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AGROFORESTRY SYSTEMS

Contour Hedgerows of Woody Perennials (Alley-Cropping) Reduce Erosion, Improve Soil Structure, Increase Food Crop Yields, and Produce an Abundance of Fodder and Fuelwood

S&T/FENR Agro-forestation
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July 7, 1987

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Written by Michael D. Benge, Agroforestry Officer, Bureau for Science and Technology, Office of Forestry, Environment, and Natural Resources, Agency for International Development, Washington, D.C. 20523

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Introduction

Agroforestry systems using nitrogen-fixing woody perennials, such as Leucaena leucocephala and Gliricidia sepium, planted in contour hedges on hillsides (or alleys on level ground), have proven to be an inexpensive and effective technology to control soil erosion, improve soil structure, and increase crop yields. Simultaneously, these systems produce abundant forage and fuelwood.

Research at the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria, has shown that Leucaena leucocephala (Leucaena) grown in an alley-cropping system--cut and added to the soil as a green fertilizer--tripled maize yields by the fifth year as compared to the control where nothing was added to the soil. Only by adding uneconomical amounts of chemical nitrogen fertilizer could equivalent yields be achieved (IITA, 1986). Although hedgerows of woody perennials take up space that would normally be occupied by food crops, the sustained and increased yields of food crops, plus the abundant forage and wood produced in these systems more than compensate for this loss of space.

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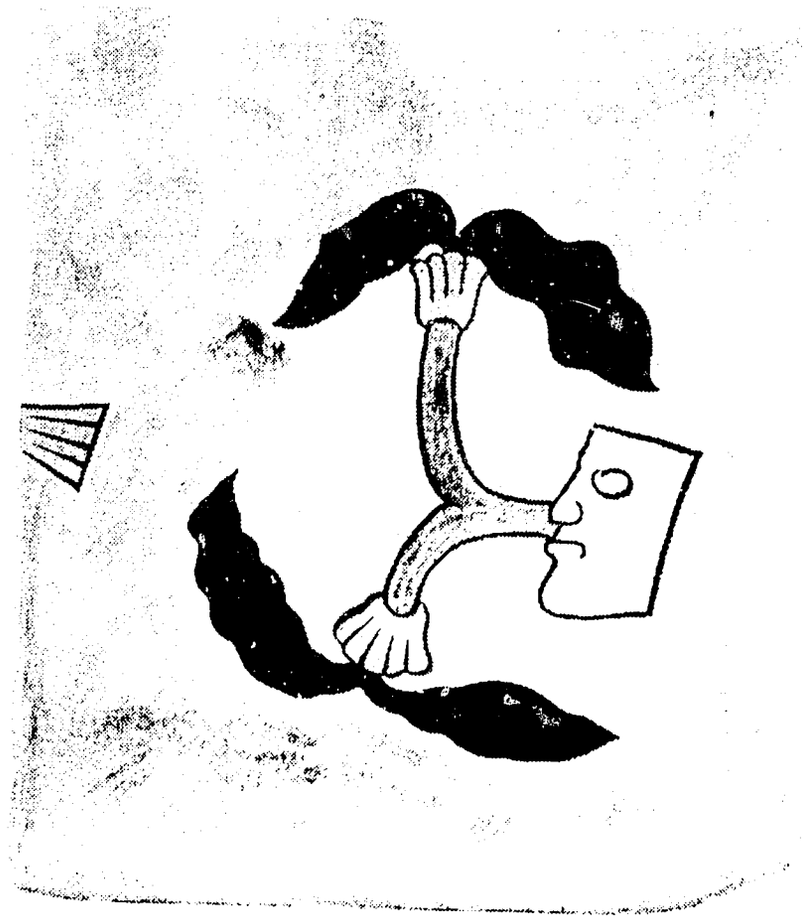
*By Michael D. Benge, Agroforestation Officer, Bureau for Science and Technology, Office of Forestry, Environment, and Natural Resources, Agency for International Development, Washington, D.C. 20523. This is a revision of Agro-forestation Systems Using Leucaena as Erosion Control Barriers published in 1980.

These types of agroforestry systems are not new; it is thought that the Aztec, Nahuatl and other civilizations in Central America--whose main food staple was maize--had to use similar systems to provide nutrients to sustain yields and to control erosion on the steep mountain slopes they farmed. This also provided the basis for forest regrowth after their civilizations crumbled. Similar environments that have been continously cropped most often do not regrow to forest cover. Leucaena leucocephala played such an important role in their civilizations that it is recorded by their pictographs.



Earliest reference to Leucaena: West-central Mexico, circa A.D. 1550. A Nahuatl (Aztec) pictograph representing "uazin," meaning "the place where Leucaena grows." (NAS, 1977).

Djikman (1950) records Leucaena leucocephala being recognized early in the 19th Century in Indonesia as a nutrient-rich nurse crop for coffee and teak. There, research showed an almost 100% increase in growth of the teak when interplanted with Leucaena, over the control plots planted to solid teak. With its deep-growing root system, Leucaena can be compared to a pump obtaining nutrients from soil strata that are not accessible to most other plants, transposing them to the leaves and supplying them to the topsoil through decaying leaf litter.

In 1923, a small barrio in the Philippines, Naalad, began using Leucaena as a rotational fallow cover crop, for terracing steep slopes, and as green mulch to increase and sustain the yields of tobacco, maize, onions and other crops. Agricultural production is much higher there than in nearby villages (Benge, 1977).

Contour Hedgerows

The first recorded research of using Leucaena in contour hedgerows (alley-cropping) to control erosion on hillsides and increase maize yields was conducted in 1953 by the Soil Conservation Service in Alabang, Rizal, Philippines. A common variety of Leucaena, which is less productive than the new high-yielding Giant varieties, was intercropped with a local variety of maize on severely eroded slopes of over 25%

with soils devoid of organic matter. Paired rows of Leucaena, spaced 10 cm. between the rows and 10 cm. in-row, were planted 1 meter apart on the contour of the hillside and maize was planted between the hedgerows; the Leucaena was cut back every 2 months and the cuttings were placed between the hedgerows to decompose. Continuous interplanting of maize was made throughout a period of four years. Corn yield increased 380% compared to the control, and erosion was less than 2.5% of that on the control plot (Hernandez, 1961).

Later the Philippine government launched a Leucaena/maize improvement program (Masaganan Maize 33) in the early 1980s in the Visayas, the major maize producing area where yields were only 0.66 m.t. per hectare. (The national average was 0.84 m.t.) Farmers were furnished improved maize varieties and Leucaena seed, and subsidized fertilizer was provided to accelerate establishment of the contour hedgerow systems. After the second year the fertilizer was no longer supplied since the system supplied the fertilizer. Maize yields were markedly increased in the region, and Leucaena leaf meal was sold for additional income to feed mills for domestic use and export.

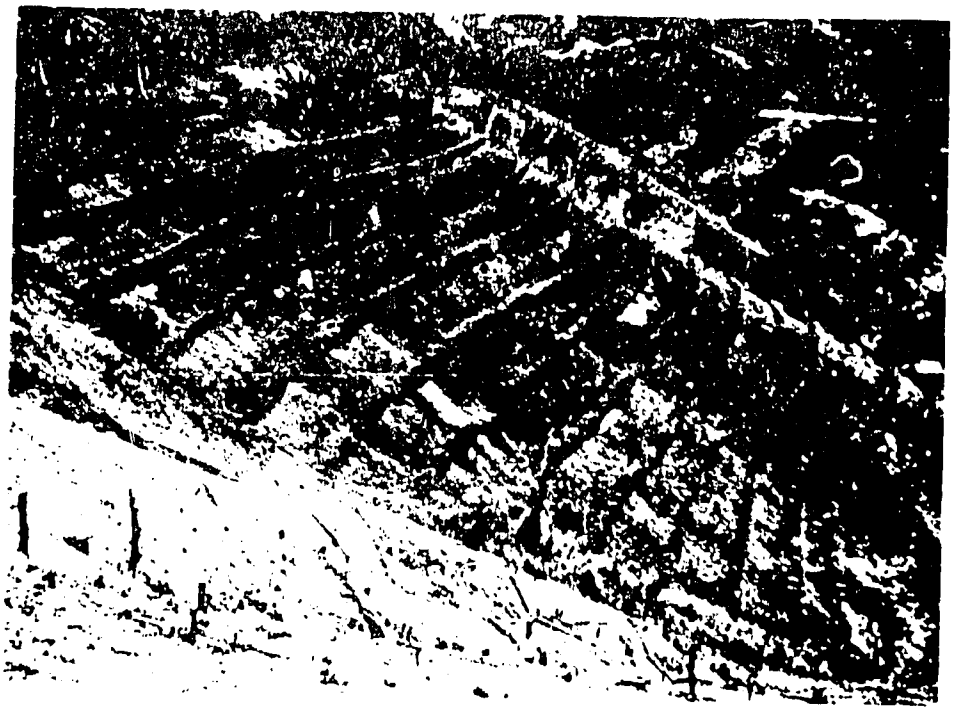
In 1975, Guevarra (1976) researching at the University of Hawaii estimated the chemical fertilizer equivalent of one hectare of Giant Leucaena, harvested over a one-year period and applied as a green manure crop, as more that 500 kg of

nitrogen (N), 200 kg of phosphate (P), and 500 kg of potash (K). When applied as a green manure to a single cross, field hybrid maize variety (H610), a yield of 9 metric tons per occupied hectare was obtained (Guevarra, et al, 1978). It was also found that Leucaena prunings are a more effective nitrogen source when incorporated in the soil than when applied as mulch (Gueverra, et al, 1978; and Kang et al., 1981).

The Island of Flores in Indonesia was hit by a series of typhoons and a successive drought early in the 1970's. A priest, using PL480 food assistance provided through the Catholic Relief Services, started a food-for-work program to establish contour hedgerows of Leucaena on the severely eroding hillsides. He had read about this technology in early agricultural books published by the Dutch colonial government. The hedgerows were planted 2-5 meters apart, depending on the slope of the land.

Since the new Giant varieties were unavailable at that time, the priest paid-in-kind (PL480) people to gather seed of the common variety of Leucaena, which grew prolifically all over the island. The common farming practice on Flores was slash-and-burn cultivation. Much of the once-lush tropical forest land had been abandoned or degraded because of erosion

Once barren and eroding hillsides are turned into productive and sustainable cropping systems by establishing contour hedgerows of Leucaena leucocephala. On the Island of Flores, Indonesia --Leucaena has been planted in contour hedgerows for erosion control and soil improvement, for fodder and fuelwood production and to increase food crop yields. It survives low annual rainfalls of 700 mm without adverse effects, and with its deep taproots, survives the long dry season by reaching water that other plants cannot get to. Thus, Leucaena remains green and continues to grow, while other plants do not.



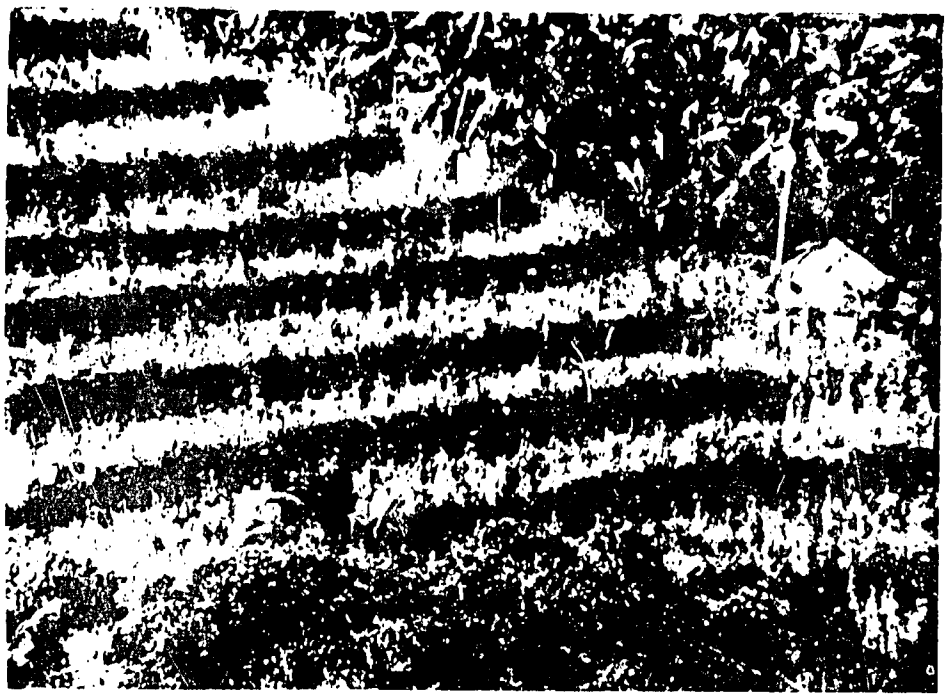
Leucaena's long taproot and its downward growing sideroots penetrates the layers of hard clay soils. This improves the soil structure, the roots bind the soil, and water is able to percolate into the soil--important characteristics for stabilizing steep slopes. Indirect terraces are established when the washed-off soil is collected by the hedges along contour lines.

(Pictures Courtesy of World Neighbors)

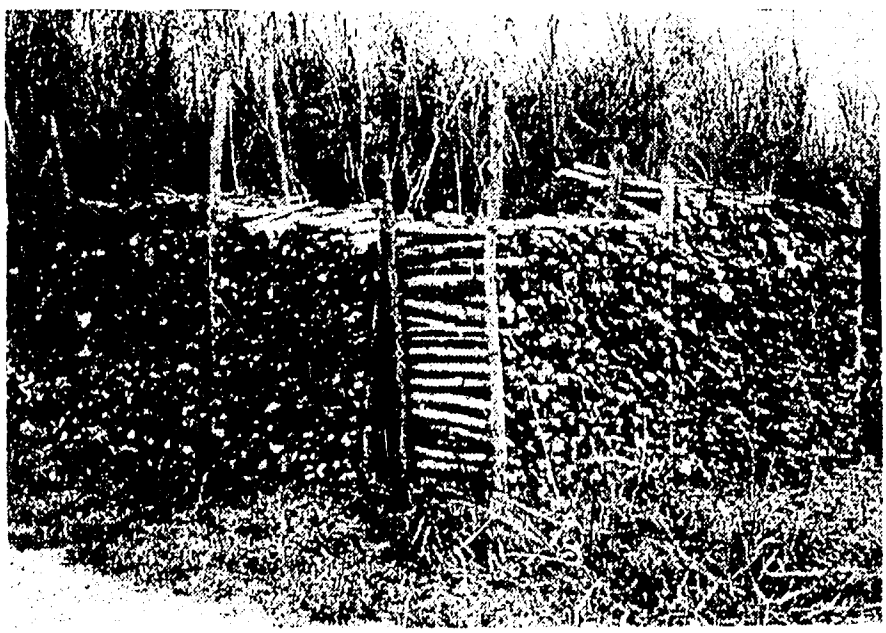
and soil infertility, farmers were unable to sustain crop yields beyond 2-3 years, and streams were drying up (Benge, 1980a).

Since the establishment of contour hedgerows on Flores, farmers are sedentary and no longer practice slash-and-burn, crop yields have increased, erosion has been arrested, and once-scarce livestock forage and fuelwood are now abundantly harvested from the hedgerows. The government has begun a program to supply cattle to farmers for stall feeding, and livestock are now exported to neighboring islands. The cattle (and goats) are tethered and fed on a diet composed mainly of Leucaena, which contains as much as 30% protein by dry weight (NAS, 1977).

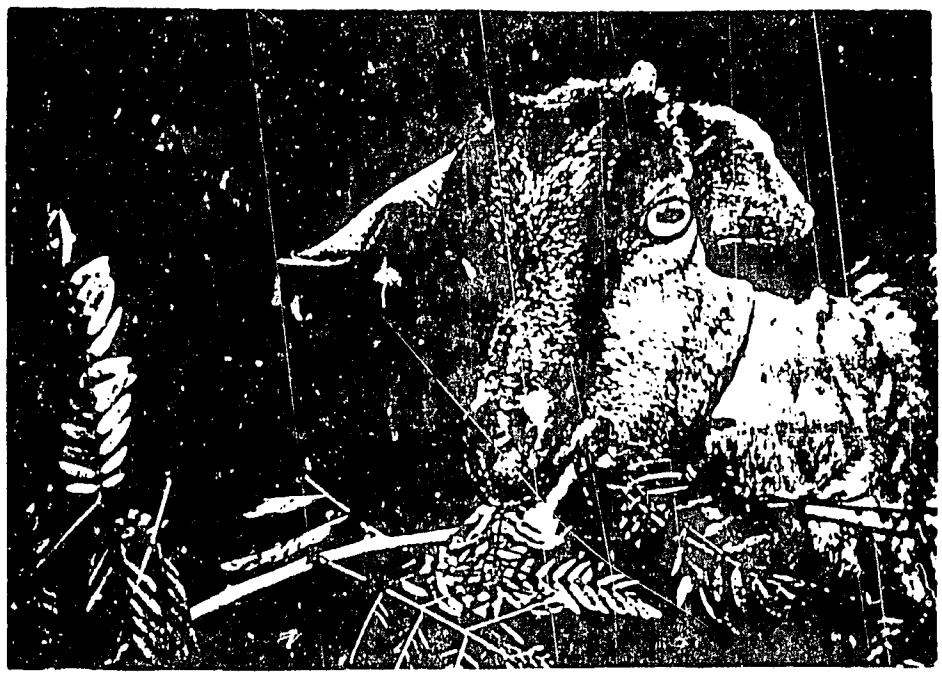
MIMOSINE TOXICITY--Mimosine toxicity, based on information emanating from Australia, was once considered a major constraint to feeding ruminants large amounts of Leucaena forage (Hegarty et al., 1979). However, scientists with the Commonwealth Scientific and Industrial Research Organization (Jones and Meggarrity, 1983; Jones, 1981; Jones and Lowery, 1984) discovered that goats in Indonesia and Hawaii had microbial populations in the rumen that degraded the goitrogen DHP (the toxic metabolite in mimosine), and when fed a sole diet of Leucaena, these goats showed no toxic effects and remained healthy. Furthermore, research proved that these microbal populations could be transferred from adapted ruminants in Indonesia and Hawaii to unadapted ruminants (both cattle and goats) in Australia (Jones, et. al., 1985).



Since the establishment of the contour hedgerows on Flores, slash-and-burn cultivators have become sedentary farmers. Food crop yields have increased, and wood, which had become scarce on the island, is now plentiful and exported to nearby islands.



(Courtesy of IITA)



Goats, which before ran wild and caused serious environmental damage, are now tethered and fed Leucaena forage on which they thrive. After the contour hedgerows were established on Flores, streams that had been dry for 15 years are once again flowing year around. (Pictures Courtesy of World Neighbors)

The farmers are adapting this agroforestry system to suit their needs. Fruit trees are also being planted between the hedgerows, and an increase in fruit yield has been noted compared to those trees not fertilized with Leucaena. Giant varieties of Leucaena, which were later introduced, are being interplanted between the hedgerows to support yams, pepper and other spice crops as "living poles" (Benge, 1984). Now a technical agricultural school has been established in order to further improve agricultural production on Flores.

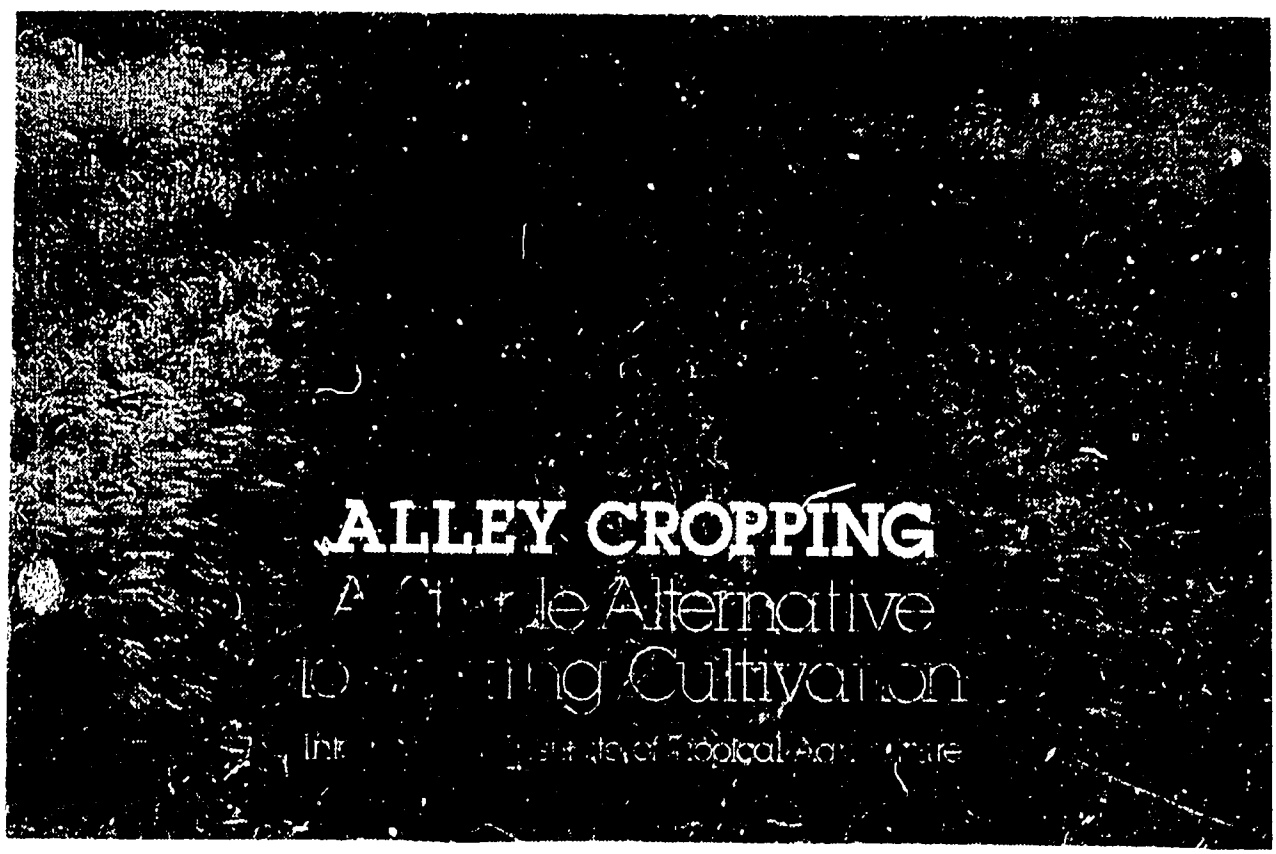
By 1981, about 20,000 hectares of Leucaena contour hedgerows had been established on Flores, but the remarkable thing is that over half were established by the farmers themselves without any payment of food-for-work commodities or technical assistance from the Catholic priest and his extension agents. This proves that the technology must work or the farmers would not go to the trouble and hard work to establish the contour hedgerows of Leucaena. This technology did not stop with the Catholic priest and CRS, but was also taken up by other missionary groups and PVOs working in agricultural extension on Flores and on other islands in Indonesia, and has been adopted for extension by the Indonesian government services. It is now practiced on the main island of Java down to the remote island of Timor.

(Pictures Courtesy of B.V. Parera)

Leucaena is girdled at approximately breast height. Girdling kills the upper portion of the tree, cuasing the leaves to fall, thus no shading of the yams and other light demanding climbing plants occurs. Girdling at this height allows ample space on the stem for coppicing, which is pruned until the yam is harvested. At this time, the dead pole is cut for fuelwood and a new stem is allowed to grow from the coppice providing the "living yam pole."

Alley-Cropping

In the late 1970's, scientists B.T. Kang, G.F. Wilson and T.L. Lawson pioneered research on alley-cropping at IITA*, one of 13 nonprofit international agricultural research and training centers, at Ibadan, Nigeria. Alley-cropping is a cropping system where food crops are grown in alleys formed by hedgerows of woody perennials. The hedgerows are cut back at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. When food crops



*The material for the segment on alley-cropping at IITA was drawn from its 1984 pamphlet on their research: ALLEY CROPPING: A Stable Alternative to Shifting Cultivation.

are not grown, the hedgerows are allowed to grow fully and form a green cover crop. Brian Walker, President of The International Institute for Environment and Development (1987), states in its book, The Greening of Africa, "Successful techniques like alley-cropping are carefully analysed and, throughout, the analysis is scientifically sound."

The International Livestock Center for Africa (ILCA), headquartered in Addis Ababa, Ethiopia, has now joined IITA in its alley-cropping research in Nigeria to fully develop the livestock component of this farming system. Together, IITA and ILCA provide the center of expertise and leadership at IITA in Ibadan, Nigeria for a collaborative alley-cropping research network between these two centers and national agricultural research systems of Africa comprising scientists from Nigeria, Mali, Kenya, Sierra-Leone, Benin, Ghana, Zaire, Zimbabwe, Ivory Coast, Togo, Guinea-Bissau, Malawi, Niger and Cameroon.

One of the challenges presented to IITA from its beginning has been to develop alternatives to the centuries-old bush fallow and shifting cultivation systems predominant in tropical regions, especially for Africa. The fertility and productivity of these tropical soils have been maintained by short periods of cultivation (1 to 3 years) followed by long periods of restorative bush fallow (6 or more years).

The restorative power of bush fallow (and shifting cultivation) is linked to the regrowth of deep-rooted trees and shrubs that recycle plant nutrients and build up soil organic matter (Nye and Greenland, 1965). During the fallow period, plant cover and litter protect the soil from the impact of high-intensity raindrops and the roots help bind the soil, increase water infiltration and reduce runoff and soil erosion. Moreover, litter mulch and shading by tree and shrub canopies reduce soil temperature and maintain soil moisture conditions that are favorable to the growth of beneficial soil macro- and micro-organisms, and shading also reduces weed infestation (IITA, 1984). In addition to restoring soil fertility, bush fallow provides supplementary food, animal feed, staking material, firewood and herbal medicine (Okigbo, 1983).

Alley-cropping retains the basic features of bush fallow and shifting cultivation, and can be easily adopted by resource-poor farmers in the tropics. The nitrogen-fixing woody perennials provide:

-nutrients for companion food crops through the foliage cut from the woody perennials and applied as a green mulch: biologically fixed nitrogen from the air, and phosphorus and potassium and micronutrients drawn from soil strata by the deeply penetrating roots.

-both shade and prunings, when applied as mulch, which suppress weeds.

-favorable conditions for soil macro- and micro-organisms.

-prunings for fodder (or browse during fallow), staking material and firewood.

Genera/Species Selection

A number of woody perennials are potentially suitable for contour hedgerows and alley-cropping, but only a few have been tested. Leguminous woody perennials are preferred over non-legumes because of their ability to fix atmospheric nitrogen. Woody perennials selected for use in alley-cropping systems should meet most of the following criteria: (a) can be established easily, (b) grow rapidly, (c) have a deep root system, (d) produce an abundance of foliage, (e) have good coppicing ability and regenerate readily after pruning, and (f) provide useful by-products. Few species meet all these criteria and some have disadvantages that must be overcome (IITA, 1984). Leucaena, for example, has slow early growth, and seedlings do not compete well with weeds during this period, but once established, it grows vigorously.

IITA found Leucaena leucocephala and Gliricidia sepium (Gliricidia) to be most promising for use in alley-cropping systems in the environments where they work. Although Leucaena

performed very well. Gliricidia was added because it (a) gave the system biodiversity and insurance in case of insect or disease attack, (b) had a bigger leaf, increasing organic matter because it doesn't break down as rapidly as Leucaena, and (c) helped to balance the forage output of the system, for livestock is a very important component. Depending upon farmer's preference and cropping patterns, IITA often alternates alleys of Gliricidia with alleys of Leucaena.

Gliricidia is also used in many places as an effective rat poison derived from a poisonous mash made by mixing ground leaves with cooked grain (Standley and Steyermarck, 1946). Fermentation causes bacteria to convert coumarin in leaves into the hemorrhagic agent dicoumerol (Hockman, 1966). In many areas of the LDCs, rodents cause extensive post-harvest losses and are health hazards, and agroforestry systems could provide as a by-product raw materials for cottage industries to produce poisons for rat control.

Currently available lines of Leucaena do not do well on highly acidic soils, but Dr. Mark Hutton has developed a hybrid that is more tolerant. He and another scientist at the Malaysian Agricultural Development Institute are refining this line and will have it ready for release in three years (Wong, 1987).

The International Livestock Center in Addis Ababa, Ethiopia, has found that Sesbania sesban (nubian) shows much promise for highland areas, producing more foliage than Leucaena at higher altitudes (Tothill, 1987). Although excellent as a livestock forage, this type of Sesbania is not a prolific wood producer.

Chameaecytisus prolifer (Tagasaste or Tree Lucerne) and Medicago arborea (Tree Medik) are similar to Sesbania, and may do as well at higher altitudes. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, is researching perennial pigeon peas (Cajanus cajan) for biomass production and for use in agroforestry systems (Ong, 1987), and in Haiti, where pigeon peas are a popular food, they are being planted in contour hedgerows for erosion control. However, this system will not be as effective as one comprising Leucaena and Gliricidia since little organic matter or nutrients will be added to the intercropped food crops. Another variety of Sesbania sesban is being intercropped with maize in Kenya and the biologically fixed nitrogen has reportedly increased maize yields significantly (Getahun, 1987 and Spears, 1987).

Establishment and Management

DEMONSTRATION FARMS--Marginal and subsistence farmers cannot afford the risk of change, for to do so and fail may mean disaster for them and their families. However, they will readily adapt new methods if these innovations demonstrate an increase in food crop

yields; produce needed forage and fuelwood; are an improvement over what they are presently doing; and are afforadable in terms of available resources. Project implementors should work with farmer leaders to demonstrate the value of contour hedgerows and alley-cropping systems. Ideally, these leaders would demonstrate the cropping system on one-half of their farm, using their resources, in order to provide a comparison between the old and new systems. They should be given assurances that by using the new system, food, forage and fuelwood production will equal or surpass that on untreated land. Most of IITA's alley-cropping research has been on relatively level terrain. Once the value of the new system has been demonstrated, nearby farmers should be invited to the farm site, so the farmer leader can tell about increased yields. Assistance should then be offered to those farmers who wish to establish similar systems on their farms.

HEDGEROW SPACING--All hedgerow or alley-cropping systems should be designed in close consultation with farmers to fit their needs, and they will adjust them as time goes by. On hilly lands, a spacing of 2-5 meters between hedgerows is generally used, depending upon the slope and what is being intercropped. (On steeper slopes hedgerows are more closely spaced.) IITA recommends four meters between hedgerows on more level ground as satisfactory for food production with or without the use of a tractor, but two meters for in-situ staking material for a yam crop.

IN-ROW SPACINGS--Depending upon the species, IITA (1984) recommends a 25 to 100 cm in-row spacing between the woody perennials, a much greater in-row spacing than that used for contour hedgerows for erosion control on hillsides. For erosion control on hillsides, a 2.5 cm in-row spacing is recommended, with paired rows within a single hedgerow 10 cm apart. The design and layout of a contour hedgerow system can be done by using a simple A-Frame (depicted in a World Neighbors' film strip, and available in English, French, and Spanish--see Appendix A).

INDIRECT TERRACE FORMATION--Once contour hedgerows have been established, "indirect terraces" form from washed-off soil that collects behind the hedges (see page 7). The formation of these terraces can be accelerated by plowing between the hedgerows with a mowboard plow, turning the soil so that it is thrown against the hedgerow downhill.

PLANTING--Direct seeding is the easiest and cheapest method of establishing nitrogen-fixing woody perennials in hedgerows, and sowing simultaneously with a food crop such as maize can be beneficial (Benge, 1980b; and IITA, 1984). With this method of establishment, there is no extra weeding labor requirements during early growth. Newly emerging seedlings are usually very fragile and relatively slow starters, and do not compete well with aggressive weeds. If the food crops are cultivated, weeded and sometimes fertilized, the seedlings grow faster. At the time of maize harvest, Leucaena can reach a height of 750 cm (IITA, 1984).

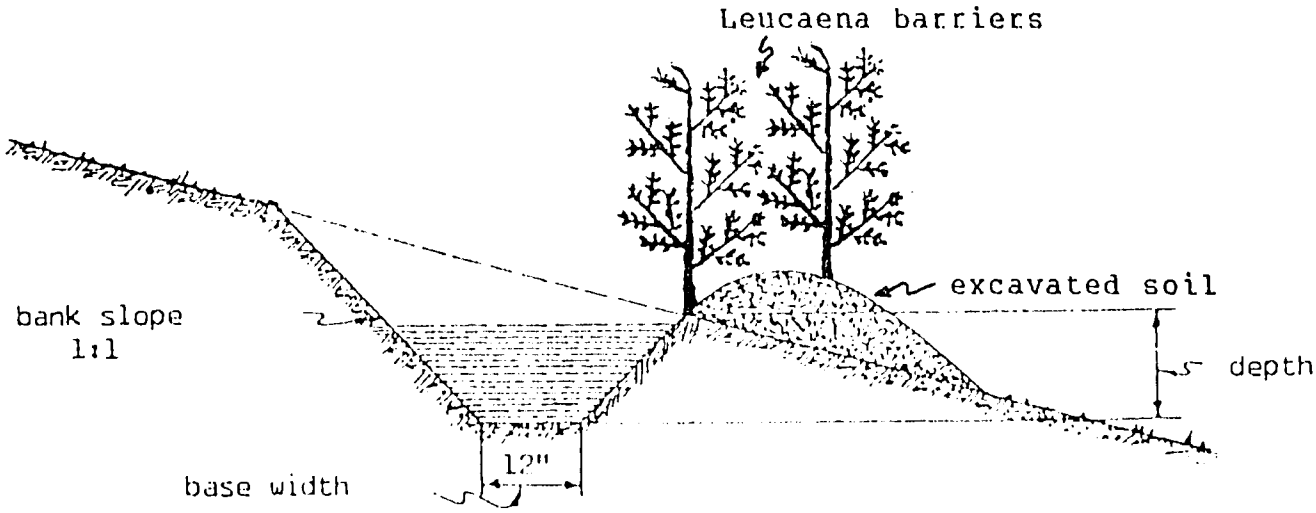
CAUTION--Contour hedgerow and alley cropping systems are best established by direct seeding or by transplanted seedlings, the latter being more costly and labor-intensive. Although some woody perennials, such as Gliricida (quick stick) establish easily from cuttings, this will result in extensive lateral root development and cause severe competition with food crops for space, water and nutrients (Benge, 1987).

SEED REQUIREMENTS--The amount of seed needed for hedgerow establishment depends upon (a) the in-row spacing of the plants, the intra-row spacing of the hedgerows (sometimes double rows of plants make up an individual hedgerow), and the distance between the hedgerows, and (b) the quality of the seed which determines the germination percentage. The amount of Gliricidia seed required to establish contour hedgerows would be much less than for Leucaena, for there would only be an occasional Gliricidia, spaced about 1 meter apart.

Leucaena--One kilogram of Leucaena has over 12,000 seeds. To create an effective contour hedgerow erosion control barrier on slopes, a double row hedgerow with an in-row spacing of 2.5 cm. and 10 cm intrarow within a single hedgerow are recommended. This would require 120 seeds per meter or 1 kg per 100 meters for the doubled row hedgerow (an additional 50% has been added to to allow for loss due to ungerminated seed, insect damage, etc.).

(Picture Courtesy of World Neighbors)

Ideally, for maximum erosion control and water infiltration on sloping lands, ditches (canals) should be dug on the contour of the hillside with a 1% slope to allow excess water to drain off into a grass or stepped waterway.



Since large amounts of seed are required for these closely spaced hedgerows, it may be necessary to establish seed orchards to ensure that adquate amounts of seed are available. The K67 variety of Leucaena is a prolific seeder, as is the Cunningham variety, and as a rule of thumb, K67 variety can produce over 1 kg of seed per tree per year.

SCARIFICATION of Leucaena--Seeds of many plants need to be scarified so that they will germinate evenly. This is how Leucaena can be scarified:
Boil water, remove from the heat and allow to cool for 1-2 minutes (instant coffee or tea 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, soaking the seeds overnight. The seeds should then be drained, and while still damp, inoculated with Rhizobium and planted.

INOCULATION of Leucaena--It is extremely important to inoculate legumes before planting with the appropriate strain of Rhizobium to ensure optimum nitrogen-fixation and production. Failure to do so may reduce the production of the system. Not all soils contain the

correct strain or the necessary amount of Rhizobium to inoculate the plant properly. Research at IITA (1984) showed that prunings from plants inoculated with an improved strain of Rhizobium added 2.5 times more nitrogen than those from plants inoculated with a local strain and maize grain yield was increased by 66%.

Research and commercial quantities of inoculum can be obtained from several sources, which include: USDA Germ Plasm Resources Laboratory, Attn. Dr. George A. White, Plant Introduction Officer, Bldg. 001, Room 322, Beltsville, Maryland 20705, and NifTAL Project, P.O. Box "O", Pia, Hawaii 96799; Nitragin Corp., 301 West Custer Ave., Milwaukee, Wisconsin 53209 (both under contracts with the Agency for International Development); and CSIRO, Davies Laboratory, Private Mail Bag P.O., Townsville, Queensland, Australia. Inoculants are inexpensive.

Inoculum should be stored at temperatures ranging from 0° to 7° Centigrade (Celsius), or 32° to 45° Fahrenheit, approximately the temperature of a refrigerator. If refrigeration is not available, store in a cool dry place out of the sunlight. After the Leucaena seeds are scarified, sprinkle the damp seeds with a light coating of inoculum.

Gliricidia--ILCA has identified four most promising lines of Gliricidia for alley-cropping (Reynolds, 1986). One kilogram of Gliricidia contains approximately 6,500 to 8,000 seeds. Each seed pod contains 8 to 10 seeds; the seed yield per tree is unknown. Gliricidia can be successfully established by direct seeding (Oakes and Skov, 1962), with complete germination in 7 to 10 days.

SCARIFICATION of Gliricidia--Glover (1986) states that no pre-treatment is necessary; however, Von Carlowitz (1986) lists immersion in boiling water or mechanical scarification as pre-treatments.

INOCULATION of Gliricidia--In most countries where Gliricidia is native or naturalized, it is nodulated well by native bacteria (Allen and Allen, 1981; Banados and Fernandez, 1954; DeSouza, 1966; Holland, 1924; Roskoski et al., 1980); however, when it is being introduced, studies in Australia have found the most effective rhizobium strain to be CB3090 (Akkasaeng et al., unpublished).

PRUNING OF HEDGEROWS--During the cropping season, the hedgerows of fast-growing woody perennials such as Leucaena and Gliricidia should be cut back every five to six weeks to prevent shading of the intercrop. As the intercrop matures,

the pruning can be less frequent. Pruning intensity varies with the species. The hedgerows can be pruned to a height of 25 to 75 cm, but too low and too frequent pruning may result in dieback. A sharp cutlass or bolo should be used, for a dull one strips the bark and causes a delay in coppicing and may result in dieback. One hectare of one-year-old Leucaena hedgerows spaced 4 m apart can be cut in about an hour (IITA, 1984).

During the noncropping season, pruning frequency will depend upon what kind of products will be harvested from the hedgerows, forage or fuelwood. For the latter, the pruning frequency would be less, but for a cut-and-carry forage production system, a portion of the hedgerow would be cut daily.

YIELD--Giant varieties of Leucaena produce large volumes of biomass, and IITA (1984) reports a yield of 15-20 tons of fresh prunings (5.0 to 6.5 tons of dry matter) per hectare with five prunings per year from well established hedgerows 4 meters apart. NAS (1977) reports Leucaena leaves contain 27-34% protein (dry weight). Kidd and Taogaga (1975) report an annual herbage yield for Gliricidia of 7.9.dry tons/ha (3 X 5 meter spacing) when cut bimonthly and intercropped with Taro. Glover (1986) reports an average protein level for

Gliricidia between 22 and 27% (dry weight). Fully grown Leucaena and Gliricidia hedges subsequently cropped with maize and cowpeas and periodically pruned back to a height of 75 cm produced over 5.7 (Leucaena) and 1.4 (Gliricidia) tons/ha of dry weight of stakes. Most of the stakes were produced when no food crops were being grown.

YAM POLES--In many parts of the world, yams are an integral part of the farming system, but production in many areas of the LDCs has decreased due to the scarcity and high price of yam poles. A hedgerow or alley-cropping system provides a plentiful supply of wood for poles to stake climbing plants such as yams. The method favored by farmers testing alley-cropping in east central Nigeria is to cut stakes from the system and use them to stake yams in a separate field (IITA, 1984).

Hedgerow systems can also be designed to provide living poles, such as those in Indonesia and the Philippines (Benge, 1987). There farmers allow individual trees in the hedgerows to grow to full height and yams are planted at the base (see p. 12). Sometimes trees are grown between the hedgerows to support yams, pepper, vanilla or other climbing plants, and in this case the variety of Leucaena is selected for a small crown so that it minimizes shading of other food crops.

Yams prefer shade at initial growth, but require full light for maximum production when the tuber begins to form. The tree is girdled at chest height, which kills the upper portion of the tree and causes the leaves to fall almost immediately. The vine climbs out on the branches, which allows to plant to absorb maximum energy for yam production. The tree will coppice at the base, which is cut and used as a mulch or for forage. Once the yam is harvested, the dead stem is cut and used for fuelwood and another sprout is allowed to grow to provide a stake for the next yam planting.

Conclusion

The major function of fallow is to allow forest regrowth to (a) rejuvenate soils by increasing soil fertility and organic matter, (b) suppress noxious and tenacious weeds, and (c) break the life cycle of harmful insects and fungus.

Mocking Mother Nature's way, hedgerows of nitrogen-fixing woody perennials accelerate the rejuvenation process. Nitrogen is taken from the air, fixed in the rhizobal nodules on the roots, and phosphorus, potash and essential micronutrients are drawn from substrata by the deeply penetrating roots, transposed to the leaves, and added to the topsoil through decaying leaves. Shading by Leucaena trees or fully grown hedgerows suppresses weed growth and breaks the life cycle of insects and fungus (Benge, 1976, IITA, 1984).

Deeply penetrating roots of the hedgerows break up the hard soil, allow water to percolate in, recharge ground water aquifers and sustain stream flow. The organic matter between the hedgerows reduces raindrop impaction and erosion and provides a microenvironment for soil-improving microoragnisms, and the contour hedgerows further reduce erosion.

In many parts of the tropics, the fallow period has been shortened because of increased land pressures caused by a burgeoning population. This causes a rapid loss of nutrients and soil degradation, a decline in crop yield and invasion by tenacious weeds. Since most farmers in the LDCs cannot afford costly imputs, or these imputs are not available, it is necessary to develop low-input soil management technology that can sustain crop production--systems such as contour hedgerows or the alley-cropping systems as developed by IITA.

The major advantage of contour hedgerows and alley-cropping over bush fallow and shifting cultivation is that cropping and fallow phases take place concurrently on the same land, allowing the farmer to crop for an extended period without returning the land to fallow.

REFERENCES

Allen, O.N., and E.K. Allen. 1981. The Leguminosae: A Source Book of Characteristics, Uses and Nodulation. Wisconsin Press, Wisconsin. 812. pp.

Banados, L.L. and W.L. Fernandez. 1954. Nodulation Among the Leguminosae. Philipp. Agric. 37:529-533. as cited by Glover, 1986.

Benge, M.D. 1987. Contour Hedgerows for Fodder, Planting Stock, Fuelwood and Increased Food Production and for Minimizing Soil Erosion in Highland Regions. S&T/FENR Agro-forestation Series No. 29. Agency for International Development, Washington, D.C.

Benge, M.D. 1984. "Living" Yam Poles. S&T/FENR Agro-forestation Series No. 26. Loc. Cit.

Benge, M.D. 1980. Agro-forestation Systems Using Leucaena as Erosion Control Barriers. Occasional Paper. Development Support Bureau, Office of Agriculture, Agency for International Development, Washington, D.C.

Benge, M.D. 1980. Leucaena leucocephala: An Excellent Feed for Livestock. Technical Series Bulletin No. 25. Agriculture Technology for Developing Countries. Office of Agriculture, Technical Assistance Bureau, Agency for International Development, Washington, D.C.

Benge, M.D. 1977. How Naalad Farmers Plant Ipil-Ipil for Profit. Modern Agriculture and Industry-Asia. Manila.

Benge, M.D. 1976. BAYANI [Giant Ipil-Ipil (Leucaena leucocephala)] A Source of Fertilizer, Feed and Energy for the Philippines. USAID Agriculture Development Series. U.S. Agency for International Development, Manila.

DeSouza, D.I.A. 1966. Nodulation of Indigenous Trinidad Legumes. Trop. Agric. Trinidad 43:265-267. as cited by Glover, 1986.

Dijkman, M.J. 1950. Leucaena: A Promising Soil Erosion Control Plant. Econ. Bot. 4:337.349.

Getahun, A. 1986. Personal Correspondence. Kenya Renewable Energy Development Project, Nairobi.

Glover, N.L. 1986. Gliricidia sepium (Jacq.) Steud Germplasm Collection, Conservation and Evaluation. Unpublished Master's Thesis, University of Hawaii.

Guevarra, A.B. 1976. Management of Leucaena leucocephala (Lam. de Wit) for Maximum Yield and Nitrogen Contribution to Intercropped Corn. Unpublished Doctoral Thesis. University of Hawaii.

Guevarra, A.B., A.S. Whitney and J.R. Thompson. 1978. Influence of Intra-row Plant Spacing and Cutting Regimes on the Growth and Yield of Leucaena. Abstr., Agron. J. 70(b):1033-1037.

Hegarty, M.P., C.P. Lee, G.S. Christie, R.D. Court and K.P. Haydock. 1979. The Goitrogen 3-hydroxy-4(1H)pyridone, a Ruminal Metabolite from Leucaena leucocephala: Effects in Mice and Rats. Aust. J. Biol. Sci. 32:27.

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

Holland, T.H. 1924. Some Green Manure and Cover Plants. Dept. Agric. Ceylon Leafl. 30. 6p. as cited by Glover, 1986.

International Institute of Tropical Agriculture (IITA). 1984. Alley-Cropping: A Stable Alternative to Shifting Cultivation. IITA, Ibadan, Nigeria.

International Institute of Tropical Agriculture (IITA). 1985. Annual Report for 1984. Ibadan, Nigeria.

International Institute of Tropical Agriculture (IITA). 1986. Annual Report for 1985. Ibadan, Nigeria.

Jones, R.J. 1981. Does Ruminal Metabolism of Mimosine Explain the Absence of Leucaena Toxicity in Hawaii. Aust. Vet. J. 57:55.

Jones, R.J. and R.G. Megarrity. 1983. Comparative Toxicity Responses of Goats Fed on Leucaena leucocephlala in Australia and Hawaii. Aust. J. Agric. res. 34:781.

Jones, R.J., J.B. Lowry and R.G. Megarrity. 1985. Transfer of DHP-Degrading Bacterial from Adapted to Unadapted Ruminants. Leucaena Research Reports. Vol. 6.

Kang, B.T., L. Sipkens, G.F. Wilson, and D. Nangju. 1981. Leucaena (Leucaena leucocephala (Lam) de Wit) Prunings as Nitrogen Source for Maize (Zea mays L). Fert. Res. 2:279-287. As cited by IITA, 1984.

Kidd, T.J. and T. Taogaga. 1984. Survival and Herbage Yield of Six Nitrogen Fixing Trees Intercropped with Taro in Western Samoa. Nitrogen Fixing Tree Research Reports 2:22-23. As cited by Glover, 1986.

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

Nye, P.J., and D.J. Greenland. 1965. The Soil Under Shifting Cultivation. Technical Communication 51. Harpenden, England: Commonwealth Bureau of Soils. As cited by IITA, 1984.

Oakes, A.J. and O. Skov. 1962. Some Woody Legumes as Forage Crops for the Dry Tropics. Trop. Agric. 39:281. As cited by Glover, 1986.

Okigbo, B.N. 1983. Plants and agroforestry in land use systems of W. Africa. In Plant Research in Agroforestry, ed. P.A. Huxley. pp. 25-41. Nairobi, Kenya: International Council for Research In Agroforestry. As cited by IITA, 1984.

Ong, C.K. 1987. Personal Correspondence. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Hyderabad, India.

Reynolds, L. Personal Correspondence. International Livestock Centre with IITA, Ibadan, Nigeria.

Roskoski, J.PL et al. 1980. Woody Tropical Legumes: Potential Sources of Forage, Firewood, and Soil Enrichment. In Tree Crops for Energy Co-Production on Farms. National Technical Information Service. Springfield, Virginia. pp. 135-155. As cited by Glover, 1986.

Spears, J. 1987. Personal Correspondence. World Bank, Washington, D.C.

Standley, P. and J. Steyermarck. 1946. Flora of Guatemala. Chicago, Natural History Museum 24(2).

Tothill, J.C. 1987. Personal Correspondence. International Livestock Centre. Addis Ababa.

Von Carlowitz, P.G. 1986. Multipurpose Tree & Shrub Seed Directory. International Council for Research in Agroforestry, Nairobi.

Walker, B.W. 1987. President of the International Institute for Environment and Development (IIED) in personal correspondence to M. Peter McPherson, Administrator, Agency for Internatonal Development, Washington, D.C.

Wong, C.C. 1987. Development of Acid-Soil Tolerant Leucaena Lines for Forage Production. Unsolicited proposal funded by the Bureau for Science and Technology, Agency for International Development, Washington, D.C. from the Malaysian Agricultural Research and Development Institute (MAARDI), Kuala Lumpur.

5722A

A World Neighbors Filmstrip

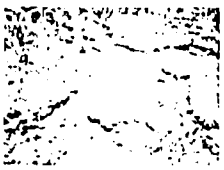
SAVING OUR SOIL WITH THE A-FRAME

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

SAVING OUR SOIL
WITH THE A-FRAME

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

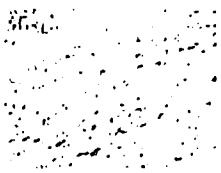
2. All the food we eat, clothes we wear, and most of the things we use come from the soil.



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

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

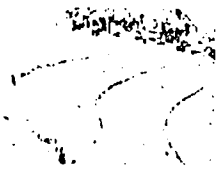
5. When planting on hillsides, we often plant rows running up and down. This is a bad practice.



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

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

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



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

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

11. Because it can save our soil.

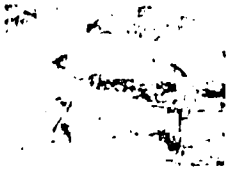
12. These are the only materials you need for making an A-frame: three poles, a piece of cord or vine, a rock and a machete. (Narrow boards, if available, can be used.)

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

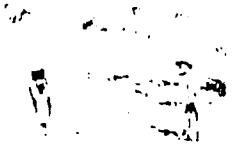
14. Now tie a shorter pole across the other two to form the letter "A." Tie both ends securely.

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

16. Tie a rock to the end of the cord, below the crossbar.



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



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

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

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

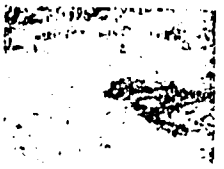
21. The left leg now touches the stake where the right leg was, and the right leg touches the stake where the left leg was.

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

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

24. In order to keep from erasing this mark, cut a notch there with your machete. When the weighted cord hangs directly in front of the notch, we know that the two legs are level.

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



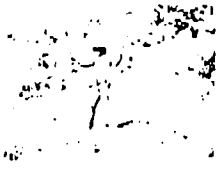
26. First, study the area of your field on which you want to construct contour barriers. It is good to start near the top of your field.

27. Cut a supply of stakes. These stakes are used for marking the level lines where the ditches will be dug or the rock barriers will be constructed.

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

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

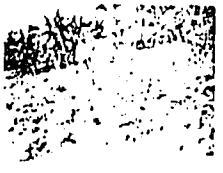
30. With the string passing exactly the point of the level position, drive another stake into the ground just below and touching the second leg of the A-frame.



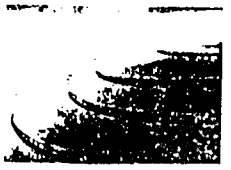
31. Now pick up the A-frame and move it along.

32. Place it so that one leg of the A-frame touches the stake you just drove into the ground.

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

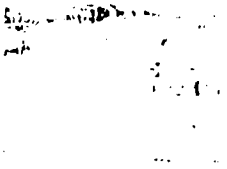


34. Continue across the field this way. Now we have a level line of stakes which tell us where the first contour barrier will be constructed. But one contour barrier is not enough.



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

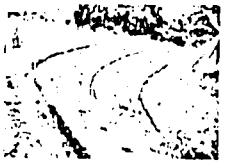
36. An easy method of finding the five feet of difference in elevation is to walk backwards down the hill from the row of stakes. When the stakes are at eye-level, you have found the place to begin marking the next contour line.



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

38. Then, dig canals along the line of the stakes. The canal should be .5 meter wide and .5 meter deep.

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



40. Now the field is prepared for planting and is protected from erosion.

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

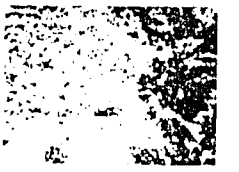
42. On some fields you can make both canals and rock barriers. In rocky areas, construct rock barriers. In other areas, dig canals.

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

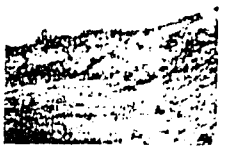
44. As the soil is caught behind the grass or rock barriers, terraces will gradually build up.

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

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



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



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

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

50. The End.

QUESTIONS FOR DISCUSSION

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

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

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

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