BIBLIOGRAPHIC DATA SHEET

PN-AAJ-152

LEUCAENA LEUCOCEPHALA: AN EXCELLENT FEED FOR LIVESTOCK

PERSONAL AUTHORS - BENGE, M. D.

CORPORATE AUTHORS - AID/DS/AGR

1980, 2BP.
(AGRICULTURE TECHNOLOGY FOR DEVELOPING COUNTRIES, TECHNICAL SER. BUL. NO. 25)

ARC NUMBER - 636.086.B466
CONTRACT NUMBER - DS/AGR
PROJECT NUMBERS -
SUBJECT CLASS - AL3019500000

DESCRIPTORS - LEUCAENA
LEGUMINOUS PLANTS
FEEDING STUFFS
LIVESTOCK
SEED PRODUCTION
FORAGE LEGUMES

636.086
B466

PN-AAJ-152

AGRICULTURE TECHNOLOGY FOR DEVELOPING COUNTRIES

Technical Series Bulletin No. 25

Leucaena leucocephala: an excellent feed for livestock

September 1980

Office of Agriculture
TECHNICAL ASSISTANCE BUREAU
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

Leucaena leucoceopala: an excellent feed for livestock

Prepared by: Michael D. Benge

DIVISION OF RENEWABLE NATURAL RESOURCES
AGRO-FORESTATION

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

PREFACE

In 1976 near Batangas City in the Philippines, I stood and marveled at the canopy of feathery Leucaena foilage towering over my head as high as a two-story building. It was hard to believe that a year before the site had been open wasteland!

Because of such performance the leguminous tree, Leucaena leucocephala, long disdained as a nuisance weed, now promises to become one of the most valuable crops for the world's less developed countries.

Depending on variety, Leucaena is either a tall tree or a branchy bush. It can be used for timber, firewood, fiberboard, paper, forage, fertilizer, landscaping, soil reclamation, shading for sun-sensitive crops, windbreaks and firebreaks as well as for dye, mucilage, jewelry and even human food. Moreover, Leucaena seems adapted to many soils too barren for conventional crops and it is one of the fastest growing plants measured. On top of all that, it obtains its own nitrogen fertilizer from air, survives drought, tolerates the salt of costal areas and has a high resistance to pests and diseases.

Truly, Leucaena seems to be a "tree of life"!

Noel D. Vietmeyer
Professional Associate
Board on Science and Technology
for International Development
National Academy of Sciences
Washington, D.C. 20418

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 (see page 8)] or in hedgerows to control erosion in fields or as a windbreak, fence or boundry marker around the house or field [below (see pp. 6, 9, & 10)].

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 [above left]. 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 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 when other forage sources have dried up and become unpalatable [above right (see page 8)].

The abundant-lush growth of Leucaena, harvested in a cut-and-carry system (above), is fed to and relished by tethered livestock [below (see page 9)].

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

---

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

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 Investigacion Agricultura Technologies (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.

---

*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.

---

*Dr. Raymond J. Jones, Senior Principal Research Scientist, Davies Laboratory, Commonwealth Scientific and Industrial Research Organization, Private Mailbag P.O., Townsville, Queensland, Australia.

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 or Leucaena pasture. 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.

---

*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. Conventional methods 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. 8 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 HOLE 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.

---

*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.

Literature Cited

1. Anon. (1942) - Methods of Increasing the Germination of Koa Haole Seed - Hawaii Agriculture, Exp. Sta. Circ. 21: 1-14.

2. Benge, M. D. and H. Curran. (April 1976) - Bayani (Giant Ipil-ipil Leucaena leucocephala). A Source of Fertilizer, Feed and Energy for the Philippines. USAID Agriculture Development Series. United States Agency for International Development. Manila, Philippines.

3. Benge, M. D. (May 1977) - How Naalad Farmers Plant Ipil-ipil for Profit. Modern Agriculture and Industry. Manila, Philippines.

4. Benge, M. D. (September 1977) - Giant Ipil-ipil Can Suppress "Hagonoy." Crops and Soils, UPLB-CA. College, Laguna, Philippines.

5. Benge, M. D. (Aug., 1978) - Dibbling Ipil-ipil and Cutting Costs of Reforestation. Canopy, FORRI, College Laguna, Philippines.

6. Benge, M. D. - Leucaena: a tree that defies the woodcutter, (in press).

7. Brewbaker, J. L. (March 1976) - "The Woody Legume, Leucaena: Promising Source of Feed, Fertilizer, and Fuel in the Tropics." Acapulco, Mexico, March 10, 1976, Sponsored by Banco de Mexico.

8. Brewbaker, J. L. (March 1976) - "Establishment and Management of Leucaena for Livestock Production." Paper presented at the International Seminar on Livestock Production in the Tropics. Acapulco, Mexico, March 10, 1976, sponsored by Banco de Mexico.

9. Grey, S. G. (1962) - Hot Water Seed Treatment of Leucaena glauca. (2) Berth. Aust. J. exp. Agri. Anim. Husb. 3:173-80.

10. Heley, F. (1965) - Survival studies with Rhizobium trifolis on seed of Trifolium incarratum L. inoculated for aerial sowing. Australian Journal of Agriculture Research 16:575-589.

11. Hernandez, C. C. (July 1961) A New Method of Farming Hillsides. Coffee and Cacao Journal. Vol. 14, No. 5. Manila, Philippines.

12. Hutton, E. M. (November 1974) - Tropical Pastures and Beef Production, Reprint from World Animal Review. No. 12. FAO, United Nations. Rome.

13. Leary, D. F. and S. P. Perdido, (1976) - The Effectiveness of Leucaena Leaf Meal as a Supplement Feed for Bangus in Brackish Water Fishponds. Semi-annual Technical Report of the National Science Development Board of the Philippines.

14. Mendoza, R. C. et. al. (November 1975) - Herbage Crude Protein and Digestible Dry Matter Yield of Ipil-ipil (Leucaena latisiliqua cv. Peru) in Hedge Rows. Paper presented during the 1975 Animal Scientific Convention of the Philippines Society of Animal Science.

15. Norris, D. O. (1967) - The Intelligent Use of Innoculants and Lime Pelleting for Tropical Legumes. Tropical Grass-lands, Vol. 1, No. 2 C.S.I.R.O., Queensland, Australia.

16. Plucknett, D. L. (September 1971) - Use of Pelleted Seed in Crop and Pasture Establishment. Cooperative Extension Service Circular 446. University of Hawaii.

17. Rivas, E. T. et. al. The Production Performance and Carcass Characteristics of Growing Finishing Pigs Fed High Levels of Ipil-ipil (Leucaena leucocephala Lam. de Wit) Leaf Meal With and Without Ferrous Sulfate Supplementation. Paper presented during the Graduate Seminar, December 2, 1977. Department of Animal Science, UPLB, College of Agriculture, College, Laguna, Philippines.

18. Sayaboc, V. S. et. al. The Effects of Ferrous Sulfate (Fe SO_4 $7H_2O$) on High Ipil-ipil Fed Layers. Paper presented during the Graduate Seminar, December 16, 1977. Department of Animal Science, UPLB, College of Agriculture, College, Leguna, Philippines.

19. Vietmeyer, N. (ed.). (1977). Leucaena: Promising Forage and Tree Crop for the Tropics. National Academy of Sciences, Washington, D.C.