowth; therefore, "Leucaena virtually defies the woodcutter."

The land is unquestionably man's greatest material resource. The study of how a society uses its land indicates its future.

The best point to emphasize the need for reforestation is a quote from T. Dale and V. G. Carter's 1955 book Topsoil and civilization:

> Man, whether civilized or savage is a child of nature -- he is not the master of nature. He must conform his dominance over his environment. When he tries to circumvent the laws of nature, he usually destroys the natural environment that sustains him. And when his environment deteriorates rapidly, his civilization declines. How did civilized man despoil this favorable environment? He did it mainly by depleting or destroying the natural resources. He cut down or burned most of the usable timber from forested hillsides and valleys. He overgrazed and denuded the grasslands that fed his livestock. He killed most of the wildlife and much of the fish and other water life. He permitted erosion to rob his farm land of its productive topsoil. He allowed eroded soil to clog the streams and fill

his reservoirs, irrigation canals, and harbors with silt. In many cases, he used and wasted most of the easily mined metals or other needed minerals. Then his civilization declined amidst the despoilation of his own creation or he moved to new land. There have been from ten to thirty different civilizations that have followed this road to ruin."

Perhaps we may learn from Lewis Carrol who wrote in his classic Through the Looking Glass (Alice in Wonderland):

"Cheshire-Puss," she began, rather timidly" ... would you tell me please, which way I ought to go from here?"

"That depends a good deal on where you want to get to" said the Cat.

In the Philippines, in order to formulate and preserve the needed ethic and wipe out past negative connotations of the local variety of Leucaena leucocephala, some people have christened the giant varieties of Leucaena with a new name, "Bayani," which means "savior" or hero." Others have named it "Pamana," meaning "heritage." If empirical data are true, for many in the Philippines as well as elsewhere, Leucaena may well be a "savior" or "hero" and truly become a part of their "heritage" as it was in the ancient Maya and Zapotec civilizations of Mexico.

Leucaena leucocephala: an excellent feed for livestock

Introduction

Because there is an acute shortage of animal feed throughout the tropics, the need for high-protein forage and digestible nutrients is a chronic concern. Nowhere is the shortage more serious than in the seasonally dry tropics--vast scattered areas where recurring dry seasons inhibit the growth of shallow-rooted perennial forage grasses and pasture legumes. Pastures containing *Leucaena leucocephala* (Leucaena) are among the most productive in the tropics. Leucaena promises to become an especially useful forage source for the dry tropics. It can be harvested and carried fresh to animals, dried into leaf meal, fermented into silage, or animals can be allowed to browse the standing bushes. Whether it is young or mature, green, dry or ensiled, the Leucaena foliage is relished by livestock and by wildlife as well, particularly when green feeds are scarce. Succulent young Leucaena foliage is now used in various parts of the tropics to feed cattle, water buffalo, and goats (19).

Leucaena is indigenous to Central America. The Mayans and the Zapotecs disseminated it throughout that region long before the arrival of the Europeans. It is theorized that Leucaena as an intercrop and erosion control barrier served as a principal source of nitrogen

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fertilizer for corn, the staple food of both civilizations. Leucaena was so important to their agriculture that they recorded it in their pictographs. Mexico's fifth largest state, Oaxaca, derived its name from "hauxin," a pre-Columbian word meaning "the place where Leucaena grows."

Leucaena As Forage

As a forage crop, Leucaena has yielded as much as 20 metric tons (MT) of dry matter per hectare (ha) per year. In some areas, alfalfa may yield more green forage than Leucaena, but the nutritive value of green and dry Leucaena forage is equal or superior to that of alfalfa. Leucaena also is equivalent or superior to alfalfa in digestibility, and is markedly superior to alfalfa in percentage of protein, since the protein content of green Leucaena leaves generally exceeds 25%. The content of total digestible nutrients (TDN) is comparable, and Leucaena contains almost twice as much carotene (which provides vitamin A) as alfalfa. Dry Leucaena contains almost four times as much protein as napier grass (Pennisetum purpureum). The pelletized leaves of Leucaena are in demand as an animal feed mix in non-tropical areas such as Japan and Europe (19).

Recent experiments have shown that improved breeds of cattle will gain as much as 1 kg in weight per day when fed a 100% ration of protein-rich Leucaena for a 3 month period prior to slaughter. These tests were conducted by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. The leaves of improved strains of Leucaena contain 23%-30% protein by dry weight. Cattle can consume a high intake of Leucaena for a period of four months without any adverse effects, a length of time ideal for the fattening of cattle prior to slaughter (12).

Adaptation

Leucaena is persistent, rugged, and thrives on the steepest, rockiest slopes where its roots penetrate deep into rock crevices. It withstands prolonged periods of drought [22 centimeters (cm) of rain/year] and does very well in areas having as little as 60 to 150 cm of rainfall per year. In contrast, alfalfa and other similar forage-pasture plants usually require the best and most arable lands for their growth--land needed to grow food crops for human consumption (19).

Leucaena has a vigorous taproot and limited lateral branches that angle downward. Roots are commonly 2/3 as deep as the tree is tall. With its deep-growing root system, Leucaena can obtain water and nutrients from soil strata which are not accessible to most other plants (6).

Leucaena is found at elevations as high as 1,500 meters (m.). Higher altitudes often mean lower temperatures, shorter days (and thus less light), and more acidic soils; conditions which do not enhance Leucaena's growth. Leucaena does not normally tolerate water-logged soils, although strains growing along canals in Thailand seem to have adapted (8).

Leucaena is a legume and Rhizobium, nitrogen fixing bacteria, live in symbiotic relationship in the plant root nodules enabling it to fix nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena as well as for other plants. Not all soils contain the correct strain nor the necessary amount of Rhizobia to ensure proper inoculation and growth of Leucaena. Therefore, Leucaena should be inoculated before planting (for detail see pp. 17 & 18).

Leucaena is generally found growing on neutral or alkaline soils and an acid-exuding strain of Rhizobium (31A3) is commonly associated with the plant. Characteristically, Leucaena does not thrive on highly acidic soils. However, research indicates that Leucaena may adapt to more acid soils if it is initially established with an alkaline-exuding Rhizobium (CB81) developed by CSIRO. Further research on the adaption of Leucaena to acid soils is being conducted at the Centro Internacional de Agricultura Tropical (CIAT).*

Leucaena has few serious enemies other than man who cuts it down; and monkeys which ravish the young pods. Other problems affecting Leucaena include the following: its roots will sometimes harbor soil fungi and young plants will damp-off in wet soils; weevils will attack the seeds, especially in the wet season or when the seeds are old (this problem is easily overcome by the use of insecticides); and isolated incidents of stem-borer damage to Leucaena branches have been reported.

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*Dr. Mark Hutton, former Chief, Division of Tropical Crops and Pastures, Cummingham Laboratory (CSIRO), is the principal researcher on the CB81 strain of Rhizobium and its use in the adaptation of Leucaena to acidic soils. Dr. Hutton can be contacted by writing him c/o Centro Internacional de Agricultura Tropical, Apartado Aero 6713, Cali, Columbia.

Also, animals will graze young plants to the ground, but Leucaena reasserts itself when grazing pressures are removed.

Plant Characteristics

In field trials conducted by the Pastures Division of the University of the Philippines at Los Banos (UPLB), an improved variety of Leucaena was used (cv Peru) and a yield of 18 MT of dried leaf meal/ha/yr was recorded (14). In other test plots, yields of 28 MT/ha were projected (6).

Leucaena is not wholly without fault as a tropical forage plant, as it contains a toxic alkaloid, mimosine (some varieties contain higher amounts than others). This may cause thyroid problems or other harmful side effects when excessive amounts of Leucaena forage are fed to animals over a sustained period of time. Ruminants can be fed a continuous ration containing 40% Leucaena by dry weight without suffering from the effects of mimosine toxicity. Non-ruminants generally will not tolerate rations that contain an excess of 5-10% Leucaena (dry weight). Mimosine toxicity symptoms will disappear after a short period of time and leave no residual effects when the animals are removed from the high level Leucaena diet. CSIRO in Australia has been working on the development of a low-level mimosine line of Leucaena which should soon be released (7).

Growing and finishing pigs can be fed rations containing as much as 20% Leucaena leaf meal (dry weight) provided that 0.4% ferrous sulfate is added to the ration, according to research conducted at UPLB (17). In the Philippines, pigs are often fed a diet composed of 100%

Leucaena one month prior to slaughter. This high intake causes the pig to loose its hair (bristles), thus alleviating the arduous task of removal.

Laying hens were fed a ration containing 10% Leucaena leaf meal (dry weight) and 0.2 to 0.4% ferrous sulfate supplement in similar experiments at UPLB. The hens showed no significant decrease in egg production compared to those fed on commercial rations. However, when the ration was increased to 20% of their total intake, egg production was reduced (18).

Leucaena leaf meal contains high amounts of carotene which provides the ration with vitamin A. A diet containing 4 to 6% Leucaena leaf meal restores health to chicks and pigs suffering from vitamin A deficiency. Also, carotene is a desirable additive to poultry rations because it enhances the yellow coloring of the egg yoke as well as the fat of the chickens.

Batangas beef is well known in the Philippines for its excellent quality and tenderness. It is obtained by force-feeding young calves in the "SUPAK" system of back-yard fattening, in which the ration contains a mixture of chopped Leucaena leaves, rice bran and water. The Leucaena for the ration comes from the hedgerows around the farmers' home lots, the Leucaena serving both as a fence and a source of forage.

Tests conducted at the Brackishwater Aquaculture Center (BAC) in Leganes, Ilo-ilo, Philippines concluded that bangus (milkfish), talapia, bass, and shrimp fed with Leucaena leaf meal grew faster and heavier than those not given the meal (13). Because Leucaena contains high amounts of protein, as well as large amounts of nitrogen-phosphorus-potassium (NPK), its leaves served not only as a fish food, but as a fertilizer for the pond, increasing plant growth and providing natural fish food.

Philippine farmers in Barrio Naalad, Naga, Cebu feed their goats a diet consisting only of Leucaena, banana and coconut leaves. The latter two have high cellulose and fiber content and contain few nutrients. One of the reasons Naalad farmers raise goats is to recycle Leucaena leaves for the production of high-nitrogen fertilizer which is then applied in a tobacco-onion-corn cropping system. High levels of Leucaena are also fed to their hogs and chickens. Research indicates that certain breeds of animals, as well as individual animals within a breed, are capable of ingesting greater amounts of Leucaena than others (3).

Recent research conducted in the Philippines and Hawaii by Dr. Raymond Jones*, CSIRO, indicates that some goats may develop bacteria in their rumen which breaks down the chemical compounds in mimosine, thus nullifying harmful side-effects. If this is so and these bacteria can be isolated and multiplied, it is possible that other ruminants can be injected with these bacteria which would enable them to consume a diet consisting of 100% Leucaena without suffering harmful side-effects.

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Pasture Systems and Management

Leucaena pastures, with their vigorous growth and high nutritive value, can support heavy stocking with livestock. They have demonstrated some of the highest carrying capacities of any tropical pastures. Leucaena pastures interplanted with Guinea grass (*Panicum maximum*) often carry up to 2.5 cows per ha (1 per acre). In favorable locations, Leucaena-grass pastures extend into dry seasons much longer than those with shallow-rooted forages, and when rains commence, Leucaena recovers rapidly so that animals can be restocked early. Leucaena pastures require little more care than grasses and continue to produce year after year, especially where soils are good (19). Planting systems can be varied to suit the terrain and specific conservation objectives.

BALANCED PASTURE-FORAGE SYSTEM--For prepared fields and planted pastures, it is desirable to interplant Leucaena with some sort of grass cover. A balanced pasture-forage system may be established by planting alternate bands of Leucaena and improved grasses/legumes with a Leucaena to grass ratio of 40:60 by area. Interplanting will keep the weed growth to a minimum, reduce erosion, increase ground water levels, add materially to the carrying capacity, and provide a more varied and better-balanced forage. The interplanted grasses will probably receive sufficient nutrients from the associated legume, therefore, little or no fertilization is required. Under a paired-row layout, two rows of Leucaena are planted about 1 m. apart with a 2 m. space between paired rows of Leucaena and an in-row spacing of 4 cm between plants. The grass should be planted 2 to 3 months after the seeding of Leucaena to permit free cultivation of inter-row spacing during the early stages of growth and also to give the slower-starting legume sufficient time to become well established. Guinea (Panicum maximum), Bermuda (Cynodon dactylon), Dallis (Paspalum dilatatum), Pangola (Digitaria decumbens), and Kenya Sheep (Brachiaria decumbens) grasses work well for such interplantings (2).

CUT AND CARRY FORAGE SYSTEM--For marginal and steep hillyland areas, as well as for extremely dry areas, another planting system is recommended. Giant varieties of Leucaena (K8, K28 or K67) are planted at a spacing of 1 m. by 1 m. and allowed to grow until they reach a 10 cm (4 inch) base diameter, or approximately 1 1/2 years, before cutting back. The trees are then cut to a stump height of 1 m. and allowed to coppice (regrow). The foilage is then cut every three months. The 1 1/2 year period before cutting allows the growth of a long taproot. It is this taproot, penetrating the water table, which enables the plant to draw on deep water resources during the dry season as well as tap substrata nutrients, thus increasing forage production. Production remains high even during the critical dry season months when other forage sources have dried up and become unpalatable. In addition, the deep roots help hold the soils. Improved grasses, such as Guatemala (Tripsacum laxum), can be planted in the spacing between the stumps for additional forage production. Guatemala grass is relatively shade tolerant and will flourish under this system. The lush forage growth can be cut and carried to a feed lot, dried for leaf meal, or browsed by cattle. The 1 m. x 1 m. spacing provides ample space for the passage of browsing cattle. However, Guatemala grass will not withstand heavy grazing.

As a pasture legume Leucaena requires careful management. Since it is exceptionally palatable, overgrazing will seriously impair the rapidity of recovery and subsequent productivity (17). It should be noted that Leucaena will grow into trees if neither grazed nor perodically cut.

Erosion Control

In areas where soil erosion is commonplace, well designed pasture forage systems can markedly reduce erosion rates. The use of Leucaena in cropping systems to effectively reduce soil erosion was demonstrated in an innovative farming system introduced in 1953 at the Alabang Soil Conservation Project, Alabang, Rizal, Philippines. The experiment site was severely eroded and devoid of organic matter, Exposed "adobe" stones were visible and the top soil was completely absent in parts of the experimental area. The land had a slope of 25% (a drop of 2 1/2 m. every 10 m.). Paired rows of Leucaena were planted on the contour, the rows were 10 cm apart and the in-row spacing was 4 cm between plants. The paired rows were spaced 1 m. apart throughout the cropping system. When the Leucaena reached a height of approximately 1 m.,it was cut back to 35 cm, and the trimmings were allowed to decompose between the rows. Tests indicated that 12.28 kg of nitrogen (equivalent to 68.4 kg of ammonium sulfate) was added to the soil for every ton of fresh material incorporated into the soil. In addition, the erosion on the plot with the Leucaena bands was only 2% of that which occurred on the control plot. The top soil on the Leucaena planted plot was improved physically, chemically, and biologically.

Leucaena not only builds soil fertility on marginal land, but it will suppress undesirable plants and grasses when planted at 1 m. x 1 m. spacing. Leucaena will suppress tenacious grasses, such as _Imperata cylindrica_ and _Saccharum spontaneum_, as well as noxious weeds, such as

Chromolaena ordorota [L.]. In many pastures in the Philippines, it drastically reduces the cattle carrying capacity of the land. It is fatal when ingested in large amounts, and over an extended period, Chromolaena deposits a high concentration of nitrate in the soil which will act as a suppressant to plant species having low tolerance to high levels of nitrates (4). The former are tenacious grasses and often considered as weeds. These grasses are relatively low in nutrient content, however, and exude plant suppressants which retard the natural succession of more desirable grasses and other plant species. Nevertheless, Imperata is one of the main sources of pasture grass in many parts of Asia. Imperata requires frequent burning to burn off coarse stems and to promote the growth of new grass. This "firing" burns the organic matter in the soil, reduces soil fertility, breaks down the soil structure, and creates an environment for accelerated erosion and degradation by exposing the soil to the leaching rainfall and solar radiation.

Establishment Procedures

Two determinations must be made before undertaking the establishment of Leucaena pastures. One has to do with the nature of the soil, its mineral content, and the other concerns the method of planting. A soil analysis will determine if fertilizer application is necessary to obtain optimum plant growth. The land selected for Leucaena pasture establishment should be prepared according to the planting method chosen. The necessity for these early decisions is explained in the following paragraphs.

'FERTILIZER REQUIREMENTS--Leucaena requires adequate levels of phosphate, potash and sulfur. High levels of magnesium and low calcium content in surface soils may cause retardation in the growth of Leucaena. Adequate levels of available trace elements--molybdenum and cobalt--are necessary for maximum efficiency of the nitrogen fixing bacteria (see INOCULATION pp. 14 & 15). Therefore, it is important that sufficient levels of these elements are available in soil in which Leucaena is to be grown. A soil test should be made on the site selected for the establishment of Leucaena prior to planting to determine the appropriate fertilizer that will be required to gain maximum growth.

SEED SELECTION--One kilogram of Leucaena seed would be sufficient to plant nine hectares of land at a spacing of 1m. x 1m., if 100% of the seeds germinated and all of the seedlings survived. It is almost impossible, however, to obtain these results under normal conditions. Scientific procedures should be followed when establishing Leucaena plantings so that maximum and uniform growth can be obtained. Leucaena seeds should therefore be selected according to size (large) and density (heavy). This can be done by using a "hardware screen" and separating the seeds by specific gravity.

It is recommended that the seeds be graded into four sizes which can be done by using three different sizes of hardware screen. If adequate amounts of seed are available, is is recommended that only the largest 50% of the seeds be used. This will give more uniform germination and growth rates as well as size. The germination percentage will be quite high and the seedlings more vigorous, which will markably reduce establishment costs. However, germination percentage will also depend upon how the seeds are handled and stored and if the seeds were properly scarified.

Generally, the largest seeds will be the heaviest unless the seed was not mature when picked, or damaged by disease or insects. Therefore, seed selection by specific gravity is optional. Mechanical devices are available for the selection of seed by specific gravity. However, they are rather expensive. A more simple method is separation in a salt solution. Salt can be added to water until the solution is thick enough to obtain the desired gradation. The lighter seeds will float to the top and a greater portion will surface as more salt is added. Rinse the seeds with fresh water after separation.

Recommended Leucaena Varieties

The genus Leucaena is diverse and to avoid confusion, the different varieties have been assigned numbers with the prefix "K." The growth characteristics of different varieties are often referred to as Hawaiian, Peruvian, Salvadorian, and "Hawaiian Giant"; however, these are not varieties and the use of these names adds to the confusion. Furthermore, the varities termed Peru, Peruvian, CV Peru and Peru (Cunningham) are all the same (6) (7).

Of the "Giant" varieties, K-8, K-28 and K-67 have shown the most promise in terms of growth rate and forage production, all of which are dual purpose--wood and forage. None of the varieties have been researched extensively to establish their specific growth differences. The K-8 variety is a sparse seed producer and may produce a little more wood; however, this has not been verified. The K-28 variety produces more seed than the K-8, but not as much as the K-67. The K-67 variety is a prolific seeder, therefore, it is excellent for programs which are large in scope and where a large amount of seed is needed. The K-67 variety may branch more than the other varieties. Another variety, the Peru (Cunningham), is often recommended as a good forage plant, but it will not produce large volumes of wood since it has bushy growth characteristics. In appropriate management systems, K-8, K-28 and K-67 varieties can equal the forage yield of Peru (Cunningham). However, these varieties will grow into trees if left unmanaged.

Seed Treatment

SCARIFICATION--Leucaena seeds must be scarified prior to planting to obtain maximum and uniform germination. Common methods are hot water, chemical and mechanical; the simplest being scarification by hot water (1)(2)(9). The easiest way to scarify by hot water is to:

> heat water to boiling point, remove from the heat and allow to cool for 1-2 minutes (instant coffee temperature). Place the seed in a container and pour the hot water over the seed; the volume of water should be twice the volume of the seed. Stir the seeds so that they are uniformly treated, allow the water to cool, and soak the seeds overnight.

STORAGE--Leucaena seed can be dried after they have been scarified. Either solar or oven drying is effective. As many as 97% of the seeds will germinate up to 11 months after scarification if they are properly dried and stored in air-tight containers and under conditions of low humidity (1). It is recommended that seeds not be scarified until just prior to planting.

INOCULATION--Nitrogen fixing bacteria, Rhizobia, live in symbiotic relationship with Leucaena, fixing nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena as well as other plants. Not all soils contain the correct strain nor the necessary amount of

Rhizobia to insure the proper inoculation and growth of Leucaena. Therefore, Leucaena seeds should be inoculated before planting. Leucaena generally grows in neutral or alkaline soils and an acid-exuding strain of Rhizobium (31A3) is associated commonly with the plant under these conditions. The Commonwealth Scientific and Industrial Organization (CSIRO) in Australia has developed a strain of Rhizobium (CB81), reported to be alkaline-exuding thus enabling Leucaena to grow in more acidic soils. In requesting Rhizobia strains, it is desirable to specify both the plant (Leucaena) and the pH of the soil in which it is to be grown.

Small quantities of the inoculum, CB81, may be obtained for research purposes from CSIRO, Davies Laboratory, Private Mail Bag P.O., Townsville, Queensland, Australia. Commercial and small quantities of 31A3 may be obtained from Dr. J. Burton, Nitragin Corp. 3101 West Custer Ave., Milwaukee, Wisconsin 53209, U.S.A. Small experimental samples of CB81 and 31A3 inoculums as well as information and training in Rhizobium production can be obtain form the University of Hawaii-NifTAL Project, P.O. Box "O," Paia, Hawaii 96779, U.S.A. Rhizobia inoculants are inexpensive. The Rhizobia should be stored at temperatures ranging from 0° to 7° Centigrade or 32° to 45° Fahrenheit, approximately the temperature of a refrigerator. Seeds are easily inoculated after scarification by sprinkling the damp seeds with a light coating of inoculum.

PELLETIZATION--If Leucaena is to be direct seeded, it is recommended that the seeds be pelletized (coated) with the appropriate fertilizers to overcome nutrient deficiencies during its establishment phase (5)(10)(15)(16). Each 4 kg of scarified seed should be wet with a 3% aqueous solution of a non-toxic stickler, cellophas (methyl ethyl cellulose). A high density of inoculum is then applied. The seeds are than coated by rolling them in a mixture consisting of 1 kg of finely ground rock phosphate to which 400 grams of molybdemum trioxide has been added. This amount of molybdenum is enough to last for five to seven years. Molybdenum is important in the promotion of nitrogen fixation by the Rhizobium nodules. In acid soils, lime also plays an important role. The Rhizobium strain recommended for acid soils is CB81 (alkali exuding) and 31A3 (acid exuding) for alkaline soils. The pelletization should be done just before planting and the pelletized seed refrigerated prior to use maintain Rhizobium viability.

Field Preparation

Field preparation will vary depending upon terrain, size of area to be planted, soil conditions, available equipment and establishment cost constraints.

1. Controlled burning is the most simple and inexpensive method of land clearing. However, this method has its limitations. There is an inherent danger that the fire could not be adequately controlled and result in damage to adjacent properites. In addition, a portion of the organic matter in the topsoil may be destroyed and some soil erosion may occur. Furthermore, fires endanger wildlife that live in these areas. Nevertheless, there are always certain trade-offs in any system. When ground cover is burnt the ash is a ready source of fertilizer. When burning grasses, such as *Imperata cylindrica* and *Saccharum spontaneum*, it is recommended that the old grass is fired when new green growth is approximately 22 cm (8 in) high at the first part of the rainy season. This will help set back

new growth by draining stored energy from the grass roots. Seeds are dibbled directly into the ash. Herbicides have also been used to reduce weed (grass) competition in seed bed preparation.* However, this method only kills the grasses and the dead-dry grass poses a fire hazard to interplanted crops.

2. Ring weeding is simply a method of hoeing or cutting down the weeds around the Leucaena seedling after it has been transplanted into the field. A circle, 1 m. in diameter, surrounding the plant, is cleared of weeds. It is necessary to do this 2 or 3 times before the Leucaena will reach a height so that it can compete with surrounding weeds.

3. Furrows are plowed (animal or tractor) in the field at desired spacings between rows and the seeds are simply dropped in the furrow and lightly covered with soil.

4. A more intensive method of field preparation is that which would be done as if preparing the field to plant corn. The seed is dibbled, broadcasted or drilled into the seedbed.

Propagation and Sowing Procedures

Leucaena is conventionally grown in polyethylene bags, other containers (bamboo tubes, cans, etc.), or grown in seedbeds and then transplanted to the field. However at times, direct seeding may be a more appropriate technology. There are advantages and disadvantages to both methods, but direct seeding is a much less expensive method of planting.

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*Oregon State University (under an A.I.D. contract) used a herbicide, glyphosate, to kill "giant perennial grasses" in land preparation. Corn and beans are then "dibbled" through the residual mulch. The mulch greatly reduces annual weeds and soil erosion, saving time and money in land preparation. It is felt that this system could be used in establishing Leucaena stands.

1. <u>Conventional methods</u> of propagating Leucaena include the use of:

(a) Polyethylene bags [3 in. dia. x 6 in. high (7.5 cm x 15 cm] are filled with fertile potting soil. In place of potting soil, a mixture of river silt, sand and manure (equal parts) is recommended. If chicken manure is used, then reduce the manure proportion to 1/6 of the total. The bags should be perforated bottom to prevent the soil from being waterlogged causing the plant plant "damping off." After scarification, the seeds should be planted at a depth of 1 in. (2.5 cm) and covered with soil.

The bags should be placed under 3/4 shade. The shade can be made easily from grass, palm fronds, bamboo, colored polyethlene or commercial shade screen. The seeds should germinate 3-5 days after planting. The newly sprouted seedlings should be kept under 3/4 shade for approximately 1 week, then 1/2 shade for one week and full light after 3 weeks. It is recommended that the seedlings be fertilized every two or three weeks by disolving a heaping tablespoon of chemical fertilizer (15-15-15) in 2 gallons (approx. 6 liters) of water. This is applied as a normal application of water. The seedlings should be transplanted no later than 40-45 days after emergence or at a height of 9 in. (22.5 cm). This will minimize root-curl in the bag. Root curl will deform the tap root, thus reducing depth penetration and limiting the amount of water and minerals available to the plant.

Leucaena should be transplanted at the beginning of the rainy season. The seedling should be removed from the plastic bag without root disturbance to reduce transplant shock. The seedling should be placed in a hole and soil filled in around the plant and lightly compressed by pressing down on the soil around the plant with the foot. The plant should be recessed approximately 1-2 in. (2.5-5 cm) below ground surface level to act as a catchment for rain water. Additional applications of fertilizer are recommended. At the time of transplanting, a time release chemical fertilizer, such as Mag-Amp, could be placed in the hole as a one-time application. While the application of fertilizer may not be necessary, it will optimize growth.

(b) The use of seedbeds is a common practice when propagating Leucaena. However, the author does not recommend this method because of injury to the roots (transplant shock) when the seedling is pulled or dug for transplanting. If circumstances necessitate the use of a seedbed, it is recommended that the seedbeds be trenched and filled with sand or humus and then bedded to provide adequate drainage and to minimize root damage when seedlings are lifted for transplanting. The seedbed should have a pH as near as neutral as possible. Seeds should be drilled at an approximate spacing of 1 1/2 in. (approx. 4 cm.) in-row and 10 in. (25 cm.) between rows. If thoroughly mixed with the soil, 10 grams of complete chemical fertilizer [N-P-K (15-15-15)] per square meter of surface should be adequate. Animal manure can be substituted.

PRUNING--When Leucaena is transplanted, the leaves should be stripped from the seedling, leaving only 2 or 3 of the topmost compound leaves. This reduces evapotranspiration and reduces dieback. A less desirable practice entails pruning the top portion of the seedling, leaving only the brown wood, and pruning tow-thirds of the tap root prior to transplant. However, pruning the top of the seedling will cause excessive branching, an undesirable development if the tree is to be harvested as a pole at the time it is cut back. Furthermore, the tap root of a great many legumes will not regenerate once pruned, and pruning causes transplant shock and growth retardation. The author has observed that once the tap root of Leucaena has been cut, it does not regenerate. In areas with a pronounced dry season, it is essential that Leucaena achieves maximum tap root development so that maximum subsurface water and nutrients are available for optimum forage yield (2).

2. Direct seeding greatly reduces the costs incurred in planting Leucaena by eliminating the nursery and transplanting operations. Emperical observations indicate that growth is optimized by eliminating transplant shock in the establishment phase, thus the plant reaches maturity in a shorter period of time. However, planting must coincide with the onset of the rainy season. When Leucaena is to be direct seeded, it is recommended that the seed first be pelletized prior to sowing (see: PELLETIZATION under Seed Treatment). However, when seed is dibbled in the AUGER HOLE method (see below) pelletization is unnecessary if the soil is fertile and the seed inoculated with Rhizobia.

(a) Dibbling is a simple method of direct seeding whereby a pointed stick is used to punch a hole in the ground into which 1-3 seeds are placed, then covered with dirt by a sweep of the foot. It is recommended that the seed be pelletized. This can be the most appropriate method of establishing a 1 m. by 1 m. Leucaena system. The efficiency of the dibble method could be increased by the use of a modified corn planter.*

AUGER HOLF method is when a hole is augered or bored into the ground (with a common soil sample auger) prior to the onset of the rainy season. The bore hole is 3 in. by 6 in. (7.5 cm by 15 cm) and the hole is filled with a fertile potting soil (previously described). Preferably, a time release fertilizer (such as Mag Amp) is added to the soil to provide continued fertilization to the plant while growing. After scarification and inoculation with Rhizobium the seed is dibbled into the hole at the onset of the rainy season.

(b) Seed can be drilled by using a simple mechanical hand seed drill*, by a tractor drawn seed drill (such as those used to plant peas, corn, etc.) or by simply dropping them into the furrow.

(c) Broadcasting can be done by a simple hand seed broadcaster*, by a more sophisticated commercial mechanical device or by aerial seeding. Aerial seeding would be the most efficient method of sowing large tracts of land (19).

"Giant" Leucaena, a lush, protein-rich livestock feed that thrives on marginal land, will multiply the carrying capacity of tropical pastures, thus intensifying livestock production and increasing farm income.

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*Blueprints of a corn planter, a simple seed broadcasting machine and a seed drill may be obtained from Volunteers in Technical Assistance (VITA), 3706 Rhode Island Ave., Mt. Ranier, MD 20822. The hand corn planter can be modified to accommodate the pelletized Leucaena seed by simply enlarging the outlets.

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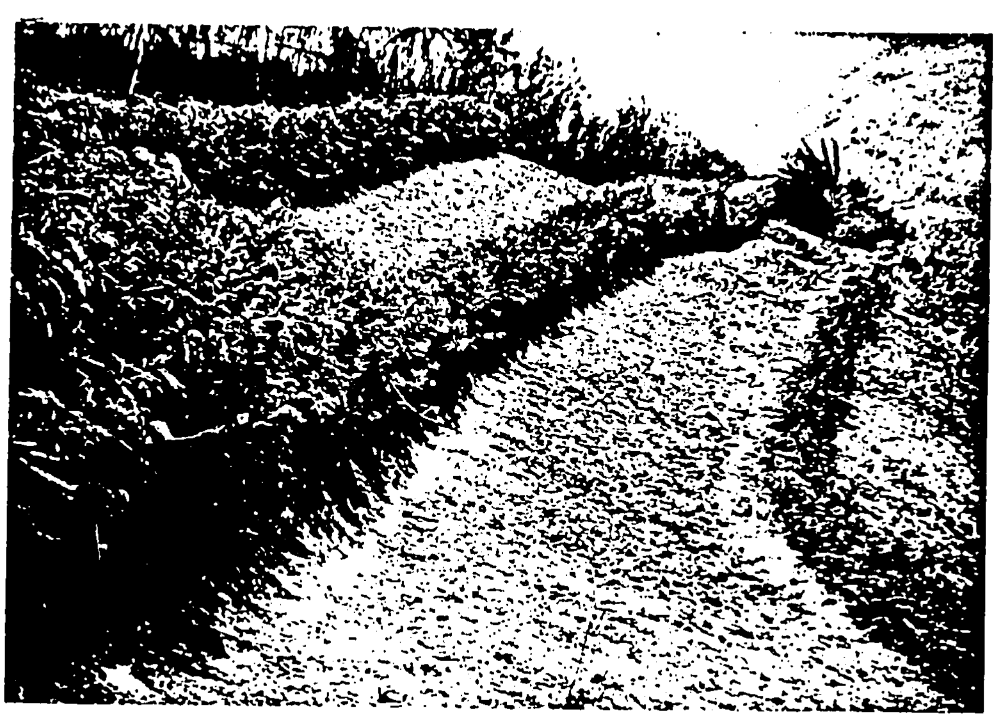
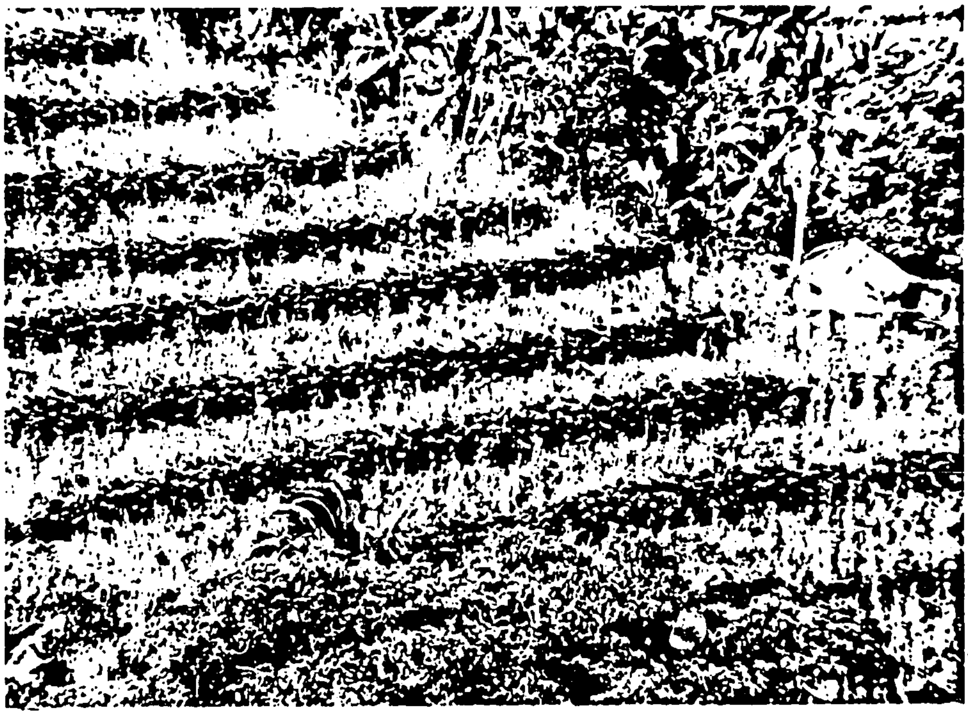
Island of Flores, Indonesia -- Leucaena leucocephala, planted in contour hedgerows for erosion control and soil improvement, survives low annual rainfalls of 700mm without adverse affects. Leucaena, with deep taproots, can survive the long dry season by reaching water that other plants cannot get to. Thus, even during the long dry season, Leucaena remains green, one of the few plants that does so.

Leucaena's long taproot and its downward growing sideroots can penetrate layers of hard clay soils, thus, it improves the soil structure and binds it, an important characteristic for stabilizing steep slopes. Indirect terraces are established when the washed off soil is collected by the hedges along contour lines.





Leucaena is an excellent source of fertilizer and its leaves contain abundant amounts of nitrogen, potassium and phosphorus. The Leucaena, cut approximately every 30 days and applied as a green mulch, can substantially increase yields of food crops intercropped between the hedgerows while maintaining soil fertility. Once these Leucaena cropping systems were established on Flores, water began to once again flow in the streams below; the first time in 15 years.

Agro-forestation Systems Using *Leucaena* as Erosion Control Barriers

Agro-forestation systems using *Leucaena leucocephala* (Leucaena), planted in contour hedges on hillsides, has proven to be an inexpensive and effective means of controlling soil erosion and increasing crop yields (Tab A). It also improves water infiltration, thus enhancing perennial water availability. In Indonesia, some twenty thousand hectares of land have been converted to these Agro-forestation systems.

Much of the land converted to these systems had either been abandoned, was degraded, or was being farmed by slash-and-burn cultivators. Formerly, slash-and-burn cultivators were unable to sustain crop yields beyond two or three years before erosion and soil infertility would force them to abandon their fields and move to new areas. Since the establishment of the Leucaena soil erosion control systems, some slash-and-burn cultivators have now become sedentary farmers. They have remained on the same land for as long as eight years, while maintaining or increasing crop yields.

Seed Production

Leucaena soil erosion control barriers require large amounts of seed in their establishment. Therefore, it is necessary to establish a dependable seed source of the appropriate variety of Leucaena prior to the launching of a large scale program. The K67 variety of Leucaena is a prolific seeder, therefore, it is an ideal variety for this system.

One way to develop appropriate seed supplies, is to encourage farmers to plant a number of trees around the border of their fields or around their houses. In some cases, farmers may be subsidized to grow the seed by paying them, either monetarily or in kind, to plant and maintain the trees. The K67 variety of Leucaena usually begins producing seed nine months to one year after transplant. If the planting of trees and the growing of seed is subsidized, it is recommended that the farmer be paid (1) at the time that he plants the trees, (2) at six months for maintaining the trees, and (3) for the seed produced. Once an adequate amount of seed is produced, the trees could be cut for poles, firewood, etc., or cut back to a stump height of 1 meter, and allowed to coppice and the foilage cut for livestock forage.

Demonstration Farms

Marginal and subsistence farmers cannot afford the risk of change, for to do so and fail, may mean disaster for them and their family. However, they will readily adapt new methods, if these innovations demonstrate an increase in crop yields; are an improvement over what they are presently doing; and are affordable. To demonstrate the value of Leucaena erosion control systems, it is suggested that farm leaders be identified in areas targeted for treatment. These farm leaders should then be contracted for a period of no less than two years to establish these systems on no more than half of their farm. These farmers should be given a guarantee that by using the new system, their crop yields will equal or surpass that on untreated land. In this way, a comparison between the old and the new system can readily be made. Once the value of the new system has been demonstrated, nearby farmers should be invited to the demonstration farm sites to make comparisons. Assistance should then be offered to those farmers who wish to establish Leucaena erosion control barriers on their farm sites.

Technical Aspects

Leucaena erosion control barriers should be established first by digging ditches (canals) on the contour of the hillside (see figure 1 Tab B). The design and layout of this system can be done by using a simple A-frame (see Tab C). Some soil-water engineers recommend that these hillside ditches be constructed with a 1% slope to allow excess water to drain off into a grass or stepped waterway.

Just prior to planting, Leucaena seed should be scarified and inoculated (see Tab D) with the appropriate strain of Rhizobium (nitrogen fixing bacteria). The Leucaena should be planted on the bund (dike) of the hillside ditch. When planting the Leucaena, make a small furrow on the top of the bund, spread the seed in the furrow at an approximate 2.5 centimeters (2 in.) spacing, and cover with no more than 2.5 cm of soil. Additionally, a grass barrier can be planted on the uphillside of the hillside to reduce the volicity of the water running into the ditch (see figure 2, Tab B). Napier grass (Pennisetum purpureum) is well suited for this purpose and it is an excellent cut-and-carry forage grass for livestock. The distance between the hillside ditches may vary, considering the size of the farm site, the type of crops grown and the slope of the land. One recommendation is, one contour barrier for every 1.5 meters, (5 feet) difference in elevation.

Leucaena leucocephala Fertilized Hybrid Corn Yields 9 m.t. per hectare.*

The value of Leucaena leucocephala (Leucaena) to maintain soil fertility was documented in Indonesia as early as 1900. In 1975, Dr. Anacleto Guevarra, at the University of Hawaii, researched the actual chemical fertilizer equivalent to the termed "Hawaiian Giants varities (K8, K28 and K67)," applied as a green manure crop (3). He found that the fertilizer equivalent of one hectare of Leucaena harvested over 1 year was estimated as more than 500 kg of nitrogen (N), 200 kg of phosphate (P), and 500 kg of potash (K). Alfalfa will add only about 300 kg N/ha per year and clover 100 to 200 kg/N/ha/yr.

Yields of 9 m.t. per occupied ha of a single cross, field hybrid corn variety (H610), have been achieved under experimental conditions at the University of Hawaii, using a "Giant" variety of Leucaena leucocephala, as a fertilizer. These experiments were conducted by Dr. Gueverra (4), one of a group of scientists researching the multiple uses of Leucaena under tropical conditions.

Guevarra's Method

Guevarra planted Leucaena 91 days before the corn in single and double rows. This would allow the Laucaena to establish its roots without having to compete with the corn. A "Giant" variety of Leucaena (K8) was used because of its rapid and upright growth habit.

Article by Michael D. Benge, Office of Agriculture, Agro-forestation, Development Support Bureau, Agency for International Development, Washington, D.C. 20523.

The hybrid corn was planted between one single row or two paired rows of Leucaena. The spacing between the Leucaena rows was 0.5 meters. The spacing between the Leucaena and the corn rows was also 0.5 m. Spacing between the leucaena plants was 15 cm. in-row. For the corn, spacings of 30, 50, 70 cm. per hill, were used.

Just before planting the corn, the Leucaena was harvested, chopped, and turned into the soil. The fertilizer value of the Leucaena was soon apparent. In the 1 to 1 planting (1 row corn, 1 row Leucaena), the Leucaena was cut back and applied as a green mulch side dressing at 40, 61, and 92, days. This method gave a corn yield of 7.5 m.t. of corn per hectare. The 2 to 1 planting regime, using the same method, yielded 9.4 m.t. of corn per hectare. On the control plot fertilized with chemical fertilizers (75 kg. Urea-N per ha), the yield of corn was 5.25 m.t. per has. A second control plot was fertilized with 150 kg. of Urea-N/ha resulting in only a 9% yield increase. Nitrogen,in synthetic form,applied in excess of 75 kg/ha gave no significant yield increase, while N applied in the form of organic fertilizer (Leucaena) was more effective.

Guevarra's experiment was not unique. In 1953 at the Alabang Soil Conservation project, Alabang, Rizal, Philippines, a less productive common variety of Leucaena was intercropped with a local variety of corn, Pangasinan yellow flint, under conditions similar to those found among the hilly land corn farmers throughout the Philippines (4). The land where the experiment was conducted was severely eroded and devoid of organic matter. In some parts of the experimental area adobe stones were exposed and the top soil was completely removed. The area has a slope of 25% (a drop of 2.5 m. every 10 m.).

Paried rows (bunds) of Leucaena spaced 10 cm. between the rows and 10 cm. in-row were planted on the contour of the experimental field. The distance from one pair of rows to the next was 1 m. When the Leucaena waa about 1 m. high it was cut back leaving stumps 35 cm. high. The trimmings were allowed to decompose between the rows. Sometimes the cuttings were turned under and incorporated in the soil. The cutting frequency was from 1½ to 2 months apart. Continuous interplanting of corn was made throughout a period of four years.

The continuous addition of Leucaena as a green manure increased the yield of the corn by 380% Erosion of the experimental plot under this modified form of cropping, was less than 2.5% of the erosion of the control plot.

At the University of the Philippines at Los Banos, Leucaena plots yielded as high as 18 m.t. of forage/ha/yr (5). In Guevarra's experiment, the average forage yield of Leucaena in a single row was 15 m.t./occupied ha., or a 28% yield increase. Whereas the corn gave only a 25.7% increase under the double row, therefore, the competition between the two rows of Leucaena was stronger than that between the corn and the Leucaena. In the double row plot, the Leucaena occupied an additional 1/3 of the total land area while producing only ¼ more yield, a significant factor to consider.

In 1976, the Philippine national corn harvest average was 0.84 m.t. per hectare. This is far below Guevarra's experimental results. Even though many conditions relating to production vary between Hawaii and the Philippines, this crop management system could significantly increase corn yields. This especially could be so among the impoverished farmers in the Visayan area, whose average corn yield is 0.66 m.t. per hectare. It might prove beneficial for the Philippines as well as elsewhere to adopt this corn/Leucaena system.

There is much evidence for the need to improve crop management techniques. The costs involved in fertilizing, not to mention irrigation facilities, are generally prohibitive to the small farmer. Synthetic fertilizers are costly and likely to increase in price in the future.

These facts all emphase the need for alternative methods of fertilization. Leucaena as a natural fertilizer, fixes and accumulates Nitrogen while making Phosphorous, Potassium and trace elements in the soil into a more readily available form. In addition, it improves the soil structure and porosity through the addition of organic matter. By using the "Giant" varieties of Leucaena is one such alternative which is cheap and readily available.

The mounting cost of chemical fertilizers has placed them out of reach for most small scale farmers; and investment they usually cannot afford. Spiraling costs, the population explosion and increased demands for food production therefore make it imperative that alternative farm technology is made available to the small scale farmers. Leucaena an excellent source of organic fertilizer, is one such excellent alternative.

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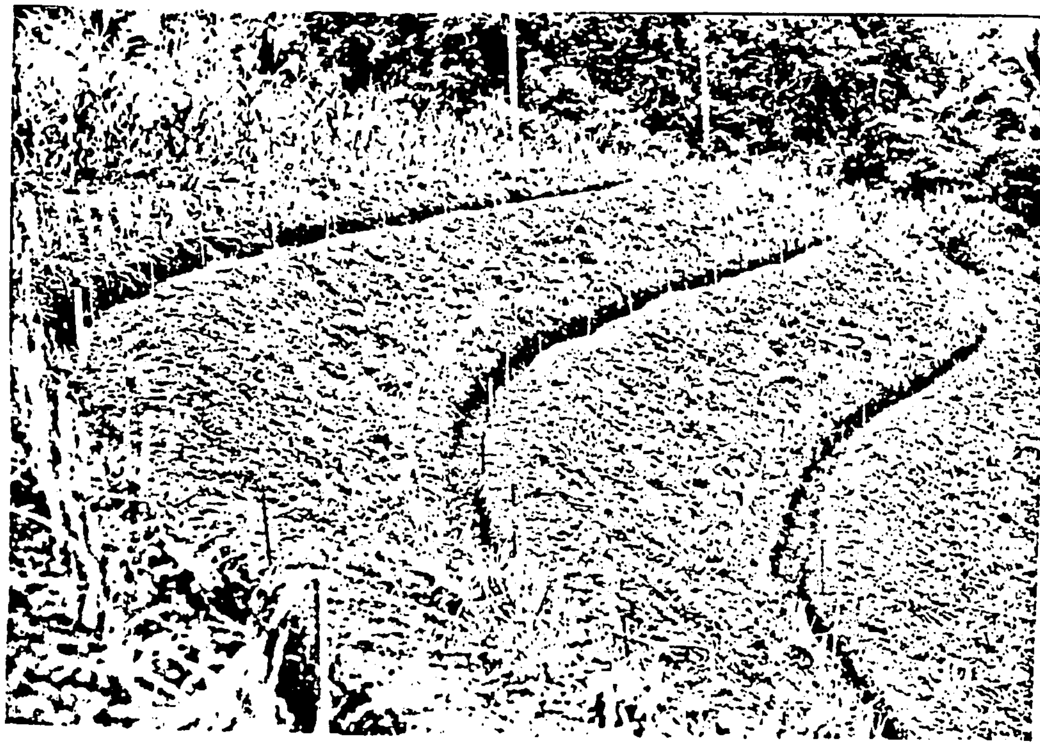


Figure 1

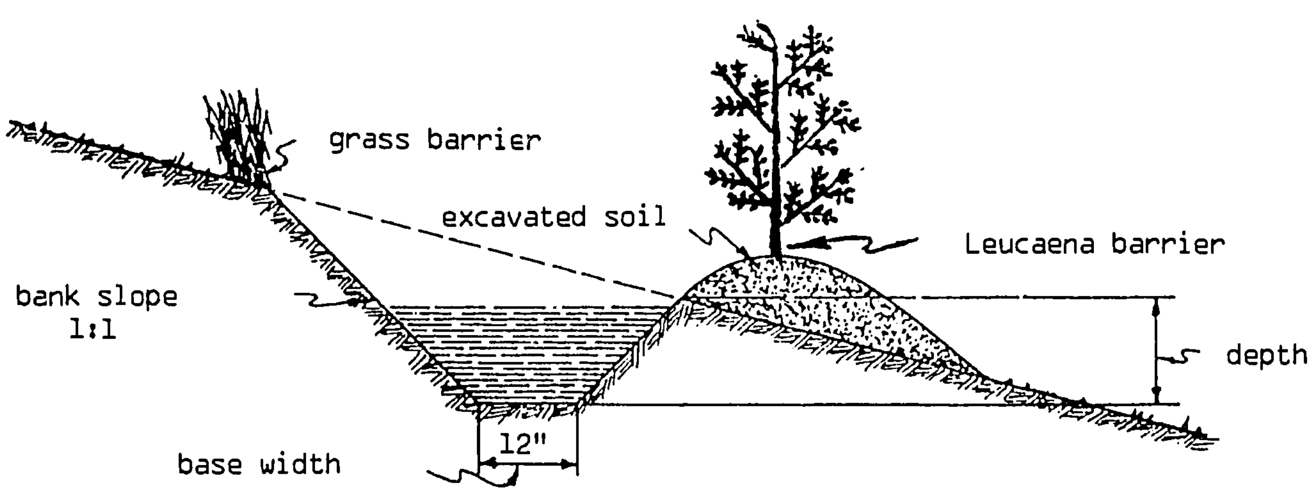


Figure 2

A World Neighbors Filmstrip

SAVING OUR SOIL WITH THE A-FRAME

World Neighbors believes that development cannot be accomplished alone, but is achieved by working and sharing together. Its goal is a better world and its means is the sharing of knowledge, talents, skills, money and most of all, love

SAVING OUR SOIL
WITH THE A-FRAME

1. A handful of soil . . . how much is it worth? It's the most valuable resource on earth.

2. All the food we eat, clothes we wear and most of the things we use come from the soil.

3. But if our lands are left unprotected, erosion can destroy our precious soil.

4. Rain is a blessing when it is soaked up by the soil, but long, heavy rains can also wash away the top soil and cut deep gullies in our fields.

5. When planting on hillsides, we often plant rows running up and down. This is a bad practice.

6. Many farmers burn away corn stalks, leaves, grass, etc. This is also a bad practice. To make the soil better, these things should be turned back to the soil.

7. We need to protect our slopes and hillsides by planting all our crops on the "contour": that is, in rows running across the slopes and around the hillsides.

8. We also must construct contour canals or barriers running across the slopes and around the hillsides.

9. In rocky places, the rocks can be made into rock walls, which slow down the flow of the rain water and hold back the soil.

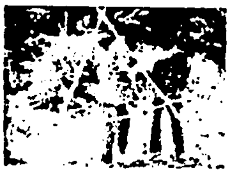
10. Where there are no rocks, level canals can be dug to absorb the rain water. Grass barriers on the upper side of the canals hold back the soil.

11. In order to mark level rows, we need a special tool which is called an A-frame. The A-frame is easy to make and easy to use, plus it is one of the most important tools in the world.

12. Because it can save our soil.

13. These are the only materials you need for making an A-frame: three poles, a piece of cord or vine, a rock and a machete. (Narrow boards, if available, can be used.)

14. First, cross two poles at the top and tie them together securely. (If boards are used, nails can be used to help faston them.)



15. Now tie a shorter pole across the other two to form the letter "A." Tie both ends securely.

16. Now tie another length of cord to the top of the A and let it hang down below the crossbar.

17. Tie a rock to the end of the cord, below the cross bar.

18. Now the A-frame is almost finished but before we can use it to mark level contours, we must find the point on the crossbar which will tell us when the two legs are in a level position.

19. First, stand the A-frame upright. Using stakes, mark the points where the legs of the A-frame touch the ground.

20. With a pencil, mark the point where the string passes the crossbar of the A-frame.

21. Move the frame so the placement of the legs is reversed.

22. The left leg now touches the stake where the right leg was, and the right leg touches the stake where the left leg was.

23. Again mark the point where the string passes the crossbar. Usually the two marks will be separate. If the ground is level, the two marks will be at the same place.

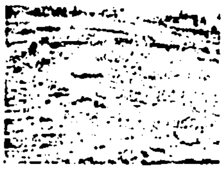
24. Now make a third mark halfway between the first two. This is the point on the crossbar which will tell us when the two legs are in a level position.

25. In order to keep from erasing this mark, cut a notch there with your machete.

26. When the weighted cord hangs directly in front of the notch, we know that the two legs are level.

27. Now the A-frame is finished and marked, and we are ready to mark level lines on our hillsides.

28. In our country much of the land is very steep. Many other areas have gently sloping hillsides. Both should be protected with contour canals and barriers, and the crops should be planted in level rows across the slope.



29. Study the area of your field on which you want to construct contour barriers. It is good to start near the top of your field.

30. First, cut a supply of stakes. These stakes are used for marking the level lines where the ditches will be dug or the rock barriers will be constructed.

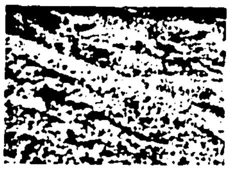
31. Drive the first stake at the edge of the field near the highest point. You will begin marking the contour lines at this point.

32. Place one leg of the A-frame just above and touching the first stake. Adjust the other leg so that the string passes the level position point you notched on the crossbar.

33. With the string passing exactly the point of the level position, drive another stake into the ground just below and touching the second leg of the A-frame.

34. Now pick up the A-frame and move it along, placing it so that one leg of the A-frame touches the stake you just drove into the ground.

35. Again adjust the other leg of the A-frame until the string passes the level position notch. Drive another stake just below and touching the second leg.



36. Continue across the field this way. Now we have a level line of stakes which tell us where the first contour barrier will be constructed. But one contour barrier is not enough.

37. A hillside must be protected with one contour barrier for every five feet (1.5 meters) of difference in elevation. On steep hills, the barriers will be close together. On gentler slopes, they will be further apart.

38. Continue marking level contour lines across the field until you reach the bottom of the slope.

39. If the field is rocky, use the rocks to construct rock barriers along the level lines marked by the stakes.

40. Some fields are not rocky, though. Use the A-frame in the same way to mark level contour lines across the field.

41. Then dig canals along the line of the stakes. The canal should be 1/2 meter wide and 1/2 meter deep.

42. Plant grass along the top of the canal. A tall, thick variety, such as elephant grass, napier grass or guinea grass, is best.

43. Be sure to follow the line of stakes when digging canals. Remember, these stakes mark the level lines across the field.

44. Use a hoe, or hoe and shovel to dig the canals.

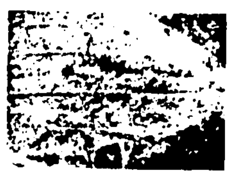
45. On some fields you can make both canals and rock barriers. In rocky areas, construct rock barriers. In other areas, dig canals.

46. When the heavy rains come, the grass or rock barriers will catch the soil and prevent it from being washed down the slope.

47. As the soil is caught behind the grass or rock barriers, terraces will gradually build up.

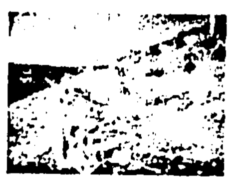
48. Within a few years, our contoured fields will look like this. As the terraces build up, not only is the soil saved, but the fields become easier to work because they are becoming more level.

49. In many parts of our country, soils are already being protected with contour ditches.



50. Local farmers with the help of government agencies and international groups are beginning to build contour barriers and dig canals like these on their farms.

51. Farmers are beginning to protect their fields by planting their crops on the contour.



52. Even on steep rocky slopes like this the soil can be saved for reforestation.

53. Here's an example of what can be done. Slopes which are too steep or rocky for food crops can produce trees for lumber and fuel. The forests also help to conserve the soil.

54. So when we look at a hillside and see contour canals like these, we know that here lives a farmer who understands the value of his soil and how to conserve it.

55. He knows that the soil is the most valuable resource on earth.

FIN
THE END
FIN

THE END

QUESTIONS FOR DISCUSSION

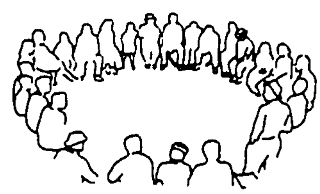
1. Why do you think soil is the most valuable resource on earth?
2. What are some good things rain does for the soil? What are some bad things rain does for the soil?
3. What are some bad farming practices which you have seen in your community?
4. What are some good farming practices which you have seen in your community?
5. What does "planting our crops on the contour" mean?
6. How can a farmer find the contour on his field?
7. Where is the best part of the field to begin marking the contour?
8. Ask someone to explain how to use the A-frame.
9. Name the different kinds of contour barriers.
10. How much difference in elevation should there be between barriers?
11. Does a steep slope have more or less barriers than a gentle slope?
12. After marking the field with stakes, what is the next step?
13. What are the dimensions of the canal?
14. How can rocks and grass be used?

NOTE: Join together with your neighbors to study recommendations given through a filmstrip or film. Many problems cannot be solved by one person working alone. These same problems can be solved when people and communities work together – with each person contributing and cooperating to achieve a common objective.

Materials for education in health, family planning, agriculture and community development.

WORLD NEIGHBORS

International Headquarters – 5116 N. Portland Ave. – Oklahoma City, Oklahoma 73112 U.S.A.



Overseas Development Materials

Inoculation and Scarification Procedures

Nitrogen fixing bacteria, Rhizobium, live in symbiotic relationship with Leucaena, fixing nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena, as well as, other plants. Not all soils contain the correct strain, nor the necessary amount of Rhizobium to insure the proper inoculation and growth of Leucaena. The Leucaena seeds should, therefore, be inoculated before planting. Leucaena generally grows in neutral or alkaline soils and an acid-exuding strain of Rhizobium (31A3) is associated commonly with the plant. The Commonwealth Scientific and Industrial Organization (CSIRO) in Australia has developed a strain of Rhizobium (CB81), reported to be alkaline-exuding, thus, enabling Leucaena to grow in more acidic soils. In requesting Rhizobium strains, it is desirable to specify both the plant (Leucaena) and the pH of the soil in which it is to be grown.

Small quantities of the inoculum, CB81, may be obtained for research purposes from CSIRO, Davies Laboratory, Private Mail Bag P.O., Townsville, Queensland, Australia. Commercial and small quantities of 31A3 may be obtained from J. Burton, Nitragin Corp. 3101 West Custer Ave., Milwaukee, Wisconsin 53209, U.S.A. Small experimental samples of CB81 and 31A3 inoculums, as well as, information and training in Rhizobium production can be obtained from the University of Hawaii NifTAL Project, P.O. Box "O", Paia, Hawaii, 96779, U.S.A. Rhizobium inoculants are inexpensive.

The Rhizobium should be stored at temperatures ranging from 0° to 7° Centigrade or 32° to 45° Fahrenheit, approximately the temperature of a refrigerator. The seeds are easily inoculated after scarification by sprinkling the damp seeds with a light coating of inoculum.

Leucaena seeds must be scarified to obtain maximum and uniform germination. Common methods are hot water, chemical and mechanical, however, the simplest is scarification by hot water. The easiest way to scarify by hot water is to:

> Heat water to boiling point, remove from the heat and allow to cool for 1-2 minutes (instant coffee temperature). Place the seed in a container and pour the hot water over the seed; the volume of water should be twice the volume of the seed. Stir the seeds so that they are uniformly treated, allow the water to cool, and soak the seeds overnight.

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON D C 20523

Dear Sir or Madame:

There are few reliable sources of seed of the GIANT varieties of Leucaena leucocephala. The price may vary from one place to the other, depending upon labor and shipping costs and the quality of seeds. I generally recommend three sources, two in the U.S. and one in the Philippines.

Maryland: Tree Seeds International
2402 Esther Court
Silver Spring, MD 20910
ATTN: Dr. Fariyal Sheriff

Hawaii: Dr. Linden Burzell
Lowe Inc.
P.O. Box 131
Kahuku, Hawaii 96731

Philippines: Philipinas Plant Center
P.O. Box 3350
Manila, Philippines
ATTN: Miss Belen H. Abreu

I generally recommend three varieties, K-8, K-28, and K-67, all of which are dual purpose, wood and forage. None of the varieties have been researched extensively to establish their specific growth differences. The K-8 variety is a sparce seed producer and may produce a little more wood, however, this has not been verified. The K-28 variety produces more seed than the K-8, but not as much as the K-67. The K-67 variety is a prolific seeder, therefore, it is excellent for programs which are large in scope and where a large amount of seed is needed. The K-67 variety may branch more than the other varieties. Another variety, the Peru (Cunningham), is often recommended as a good forage plant, but it will not produce large volumes of wood, since it has bushy growth characteristics. In appropriate management systems, K-8, K-28, and K-67 varieties can equal the forage yield of Peru (Cunningham). However, these varieties will grow into trees if unmanaged.

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The Rhizobium should be stored at temperatures ranging from 0^o to 7^o Centigrade or 32^o to 45^o Fahrenheit, approximately the temperature of a refrigerator. The seeds are easily inoculated after scarification by sprinkling the damp seeds with a light coating of inoculum.

Leucaena requires adequate levels of phosphate, potash and sulfur. High levels of magnesium and low calcium content in surface soils may cause a retardation in the growth of Leucaena. Adequate levels of available trace elements, molybdenum and cobalt, are necessary for maximum efficiency of the nitrogen fixing bacteria, therefore, it is important that sufficient levels of these elements are available in soil in which Leucaena is to be grown. A soil test should be made on the site selected for the establishment of Leucaena prior to planting to determine the appropriate fertilizer that will be required to gain maximum growth.

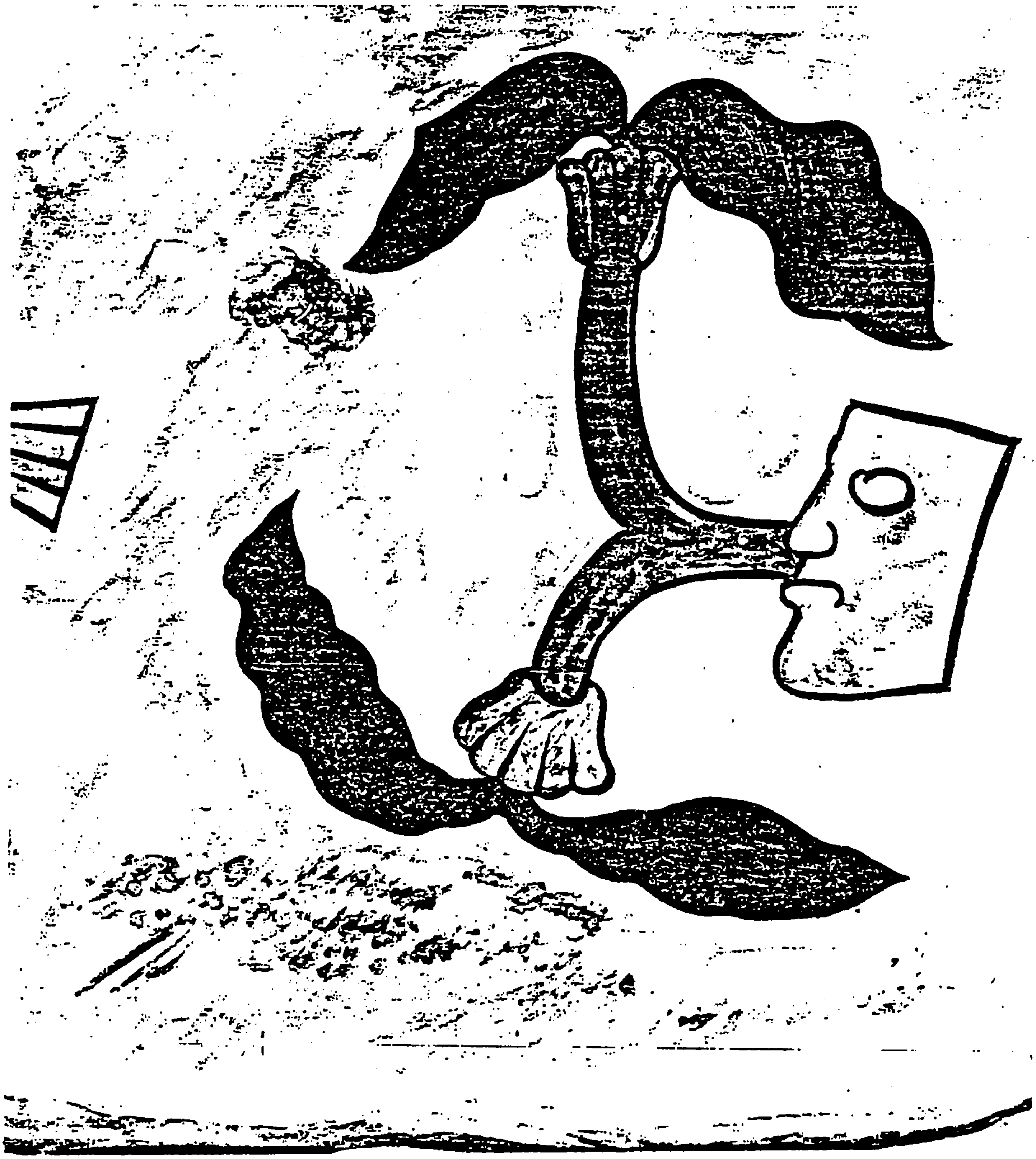
Usually, government clearances must be obtained prior to importing seeds or inoculum. If clearances for the inoculum are difficult to obtain, perhaps an arrangement can be made with the host country's soils bureau laboratory or with a college or university's soils laboratory to produce the amount needed. NifTAL, Hawaii might assist in this matter. They follow accepted sanitation precautions when shipping Rhizobium cultures.

Thank you for your interest in Leucaena. I would be pleased to learn of the results of your experimental trials.

Sincerely,

Michael D Benge

Michael D. Benge
DS/AGR, Agro-forestation
Rm. 420-B, SA-18



"The Place Where Leucaena Grows"

(A Nahuatl (Aztec) pictograph, circa 1550)

Preface

Leucaena leucocephala, a versatile legume whose full potential, thus far, is untapped. A "new" crop plant for tropical and subtropical countries, its possibilities are particularly important to marginal lands and low-income farmers. *Leucaena* was used 2,000 years ago by Mayans and Zapotecs of Central America, but only in the past two decades has a suggestion of its promise become apparent.

During that brief period several significant factors emerged: researchers in Hawaii and tropical Australia have found that cattle feeding on *Leucaena* may show weight gains comparable to those of cattle feeding on the best pastures anywhere; private firms in the Philippines have developed a sizeable trade in processed animal feeds containing *Leucaena*; researchers in the Philippines demonstrated Leucaena's potential for reforesting eroded hill slopes, for use as firewood, for fueling industrial boilers, and for producing paper pulp; while in Mexico (*Leucaena's* native habitat) researchers have located over 100 varieties for future testing. (Vietmeyer, Cotton and Ruskin).

It has been theorized that the Mayans and Zapotecs used *Leucaena* as an intercrop to supply the N-P-K needed for their corn based agricultural society. A rotational-cropping-system, utilizing *Leucaena* as a cover crop, has been in existence in the Philippines for over 97 years. The hillsides have slopes in excess of 100% and are comprised of highly erodable calcarious soils. The people who farm these slopes are among the most prosperous in the area. The Bureau of Soils in Alabang, Philippines, conducted experiments utilizing a common variety of *Leucaena* in bands and intercropped with corn. The *Leucaena* was cut and applied as an organic fertilizer. The experiment was conducted on slopes with a 25% slope comprised of highly eroded-leached-infertile soils. Soil erosion was reduced by 97% and yields of intercropped corn were increased by 38%.

The University of Hawaii conducted experiments whereby *Leucaena* was intercropped with corn and applied as a green mulch. Yields of 9 m.t./occupied ha were obtained using a single-cross field hybrid variety of corn. The growth rate of teak and mahogany have been increased by 100% when *Leucaena* was utilized as a nurse crop for the teak in Indonesia. Trees have fruited 2-3 years earlier in the Philippines after being mulched with *Leucaena*.

Leucaena coppices readily after cutting, producing large amounts of biomass and forage; truly a tree that "defies the woodcutter".

THE USE OF LEUCAENA FOR SOIL EROSION CONTROL AND FERTILIZATION

Leucaena leucocephala has been used to successfully control erosion and increase corp yields in Southeast Asia. Planted in contour bands. the Leucaena, cut and applied as green manure, increased the corn uield by 380% and reduced erosion by 97% in a 1953-1957 soil conservation project in the Philippines. A less productive common variety of Leucaena was intercropped with a local variety of yellow flint corn (Pangasinan) under conditions similar to those found among the hilly land corn farmers throughout Haiti. The land on which the experiment was conducted was severely eroded and devoid of organic matter. Adobe stones were exposed and the top soil was completely removed in some parts of the experimental area. The area had a slope of 25% (a drop of 2.5m every 10 m).

Paired rows (bunds) of Leucaena were planted on the contour of the experimental field spaced 10 cm between the rows and 10 cm in-row. The distance from one pair of rows to the next was 1 m. The Leucaena was cut back leaving stumps 35 cm high when it was about 1 m high. The trimmings were applied as organic fertilizer and allowed to decompose between the rows. The Leucaena not only served as a fertilizer but as a weed suppressant as well. Sometimes the cuttings were turned under and incorporated in the soil. The cutting frequency was from 1-1/2 to 2 months apart. Continuous interplanting of corn was made throughout a period of four years.

The continuous addition of Leucaena as a green manure increased the yield of the corn by over 380%. Erosion on the experimental plot was less than 2.5% of the erosion on the control plot, under this modified cropping system, a reduction of 97% (Hernandez, 1961).

In one area of the Philippines, the people have used a local variety of Leucaena in a "modified terracing system" for erosion control, fertilizer, fuel, and animal feed since 1896. Like their contemporaries in the Philippines, the millions of marginal farmers in Haiti, who cannot afford to purchase chemical fertilizers, can afford farming systems that incorporates Leucaena (Benge, 1978, a.).

A Soil Erosion—Organic Fertilizer System

It takes 75 seeds/linear meter (double row) to establish a Leucaena soil erosion and organic fertilizer system, such as the one previously mentioned (a system encompassing Leucaena planted in parallel rows with an in-row planting density of 10 cm and a 10 cm spacing between rows; a paired row spacing of 1 m between rows; and planted on the contour of the hill). It would require approximately 68.25 kg of "viable" seed/ha (with a 400% built in safety factor), therefore, to establish a system of this kind. A seed orchard of 25 ha would be required to provide enough seed to treat 100 ha of land with this system (a rate of 1 to 4).

Leucaena Cover-Crop System

Leucaena would be planted at a spacing of 1m x 1m in a "cover crop system" to reduce soil erosion, rejuvenate the soil and provide a source of firewood, livestock forage and organic fertilizer.

It would require 300 kg of "viable" seed to plant 100 hectares of land to a Leucaena cover crop system, therefore, necessitating a seed orchard of 1.1 hectares.

Seed Orchards

It is recommended that a spacing of 1m x 1m can be used in the initial establishment of a Leucaena seed orchard. The Leucaena should be thinned to a 3m x 3, spacing 10 months after establishment, selecting out undesirable trees. It will take 3 kg of seed/ha to establish a seed orchard. A yield of approximately 1,100 kg of seed/ha/year (about 10 million seeds) should be obtained from prolific varieties of Leucaena if the seed orchard has been properly established and managed and conditions are favorable. Of this amount, 275 kg of seed (approx. 2.75 million seeds) should be considered as "viable", allowing for sizing, germination percentages and seedling survivability (see selection below).

Recommended Leucaena Varieties

There are several different recommended (popular) fast growing "giant" varieties of Leucaena, K8, K28, and K67 are some examples. Each variety has, however, different characteristics. I would recommend K67 for projects that require the reproduction of large amounts of seed since that variety is the most prolific among "Giants". The K67 variety of Leucaena can produce up to 1 kg of seeds (10,000 seeds)/ha/year when grown under favorable conditions.

Seed Selection

One kilogram of Leucaena seed would be sufficient to plant nine hectares of land at a spacing of 1m x 1m if 100% of the seeds germinated and all of the seedlings survived. It is impossible to obtain these results, however, under normal conditions. Scientific procedures should be followed when establishing seed orchards to produce the highest quality of seed form parent stock so that maximum growth and seed production as well as a uniform growth can be obtained. Leucaena seeds must, therefore, be selected according to size (large) and density (heavy). This can be done by using a "hardware screen" and a simple specific gravity machine. In addition, allowances should be made for seeds that may not germinate and seedlings that may not survive after planting. A figure of 3 kg of seeds/ha is recommended, therefore, as the amount to be used when making seed requirement calculations in planning Leucaena systems that incorporate a 1m X 1m spacing.

Seed Treatment

1. Scarification - Leucaena seeds must be scarified in order that maximum and uniform germination will be obtained. The three most common methods of treatment are hot water, chemical and mechanical (Benge and Curran, 1976). The simplest of the three methods is scarification by hot water. There are two methods of seed scarification by hot water:

a. heat water to boiling point, remove from the heat and allow to cool for 1-2 minutes (instant coffee temperature). Place the seed in a container and pour the hot water over the seed; the volume of water should be twice the volume of the seed. Stir the seeds so that they are uniformly treated, and allow them to cool. Let the seeds soak for 8-12 hours.

b. the seeds can be wrapped in a cheese cloth and dipped into water, heated to a temperature of 80 degrees Centigrade, three times for a period of 1 minute each.

2. Storage - Leucaena seeds can be dried once they have been scarified by either solar (sun) or oven drying. The seeds will maintain as high as 97% germination after 11 months if properly dried and stored under conditions of low humidity and in air-tight containers.

Inoculation and Pelletization Procedures for Leucaena

Leucaena requires adequate levels of phosphate, potash and sulfur. High levels of magnesium and low calcium content in surface soils may cause a retardation in the growth of Leucaena. Adequate levels of available trace elements, molybdenum and cobalt, are necessary for maximum efficiency of the nitrogen fixing bacteria. A soil test should be made on the site selected for the establishment of Leucaena prior to planting to determine the appropriate fertilizer that will be required to gain maximum growth.

Nitrogen fixing bacteria, rhizobium, live in symbiotic relationship with Leucaena enabling it to fix nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena as well as other plants. The Leucaena seeds are inoculated with the rhizobium* after scarification by simply soaking the seeds in an inoculum "wash" (a solution of rhizobium and water) prior to planting; the inoculum

* Commercial quantities of inoculum may be obtained from J. Burton, Nitratin Corp., 3101 West Tuster Ave., Milwaukee, Wisconsin 53209. Further information and training in rhizobium production can be obtained from the University of Hawaii, NIFTAL Project, Maui Agriculture Research Center, P.O. Box 187, Kula, Maui, Hawaii 96709.

mixed with water and sprinkled over the surface of the soil if the seeds are already planted; or if the seeds are to be planted in a flat and transferred to the field as seedlings, the peat inoculum can be mixed with the soil or substrate in the seed flat, plastic bag, container or seed bed. In the latter two situations it is recommended that the soil be sterilized prior to sowing or transplanting if the soil has not been sterilized. Whatever strain of rhizobium that is present in the soil at the time of planting will adopt and dominate the host plant upon contact. This would mean that if the rhizobium strain is an acid exuding or a weak strain and low producer, another strain of rhizobium cannot be superimposed upon that plant. It is therefore recommended that the seed be inoculated prior to planting.

The seed should be pelletized* with the appropriate fertilizers to overcome nutrient deficiencies during its establishment phase if Leucaena is to be dibbled, broadcast or drilled. One should pelletize the seed at a rate of : for each 4 kg of seed, wetting is done with a 3% aqueous solution of a non toxic stickler, cellophas (methyl ethyl cellulose); a high density of inoculum is then applied; after which the seeds are coated by rolling them in a mixture of 1 kg of finely ground rock phosphate with 400 grams of molybdenum trioxide added. This amount of molybdenum is enough to last for 5-7 years. Molybdenum is important in the promotion of the establishment of rhizobium. The rhizobium strain recommended for acid soils is CB81

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* Dr. Mark Hutton, c/o Centro Internacional de Agricultura Tropical (CIAT) Apartado Aero 6713, Cali, Colombia, has expertise in the field of establishing Leucaena under these conditions.

(alkali exuding) and 31A3 (acid exuding) for alkaline soils (Benge and Curran, 1976; Vietmeyer, Cottom and Raskin, 1977; and Benge, 1978.)

Establishment Procedures

Lencaena can be planted by either directly seeding or by transplanting. There are advantages and disadvantages to both methods. Field preparation varies with the different establishment procedures used. For transplanting from a nursery to the field, competition from surrounding plants should be reduced and the Leucaena transplanted into holes. A 1 meter diameter area should be ring-weeded 2-3 times the first 6-9 months after the Leucaena is planted. If drilled, the seeds can be simply dropped into the furrow and lightly covered. If broadcast, the planting site should be prepared and cared for (weeded) as one would a field of corn. If dibbled, the field preparation is simply done by reducing the ground cover by burning.

(1) Direct Seeding - The advantages of direct seeding are:

a. Less time is required in establishing Leucaena by useing this method because transplanting is not necessary, thus, labor costs are reduced.

b. Earlier growth is obtained by dibbling Leuceana seed in comparison to transplanting for the plant suffers no transplant shock.

c. Earlier seed production is obtained since Leucaena reaches maturity in a shorter period of time (Benge, 1977, see appendix A).

Direct seeding can be done by dibbling, broadcasting or drilling.

a. Dibbling* (see appendix A) can be the most appropriate method of seeding used to establish a 1m X 1m Leucaena system. Field preparation for seed orchard establishment has been previously mentioned. Fireing (burning) is the most efficient method of preparing large tracts of land. A modified corn planter would increase the efficiency of the dibble method.**

b. Broadcasting can either be done by hand, by a simple machine**, or by aerial seeding. Aerial seeding*** would be the most efficient method of sowing large tracts of land. Fireing of the land would reduce plant competition and keep field preparation costs to a minimum.

c. Drilling of seed can be done by either hand or by simple machine**** when establishing Leucaena in rows. Ground preparation can be done simply with an animal drawn plow and the seed drilled in the furrow.

(2) Transplanting - Leucaena seedlings can be grown under nursery conditions in plastic bags, bamboo tubes, in root trainers and other containers or in seed beds. The seeds are planted at a depth of 2-3 cm

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* Dibbling is a simple method if direct seeding whereby a pointed stick is used to punch a hole in the ground into which seed is placed and covered with dirt by a sweep of the foot..

** A hand corn planter can be redesigned to accomodate the pelletized Leucaena seed by simply enlarging the outlets. Blueprints for a corn planter may be obtained from Volunteers in Technical Assistance (VITA), 3706 Rhode Island Ave., Mt. Ranier, MD 20822.

*** The most extensive literature covering this subject is in Norris, 1967.

**** Blueprints may be obtained from VITA, op. cit.

and covered with dirt after scarification and inoculation. Another alternative is after scarification, the seeds are placed between damp bags or sheets of paper and allowed to sprout. The seed is then planted in the container after sprouting. This method insures that each bag is planted with a viable seed and eliminates the sorting of containers at a later time.

The seedlings are transplanted after forty days. The leaves should be pruned or stripped from the seedling leaving only the tip. This reduces the loss of water by transpiration. In some cases, the top portion of the seedling is pruned, leaving only the brown wood, and two thirds of the tap root is pruned prior to transplant. It is the belief of the author that the latter method puts the plant into shock, retarding its initial growth and the development of an adequate tap root. It is essential that mazimum tap root development take place in order to tap adequate ground water sources to promote maximum growth in drier climates.

It is necessary that good potting soil be used. A mixture of 1/3 organic matter should be used whenever possible. Animal manure is recommended as the source of organic matter.

The seedling can be fertilized after the second week by dissolving a complete fertilizer (N-P-K) in water and applying it to the seedlings while watering. This method can be repeated after transplanting. Regular applications of chemical fertilizer can be applied, preferably in the form of a time release preparation.*

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* MAG-AMP is one such brand name fertilizer. It contains magnesium and amonium sulfate which has been coated with a soluable substence that slowly dissolves when moisturized and slowly releases the nutrients.

Recommendations for Haiti

It may be somewhat impractical to establish large scale seed orchards, despite the fact that "soil erosion control—organic fertilizer systems" are drastically needed throughout Haiti in the immediate future. I would then recommend an alternative strategy for extablishing these Leucaena systems that would not require a large amount of land to be committed to seed orchard if land availability is a problem.

Many farmers in Haiti do not cultivate all of their land at one time, a portion of which might lie fallow. The soils have been leached and depelated of soil nutrients in many areas and eroded to such a stage that renders the land impractical to farm because it will not grow a profitable crop. Areas such as these have been planted to Leucaena in the Philippines, Indonesia and Fiji and the soils rejuvenated so that crops may once again be profitably grown (Benge, 1976; and Parkham, 1938). These systems have evolved over a period of years on soils under conditions similar to those found in Haiti. Research has dated one such system in the Philippines as far back as 1896. Those persons, who maintain this system, are some of the most prosperous in the area. The farmers grow tobacco, corn and onions on highly erodable 45 degree slopes on soils derived from limestone. One third to one half of the farmers' fields are kept in a Leucaena cover crop. Some of the Leucaena is periodically harvested as a source of firewood, organic fertilizer and livestock forage. The Leucaena is completely harvested and the leaves used as a green manure mulch when the field is planted to crops. This is usually after the field has been in a Leucaena fallow for 3-7 years.

It is suggested that in lieu of trying to establish the aforementioned "soil erosion control — organic fertilizer systems" over the entire targeted watersheds at one time, the areas could be initially treated in three ways: (1) The farmers could continue farming under their present system in those areas presently under cultivation. (2) A protion of those areas which are lying fallow could be put into demonstration plots under "Leucaena soil erosion control — organic fertilizer systems". These demonstration plots should be scattered throughout the representative areas that are farmed.;and (3) Those remaining fallow areas could be treated with a system using Leucaena as a "cover crop". This system should be maintained until either enough seed is produced to treat the entire area with "Leucaena soil erosion control — organic fertilizer systems" or the farmers could rotate their fields of cultivation to those areas that have a Leucaena cover crop.

Land for Seed Orchards

It is generally the practice to rent land from farmers for project purposes such as for the establishment of seed orchards. Farm land is very difficult to rent under normal conditions in many parts of Haiti. The farmer may have nothing to do if he rents his land; a farmer may feel insecure when he has no land to farm; and the money that the farmer receives for rent may not be sufficient to purchase enough food to replace that which he would normally raise due to a lack of surplus in the ares.

It is recommended that DARNDR not only rents the farmer's land at the assessed rent value, but they hire the farmer to work in the Leucaena seed orchards. This would act as an incentive to the farmer and should overcome his reluctance to rent his land.

The Production of Seed by Contract

Farmers could be contracted to grow Leucaena seed if an adequate amount of land is not available to establish seed orchards of the magnitude required. The plantings in the farmers fields could be supervised by the Department of Agriculture, Natural Resources and Rural Development (DARNDR) to insure that the recommended planting procedures are followed. An agreement would have to be reached on the quality of seed to be produced and the price to be paid prior to the establishment of these "farmer seed orchards". The profit margin would have to be enough to allow an ample return on the farmers investment. This is a very practical method of establishing these systems for it would provide a source of income to the farmer and at the same time he would be able to see the benefits of growing Leucaena. One forseeable problem is that farmers may adulterate the "Giant" seeds with those of a local variety in order to increase their profits.

Seed Procurement

Seeds of quality must be purchased prior to the establishment of Leucaena seed orchards. The most reliable source of seeds of any quantity is the Philippines. USAID/Port-au-Prince could assist in the procurement of these seeds by requesting their purchase through the USAID/Manila Mission. The seeds could be shipped via AID POUCH to reduce the problems of procurement and shipment (see appendix B). It will be necessary to allow enough time for procurement and shipment so that the seeds will arrive in Haiti prior to the onset of the rains.

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Inoculation and Pelletization Procedures for

Leucaena Leucocephala

Leucaena requires adequate levels of phosphate, potash and sulfur. High levels of magnesium and low calcium content in surface soils may cause a retardation in the growth of Leucaena. Adequate levels of available trace elements, molybdenum and cobalt, are necessary for maximum efficiency of the nitrogen fixing bacteria. A soil test should be made on the site selected for the establishment of Leucaena prior to planting to determine the appropriate fertilizer that will be required to gain maximum growth.

Nitrogen fixing bacteria, Rhizobium, live in symbiotic relationship with Leucaena enableing it to fix nitrogen from the air. Nitrogen is essential for the optimum growth of Leucaena as well as other plants.

NURSERY PRACTICES

The Leucaena seeds are inoculated with the Rhizobium* after scarification by simply soaking the seeds in a inoculum "wash" (a solution of Rhiz - bium and water prior to planting; the inoculum mixed with water and sprinkled over the surface of the soil if the seeds are already planted; or if the seeds are to be planted in flatsand transferred to the field as seedlings, the peat inoculum can be mixed with the soil or substrate in the seed flat, plastic

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* Commercial quantities of inoculum may be obtained from J. Burton, Nitratin Corp. 3101 West Tuster Ave., Milwaukee, Wisconsin 53209. Further information and training in rhizobium production can be obtained from the University of Hawaii NIFTAL Project, Maui Agriculture Research Center, P.O. Box 187, Kula, Maui, Hawaii 96709.

bag, container or seed bed. In the latter two situations, it is recommended that the soil be sterilized prior to sowing the seeds. Soil scientists advise that plants or seeds should be inoculated prior to sowing or transplanting if the soil has not been sterilized. Whatever strain of _Leucaena rhizobium_ that is present in the soil at the time of planting will adopt and dominate the host plant upon contact. This would mean that if the _Rhizobium_ strain is an acid exuding or a weak strain and low producer, once the plant has nodulated, another strain of _Rhizobium_ cannot be superimposed upon that plant. _It is therefore recommended that you inoculate seed prior to planting._

DIRECT-FIELD SEEDING

The seed should be pelletized with the appropriate fertilizers to overcome nutrient deficiencies during its establishment phase if _Leucaena_ is to be dibbled, broadcast or drilled. One should pelletize the seed at a rate of: for each 4 kg of seed, wetting is done with a 3% aqueous solution of a non-toxic sticker, cellophas (methyl ethyl cellulose); a high density of inoculum is then applied; after which the seeds are coated by rolling them in a mixture of 1 kg of finely ground rock phosphate with 400 grams of molybdenum trioxide added. This amount of molybdenum is enough to last for 5 to 7 years. Molybdenum is important in the promotion of the establishment of _Rhizobium_. The _Rhizobium_ strains currently recommended for acidic soils are CB81 (alkali exuding) and alkaline soils 31A3 (acid exuding) /Benge and Curran, 1976; Vietmeyer, Cottom and Raskin, 1977; and Benge, 1978/.

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Leucaena leucocephala promotes increased growth, fruiting and seed production of fruit and forest species of trees.

In Indonesia, wide scale reforestation is being carried out by using *Leucaena leucocephala*, "Lamtoro," as a primary reforestation species for the purpose of reclamation of vast regions of denuded, idle and unproductive lands covered with noxious grasses, such as *Imperata cylindrica* (Alang-alang or kogan grass), and for soil rejuvenation. In Indonesia, *Leucaena* has long been known as an excellent source of fertilizer and nurse crop and shade tree for crops such as coffee, cacao, kapok, vinilla and as an understory in coconut plantations. Presently, a large scale reforestation and soil stabilization program is being carried out on the Island of Flores in East Nusatenggara, Indonesia. *Leucaena* is being planted in contour hedgerows for the purpose of terracing more than 30,000 hectares of unstable volcanic slopes (1).

In Indonesia, they have been using native *Leucaena* (Lamtoro) since the early 1900's as a nurse crop for other forest species. Inter-plantings of *Leucaena* with tropical hardwoods and dithocarps have resulted in growth increases as high as 50% to 100% compared to areas not interplanted with *Leucaena* (2).

In the Philippines, the Forestry Division of San Carlos University, has reported similar results with the interplantings of *Leucaena* and mahogany and are presently publishing a research paper with the accumulated information.

The Philippine American Timber Company in Negros Oriental and NASIPIT Lumber Company in Butuan, Agusan del Norte reports that Bankal and Acacia auriculaeformis interplanted with Leucaena shows remarkable growth increase over those trees planted in pure stands or planted with other species. Provident Tree Farms in San Teodoro, Occidental Mindoro was able to get a'Banlag'tree to set seeds 2 years earlier than adjacent plants because of planting new "Giant" Leucaena around the tree about 1 meter to 1 ½ meters radius. The Leucaena was cut back at a period of every 2 to 3 months to prevent shading of the tree and the leaves were thrown around the base of the tree. Mr. Florante Salvador of Iloilo has interplanted mangos, rambutan and other fruit trees with Leucaena and he reports exceptional growth and production of his fruit trees compared to other fruit trees planted in the general area. Furthermore, he states that his fruit trees are more disease free than others planted adjacent to his orchard.

In the tropics . . . forest removal takes away the lands' ability to hold and recycle nutrients . . . in the face of high year around temperatures and periods of leaching rainfall (3).

The bulk of minerals available in the tropical ecosystems is tied up in dead and living organic systems. Little available mineral ever occurs free in the soil at any one time. Mycorrhiza, which is estremely abundant in the surface litter and thin humus of the forest floor, is believed to be capable of digesting dead organic litter and passing minerals and food substances through the hyphae to living root cells. In this manner, little soluble mineral leaks into the soil where it can be leached away. Many trees will not grow without mycorrhizal . . . fungal symbionts . . . Leucaena leucocephala, has masses of mycorrhizae which are able to metabolize "unavailable" phosphorous and other minerals. They are taken up by the mycorrhizal mass, then slowly released to the plant (4).

In addition, symbiotic nitrogen fixing bacteria takes nitrogen from the air and stores it in bacterial clusters on the roots of the Leucaena plant. The plant then transfers minerals as well as nitrogen to its leaves. The constant leaf drop provides a rich organic litter making the plant a most efficient recycler of these nutrients and a constant, readily available source of "free" fertilizer.

For the promotion of fruit tree growth, it is recommended that new "Giant" varieties of Leucaena leucocephala be planted at a radius of 1 to 1-½ meters around the trees. The spacing between the Leucaena should be 7-10 centimeters. The Leucaena should be allowed to grow to a maximum height as long as it does not compete for sunlight with the companion tree. The cutting frequency of the Leucaena should be every 2-3 months and the cut material laid around the base of the fruit tree. The larger the diameter of the Leucaena before cutting, the larger the amount of coppice foilage it will produce.

As a nurse crop for forest species, Leucaena can either be planted in the above manner or at a spacing of 1 meter x 1 meter between the normal spacing of the forest species. If the forest species are shade tolerant, the cutting back of the *Leucaena* is not necessary; but cutting back will promote increased coppicing - thus increase the foilage production as well as the fertilization effect. (1)

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HILLSIDE AGRICULTURAL MANAGEMENT SYSTEMS

Ecological problems, dwindling natural resources and the need to increase food production, brought about by a growing population and subsequent disproportionate area of available arable lands, have drawn attention to the need for re-examination of our present agricultural and forest practices. Until the mounting population explosion is checked and job opportunities outside agriculture are numerous enough to absorb the excess labor force, we must deviate from traditionalism in development and seek new revolutionary ideas in problem solving.

In a recent article published in the United Nations magazine, CERES, Eric Ekholm of Worldwatch Institute stated that, "Even if we find ways to raise more food to feed the growing population, we won't have enough wood to cook it with." To meet the demands of food, population and energy, new agricultural and forest systems must be devised whereby we can increase food production by a more efficient use of slopelands and mountainsides. Such a system would not only offer a maximum environmental eco-system balance through inter-graded crop production but would also include a solution to land tenure for hillside farmers. It would also help alleviate the inherent problems credited to the swidden/slash and burn system of cultivation in tropical and sub-tropical countries. No longer can we speak of reforestation in terms of sylviculture but we must find ways to increase food production by combining annual crops with perennial crops. Such a system could be termed Agro-forestation.

More often than not, we seek escape goats to blame for denudation, the result of our unimaginative minds. Such is the case of the shifting/slash and burn cultivators, on whom we try to place part of the blame for denudation, which results in flooding, soil erosion and the like. Are we to blame these shifting agriculturists, who only desire to eke out a living, or does the fault lay with us, who as technocrats, not only fail to envision alternative systems of agriculture, but also fail to create other forms of employment. Such systems of agriculture could b based on indigenous crops and techniques to which the people can easily relate; other forms of employment could include locally based industry. For lack of a better term we might call such a system Agro-forestation.

As defined, Agro-forestation is the planting of denuded or cultivated slope lands with perennial tree-species and simultaneously cultivated with other tree species and/or with annual crops. The perennial trees may be in a pure stand but cultivated on a short rotation basis for the specific purpose of producing particular end-use products for specific markets.

The growing concern towards the dwindling supply of natural resources, the erosive results of denudation and a deterioration of eco-systems has led impetus to the search for and development of new plant species and varieties, as well as the re-examination and re-discovery of indigenous plant species which show promise when worked into Agro-forestation systems.

One such plant is Leucaena leucocephala, commonly called Ipil-ipil in the Philippines. A new variety, dubbed the "Hawaiian Giant", was re-discovered by a group of scientists at the University of Hawaii, led by Dr. James Brewbaker.

Properties - Leucaena, as a member of the legume family, is known to possess the characteristics of nitrogen fixation in its roots as well as the accumulation of nitrogen, phosphate and potash in its leaves. The exact quantity of the available amounts of each mineral is yet to be determined but tests carried out at the University of Hawaii (Guevara 1976) has established the fact that it produces sufficient quantities of N-P-K to adequately fertilize (applied as a green manure mulch) annual crops at a ratio of 1 ha. of Leucaena to 2 has. of annuals. This is, of course, dependent upon soil fertility and population density. Leucaena's reputation as a fast growing species (Brewbaker 1975, Bawagan, and Semana 1976) makes it a financially competitive species to be seriously considered as both a forest crop on a short rotation as well as a viable pioneer reforestation species for denuded lands (Francia, 1961 and Amos, 1955).

Leucaena has an amazing regenerative characteristic which permits regrowth after cutting. It virtually "defies the woodcutter". Giant Ipil-ipil offers a continuous source of fertilizer, something the kaingero can ill-afford.

Cultural Practices - Leucaena used as a component in an Agro- forestration scheme can serve well as a companion tree crop and shade tree. In areas suited for its growth, Leucaena planted as a source of fertilizer can easily be worked into schemes incorporating banana, abaca, coconut, coffee, cacao, bamboo or other trees. Leucaena which is planted for the primary purpose of short or long term wood production such as firewood, charcoaling materials, etc. could be feasibly interplanted with shade tolerant annual crops such as the family of Dioscorea and the edible aroids. Other schemes could be devised whereby denuded hillsides in proximity to lands cultivated by shifting (swidden slash and burn) cultivators could be planted to Leucaena in five meter bands on the contour of the hillside with interspacings of one meter by one meter; and alternating ten meter bands could be left open to be planted at a later time with annual crops of corn, rice, etc. Leucaena after 1-1/2 to 2 years could be harvested as a wood crop and the remaining stumps allowed to coppice. The regrowth could be cut and applied as a green manure to annual crops planted in the vacant areas. Such a planting would allow for a well established root system to develop which would insure larger supplies of minerals stored in the Leucaena leaves, giving them a greater fertilizer value. Agro-forestation schemes such as these would stop the destruction of of valuable timber cut in the slash and burn process; reduce soil erosion and degredation, while decreasing the area of land required to support shifting cultivators, transforming them into sedentary (stationary) agriculturists.

Leucaena- is adaptable to varying systems of cultivation aside from the above mentioned and numerous schemes may be in actual practice, but, as of this time they are unknown. Much research is needed to answer the many questions which may evolve from the use of Leucaena in Agro-forestation systems; this is in the areas of production and environment. Yet such agro-forestation schemes offer promising alternatives to the existing problems faced, embracing hillside farming and denudation.

Production Estimates - Agro-forestation systems which include Leucaena have the potential to increase income of the hillside and shifting (swidden slash and burn) cultivators. In the case of the shifting cultivators it should decrease his labor input of field preparation which could be diverted to other activities to include increased area which he could cultivate. In areas of limited available arable land, it is important to note that an increase of one-third total land area would be required in a system utilizing Leucaena as a source of cut and carry fertilizer. Such a system would provide a source of free fertilizer, a commodity which is normally unavailable to the shifting cultivators. Brewbaker and Guerrero (1975)report a 133% yield increase of corn fertilized with Leucaena over that of an unfertilized plot. Francia (1961) reported a doubled income return per hectare by growing a common Philippine variety of Leucaena as a firewood compared to rice, corn, coffee and bananas.

Bawagan and Semana (1976) recorded a trunk yield of 45 cu.m./ha./yr. and a branch yield (down to four cms.) 10 cu.m./ha./yr on a stand of K-28 Leucaenplanted at Canlubang Sugar Estates, Calamba, Philippines. Other projected yields from dense stand of Leucaena at the University of the Philippines at Los Banos were considerably higher. A yield of this type sold at $4.25/cu.m. would give a farmer an income of $300/ha/yr. Benge and Curran (1976) estimated that Leucaena firewood farmers at Los Banos were capable of earning $750/ha./yr. by selling wood at a roadside price of $.15 per bundle. Lugod (1975) estimated yields of 30 mt./ha. of a variety of the root crop Dioscorea could be gained from interplanting this crop under a normal forest canopy. This yield seems exceptionally high. A market price of Dioscorea at $.06/kg., multiplied by Lugod's projection of 30 mt./ha. would give an income of $2,000/ha./yr in addition to the wood crop. Root crops normally give a 25% to 50% response to fertilizer applications. Root crops planted under Leucaena would presumably give a higher yield.

PICOP (Paper Industries Corporation of the Philippines) (1975) gave a profit of $310/ha./yr. for tree farmers who raised Albizia falcataria. This was over and above their maintenance crops of rice, corn, sweet potatoes, etc. which had been intercropped. Leucaena sold as a firewood or converted to charcoal has a much higher per cu. meter value than that of Albizia. Benge and Curran (1976) gave a per ha. income of $320 for charcoal producers who sold their product at a wholesale price of $26.50/m.t. The aforementioned Agro-forestation production estimates are by no means conclusive. Yields, of course, depend upon soil fertility, management practices as well as many other factors. The net profit gain depends upon the type of product, market price and logistics involved. The point that is stressed is that Leucaena is a versatile plant which can be utilized in many ways in systems which will reforest (not in the classical sense); offer environmental protection to the soil; while producing food and/or forest products with a market value to enable hillside farmers to significantly improve their standard of living.

FIRE PROTECTION AND WINDBREAK

Fire has always been a major problem in reforestation efforts. Each year, sizable areas of forest lands as well as newly planted areas are destroyed due to the lack of protective measures. Firelines constructed by clearing 10-20 meters wide strips around the plantation are not only expensive but also not effective and short lived. *Leucaena leucocephala* planted very closely on newly constructed firelines could provide an effective, inexpensive and year-round fire break. It will also serve as an efficient windbreak.

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September 1976

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APPENDIX A

DIBBLING "LEUCAENA LEUCOCEPHALA," IPIL-IPIL SEEDS: a low cost method of reforestating cogonal areas.[1]

In search for a way to reduce the costs of reforestating with Leucaena some are looking to the aerial seeding of Ipil-ipil seeds. This method of seeding was first tried on Corregidor, shortly after World War II. The difference between the aerial seeding of Corregidor and that of denuded mountains elsewhere is that one must remember that due to the intense bombing of that rocky island by both the Japanese and Americans, the entire island was devoid of vegetation while denuded mountains are generally covered with noxious grasses such as Imperata cylindrica "cogon" grass, Saccharum spontaneum, "talahib". These grasses not only prevent the aerial seeded Ipil-ipil seeds from reaching the ground they (1) shade out any seedlings that might sprout; (2) provide a climate for grass fires which would kill any seedlings which might become established; and (3) contain a high population of rats, that relish both Ipil-ipil seed as well as the young succulent seedlings.

On trial plots conducted in Zambales, Mindoro, and Cotabato, Leucaena leucocephala, the new "Hawaiian Giant" Ipil-ipil, seeds were dibbled directly into the ground (the method of using a pointed stick to make a hole in the ground into which seeds are dropped and then covered by a sweep of the soil by one's foot) in the following three different field preparations (1) regular Kaingin* preparation; (2) the plowing of furrows through the cogon with a carabao and plow; and (3) by the burning of the cogon prior to the seeds being dibbled into the soil. All three methods achieved a reasonable high survival rate of the Ipil-ipil seedlings (60% and over).

Perhaps the firing of the cogonal areas is one of the cheapest methods of reforestating denuded areas, although care must be taken to control and limit the area of burning for field preparation. It's best to let the young-new cogon shoots reach a height of 8-12 inches before burning off the old growth. In this way, the new growth drains the roots of its stored energy which prevents rapid recovery and regrowth. This time to burn is at the early part of the rainy season.

To insure success in the establishment of Leucaena stands, tests should be made to identify soil types and fertilizer requirements. Then prior to planting, the Leucaena seeds should be scarified, given a coating of inoculum and pelletized with necessary fertilizer additives.

By: Michael D. Benge, USAID/Manila, Agro-forestation Advisor

There are two types of Rhizobium (nitrogen fixing bacteria) that lives in symbiotic relationship with legumes and certain other plants and trees: e.g. alkali-producing Rhizobium strains are associated with legumes adapted to acid soils; acid-producing Rhizobium strains with legumes adapted to alkaline soils. Leucaena leucocephala, "Ipil-ipil," flourishes on volcanic soils of high base status such as on limestone areas. Its Rhizobium reflects this in being a fast-growing acid-producer and is highly specific. If associated with this type of Rhizobium, a nodulation response to lime on poor soils would be expected. (1)

However, there has been developed an alkali-producing strain of Rhizobium which adapts itself to Leucaena, such as the bacteria labeled CBS1*. If the seeds have been innoculated with such an alkali-producing strain, lime should be used only in small quantities and only if the soil is very acid or manganese toxic or actually deficient in calcium. (1)

The Leucaena seed should first be scarified by immersing the seed in water at 80^{o}C for two minutes. After this treatment, the seed can be dried rapidly (in the sun). It should then be stored in air tight containers. Treated in this manner, the seed will maintain as high as 97% germination after 15 months. (2)

For acid-producing Rhizobium, Australia developed a system of lime-pelleting by wrapping the seed after innoculation, in a coating of calcium carbonate stuck on with 45% gum arabic or 5% Cellofas A (methyl ethyl cellulose) or 5% pure methyl cellulose. Using this method, the acid-sensitive bacteria are protected from the acid soil while providing immediately around the germinated seed, a supply of calcium that may be needed for nodulation. Good nodulation may be induced this way by a very small amount of lime equal to about half the weight of the seed sown. (1)

On acidic soils, it is best to innoculate Leucaena seeds with an alkali-producer strain, such as CB81. After scarification of the seed, to overcome nutrient deficiencies during its establishment phase, one should pelletize the seed at a rate of: for each 4 kg. of seed; wetting is done with a 3% aqueous solution of a non-toxic sticker (cellophas), the peatnoculum (CB81) are then applied and the seeds are coated by rolling in a mixture of 1 kg. of finely ground rock phosphate with 400 grams of molybdenum trioxide added. This amount of molybdenum is enough to last for 5-7 years (molybdenum is important in the promotion of the establishment of Rhizobium). On sulfur deficient soils calcium sulfate should be used in place of rock phosphate. On acid soils calcium carbonate can be used as a replacement. (4)

*Developed by CISRO, the Cunningham Laboratory, St. Lucia, Queensland, Australia.

In specific problem areas of Southern New Wales requiring aerial sowing, pelleting is done in what is termed the "Three Step Process" (by F. Hely of C.S.I.R.O., Canberia) (3). In this process vastly increased numbers of bacteria (700,000-800,000 per seed) are stuck on by first allowing the seed to soak up a bacterial broth, then adding a pellet incorporating a heavy innoculation with peat culture (CB-81), and finally giving an outer coat of clay and lime and gum arabic to make a tough pellet. This process is designed to overcome by sheer ight of numbers excessive mortality of the bacteria in the period between air drop and the successful germination of the seed which may be several weeks later.

A more simplified process of fertilizing is suggested by Dr. Raymond Jones of CSIRO; whereby a starter fertilizer in pellet form (superphosphate) is placed somewhat below and to the side of the already scarified-innoculated seed when it is planted. (5)

A redesigned corn planter (USAID/FSDC) will plant (dibble) 2-3 _Leucaena_ seeds per hole while at the same time deposit a rock phosphate or superphosphate pellet 3-4 inches from the seeds. This pellet will provide a source of fertilizer for the seeds during establishment. The distance is to keep the fertilizer from burning the young seedlings. Plantings made in heavily infested cogonal areas may need one weeding at a later time. A recommended planting spacing is one meter by one meter.

On test plots 2-1/2 months _Leucaena_ seedlings, of the same variety, were transplanted to areas adjacent to those planted by the direct seeding method. Both planting were 1 m x 1 m. The direct seeded _Leucaena_ was planted at the same time as when the older seedlings were transplanted. The dibbled _Leucaena's_ growth exceeded that of the transplants. Both received the same treatments of fertilizer.

To reforestate large area, dibbling, _Leucaena leucocephala_, "Hawaiian Giant Ipil-ipil" seeds can markably reduce planting costs.

In cogonal areas, highly susceptible to grass fire, it is recommended that firebreaks of _Leucaena_ be planted. An easy method of establishment is by plowing furrows on the contour of the hills and planting bands of Leucaena to serve as a firebreak. This should be done prior to larger scale planting operations. For a firebreak _Leucaena_ should be planted in a five meter band consisting of paired rows one meter apart The Leucaena plants should be spaced from 10 to 15 cm in row and the paired rows 20 cm apart

Technical Assistance concerning the pelletizing of Laucaena seed can be obtained from Dr. Santiago N. Tilo of the Dept. of Soil Science, UPLB. CB81 Rhizobium can be obtained from the Soil Microbiology Laboratory, Dept. of Soil Science, UPLB (Mrs. Erlinda S. Paterno) or from the Bureau of Soils.

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Leucaena leucocephala: Ipil-ipil as an understory-fertilizer crop for coconut*

The idea of using Leucaena leucocephala, Ipil-ipil, as an understory-fertilizer crop for coconut is not new. The Dutch practiced this system of green manure cropping throughout ndonesia as far back as the 1800's.[1/] It is being rapidly adopted throughout the Philippines and the Philippines Coconut Federation has acquired a large sum of money for the establishment of Leucaena "Bayani" (Hawaiian Giant Ipil-ipil)nurseries in every "coconut municipality" throughout the Philippines.

During a most recent visit to Iligan, the author observed one meter by one meter plantings under coconut which had grown to a height of fifteen feet in seven to eight months. These plantings had been promoted by Mabuhay Vinyl Corporation, a grower of the "Hawaiian Giant" K-28 variety for the production of charcoal. This type of planting under coconuts is becoming more common, serving as both a source of fertilizer and as nutritious browze for cattle.

The bulk of minerals available in tropical ecosystems is tied up in dead and living organic systems. Little available mineral ever occurs free in the soil at any one time. Leucaena leucocephala, Ipil-ipil, has masses of mycorrhizae, fungal symbionts, and symbiotic nitrogen fixing bacteria clustered on its roots. These fungi and bacteria, through the Leucaena plant; not only take nitrogen from the air and store it in various parts of the plant, but are able to metabolize "unavailable phsophorous," potassium and other minerals, take these up in the mycorrhizal mass and then slowly release them to the plant which stores it in its leaves.[2/] The constant leaf drop of Leucaena makes Ipil-ipil a most efficient recycler of these nutrients and a constant source of available "free" fertilizer for the coconut farmer.

1/ Metzner, J. K. 1976. LAMTORONISASI: An Experiment in Soil Conservation. The Bulletin of Indonesian Economic Studies.

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CASSAVA INTERPLANTED WITH "GIANT" IPIL-IPIL: A MEANS OF PROVIDING AN INEXPENSIVE SOURCE OF FERTILIZER AND REDUCING EROSION

In order to obtain maximum yields of cassava, heavy applications of commercial fertilizer containing Nitrogen, Phosporous and Potash ane required.

In tests carried out at the University of Hawaii, it was found out that one ha. of "Hawaiian Giant" Ipil-ipil (K-8, K-28, and K-67), grown as a green manure crop, has a plant nutrient content of 500 kg of Nitrogen, 200 kg. of P_2O_5 and 400 kg. of K_2O. Incorporated as a green manure, it equals the best of commercial fertilizer carrying the same quantity of plant food. (1)

For commercial starch production, the average growth period of cassava is fourteen months. Yields average around twenty tons per ha. per crop with moderate inputs in terms of land preparation and weeding. Yields of this quantity normally require 300-400 kg. of complete fertilizer (14-14-14) per ha. Some varieties mature in shorter periods of time but yields are markedly reduced. With optimum inputs, higher yields may be obtained in areas having more favorable soil and climatic conditions. Cassava can survive on impoverished soils but very low yields are obtained.

Since the plant is very demanding in its nutrient requirements, continuous cropping with cassava on the same land rapidly depleats the soil of its plant food reserves. On hilly terrain the cultivation of cassava can lead to accelerated erosion.

Trial plantings of cassava (Java Brown variety) between rows of "Giant" Ipil-ipil were made during November of 1976, at Hacienda San Jose, Makar, General Santos City, South Cotabato.

In the trial a stand of one year old "Giant" Ipil-ipil, closely drilled in rows spaced one meter apart, were cut back to ten centimeter stumps and the stems and leaves laid in the space between every other row of "Giant" Ipil-ipil. The space between the Ipil-ipil rows, to which the green manure mulch had not been added was then planted to 25 cm. long cassava stem cuttings at intervals of one-half meter. The Ipil-ipil regrowth was cut back at one month after the cassava was planted and thereafter every two months. The cut material was laid along both sides of the cassava rows.as an organic fertilizer side dressing. The estimated yield was over 40 MT. per ha. per occupied area. The reason that every row was not planted to cassava was because the cuttings from the one year old Ipil-ipil was too voluminous and every other row was used for piling.

The commercial starch varieties of cassava used in the "Philippines have" characteristic of sprawling and branching when heavily fertilized. The unoccupied rows of the trial planting were soon covered intercepting most of the available sunlight falling on the area. This, in turn, resulted in heavy tuber formation and high yields. The leaf production was profuse and the color was a dark green indicating that adequate levels of nitrogen were available to the plant. When the crop was harvested, the tubers were numerous and large. The feeder roots had penetrated into the adjacent spaces in which

Although this trial system gave excellent results the first time, it may not be the best system for continued cropping of cassava. Due to severe competition for available light, it is thought that Ipil-ipil leaf production may not be adequate for successive crops of the nutrient demanding cassava. The time period has not been sufficient to prove nor disprove this assumption. The success of this trial planting justifies further experimentation.

However, taking the above into consideration, the following system is suggested for maintaining a vigorous stand of Ipil-ipil which would yield an adequate amount of green manure material to fertilize successive crops of cassava. Bands of Ipil-ipil ten meters wide would be alternated with ten meter bands of cassava. The Ipil-ipil would be planted in rows one-half meter apart with in-row spacing of 10-15 centimeters. The Ipil-ipil should be three months old at the time the cassava is planted. At this time it is cut back and applied as a surface dressing to the cassava The second cutting and application should be six weeks later. Successive cuttings/applications should be at two to three months intervals. A system such as this should adequately fertilize the cassava and minimize erosion.

Since successive plantings of the same crop are considered undesirable from an agronomic standpoint, it is suggested that each crop of cassava be followed by a crop of corn, sorghum, etc.

An ideal system could be one whereby the same ten meter band of Ipil-ipil is planted while the space reserved for the cassava planting would be sown to alternate paired rows of cassava and corn. The first paired rows of cassava would be one meter from the Ipil-ipil band. The spacing between the cassava rows would be one meter with in-row spacing of seventy five centimeters

A double row of corn would be alternated with the paired rows of cassava until the band of Ipil-ipil would be reached. The corn spacing would be one meter from the cassava row and one meter between the corn rows. In-row spacing would twenty five to thirty centimeters for single kernal plantings. This system would allow a farmer to harvest a crop of grain while waiting for the cassava to mature. Once the cassava was harvested, the cassava would sprawl and cover the space formerly occupied by the corn, utilizing the available sunlight.

At the University of the Philippines at Los Banos, College of Agriculture, Department of Animal Science, much wider spacings have been used. Plantings of "Giant" Ipil-ipil were spaced one meter by one meter and were allowed to grow for eighteen months before cutting back to a height of one meter. Thereafter, the regrowth was harvested at a three-month intervals. This consistently gave forage yields (green manure) equal or superior to systems with closer spacings. (2) During the establishment of such a system, one could intercrop with a shade tolerant cassava, such as the "Akleng" variety, or with other shade tolerant root crops. In addition, one could obtain a harvest of wood which could be used for fuel, charcoaling, banana props, etc.

These suggested systems of using "Giant" Ipil-ipil as a fertilizer crop for cassava could economically and environmentally benefit both the large scale producer as well as the small farmer.

Michael D. Benge
USAID/Manila
June 1. 1977

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BAYANI

[Giant Ipil-Ipil (Leucaena leucocephala)]

A SOURCE OF FERTILIZER, FEED AND ENERGY for the

USAID AGRICULTURE DEVELOPMENT SERIES

PREFACE

Leucaena leucocephala is a legume found in many places throughout the tropical and sub-tropical worlds. It is thought to have been introduced to the Philippines by the Spanish Priests from Mexico or South America.

The common or native variety, as it is referred to in the Philippines, is often known as Ipil-ipil or Santa Elena. In some places it is valued as an excellent source of cattle forage-feed while in other areas it is known as a toxic, scrubby shrub and a noxious weed.

A new improved variety of Leucaena leucocephala, sometimes called the "Hawaiian Giant" (a native variety in Hawaii is called Koa Haole), was introduced to the Philippines from a varietal collection at the Experiment Station at University of Hawaii. Dr. James L. Brewbaker is credited as the principal scientist responsible for the collection. The most common of the "Hawaiian Giants" are the K-6 (Peru), K-8 (Mexico), and K-28 (El Salvador). These varieties are not native to Hawaii but originated in their respective countries and were introduced to the Philippines through Hawaii. An Australian hybrid, which is known in the Philippines as the "Peruvian", is often mistakenly confused with the Hawaiian "Giants".

The "Hawaiian Giant" seed is thought to have been first brought to the Philippines approximately twelve years ago by the Dole Pineapple Company for use as a shade tree for Coffee. One of the most avid enthusiasts, responsible for much of the "Giants" popularization and dispersal throughout the Philippines has been Mr. Hugh Curran, a consultant in tropical agriculture and forestry. Dr. James L. Brewbaker, during a seminar on June 20, 1975, sparked the current impetus of the "Hawaiian Giants".

In a continuing effort to further popularize this tropical legume, the authors have reviewed all data available to them at this time and have condensed the information considered pertinent to present economic development trends. That information which is not scientifically credited has been derived from empirical observations by the authors and is in no way considered as a scientific study.

To offset the psychological stigma of negative connotations and to give it a nationalistic name, throughout this paper, the authors refer to the "Giant" strains of Leucaena leucocephala as "Bayani", a word in the Philippine national language meaning "Hero". For many, "Bayani" may truly be a hero.

All locations and data in this paper may be assumed to be in or from the Philippines. The metric system is used throughout and the Philippine currency the "peso" (piso) is calculated at ₱7.50 to $1.00 U.S.

Further information relating to "Bayani" may be obtained from the authors by writing to USAID/Manila, c/o Embassy of the United States of America, Manila, Philippines or to Mr. Michael D. Benge, Department of State, Agency for International Development, Washington, D.C. 20523.

MICHAEL D. BENGE

ERRATA

Page	Line	Correction
PREFACE		
	20	Coffee should read: "coffee"
FORAGE & FEED		
1	14	(reference, common Ipil-ipil) should read: "(reference, a common Hawaiian variety of Ipil-ipil)"
	18-19	(i.e., of common Ipil-ipil) should read: "(I.e. of a common Hawaiian variety of Ipil-ipil)"
footnote*	3	Leucaena latisilique, should read: "Leucaena latisiliqua"
3	1	(i.e. common Ipil-ipil) should read: "(i.e. a common Hawaiian variety of Ipil-ipil)"
	7	(i.e. Peruvian K-6) should read: "[i.e. improved Peruvian (Cunningham)] variety"
4	1	CHROMOLAENA ODOROTA (L) should read: "Chromolaena odorata (L)"
	19	The values of the 'Hawaiian Giant' should read "the values of Bayani ('Hawaiian Giant' Ipil-ipil)"
	23-24	To exceed 550 kilograms of N, 225 kilograms of P_2O and 550 kilograms of K_2O (9). should read "to exceed 560 kg of N, 225 kg of P and 560 kg of K(9).
WOOD PRODUCTION		
8	13	Since the 'Giant' Ipil-ipil should read: "Since Bayani (Giant Ipil-ipil)"
	14	Hawaiian Giant ipil-ipil should read: "Bayani (Giant Ipil-ipil)"
9	10	BAYANI should read: "Bayani"
	11	BAYANI should read: "Bayani"
	20	Using Brewbaker's Bayani projected yield of 100% increased volume production should read: "Using Brewbaker's projection of 100% increase in volume yield of Hawaiian Giant Ipil-ipil"

Page	Line	Correction
9	22	with Ipil-ipil should read: "with Bayani (Giant Ipil-ipil)"
(*c)	5	BAYANI should "Bayani"
10	10	BAYANI should read: "Bayani"
12	1	cogon grass, should read: "cogon grass (<u>Imperata cylindrica or Imperata exaltata</u>)"
<u>RECOMMENDATIONS AND OBSERVATIONS*</u>		
15	22	40,000 seeds/tree should read "approximately 35,000 seeds/tree"
	26	Cogon areas, should read: "Cogon areas (Loc. Cit.)"
16	9	a cost of ₱893.33/ha should read: "a cost of ₱832.50/ha"
	10	a cost of ₱1,583.33/ha should read: "a cost of ₱1,666.66/ha"
17	7	ganta/ha should read: "ganta of seeds/ha"
	8	ganta/ha should read: "ganta of seeds/ha"

IPIL-IPIL USES, POTENTIAL AND PRODUCTION DATA

INTRODUCTION

Much fragmented information concerning the species Ipil-ipil [*Leucaena leucocephala** (formerly *L. glauca*)], has come to the attention of the public since the recent visit of Dr. James L. Brewbaker and his USAID Ipil-ipil seminar[9] on June 20, 1975. In this paper, we will try to assemble, evaluate and distinguish between that which is the result of scientific research findings and that which is commonly assumed, in regard to the productive capacities, uses and potentials of Ipil-ipil. This will cover those species both common and improved, including that which is termed 'Giant'.

The most reliable, readily available, and extensive scientific information concerning the species and in particular the 'Giant' comes from the publications of the University of Hawaii Experiment Station. These publications stress its potential as a forage. Publication 125[8] is the most recent of the series. Other publications and related research on various specific aspects have been published in other parts of both the tropical and sub-tropical worlds[29].

We shall first cover the most valuable uses of this extremely versatile species and attempt to sort fact from rumor.

FORAGE AND FEED

1. *Volume*

a. The most comprehensive research information on this aspect (reference, common Ipil-ipil) can be found in Kinch and Ripperton's Bulletin 129, *Koa Haole, Production and Processing*[29] and Takahashi and Ripperton's Bulletin 100, *Koa Haole (Leucaena glauca), Its Establishment, Culture and Utilization as a Forage*, conducted in Hawaii[40].

Kinch and Ripperton give the following information in their bulletin: Three fields, (i.e., of common Ipil-ipil) on which research was conducted, gave a green weight yield of 67.0 MT, 71.87 MT and 77.8 MT per hectare per year, with an average of 4.6 cuttings (cut back to ten cm.) per year**, the rows were 52.2 cm. apart with a seeding of 40.65 kg/ha.*** The average yield converted to metric

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* According to a recent correspondence from Edward E. Terrel, Botanist, Plant Taxonomy Laboratory, U.S. Dept. of Agriculture, Agriculture Research Service, Northeastern Region, Agric., Research Center, Beltsville, Maryland, Dec. 30, 1975, the name of *Leucaena latisilique* [(L.) W.T. Gillis] has been changed back to *Leucaena leucocephala*, [(Lam.) de Wit].

** Kinch and Ripperton's data was given in short tons/acre which the authors subsequently converted to MT/ha.

*** Brewbaker reports that one pound of common Ipil-ipil seed contains 12,000 seeds. There was no indication whether the seeds were scarified and no germination percentage of the seed nor survival percentage of the seedlings were given; however, a reasonable estimate would be a 70% survival rate of the total number of seeds planted. The result would be 746,928 plants per ha.

measurement was 72.26 metric tons per hectare. Converted dry weight yield was 20.07 metric tons per hectare.*

b. Brewbaker mentions in his publication 125 that the 'Hawaiian Giant' Ipil-ipil produced more than twice the yield of the local variety (Brewbaker, *et. al*, 1972): yielding 95.26 MT fresh weight per hectare per year as compared to 38.15 MT of the local strain.

c. Research in the Philippines was conducted by R. C. Mendoza, T. P. Altamarino and E. Q. Javier, and written up in *HERBAGE, CRUDE PROTEIN AND DIGESTIBLE DRY MATTER YIELD OF IPIL-IPIL (Leucaena latisiliqua, C. V. Peru) IN HEDGE ROWS*(33). This extract from the department's annual report (3) gives the mean figures on the dry weight yield of the aforementioned 'improved variety' Peruvian.**

Figures, derived from data given on Peruvian Ipil-ipil planted in rows 3.0 meters apart, in hills 5 centimeters apart, and with an estimated population density of 66,000 plants per hectare, are shown in the following table.

Table 1. Dry matter yield of Ipil-ipil (*leucaena leucocephala*) harvested at different cutting heights and frequencies, tons, (i.e., metric) DM/ha/year.***

Height	Frequency in weeks			Mean a/
	8	12	16	
6 inches (sic)				10.68
1.5 meters				15.78
3.0 meters				23.61
Mean b/				16.69

a/ Means are significantly different from each other at 1 percent level.

b/ No significant differences among frequency means.

The growing consumption rate of beef in Asia has created an increasing market for high protein feeds and forage such as Ipil-ipil leaf meal. In the Philippines there is a major effort to gain self sufficiency in beef production. Japan and Taiwan offer a ready market for high protein feeds as do many local feed mills. In some places in the Philippines the dry leaves are being purchased for P0.50/dry kilo.

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* Kinch and Ripperton give a conversion rate of 3.6 green = 1 dry at 1C percent moisture.

** This variety was imported from Australia and seems to be a hybrid which gives a bushier growth as compared to other termed 'Giants' which grow much taller and produces a larger volume of wood per unit. We assume it may be the same as the K-6 variety mentioned by Brewbaker, *et. al* in Bulletin 166, *loc. cit.* This Peruvian is being sold as a 'Giant' but we must emphasize that if a 'Giant', it is a 'Giant' in forage production *ONLY*.

*** Table 1 found in the Mendoza, *et. al* paper does not give the percent moisture content of dry matter as is given in Kinch and Ripperton's report but it may be assumed to be similar.

2. *Carotene, protein and fiber content* of Koa Haole (i.e. common Ipil-ipil) in comparison to locally Hawaiian grown alfalfa.

a. Kinch and Ripperton[28] report the following in Table 9, on page 47. The average for the year (1961) of Koa Haole – whole forage was: 275 ppm-Carotene, 22.0 percent Protein and 29.8 percent Crude fiber. Alfalfa - 205 ppm. Carotene, 23.5 percent Protein and 27.5 percent Crude fiber.

b. Mendoza, Altamarino and Javier[32] report the mean crude protein content - as 20 percent. Furthermore, they list the mean vitro dry matter digestibility of Ipil-ipil (i.e. Peruvian K-6) as 72.8 percent.

3. *Dry Matter Digestibility*

Tests made by Mendoza, Altamarino and Javier indicated that the average of the total dry matter content digestibility of Peruvian Ipil-ipil leaves harvested every 8 weeks was 72.8 percent.[33]

4. *Mimosene*

Ipil-ipil contains an alkaloid called mimosene, found commonly throughout all varieties. A Texas species of the same genus, *L. pulverulenta*, has, on record, the lowest mimosene content of 18.9 mg/gm. dry weight, compared to the Hawaiian introduced Giant, K-8, with 43.2 mg/gm. dry weight; while the Philippine variety K-22 records a mimosene content of 48.1 mg/gm. dry weight. Mimosene has a depilatory (hair shedding) and a sterilization effect in some non-ruminants. The extent to which it affects all or some of the non-ruminant animals remains to be determined by research. Cattle, if fed completely on Ipil-ipil, may lose some of their coarse hairs. This is by no means lethal. However, new born calves have shown signs of enlarged thyroids which may cause death within a few days if born to cows which themselves show signs of toxicity. This is usually found only in very hot areas such as those in the Ord River area of Australia.*

Surprisingly, Mullenax reports[34] that in spite of its adverse effects on reproductive efficiency in other animals, *Leucaena* in poultry rations has been found to have a favorable effect on the hatchability of eggs. This is believed to be due to its high carotene and/or vitamin A levels.

Treatment of Ipil-ipil leaves can reduce the mimosene content as much as 80 percent. One method which will reduce the mimosene content by 50 percent, is by drying the leaves at high temperatures[9]. A second method, giving the same results, is by immersing the leaves in ferrous sulphate solutions which will lead to the precipitation of most of the mimosine. Cooking the leaves can reduce the mimosene content by 80 percent.

Through proper research, this characteristic could prove advantageous in some instances; e.g. by heavy feeding of Ipil-ipil leaves to hogs prior to slaughter to cause the loss of coarse hair and by feeding leaf meal to Tilapia to control reproduction.

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* Communication to Mr. Hugh Curran, Provident Tree Farms, Inc., Manila May 16, 1975, from Mr. Raymond Jones, Principal Research Scientist, Division of Tropical Agronomy, Cunningham Laboratory, St. Lucia, QLD.

In many parts of the Philippines 'Hagonoy' *CHROMOLAENA ODORATA* (L) has become a major threat to pasture lands. In some areas, more than 2/3 of the pastures have been abandoned. The weed is poisonous to cattle and overcomes and dominates areas inhabited by cogon or other grasses[23]. It is felt that Bayani ('Giant' Ipil-ipil), if established and pruned to three foot heights, would then dominate and suppress the 'Hagonoy' and provide an excellent forage source.

Balanced Pasture/Forage System

For prepared fields and planted pastures it is desirable to interplant Bayani (Giant Ipil-ipil) with some sort of a grass cover. Interplanting will keep the weed growth to a minimum, add materially to the carrying capacity, and provide a more varied and better-balanced forage. The interplanted grasses will probably receive sufficient nutrients from the associated legume so that little or no fertilization will be required. Under a paired-row layout, two rows of Bayani are planted about 1 m. apart with a 2m. space between two such pairs. The grasses are planted in the wide spacings between paired rows of Bayani. The grass should be interplanted 2 to 3 months after the seeding of Bayani to permit free cultivation of inter-row space during the early stages of growth and also to give the slower-growing legume sufficient time to become well established. Guinea, Bermuda, and Dallis grass work well for such interplantings. The combination of Bayani and Guinea grass is widely used in the relatively dry zones and is regarded as a first-class fattening mixture.

As a pasture legume Bayani required careful management. Since it is exceptionally palatable, over-grazing will seriously impair the rapidity of recovery and subsequent productivity[40].

FERTILIZER

The values of the 'Hawaiian Giant' and common species of Ipil-ipil (leaves and young stems) as an organic fertilizer and a green manure crop have long been known in Indonesia[15] as well as in other countries. Recent research at the University of Hawaii by Guevarra and Brewbaker have confirmed these Indonesian findings. Their findings reveal that as a green manure crop, the fertilizer equivalent of a year's harvested hectare of 'Hawaiian Giant' is estimated to exceed 550 kilograms of N, 225 kilograms of P_2O and 550 kilograms of K_2O[9]. Guevarra is conducting further experiments to determine precisely the return under different management systems. The aforementioned plant nutrient values are equivalent to 52 sacks of Ammonium sulphate, 20 sacks of Superphosphate and 18 sacks of Muriate of potash.

Mendoza, *et al.*, state that in their experiments the Peruvian variety of Ipil-ipil produced 310 to 800 kilograms of Nitrogen per hectare per year depending on the cutting frequencies and stump height. This is equivalent to 29.5 - 76 bags of Ammonium sulphate. No determination of other elements was made by this group. According to Mendoza, *et al's* calculations, the cost of the production of this amount, at ₱8.00/day of labor, was one half of the present government supported price of commercial fertilizer[33].

Further experiments on the use of 'Giant Hawaiian' Ipil-ipil as a surface-applied green manure mulch and side dressing for corn were made in Hawaii. In this experiment corn was planted between rows of Ipil-ipil cut back to 10 centimeters in height every month. The distances between rows was approximately one meter. The experiment covered one corn crop season. Unfertilized check plots yielded 1.8 MT/hectare (36 cavans). Those fertilized with only Ipil-ipil leaves yielded 4.2 MT/hectare (84 cavans). The plots treated with only Ipil-ipil leaves yielded more than those plots of corn treated with commercial fertilizer (at a rate of 75 kg/hectare of nitrogen)[9].

Bayani (Giant Ipil-ipil) has served as a fertilizer/nurse crop for seed tree orchards, as well as for other crops, and empirical evidence indicates that this can be very successful. Controlled planting between coconut trees and bananas could prove most advantageous. Bayani (Ipil-ipil) planted in contour strips in kaingins, continually cut back, is an excellent fertilizer source. It can also provide a partial solution as an erosion control; and would help to rejuvenate the soil.

With the present trend of rising prices and scarcity of commercial fertilizer this fertilizer quality of Bayani may be one of the most important of its aspects. For those hillside farmers and rural poor to whom fertilizer is either a scarce commodity or one they cannot afford, Bayani may offer the answer.

WOOD PRODUCTION

1. *Growth Characteristics*

Common Ipil-ipil, in comparison to some of the Giant varieties, is relatively slow growing, yet in high density stands, it rates as a high volume wood producing species (producing 34.66 cubic meters per year compared to *Albizia falcataria* producing 39 cubic meter per year). Brewbaker asserts that *Leucaena leucocephala* in Guatemala and other countries of South America, reach heights of 20 meters or more. The 'Hawaiian Giant' (K-8) in Hawaii, has reached heights of over 15 meters in 6 years. Others, spaced every 4 feet as windbreakers, grew to a height of 4.1 meters in 6 months, 9.1 meters in 2 years, and 16.8 meters in 6 years respectively. On another single row planting of Giant Ipil-ipil (K-8), spaced at 1.2 meters, the DBH* averaged 21.6 cm. (with a range of 10.4-32.3 cm.)[9].

In Mindoro a specimen tree, K-28 variety has reached a height of 13 meters and a DBH* 37 cm. in 8 years.**

The Peruvian variety will not give the same prolific wood-growth as the other 'Giant' varieties.

2. *Firewood*

The information on firewood yield of Ipil-ipil is very limited. A study, made by Vergara in 1960[41] of the common Philippine variety of Ipil-ipil in the Makiling area, UPLB, gave the wood yield of a three year old stand as 104 cubic meters.***

Brown[12] gives the firewood yield of a stand of one-year old common Ipil-ipil at 88 cu. m./ha.; a stand of a two-year old Ipil-ipil at 125 cu. m./ha. and a three-year old stand at 120 to 130 stacked cu. m./ha. The quality of the wood improves as the Ipil-ipil becomes more mature.

Matthews[32] measured a sample plot of a year-old coppice (i.e. stump sprouts) of common Ipil-ipil and projected the yield as 60 cu. m. in one year.

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* Diameter Breast High

** Provident Tree Farms, San Teodoro, Oriental Mindoro.

*** The authors assume that Vergara means 104 cu. m. of stacked wood per hectare.

Amos[1] conducted a study at the College of Forestry, UPLB, and measured the calorie value of one cu. ft. of dry common Ipil-ipil as 93, 447 calories [370,797.69 BTUs (or 13,089,158 BTUs/cu.m.)] *

Brewbaker[9] estimated, from observing the comparative growth characteristics of the Hawaiian Giant planted in a line four feet between trees, that the wood production of the 'Giant' should exceed that of the common tropical strains by 100 to 200 percent. Multiplying this by Vergara's figures would mean an equivalent plot of Giant Ipil-ipil would produce 208 to 312 cu. m. of wood per hectare per three-year rotation. PICOP states that *Albizia falcataria*, commonly referred to as a miracle tree, is projected to yield 200 cubic meters of pulpwood per hectare after eight years[2]**. It must, of course, be remembered that the initial stand of *Albizia*, is less dense and that minimum harvest diameter is ten centimeters. In addition, the wood density of *Albizia* is approximately forty percent that of Ipil-ipil, (i.e. It takes two and a half cubic meters of *Albizia* to equal the BTU value of one cubic meter of Ipil-ipil).

Using ₱32.00/cu. m. as the roadside delivery price of common Ipil-ipil [Vergara[41]] a Bayani (Giant Ipil-ipil) tree farmer could average a yearly income of ₱2,218.66 on a 3 ha. tree farm, by selling his wood as industrial firewood. At Los Banos, roadside vendors are selling Ipil-ipil (common) @ ₱1.10/ bundle (each bundle is approximately 0.0125 cu. mt.). Discounting a middleman, this would generate an income of ₱5,622.21/ha./year. In Manila a bundle of equivalent firewood of the same approximate volume sells for ₱1.50 and up/bundle. Some Manila bakers are still using firewood for fuel. In a recent canvass of these bakers they indicated that they would prefer Ipil-ipil as a firewood but none is available. In Los Banos, smaller bundles of young Ipil-ipil wood (approximately 0.0033 cu. mt.) were selling @ ₱0.40/bundle. Young Ipil-ipil has a lower BTU value than that of 3-year old growth. Firewood sold at this price would give a/ha. income of ₱8,428.04.

The heating value of 'Bayani' ('Giant' Ipil-ipil) wood, 3 years old (and above) is 16,438.4 BTUs/Kg.*** Liquified gas averages 45,265 BTUs/Kg.**** It therefore takes 2.75 Kg. of 'Bayani' ('Giant' Ipil-ipil) to give an equivalent heating value of 1 Kg. of liquified gas. At Los Banos the price of one bundle of wood which averages 7.33 kilo/bundle***** is ₱1.10 or ₱0.15/Kg. The price of liquified gas averages ₱2.27/Kg. bottled.**** Therefore, the cost of the 'Bayani' firewood, which would give you an equivalent BTU value as liquified gas at ₱2.27/KG., would be only ₱0.412 or 18% of the cost of liquified gas.

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* It is assumed that this wood was cut from a 3-year old stand. A younger wood should have a lower BTU value.

** In Report No. 424a-PH, *Appraisal of a Loan to the Republic of the Philippines for Financing: Small Holder Tree-farmers through the Development Bank of the Philippines*, by Dinh, T.N., E. Elizalde and P. Mistry, International Bank for Reconstruction and Development, International Association, 1975.

*** FORPRIDECOM, UPLB, 1976.

**** These figures were obtained from quoted retail prices given by the Manila offices of Manila Gas, Petro Phil., Phil. Gas, Rock Gas and Shellane. It is worthy of note that OPEC plans a 10% price increase this year.

***** It is assumed that this was air dried wood.

Another promising use of 'Bayani' as a fuel source would be in production of clay roofing tiles (as a replacement for costly G. I. sheeting) for Low-Cost-Housing units. By using this much cheaper source of fuel it makes the clay tiles less expensive and much more competitive. An even more efficient use of Bayani as a fuel in tile production would be in the charcoal making process as explained in part 3.

Firewood is a necessary item in the processing of Philippine tobacco. 'Bayani', planted as a firewood, can serve as fuel for the curing flues in Ilocos Norte, Ilocos Sur, La Union and Abra while reforestating the badly denuded hills in those areas.

3. *Charcoal*

Because of its density, rapid growth and other characteristics, 'Bayani' (Giant Ipil-ipil) makes an excellent raw material for charcoal both from an economic and quality standpoint. As the 'Bayani' ages, the quality of the charcoal made from the wood increases.

Brewbaker states that *Leucaena* is one of the most important sources of fuel (often as charcoal) in Latin America and South East Asia(9).

The U.S. Department of Agriculture Forest Service(5) gives the conversion rate of dry weight of wood to charcoal, for light hardwoods (equated to air dried Ipil-ipil grown on a short rotational period of 3-4 years) as 30.9 percent.

Taking Vergara's(41) yields of common Ipil-ipil one should, therefore, average 5.89 tons of charcoal per hectare per year.* Giant varieties should give 12 to 24 tons/ha./year.

The price of charcoal varies from area to area and according to the wood from which it is made. Bayani (Giant Ipil-ipil) wood is considered to be an excellent raw material for charcoal. In Negros Oriental the quoted wholesale price offered for Ilagan charcoal was only from ₱160.00-180.00/MT. In Iligan the quoted delivered price for mangrove and coconut shell charcoal was ₱300.00/MT. In Barrio Puray, Montalban, Rizal a small scale producer sells Ipil-ipil charcoal at ₱6.00/rice sack (approximately 13 kilos), or ₱0.46/kilo. The same size sack sells for ₱12.00 (₱1.08/kilo) at the San Juan, Rizal market. In Los Banos, Ipil-ipil charcoal is sold by the #10 can (approximately 1 gal.), which weighs .75 kilo @ ₱1.20/can (this would average ₱1.60/kilo). Dealers who advertise in the Manila Telephone Directory gave a price range of ₱800.00 to ₱1,000.00/MT. delivered. These prices seem exceedingly high. A charcoal producer in a rural area would do well to get ₱200.00/MT. which would give him a per ha. income of ₱2,400.00 (using Brewbaker's projected 100% yield increase). If a better marketing system was devised, a charcoal producer could make as much as ₱12,000/ha./yr. The heating value of Bayani ('Giant' Ipil-ipil) charcoal is 25,949 BTU/Kg.** while the heating value of liquified gas averages 45,265/KG. This would make charcoal 57% as efficient on a KG to KG. basis. The price

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* According to Brewbaker in the AID Seminar Series Publication *(loc. cit)* the specific gravity of the *Leucaena* species is approximately 0.7. Assuming that young Ipil-ipil from three year old cuttings would have less specific gravity than wood from mature trees, we used .55 as a working figure. This would put the wood of Ipil-ipil in the class of light hardwoods (U.S. standards). Conversion figure for this type of American hardwoods was given in the USDA Forest Service Report No. 2213 *(loc. cit)*. Yield of common Ipil-ipil produced on one hectare in one year x the specific gravity figure of .55 = MT of oven dry wood x the conversion factor of wood to charcoal for light hardwoods = MT of charcoal produced per hectare of common Ipil-ipil per year.

** FORPRIDECOM, UPLB, 1975

of liquified gas averages ₱2.27/Kg. Using an average market price of ₱1.00/Kg. of charcoal it would be 0.77 of the cost of liquified gas for an equivalent amount of heat.

As wood is burnt in the charcoal making process there are two by-products: a gas which can be burnt the same as liquified gas for the production of power or heat; and a hot-dry air which can be used for drying. An ideal economical processing operation would be to raise Bayani both for wood and forage crop. The wood could be made into charcoal and the resulting by-products, gas and hot-air, be channeled into a drying unit, for the drying of the Bayani (Giant Ipil-ipil) leaves. This type of operation would cut the processing cost of the drying of the Bayani leaves, therefore, reducing the cost of processed leaf meal by 43% and making it a most profitable operation.

4. *Banana props*

Bayani (Giant Ipil-ipil), planted at close plantings of 1 meter x 1 meter, produces highly satisfactory poles for banana props. The poles, to be accepted, have to be 5 meters in length and not less than 3.8 centimeters top diameter. A ready market is found among export banana growers.

5. *Lumber*

Since the 'Giant' Ipil-ipil produces a fast growing, high density wood with easy working properties, one can expect an expanded market in the near future. 'Hawaiian Giant' Ipil-ipil may be a formidable future source of timber production. Some trees of this variety have grown to 31.75 centimeters DBH and 16.66 meters in height in 6 years[8] and 40 cm. DBH and 15 meters in height in 8 years.* Maximum size to which the tree will grow is yet to be researched. The wood has a density of approximately .7 and shows a beautiful birdseye formation in certain sections among older growths. Some potential uses of this timber would be for parquet type flooring, posts, girders, etc. Preliminary tests indicate that it would make an excellent lumber source for low-cost-housing units.

6. *Fence Posts*

Ipil-ipil has long been used as an excellent tree crop for land ownership identification purposes, boundary markers and for use as 'living fence posts'. The 'Giant' when used in this manner produces a useable post in a much shorter period of time. In addition, green stem and leaf matter can be harvested from the living posts for use either as a fertilizer or as animal forage.

7. *Industrial Fuel Potential*

a. Wood as a direct fuel source for steam powered electric generators.

The most comprehensive economic feasibility study on the use of *Leucaena* (Ipil-ipil) as well as other wood species Vs. bunker fuel, to produce electricity, was made by the Forest Products Research and Industries Development Commission, College, Los Banos, Laguna in 1974[7]. There have been

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* Provident Tree Farms, San Teodoro, Oriental Mindoro.

other studies such as the one conducted by NASIPIT Lumber Inc.(*a) and from these two we have extracted the essential data for the following:

Using the data on *common Ipil-ipil* production compiled by Vergara[41] of 34.7 cu.m./ha./yr. or 25.25 bdt/ha./yr.* at a cost of ₱32/cu.m., purchased at Los Banos, stacked C and F** a cost of ₱81.20/bdt was arrived at when the Ipil-ipil was delivered to the power plant site.[7] According to NASIPIT(*a), their steam boiler which powers a 3,000 kw generator, on an average, requires 28 MT of steam fuel/hr. 1 MT of bunker fuel produces 12.8 MT of steam, therefore, 2.1875 MT of bunker fuel/hr. is consumed(*b). NASIPIT's data gives an approximate ratio equivalent of bunker to firewood as 1:5 @ 45% moisture content,(*c) therefore, approximately 10.9375 tons of firewood/hr. would be required to fuel the boiler(*d). It is estimated that one cubic meter of green BAYANI (Giant Ipil-ipil) weighs approximately one ton(*e), therefore, 10.9375 cu.m. of green BAYANI would be consumed/hr. or 262.5 cu.m./day and 95,812.5 cu.m./yr. Using Brewbaker's[8] estimate of 208 cu.m./ha/3-yr. rotation of Giant Ipil-ipil (i.e., using his estimate of 100% increased volume growth of the Giant over the common variety), it would require 1.26 ha/day or 459.9 ha/3-yr. rotation. A yearly continued supply would then require an area of three times the size projected for a 3-year rotational period or 1,379.7 ha. total plantation area required to provide a continuous supply of fuel for a 3,000 kw generator.

At present (1976) cost of bunker fuel, FOB Manila, of 0.7555/liter(*f), it would cost approximately ₱14,988,230.00 to run a 3,000 kw generator continuously for 1-yr. (i.e., cost of fuel expenses alone). Using Brewbaker's Bayani projected yield of 100% increased volume production, and Vergara's figures of ₱32.00/cu. m. of common Ipil-ipil FOB Los Banos[41], it would cost only ₱3,066,000.00/yr. to fuel the same generator with Ipil-ipil. If one estimated the transportation costs

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* bdt/ha./yr. = bone dry tons per hectare per year.

** C & F = Charge plus freight. There is no indication of distance from source of Ipil-ipil to road-side or from roadside to factory site; but later in the same paper, a distance of 50 KM. was shown as the transportation distance from roadside to factory site for *Albizia falcataria* computations. 50 KM is commonly considered as the maximum economic hauling distance of fuel wood. The figure of ₱1.00/bdt/km. is also given as the transportation cost.

(*a) This data was obtained from Mr. Pedro Nisperos, Executive Vice-President of NASIPIT Lumber Inc., based on their research data of the economics of waste wood as fuel to fire a steam powered electric generator. Manila, February, 1976.

(*b) This figure will vary according to peak loads.

(*c) Using Amos's[1] figures of 12,398,191 BTUs/cu.m. (i.e., 1 cu.m. of Ipil-ipil approximately equals 1 MT) of common Ipil-ipil and PETROPHIL's figure of 40,920,000 BTUs/MT of bunker fuel, the ratio of wood to bunker would be 1:3.3 instead of NASIPIT's data of 1:5 (i.e., waste wood), therefore, giving a safer factor of 1.7 or 34% which would indicate that the cost of the overall operation of a BAYANI fired steam generator, of 3,000 kw might be less than our final computation.

(*d) Moisture content is a variable factor.

(*e) 3-year old Ipil-ipil will sink in water therefore the weight can be approximated at 1 MT/cu.m.

(*f) This quotation was obtained from PETROPHIL and does not include the delivery rate of ₱0.0878/liter and a pumping charge of ₱0.005/liter. The basic fuel cost would increase approximately ₱0.01/liter in those areas having fuel depots in more remote locations. OPEC is planning a 10% increase in the price of oil this year.

@ ₱0.63/MT/kilometer(*g) and it was hauled 50 kilometers, it would increase the operating costs by ₱3,018,093.70, thus, the total estimated wood cost would be ₱6,084,093.70 or 40.59% that of the fuel cost of an equivalent petroleum fired generator.(*h) It should be pointed out that the price of oil continues to rise and it takes foreign exchange to purchase oil, while wood production creates jobs and saves valuable $ DOLLARS'

Discounting transportation costs, the wood @ ₱32.00/cu.m. would generate wages for 4 persons @ ₱8.00/day, 383,250 person days/yr., or furnish employment for 1,474 persons @ ₱8.00/day for 260 days/year.

Using Brewbaker's projection of 208 cu.m. of Bayani (Giant Ipil-ipil)/ha. on a 3-yr. rotation(8) or 69.33 cu.m./ha./yr. and selling the wood @ ₱32.00/cu.m.,(*i) a BAYANI farmer could earn an average of ₱2,218.66/ha./yr. In 1971, the average family income in rural areas was only ₱1,954.00. By growing Bayani and selling it for firewood, to such an installation, the farmer's family yearly income would be increased by ₱264.44(*j).

b. Alcohol as a wood derivity

With the present high prices of petroleum, the production of alcohol from wood for fueling internal combustion engines could be considered. The technology for doing so has been available for a long time(6) and the process can be found in most Chemical Engineering books relating to fermentation etc.(26). The recent oil crisis has triggered a large amount of new research in this area. The economics is favorable if quantities of cheap wood can be made available at factory site on a continuous basis. In those tropical countries having large areas of unproductive lands which could possibly be converted into major wood producing centers combined with relatively inexpensive labor, this process could be a present day reality. This would be particularly true in countries where the government places heavy specific taxes on liquid petroleum products in order to limit consumption and conserve foreign exchange. It is highly pertinent that countries relying on imported petroleum should be partially independent by having their own liquid fuel production capacities.

Information found in the textbook *Chemical Engineering*(6) gives the ethyl alcohol yield of hardwoods as 33 to 42 gallon/bdt. At the time that the book was written wood costs* were one half of the present estimated cost of Ipil-ipil firewood in the Philippines of ₱81.20/bdt, making the alcohol produced cost 35.8 centavos/liter. Since 1.5 liters of alcohol has the same fuel value as 1 liter of gasoline,

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(*g) This transportation cost was obtained from the Philippine-American Trimber Company, Manila, February, 1976.

(*h) The initial plant installation of a wood fired boiler-steam powered-electric generator would be higher due to the fact that this type of a unit has not been produced in industrial quantities for quite some time.

(*i) This is based on 1974, FOB, Los Banos given by Vergara(41).

(*j) This figure is based on 1974 prices of Ipil-ipil at Los Banos and the 1971 average family income based on *NEDA Statistical Yearbook*, 1975.

* Since the book was published in the U.S. in 1936, the computed wood costs were based on the price of firewood there at that time.

this would give an equivalent cost for equal fuel value of 53.7 centavos per liter. Since the cost of the wood was 40 percent of the cost of fuel production, this would raise the cost of production of an equivalent amount of alcohol/liter of gasoline to 75.18 centavos discounting the inflationary production costs. If we estimate that production costs have doubled since original printing of the book, the cost of the alcohol equivalent of one liter of gasoline would be 1.074 pesos.

The above figures in no way constitute a production cost analysis but are only a rough projection estimate. A more accurate computation is being obtained.

In addition to the alcohol derived, there is a lignin residue by-product which is estimated at 30 percent of the bdt weight of the wood which presses easily into a briquette to be sold as a fuel. This would increase the profit margin on the entire operation.

c. Producer gas

Wood or charcoal can be burnt under special conditions to produce a combustible gas mixture comparable to liquified petroleum gas but with much lower BTU values. About 13 pounds of charcoal is equivalent to 1 gallon of gasoline. Cars and trucks burning producer gas were found in many areas during World War II.

The U.S. Department of Agriculture/Forest Service in cooperation with the University of Wisconsin published a bulletin giving general information relating to the subject[4]. In this publication they put forth that under emergency conditions, when liquid fuel is not available at any reasonable price, the use of gasogen units may be necessary. In remote regions, under special conditions gasogen operations might be practical and necessary.*

8. *Paper and dissolving pulp (Cellophane)*

Recent tests at FORPRIDECOM, UPLB, College, Laguna have indicated that young giant Ipil-ipil can be economically used as a raw material for paper pulp manufacture if short fibered pulp is desired as a component in the pulp mix.

In the Philippines, in the province of Abra, a dissolving pulp mill (cellophane) is being planned to utilize a large percentage of Ipil-ipil as a raw material.

Miscellaneous

Brown[12] reports that Ipil-ipil seeds soaked overnight can be cooked the same as mungo beans. In addition, he reports that the seeds can be ground and used as flour or roasted and used as a coffee substitute. The young leaves can be blanched and eaten as a green vegetable although a slight bitter taste persists. The young pods, also blanched, can be used in salads and Brewbaker reports that they are used in Mexico as a *taco* filler.

Bayani (Giant Ipil-ipil) has a capability to withstand low rainfall conditions. It has been recorded to survive under a rainfall as low as nine inches a year. In such conditions the foilage production is appreciably decreased.

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* Due to the recent oil crisis the economics of gasogen production may be more feasible.

Reforestation

Ipil-ipil has been used in the Philippines as a pioneer species to eradicate cogon grass. However, continued natural reseeding of the common variety can result in dense stands which can shade out many other species of a ground cover nature. Sheet erosion, in this case, may become a problem. 'Bayani' the 'Giant' variety, is not as prolific in seed production. The seeds are not as resistant to the elements and to insect attack, and the seedlings are not as hard as the common variety; therefore, it may not produce such dense volunteer stands. Sterile, hybrid varieties could be developed to eliminate this unfavorable factor. Controlled planting may be the answer. Widely spaced plantings have been found to be very successful as firebreaks in grass land areas due to the aforementioned quality of shading out the ground cover. By opening furrows on the contour with a carabao and a plow and then by direct seeding, cogon grass can be overcome. Cogon serves as a natural deterrent in delaying rapid spread of the Ipil-ipil if the grass remains unburned.

Based on empirical evidence, some foresters feel that the natural climax forest on Corregidor is being restored with Ipil-ipil serving as both a nurse crop and a soil builder.

'Bayani' can serve as an excellent nurse-companion crop for reforestation. The increased demand for, the dwindling supply and the high price of bamboo makes it a viable reforestation species in many areas. Past drawbacks of planting bamboo were the heavy demands that it makes on the soil fertility. The fertilizer production capabilities of 'Bayani' will easily offset the fertilizer requirements of Bamboo when planted as a companion crop.

The most formidable constraint to present reforestation efforts is indiscriminate cutting of newly planted trees. Bayani (Giant Ipil-ipil), with its remarkable regenerative characteristic, is a most promising reforestation species in those areas suitable for its growth.

Pests, diseases and potential deterrents

Brewbaker, during his seminar, stated that Ipil-ipil has few known enemies except animals and human beings (animals which browse and humans who cut it down or eradicate it). Our empirical evidence indicates that there are more enemies than previously thought of. In contrast to the common Ipil-ipil, the seeds of the 'Giant' are not as waxy and hard. Therefore, when dried and stored, they readily attract insects of a weevil type. While the seed pods are maturing the seeds are eaten by a larvae. Similar larvae are also attracted to the emerging blossoms prior to seed set.* A fungus has also been found on the seeds but it is yet unknown if it is a primary or secondary problem. The larvae which attacks the blossoms and young seeds in the pod and the fungus on the seeds seem to be more of a problem during the rainy season.

Plantings of the 'Hawaiian Giant' (K-8) and of the Peruvian (bush), in areas with high water tables, have been partially destroyed by a fungus which attacks the roots of both the young trees and the old coppice stumps. The stand also showed a heavy infestation by nematodes. In one area it was reported that leaves were attacked by larvae and African snails.

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* There was also evidence that the same larvae attacked the common Ipil-ipil but due to its polific seeding nature, it was not as noticeable.

Seeds of the 'Giant' seem to lose viability much more rapidly than those of the common variety. Seeds and seedlings are readily attacked by rats when planted in areas of high rat population. In some known directly seeded plantings, more than 80 percent of the total seeds and seedlings were destroyed. During a rodent research conducted by Dalmacio[14] on Benguet Pine seeds coated with a protectant, the chemicals *Thiram* and *Aldrin* showed the most promise. These may be useful as a protectant for Ipil-ipil seeds.

In Hawaii, 'Giant' Ipil-ipil varieties have shown growth restrictions of a serious nature when planted in acidic soils. Soils with pH levels below 6.8 gave lower yields and growth rates, with 50 percent reduction around a pH of 6.3 and 80 percent reduction below the pH of 6.0. Brewbaker stated that it is clear that soil acidity is a major limiting factor of *Luecaena's* spread into our wet forested lands, where pH values often are quite low.*

The above research in Hawaii is not yet conclusive, for empirical evidence in the Philippines indicates that some 'Giant' Ipil-ipil strains, under certain conditions, may do well even in soils having lower pH levels such as at Monterey Farms, located in Ibaan, Batangas, Philippines, on what is termed the 'Ibaan Series' of soils which have an average pH of 5.6 to 6.0. Some soils at IRRI, UPLB, have a pH level ranging from 5.8 to 6.0[33] yet growth rates of the 'Giant' Ipil-ipil varieties planted on them show little or no retardation. Mendoza explains that the reasons for the lack of retardation are a more even rainfall, higher temperatures during winter months, a less dense cloud cover and a longer dry season. The latter is of utmost importance since Ipil-ipil produces well during moderately dry seasons.

In North Samar, municipality of Naval, plantings made on acidic surface soils laying on limestone formations performed well after initial growth retardations. Seemingly, once the tap-root reached the limestone sub-soil levels, normal growth ensued.

Soil technologists state that certain minimum levels of available trace elements such as molybdenum and cobalt, are necessary for maximum efficiency of the nitrogen fixing bacteria.

Low levels of available potash and/or phosphate or a high magnesium and low calcium content in surface soils may cause a retardation in the growth of *Leucaena*.

In New Guinea, *Leucaena* has been found to be highly sensitive to sulphur deficiency[39].

In the Philippines, 'Bayani' ('Giant' Ipil-ipil), planted at altitudes above 450 meters, seems to show relative retardation. In Hawaii, 152 meters is the height at which growth retardation begins. The lower latitude of the Philippines seems to be the reason for the difference in related growth. Trial plantings of Ipil-ipil on limestone soils of high altitude have shown relatively reasonable growth rates.

For mimosene effects see page 3 of this report.

The above factors could be minimized with the development and propagation of more acid and altitude tolerant varieties and hybrids.

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* Recent communication from Dr. James Brewbaker to Mr. Hugh Curran, Provident Tree Farms, Dec. 1974.

RECOMMENDATIONS AND OBSERVATIONS*

1. *Seed treatment*

a. Scarification

To enhance germination, it is recommended that the seeds be given a scarification treatment by one of the following methods:

1) Hot water – The water should be heated to a temperature of 80°C for 3 seconds; after which, the seeds, wrapped in a cloth, should be treated with three dippings of one minute each. Another method is to measure a volume of hot water (raised to just under its boiling point) equal to the amount of seed to be scarified, pour it over the seeds which have been placed in a suitable container, and allow the seeds to soak for 12 hours.

2) Takahashi and Ripperton[40] recommended acid treatment of common Ipil-ipil consisting of immersion in commercial sulphuric acid for 15 minutes followed by thorough washing. Seed treated this way retained its viability for several months, but undesirable features of the method are risk of injury both to the seed and to the operator and the lengthy washing and drying process. The 'Giant' variety, with delicate seed characteristics, would be more sensitive to seed damage with an acid treatment.

3) Mechanical scarification can be done simply by sanding the seeds with sandpaper.

b. Innoculation

After scarification, for maximum nitrogen fixation, it is recommended that the seeds be treated with a suitable carrier of nitrogen fixing bacteria. If this commercial preparation is not available, soil can be taken from under a stand of common Ipil-ipil, which is known to be well innoculated, and mixed with the potting soil. This should suffice as a suitable substitute.

2. *Soil amendment and fertilization*

a. If soil acidity is too high, resulting in retardation of growth, agricultural lime should be applied.

b. If one can afford it, initial starter applications of complete fertilizer will increase the initial growth rate enabling the seedlings to compete more favorably with other plant species. Subsequent fertilizer applications will only be needed if the plant food reserves of the soil are known to be very low. Superphosphate (P_2O_5) enhances rooting and induces heavier seeding.

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* This portion is based on both scientific fact and empirical evidence obtained through observations in the field and through discussions and correspondence with those in the scientific field, industrial and small scale farmers, as well as other concerned parties.

3. Seeding and transplanting procedures

Nursery propagation*

a. Plastic bags, bamboo pots, etc. – plant two scarified (and preferably inoculated) seeds per container in approximately one cup of good soil having a pH near neutral. It is recommended that one gram of complete fertilizer be added per container. If both seeds sprout, transfer one seedling to another container (recommended after one week).

b. Seed beds – drill seeds no more than 4 cm. apart in rows 25 cm. between rows. 10 gms/sq. m. of complete fertilizer should be adequate, if thoroughly mixed with the soil. Preferably, seed beds should be trenched and filled with sand or humus then bedded to provide adequate drainage and to minimize root damage when lifted for transplanting. Again the seed bed soil should have a pH of near neutral.

Transplanting

From pots and seed beds – the seedlings may be transferred to permanent locations at an optimum age of 2-4 months. No pruning is necessary if transplanted from pots; however, if they are transplanted bare-root, the top stem should be pruned to a point where the bark has turned brown. The best procedure for bare-root removal is by digging up the plant with a sharp spade.

Seedlings may be field-pulled but the seedlings may suffer physical damage resulting in a mortality rate up to 40%. Long tap roots should be pruned to a length of 4-6 inches.

Cuttings are difficult to root, although it seems that certain seasons are better than others for this procedure. Mist propagators should give a higher survival rate. Five buds should show on each cutting.

Direct field seedling

One prevailing misconception is the high cost of the seed needed for 'Bayani' ('Giant' Ipil-ipil) plantings. There are seeds available at a reasonable cost** but even this initial high cost could be overcome if time was not of the essence. One 'Bayani' ('Giant' Ipil-ipil) tree has the capacity to produce 40,000 seeds/tree in 1½ years on good soil. Therefore, if one has the time he can produce his own seeds at almost no cost simply by planting an equivalent number of seed trees needed to fulfill his projected seed requirements. If one takes into consideration the relative high profits and quick returns obtained from 'Bayani' the planting costs are nominal.

1. Cogon areas

Successful plantings of Ipil-ipil have been made in heavy cogon areas by simply plowing a furrow through the cogon and drilling the seed directly. Difficulties have arisen due to the usual high rat

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* If soils used for nursery purposes have a pH of less than 6.0 then sufficient lime should be added to raise the pH to 6.0 or above.

** Seeds are available in a limited amount @ ₱250.00/ganta.

population found in cogonal areas. The rats eat both the seeds and young seedlings. Greater success has been gained by burning off the cogon prior to plowing. This would reduce the rat population as well as decrease cogon competition.

2. *Forage and leaf meal plantings*

For optimum results the land should be plowed and harrowed at least one time prior to planting. Furrows should be 75 centimeters apart and seeds drilled 5-10 centimeters apart in the row. The Peruvian variety produces a more bushy growth although in tests the K-8 and K-28 varieties have given equivalent yields. For field forage cutting heights can be 10 to 15 centimeters in height and at a frequency of every two to three months depending on growth rates. For forage and leaf meal planting @ a spacing of 10 cm. in row requires 3.33 ganta of seed/ha. @ a cost of ₱893.33/ha.*, 5 cm. in row requires 6.66 ganta of seed/ha. @ a cost of ₱1,583.33/ha.*

3. *Seed trees*

Previous plantings for seed purposes have shown that a spacing of 2 x 5 meters is a suitable distance for heavy seed production.

The amount of seeds required is 1/20 ganta/ha. at a cost of ₱12.50/ha.* There is a definite need for seed selection from trees exhibiting the most desirable characteristics which fulfill end use requirements.

4. *Erosion control, contour and intercropping strips for hillside cropping systems*

For hillside planting (which would also give erosion control) and intercropping, it is recommended that 'Bayani' ('Giant' Ipil-ipil) be drilled in paired contour rows 40 centimeters apart and 2-5 centimeters apart in the row. The paired rows should be approximately 2 meters from center to center. Those plantings would require: @ 5 cm. spacing = 5 ganta/ha. at a cost of ₱1,250.00/ha.*; @2 cm. spacing = 12.5 ganta/ha. at a cost of ₱3,125.50/ha.*

Another method, recommended by Brewbaker(9) for erosion control, is the planting of contour bands of 'Bayani' in strips 3-5 m. wide, spaced at a distance of 10-20 m. apart. Corn, rice, cassava and/or other crops could then be planted between the rows. A modified version of this would also serve as a firebreak. Based on rows 75 cm. apart and seeds drilled 10 cm. apart in the row, the amount of seed required and the cost of these seeds per ha. would be: strips 3 m. wide and 10 m. apart would require .769 ganta of seed @ a cost of ₱192.25; strips 5 m. wide and 10 m. apart would require 1.1 ganta of seed @ ₱275.00; strips 3 m. wide and 20 m. apart, .425 ganta of seed @ ₱106.25; and strips 5 m. wide and 20 m. apart, .666 ganta of seed @ ₱166.50.

5. *Reforestation, timber and wood production*

a. Timber production – one recommended planting pattern is 10 x 2 meters with a later thinning out of less vigorous and/or undesirable form specimens to a spacing of 10 x 4 or 10 x 6 meters depending on the ultimate tree size desired.

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* Seed costs are computed @ ₱250.00/ganta.

b. Firewood – a recommended planting would be 1 x 2 meters with a later thinning to a desired density.

c. Combination timber/wood – a recommended planting would be 1 x 2 meters with a thinning to a final stand of 10 x 4 or 10 x 6 meters.

The above recommendations may change as a result of future research findings. Climate, altitude, soil conditions and economics will undoubtedly be major variables.

A planting of: 10 x 2 meters would require 0.025 or 1/40th of a ganta/ha. at a cost of ₱6.50/ha.
1 x 2 meters would require 0.15 or 1/8th of a ganta/ha. at a cost of ₱41.25/ha.

Seed productivity

A well grown tree on a suitable site should produce at least 1 ganta (approximately 40,000) of seeds within 18 months.

Related costs

The most comprehensive and available data on the cultivation costs of 'Bayani' ('Giant' Ipil-ipil) were obtained from Maria Christina Chemical Industries, Inc. and Mabuhay Vinyl Corp. Their 1975 expense estimate of planting made on cogonal land in their industrial tree plantation at Iligan, Misamis, Lanao Del Norte included the seed, nursery, fertilizer and direct labor costs. They transplanted the seedlings from the nursery directly to hilly cogonal areas. The cogon grass had been cleared from a 30 cm. dia. area. The area around the seedling was ring weeded two times during the year. The planting density was 10,000 seedlings/ha. and plantings were made by contract labor. The costs incurred were: potting ₱16.00/1,000 seedlings; planting (transplanting) ₱40.00/1,000 seedlings; cultivation ₱36.00/1,000 seedlings x 2; replanting (10% of total) ₱3.20/1,000 seedlings; fertilizer 22 gms./seedling (2 gms. applied as a liquid fertilizer sprayed on the seedlings and 20 gms. applied after the seedlings were transplanted) @ ₱221.32/ha.; seeds were purchased @ ₱35.00/Kg. from their own nursery. The total cost incurred/ha. was ₱2,850.00. ₱1,140.00 of this total was spent for labor.

Availability and cost of seeds

'Giant' Ipil-ipil seed has been sold for as high as ₱3,000/ganta in Ilocos Sur. At the present availability level of the Hawaiian Giant, a fair price should be ₱200 to 250/ganta. In the future, the supply of seed should be large enough to cause prices to fall to a level of ₱30-50/ganta, unless there is a sudden upsurge in demand from other tropical regions.

WARNING, not all of the so called 'Giant' Peruvian varieties give large wood growth. Presently we recommend only K-8 and K-28 varieties for wood production. According to field tests conducted both in the Philippines and Hawaii, they have shown that the forage-leaf meal production of K-8 and K-28 equals that of the Peruvian variety.

WARNING, seed sources as well as variety of seeds should be *verified* prior to purchase. Some seeds from unreliable seed sources are being sold as 'Giant' but are a low percent of improved variety seeds mixed with common Ipil-ipil. Peruvian is being sold, labeled a 'Giant', but from these seeds a large wood growth will not be obtained. Random samples of each supply of seeds should be taken. Samples can be sent for testing to the Pastures Division, Dept. of Agronomy, UPLB, College, Laguna.

RESEARCH

At the present time the majority of the experimentation on Bayani (Giant-Ipil-ipil, including Peruvian bush) has been conducted in Hawaii and Australia. Although it is known to the authors that Taiwan, Indonesia, Guatemala and Thailand have conducted an appreciable amount of research, this material is presently unavailable. Texas A & M in cooperation with its counterparts in Mexico has researched both *Leucaena leucocephala* and *Leucaena pulverulenta*. The University of the Philippines at Los Banos has conducted some experimentation but mainly on forage feed production and feeding trials.

There is a dire need for additional locally conducted research on various aspects of *Leucaena leucocephala*, its growth characteristics and tolerances under various soil-climate-altitude conditions, to include not only forage production but wood production; fertilizer potentials, tolerances; mimosene effect on animals, both ruminants and non-ruminants; drying methods; inoculation; etc.

Different varieties need to be discovered and developed which are more tolerant to acidity and altitude; have a lower mimosene content; have different wood characteristics; are higher yielding; have increased resistance to diseases and pests; and do not have such prolific seeding characteristics as well as other desired qualities.

Research in Hybridization both intervarietal and interspecific should be a medium for improving performance.

As a reforestation species Bayani has excellent potentials. In plantings where reproduction by natural seeding is not desired, a solution might be obtained through the production of sterile hybrids.

Seed selection from trees having more desirable characteristics, whether for forage production, wood/timber, fertilizer, etc., needs to be made. For those interested in wood/timber production, seeds should be collected from only those trees which give high volume/density production as well as good form (straight trunks).

MISCONCEPTION

Contrary to some beliefs the Bayani varieties of K-8 and K-28, the two main 'Hawaiian Giants', have proven to yield as much and in some cases more[8] forage-leaf matter than the 'so called' Peruvian variety. Bayani (Hawaiian Giants, K-28 and K-8) are prolific in *both* wood and foliage production.

'Hawaiian Giants' are *not* low in mimosene content (see page 3 of this report). Brewbaker, Plucknett and Gonzales[12] give the mimosene content in mgs./g. dry weight of the following varieties as: K-8, 43.2 mg./g.; K-28, 47.2 mg./g.; K-6 (Peruvian), 35.4; and K-43 (Philippine common), 41.1. A Texas variety, K-19, has a mimosene content of only 18.9 mg./g.; however, it is low in forage production. Hybrids developed from the crossing of K-8 or K-28 with K-19 (*Leucaena pulverulenta)* may produce a high yielding variety with a low mimosene content.

It is reported that the K-8 variety, in Hawaii, is a light seeder producing fewer pods on a seasonal basis. Because of this characteristic, this variety would make a more desirable shade tree.

In conclusion, the potentials of *Bayani* (Hawaiian Giant Ipil-ipil) to assist the rural poor, the kainginero in particular as well as other members of the rural society, seem tremendous. Future planned demonstration plots and programs should confirm the present optimism engendered through observations of present and past plantings in various parts of the Philippines.

A list of certified seed sources may be obtained through communication with the authors.

6-7 year old. K-28 'Bayani' ('Hawaiian Giant' Ipil-ipil) located at Canlubang Sugar Estate, (Calamba), Laguna, which is part of oldest stand in Luzon. This stand was established by opening furrows in cogon grass with a carabao and plow in which seeds were sown by hand.

* * * * * * * * * *

April 12, 1976

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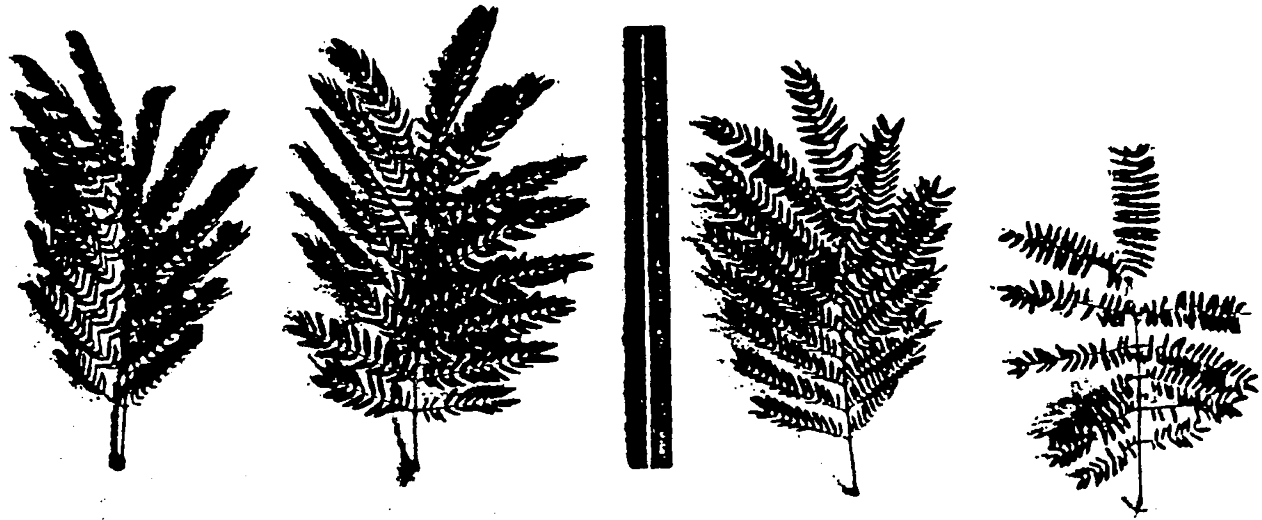
APPENDIX I TAXONOMY



K-8 K-28 PERU NATIVE

K-8

1. length of main
   rachies = 19.3 cms.
2. no. of leaflet
   pairs = 8 pairs
3. length of leaflets

		no. of pinna/leaflet
#2 leaflet	7.2 cms.	11 pairs
#5 "	11.5 "	16 "
#8 "	11.0 "	16 "

4. sizes of pinna

#2 leaflet	=	polar diameter	= 1.8 cms.
		equatorial dia.	= 0.5 "
#5 "	=	polar diameter	= 1.9 "
		equatorial dia.	= 0.5 "
#8 "	=	polar diameter	= 2.0 "
		equatorial dia.	= 0.55"

K-28

1. length of main rachis = 23.3
2. no. of leaflet pairs = 8 pairs
3. length of leaflets

		no. of pinna/leaflet
#2 leaflet	7.8 cms.	12 pairs
#5 "	10.6 "	16 "
#8 "	11.7 "	16 "

4. sizes of pinna
   - #2 leaflet = polar diameter = 1.9 cms.; equatorial dia. = 0.7 "
   - #5 " = polar diameter = 1.9 "; equatorial dia. = 0.6 "
   - #8 " = polar diameter = 2.2 "; equatorial dia. = 0.7 "

PERUVIAN

1. length of main rachis = 24 cms.
2. no. of leaflet pairs = 7 pairs
3. length of leaflets

		no. of pinna/leaflet
#2 leaflet	9.2 cms.	13 pairs
#5 "	13.5 "	18 "
#7 "	13.4 "	17 "

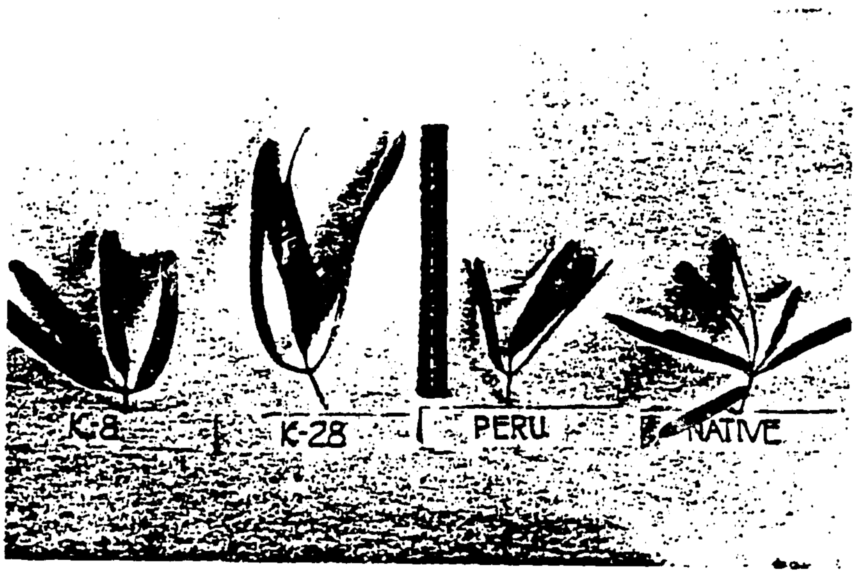
4. sizes of pinna
   - #2 leaflet = polar diameter = 2.0 cms.; equatorial dia. = 0.6 "
   - #5 " = polar diameter = 2.2 "; equatorial dia. = 0.6 "

COPIL #5 (NATIVE)

1. length of main rachis = 18.2 cms.
2. no. of leaflet pairs = 7 pairs
3. length of leaflets

		no. of pinna/leaflet
#2 leaflet	5.7 cms.	11 pairs
#5 "	8.6 "	15 "
#7 "	9.8 "	16 "

4. sizes of pinna
   - #2 leaflet = polar diameter = 1.35 cms.; equatorial dia. = 0.45 "
   - #5 " = polar diameter = 1.50 "; equatorial dia. = 0.50 "
   - #7 " = polar diameter = 1.65 "; equatorial dia. = 0.55 "



POD

K-8
Length = 27.5 cms
Diameter = 2.6 "
Seeds/Pod = 27 "

K-28
POD
Length = 27.6 cms.
Diameter = 3.1 "
Seeds/Pod = 23

PERUVIAN
Length = 18.4
Diameter = 2.5
Seeds/Pod = 23

NÁTIVE
Length = 21.5 cms.
Diameter = 22.3
Seeds/Pod = 23

SEED SIZE

K-28
polar diameter = 1.06 cm.
equatorial dia. = 0.69 "
thickness = 0.2 "
color = shiny, dark brown

K-8
polar = 1 cm.
equatorial = 0.6 "
thickness = 0.2 "
color = dark brown with very fine colorless ring

PERUVIAN
polar = 1.11 cm.
equatorial = 0.59 "
thickness = 0.2 "

NATIVE
polar diameter = 1.05 cm.
equatorial dia. = 0.55 "
thickness = 0.21 "
color = dark brown