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BAYANI

[Giant Ipil-Ipil (Leucaena leucocephala)]

A SOURCE OF FERTILIZER, FEED AND ENERGY for the PHILIPPINES

USAID AGRICULTURE DEVELOPMENT SERIES

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 (Imperata cylindrica or Imperata exaltata)"
RECOMMENDATIONS AND OBSERVATIONS*		
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"

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"

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

BAYANI

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 ₱0.50/dry kilo.

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* Kinch and Ripperton give a conversion rate of 3.6 green = 1 dry at 10 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[2,3]. It is felt that Bayan ('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(*c), 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 roadside 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 roduction 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.

AGRO-FORESTATION

As defined - 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. Agro-forestation may be multi-purpose in nature whereby Leucaena could be first planted and harvested for wood use such as banana props, fuel-wood, etc.; then allowed to regenerate to be harvested as forage, green fertilizer, seeds, etc.

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 (Guerrero 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).

Cultural Practices - Leucaena used as a component in an Agro-forestation scheme can serve well as a companion tree crop and shade tree. Planted as a source of fertilizer it 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 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 valuable timber cut in the slash and burn practices; reduce soil erosion and degradation, while decreasing the area of land required to support shifting cultivations, transforming them into a sedentary (stationary) agriculture practice.

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 to those researchers. 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) reports 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 Leucaena planted 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 ₱32.00/cu.m. would give a farmer an income of ₱2,240/ha./yr. (calculated @ ₱7.5 to $1.00 U.S.). Benge and Curran (1976) estimated that Leucaena firewood farmers at Los Banos were capable of earning ₱5,622.21/ha./yr. by selling wood at a roadside price of ₱1.20 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 ₱.50/kg., multiplied by Lugod's projection of 30 mt./ha., would give an income of ₱15,000/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 ₱2,312.00/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 ₱2,400 for charcoal producers who sold their product at a wholesale price of ₱200.00 ($26.50 U.S.)/M.T. The aforementioned Agro-fo.estation 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. Each year, sizable areas of forest lands are burned to waste. 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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SCIENTIFIC KAINGIN 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 system of farming. 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 scape goats to blame for denudation, the result of our unimaginative minds. Such is the case of the "Kaingeros" or shifting, swidden agriculturists, 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 "Kaingeros" who only desire to eke out a living, or does the fault lay with us, who as technocrats, not only fail to invision alternative systems of agriculture, but also fail to create other forms of employment. Such systems of agriculture could be based on indeginous crops and techniques to which the people can easily relate; other forms of employment could include locally based industry.

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 or Santa Elena. Leucaena is a member of the greater legume of family in a group that includes Mimosa, Albezia, and Prospis. It is a perennial, having the ability to fix nitrogen in its roots as well as accumulate nitrogen, phosphate and potash in its leaves. The leaves from one hectare of "Giant" Ipil-ipil harvested over a period of one year and applied as a green manure mulch can equal 90 bags of commercial fertilizer or 560 kg of Nitrogen, 225 kg of Phosphate and 560 kg of potash. On test plots located at the University of the Philippines at Los Banos, the leaf weight yield of one ha. of Leucaena was 16.5 dry m.t. Leucaena

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

Two types of Agro-forestation schemes in which Leucaena can be worked into are:

(1) Leucaena can be planted for erosion control while serving as a ready source of organic fertilizer for annual crops planted in the hillsides or in the kaingin. A variety of spacings can be made but one presently being tested has shown quite promising results. This is the 1 x 1 meter spacings of Leucaena planted in 5 meter bands on the contour of the hillside. The Leucaena can be transplanted or dibbed (i.e. direct seeded) as one would plant upland rice. The field preparation would be the same as for upland rice or corn. Ten meter bands of corn, rice, etc. can be planted between alternating bands of Leucaena. The one meter spacings between the Leucaena allows for the planting of grasses to help prevent sheet erosion. Casava could also be planted between the Leucaena but this scheme would not be as effective in preventing erosion. The Leucaena should be allowed to grow for one and one half years in order to establish a good root system, thus taping a huge reservoir of nutrients. Cut at the stump height of one meter, the Leucaena can be harvested as a source of firewood and charcoal, and then allowed to regrow and cut for a source of green fertilizer for annual crops. This type of planting: (1) is inexpensive; (2) will allow grass to regrow between the stumps to help prevent sheet erosion; (3) allow cattle to pass between the stumps for grazing and browsing; and (4) allow cassava, kamoteng kahoy and other crops to be planted between the stumps. If the leaf yield is shown to be insufficiant, later plantings of Leucaena could be made between the stumps. This system would negate the necessity of kaingeros and cultural minorities to continually shift their fields. More important, because the kaingeros would no longer need to burn valuable timber for fertilizer for their crops, the denudation process would be decreased.

The above planting scheme will also serve to suppress two very noxious weeds, hagonoy, Chromolaena odorata, and cogon, Imperata cylindrica, found in pasture lands and on once forested hillands.

(2) The second scheme would involve planting pure strands of Leucaena in spacings anywhere from 1 x 1 meters to 4 x 4 meters. After the first year an indigenous root crop, such as "nami" or Dioscorea hispida, can be interplanted. Professor Lugod of the University of the Philippines at Los Banos recorded a projected yield of domesticated "nami" grown under normal forest canopy as being 30 m.t./ha. With the fertilizer properties of Leucaena the per ha yield of "nami" should be appreciably higher. Other shade tolerant crops could be substituted or rotated with "nami." In this system, one could double his production per ha by growing Leucaena: (1) as a wood source, and (2) as a fertilizer source and cover crop for a tuber crop of "nami."

The possibilities and varieties of alternative systems of kaingin, swidden agriculture or Agro-forestation are many. The interplanting of Leucaena with abaca, bananas, coconut and coffee are but a few.

Leucaena is not a panacea for all the problems caused by denudation and shifting agriculture; but of the previously discussed eco-systems are implemented, maximum environmental protection can be gained. Perennial tree crops (to reduce erosion and run-off) coupled with annual food crops (to increase food production) as part of an Agro-forestation scheme can offer an answer to many of the problems inherent in hillside farming.

" "Hunger is not the tragedy of an empty stomach, but it is the tragedy of a human mind not used."

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.

4. *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 .. which seeds were sown by hand.

* * * * * * * * * *

April 12, 1976

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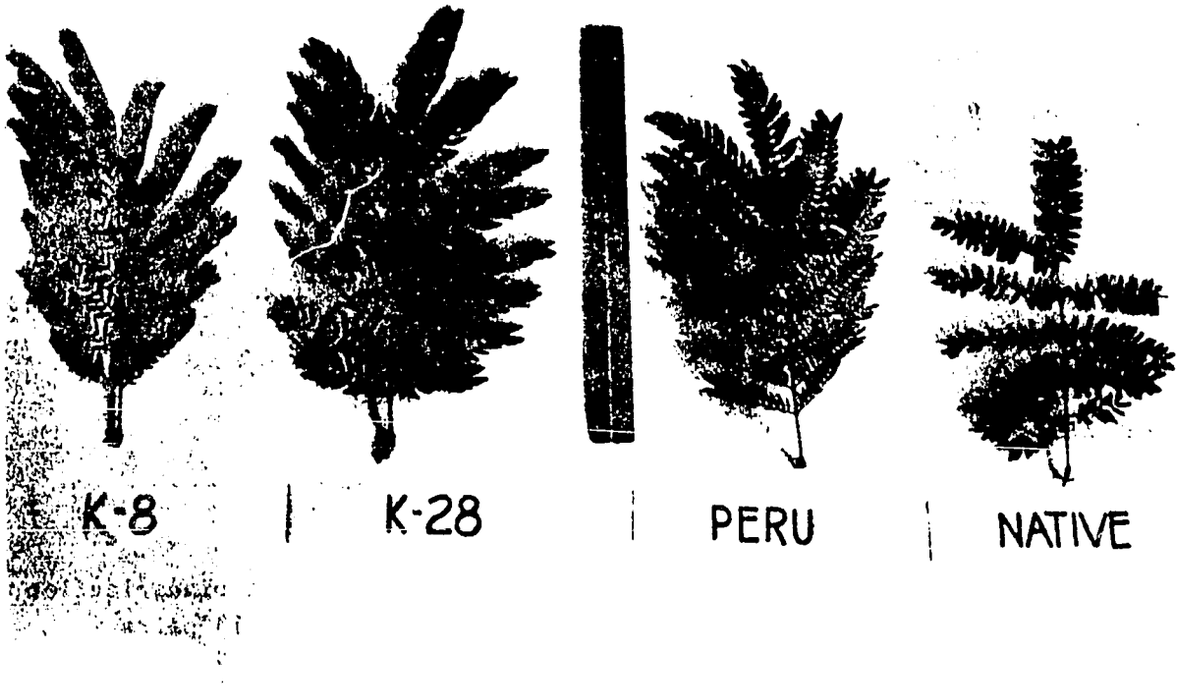
APPENDIX I TAXONOMY



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

NATIVE

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

SEED SIZE

K-28

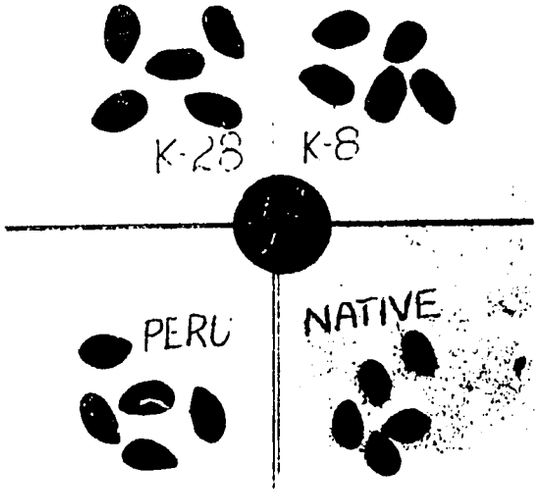
polar diameter = 1.06 cm.
equatorial dia. = 0.69 "
thickness = 0.2 "
color = shiny, dark brown

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