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FODDER AND FUELWOOD N_2 - FIXING TREES FOR NEPAL

A Report

By

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For the

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FODDER AND FUELWOOD N2-FIXING TREES FOR NEPAL

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1. INTRODUCTION

This report follows a two-weeks' consultancy for International Agricultural Development Service in March 1983. Limited travel was made to Pokhara, Rampur, Hetauda, and hills around Kathmandu. Extensive consultations were held with forestry and agricultural research and extension personnel in Nepal.

The primary objective of this consultancy was to assist in the development of a strategy to exploit trees of the genus Leucaena. This was

interpreted broadly to include species of nitrogen-fixing trees with similar versatility for small farm use in Nepal (as fodder, fuelwood, green manure).

2. ABSTRACT AND RECOMMENDATIONS

2-1 Abstract (Numbers in parentheses refer to paragraphs in Chapters of the report)

Deforestation rates of the tropics (3-1) and in Nepal (3-2) are cited that suggest severe fuelwood and tree fodder deficits within few years. Excessive animal populations (3-3) create a feed burden that cannot be met in the future without greatly expanded fodder production. The "sacredness" of trees is posed as an ancient but timely philosophy (3-3). Nepal's energy needs are reviewed, and the central role of wood emphasized (3-4). Animal tree fodder needs are placed at 300,000 ha. (3-4) and fuelwood needs at 1.1 million ha. (3-2).

Farming systems that integrate fodder/fuelwood trees with food crops are considered a mandate for Nepal (3-5).

A review is made of fodder tree species indigenous to this country (3-6); it is clear that hunting and gathering can not long continue, and that trees will disappear unless they are protected or intentionally planted as fodder. The major exotic fodder trees in Nepal are cited (3-7), and their almost universal capacity to fix nitrogen underscored.

Leucaena is considered an outstanding genus for fodder tree and fuelwood evaluations in small farm systems of Nepal (Chap. 4). Its adaptability and general limitations below 1500 m are reviewed (4-1) and its uses (4-2). Important species and varieties of the genus are cited, and the value of L. diversifolia in midland-highland tests noted (4-3). Seed sources for leucaena (4-4) and methods of establishment (4-5) are summarized; protection of the young plant from browsing animals is underscored as the single most serious problem in much of Asia, where the genus has come into wide popularity (with over 30 tons of seed marketed annually, about 600 million trees were they to survive).

Current evaluations of leucaena in Nepal (5-1) and farming systems approaches suitable there (5-2) are considered; the extreme importance of compost to upland cropping and the exceptional value of leucaena as green manure are underscored. It is recommended that agroforestry projects be initiated with fodder trees as a component in farming systems (5-3 and 2-2). Consultant itinerary (Chap. 6) and reference citations (Chap. 7) conclude the report.

2-2 Recommendations

It is recommended that an agroforestry component be incorporated in farming systems activities of Nepal (5-3). At this time, specific focus is recommended on Low Hills and Terai, primarily in conjunction with upland crop systems. Leucaena would be the tree/shrub of choice, but

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experimental work initiated with other nitrogen-fixing trees notably with highland adaptability.

Proposed leucaena management schemes for Nepal (5-2) are many, ranging from plantings solely for such uses as forage, fuelwood, green manure, and soil stabilization—and with this suspected order of priority to small farmers. However, I view the green manure use as one having greatest ultimate impact on economy of Nepal; fodder is to be sure a critical need of high concern to farmers; fuelwood needs in a decade will be incredibly severe in some areas.

Two major projects are proposed (5-3). One is based on leucaena as a 1-2m tall hedge, densely planted, on margins of terraces, or along contours and on terraces ("avenue cropping") with row crops like maize between. Green manure effectiveness would be evaluated/demonstrated as a contribution, in varying proportions, to traditional compost. Some fuelwood and fodder use is expected, and slope stabilization would be a major feature of the design; but improved crop yields through the high-Nitrogen supplement to compost would be a central target.

A second project would more generally reflect the flexibility of leucaena in small farm management; the plants would be grown as small trees to be lopped for fodder and harvested periodically for fuelwood. Trees would be spaced about 1 sq. m. per tree, normally lopped annually to provide both small fuelwood and fodder (e.g., in mid dry season). Tree location could include marginal lands, around buildings, along trails and roads. Protection during establishment is a primary concern, and transplanting of vigorous young trees at onset of monsoon would be very judicious. Optional trees would be considered experimentally for similar management—as Gliricidia sepium in lowlands, black locust (Robinia pseudoacacia) in highlands. No single fodder tree can embrace all of Nepal's ecological zones, and local preference for use of indigenous species must be respected (but appears to presage many years of adaptive research, section 3-6).

3. FORESTS AND FODDER TREES OF NEPAL

3-1 Tropical Deforestation

Closed forests (by definition = 20% or more forest cover) of the tropics were estimated in 1975 to include 1260 million ha. By the end of this century, these forests will have dwindled by 38%, to 780 million ha. (FAO/World Bank). These losses impinge in major ways on fodder use as well as fuelwood resources. In regions of heavy overpopulation of cattle and goats, as in Nepal, fodder trees can only survive through the intervention and direct care of man. The ten-fold increase in petroleum prices of the past decade have increased fuelwood demands, and many national or regional estimates of forest depletion rates may be considered very conservative.

3-2 Nepal's Disappearing Trees

Nepal is a land of about 15 million hectares, about 20% of this above timberline. Closed forests of Nepal are currently estimated at 4.5

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million ha, about 29% of total land area. Historically, forests may have covered about 70% of this country, a loss of over half the forests in the past. Present losses are estimated to occur at a rate of 100,000 ha/year, with World Bank predictions of complete forest loss in the hills by about 2000 AD and in the Terai by 2010 (Haque 1981).

The remnant forest at the end of the century will be largely inaccessible (as indeed much of it is now), on nonagricultural lands (often acid oxisols), having species like pine with no fodder value; a remnant is also expected to occur in guarded natural forests and preserves. A natural outcome of such deforestation is the loss of native tree species, adapted to the climate but not to the human pressures of this country.

Reforestation efforts in Nepal have been focussed on pines, notably Pinus roxburghii, on non-agricultural red hills. An estimated 3000 ha has been planted annually, a fine start toward a most challenging goal. One estimate (World Bank) of the complete forest needs for fuelwood alone by 2000 AD is 1.1 million ha, or 61,000 ha/yr. These forest needs seem generally well defined and known in Nepal, and receive both concern and extensive international attention and support. It is my impression, however, that the focus is far too heavily on producing forests to cover hills rather than on growing trees as an adjunct to farming systems to serve human and animal needs.

3-3 Sacred Cows and Trees

The estimated livestock population of Nepal in 1979/80 was 6.2 million cattle, 2.7 m buffalo, 0.6 m sheep and nearly 4 m goats. Despite their recognized importance for milk and power, most cattle are very poor in breeding, feeding, and disease resistance, and constitute an excessive feed burden. As symbol of man's identity with all life, the cow is viewed as sacred to Hindus. It is a problem of staggering magnitude to introduce the concept that one healthy animal can produce ten times the milk or 5 times the work, but it is being done (e.g., Bharatiya Agro Industries Foundation, Pune, India), and must occur if Nepal is to effectively control deforestation. In the meantime, fodder needs clearly seem, in the public eye, of greater importance than fuelwood needs. This will change within a decade or more, as fuelwood shortages are certain to become severe.

Gautama the Buddha, Nepalese founder of Buddhism 2500 years ago, recognized the importance if not sacredness of trees akin to that of cattle. He charged followers to plant at least one tree every 5 years. It would require that Nepalese plant at least 10 trees per year per person to achieve the goal imagined by World Bank (1.1 million ha., assuming 2500 trees/ha). A critical concept, however, is that a tree be protected from the animals until mature, and this is not understood in most of South Asia by laymen. Aggressive protection is mandated. In any tree planting area with fodder trees, measures presently viewed as severe will be essential to success—i.e., tethering of all animals, expulsion of feral animals, including monkeys; fencing will be mandated for

experiments (solar-powered electric fences might be considered). But no program will succeed unless accompanied by an education and extension program emphasizing that a fodder tree, like a corn plant or rice plant cannot be fed ad libitum to animals, wild or cultivated.

3-4 Wood Needs of Nepal

The wood needs of developing countries has been estimated at 0.8 m^3 per person, of which about half is needed directly in cooking, and 1/4 for heat, 1/4 for other wood uses around home and farm. If less than 0.4 m^3 per person is available, food quality can deteriorate and impact directly on health. Nepal's fuelwood use alone is estimated at .91 m^3, higher because of cooler temperatures and extensive use for "trekkers". This constitutes about 87% of all energy consumption, and more than 95% of total wood use in rural areas (Haque 1981). Dung and plant residues account for a very small amount of energy, while petroleum fuels make up 8.6% of energy needs.

Fuelwood will remain the principal source of energy for rural people in Nepal for many decades. Although hydropower reserves of Nepal are great, the investment to provide infrastructure bringing electricity to the average farmers is beyond comprehension. There is a clear mandate to teach farmers to raise fuel just as they raise food. It is the rare farm that does not have unused or marginal portions ideal for a few fuelwood trees.

3-5 Nepal's Fodder Tree Needs

Large animals consume about 2 T. dry matter annually, perhaps ten times that of a human being in Nepal. Nepal's animals derive an estimated 35% of their feed from trees, with most of this use occurring during the dry winter season. Seasonally deciduous trees are thus of less value. Using an estimated 10 million large animal units for Nepal, this would amount to 7 million tons (dry) of feed from trees alone (a staggering 1,400,000,000 backpacks of 50 kg each). With our best leucaena yields (15 - 20 T/ha/yr of edible dry matter from hedges harvested 4 times/yr), these feed needs could only be met by "fodder forest" land areas in excess of 300,000 ha.

Reflecting on needs of this magnitude, Panday (1981) and others urge greatly expanded growth of fodder trees. Their use is recommended on erosion-prone hillslopes and marginal areas of small farms. Immediate needs also include:

- Improvement of fodder quality, with emphasis on trees
- Reduction of animal populations and emphasis on buffalo
- Stall-feeding ("a necessity")

It is clear to me that farming systems integrating fodder trees and food crops are mandated, and that any tree planting that does not involve the fodder option or companion pastoral grazing is unwise.

3-6 Fodder Tree Species of Nepal

Very many trees serve as animal fodder in S.o. Asia, probably a greater diversity than anywhere else in the world. Trees are disrobed startlingly to serve as animal feed, with the hope that the monsoon will restore leaves normally. Almost any list of fodder trees can be very misleading, as ruminant animals, notably goats, will utilize almost any plant as feed. The following fodder trees, most of them indigenous, are of recognized importance in Nepal (Panday, 1981; Kessler, 1981; Van Swinderen, 1978). Nitrogen-fixing species are annotated (NFT), and highly favored species are noted with an asterisk:

TERAI (to 1000m)

- Albizia lebbek (NFT)
- *Bauhinia purpurea (legume, but not NFT)
- Boehmeria rugulosa
- Erythrina variegata (NFT)
- Garuga pinnata
- *Terminalia tomentosa—a favored, large leaved species
- Zizyphus incurva

LOWER HILLS (to 1500m)

- Alnus nepalensis (NFT)
- *Artocarpus lakoocha
- Bassia butyrachea
- *Bauhinia longifolia, B. variegata (legumes, but not NFT)
- Celtis australia
- Erythrina arborescens
- *Ficus spp. (cunia, lacor, *nemoralis, *roxburghii)
- Grewia spp. (titiaefolia, oppositifolia)
- Litsea polyantha (a prized wood), L. citrata
- Machilus gamblei
- Prunus cerasoides
- Quercus spp. (glauca, incana, lanuginosa)
- *Sarauria nepalensis
- Schima wallichii
- Shorea robusta

HIGHLAND (to 3000 m)

- Brassiopsis glomerulata, B. hainla
- Castanopsis tribuloides, C. spp.
- Machilus odoratissima
- Quercus spp. (semicarpifolia, lamellosa)
- *Salix spp.

Many of these species can provide fuelwood, but lack high-quality fodder; this would include native species like Acacia catechu, Betula spp., Castanopsis spp., Rhododendron spp., Schima wallachi, Shorea robusta, some of them also important timber trees. Many of the species above are multipurpose, with useable timber (Litsea), foods (Artocarpus, Bauhinia) and medicinal uses. Notably at higher elevations, many of these trees require 10-20 years to reach a fodder-useable age, and over-lopping can quickly kill some of them.

These species are collected for forage in classic hunting-gathering tradition; they are not raised for forage. This distinction must be stressed; just as wild animals can browse many of the species of my native Rockies, none to my knowledge have been grown commercially as fodder trees.

3-7 'Exotic' Fodder Trees

The diversity of Nepalese flora intimates to the uninitiated that there would be no need for introduced 'exotic' species; no such judgement would of course be made for food crops. Extensive research is needed to convert any species into a commercial crop, and none of those listed have yet been subject to such research. No sound fodder tree program can afford to ignore trees that did not happen to originate in Nepal, given good judgement of potential weediness. Among these are species that have been introduced (Haque, 1981), or are known from North India, and normally have fodder use:

TERAI
- Albizia falcataria (NFT)
- Albizia procera (NFT)
- Cajanus cajan (NFT)
- Dalbergia sissoo (NFT)
- Leucaena leucocephala (NFT)
- Parkinsonia aculeata (NFT)
- Pithecellobium dulce (NFT)
- Prosopis spp. (NFT), notably P. alba, P. pallida
- Sesbania grandiflora (NFT)

LOW HILLS
- Acacia mearnsii (NFT)
- Albizia mollis (NFT)
- Erythrina spp. (NFT)
- Leucaena diversifolia (NFT)
- Morus alba, M. nigra
- Robinia pseudoacacia (NFT)

HIGHLAND
- Acacia decurrens (NFT)
- Morus alba
- Populus sp.

Some of these species, like the Sesbania, Robinia, and Acacia are well known in nearby India as fodder trees. Other trees that appear worthy of evaluation include:

- Alnus species (glutinosa, hirsuta, rubra) (NFT); mid-highland
- Gliricidia sepium (NFT); lowland
- Inga jiniquil, I. vera (NFT); midland
- Mimosa scabrella (NFT)

Although these introduced species are referred to as 'exotic' the primary food crops of Nepal were once 'exotic' also. Nonetheless, a

sensitivity to this concern about introduction must be an intrinsic part of any program designed to modify farming systems to improve food and feed supplies of this long-isolated country.

4. LEUCAENA

4-1 Adaptability and Limitations

Leucaena is a recent introduction to Nepal, although it has been known over a century in India and has become widespread and highly valued there. Much needs to be known about the adaptability of leucaena in a country with the incredibly diverse ecosystems of Nepal. First, a definition:

"Leucaena" is used here only for L. leucocephala (Lam.) de Wit.

Leucaena leucocephala has been recorded in the literature under several (incorrect) botanic names; notably L. glauca (Willd.) Benth., L. latisiliqua (L.) W.T. Gillis, and L. salvadorensis Standley. Its most universal common name is "leucaena", but many countries use different, local names including ipil-ipil, giant ipil-ipil, lepile, and bayani (Philippines); lamtoro (Indonesia); guaje, yaje and uaxin (Latin America); koa haole (Hawaii); hediondilla (Puerto Rico); tangatan (Guam); as well as horse tamarind, white popinac, and leadtree (in various former British colonies).

Leucaena is native in Mexico and Central America (20-30 N latitude) from sea coast to about 1500 m. It is clearly less aggressive at high elevations, and is not known from the rain forests. I know of only one area in which it can be considered weedy--the North end of the coralline plateau of Yucatan, 750-1250mm rainfall, under 100m; the varieties there are of the seedy "common" type, which we do not recommend for Nepal.

Limited tests in Nepal, and more extensive tests in North India, suggest that leucaena will not be a competitive forest tree above 1000m in Nepal, but may in fact be a very useful forage as high as 2000m and frosts. However, I recommend major studies be held to regions below 1500m. There is one additional midland/highland species that should be in any studies in Nepal--Leucaena diversifolia, and it will be considered separately.

4-2 Uses

Leucaena is a multipurpose tree that tends to set the pace for tropical trees; it is an excellent fuelwood, a superb fodder for ruminant animals, a good feed to be used carticusly with non-ruminants, a valuable source of posts and small timber, an N-rich green manure, a good source of pulp for paper, a nitrogen-nurse and shade tree, and a good shrub/tree for stabilizing hillslopes (NAS, 1983; Brewbaker and Hutton, 1979). This versatility is of less interest to large-scale forestry, with a one-product mentality, than to small farmer--where the versatility is in fact its primary interest. It is thus a tree that tends to excite little interest among traditional foresters, but much among agriculturists.

In Nepal, the fodder, green manure, and fuelwood value of leucaena—in that order—would seem to be of primary interest to the small farmer. Fuelwood interests should become dominant in time, if deforestation continues and animal populations are reduced. Some examples of these uses:

FODDER; Leucaena is an historic fodder of importance in ruminant animal feeding; despite concerns to the contrary, cattle and goats can be maintained on a salt-supplemented diet of 100% leucaena, and make good gains. Normal feeding would be about 30% of dry weight. Foliage cut every 2-3 months will average around 25% protein, and dry matter yields (lowland moist tropics) of 10-20 tons/ha are recorded. Common management in So. Asia is from hedges at 75-100 cm spacing, clipped to 75-100 cm in height. Such hedges grow 100-150 cm between cuttings, thus never become so tall, for example, as to shade corn during grain dry matter formation. Thus, it is common now to consider intercropping the leucaena with food crops.

GREEN MANURE; Harvested as noted above for fodder, leucaena will return 400-500 kg/ha/yr of N, with about 300 kg of K20 and 40 kg of P205. If allowed simply to drop leaves, a full stand of leucaena produces leaf litter of 8-10 T/ha/yr which contains about 100 kg of N. The potential of this use is greatly undervalued in the tropics; only in more temperate regions have the uses of compost and green manure been well studied. Nonetheless, leucaena is well known as a "shade tree" or "nurse tree" to many other trees, a role in which N-rich green manure is of first importance.

FUELWOOD; Leucaena wood burns with 4640 cal/gm (DM basis), contains about 45% moisture (3-5 yrs) and has a specific gravity of .5-.55. It makes an excellent fuelwood, with low ash and smokiness. Dense plantations (1x1 m) average 60 m^3/ha/yr in our extensive trials, or est. 30 m^3 under farm conditions (1 T can be equated to a barrel of oil). In dense plantings, the 4 year old tree (at 25 C mean temp.) is 10-14 m high, 10-15 cm in dia., and weighs only about 25-40 kg/tree (wood only); the valuable foliage can be saved for fodder or manure use. A family of 6 needs about 5 m^3/ha/yr in Nepal for fuel, a need that can be fully met by about 1600 m^2 of trees, of which 400 are cut each year (1/day) for fuel (assumed 25 C mean temp. and short dry season). Fodder yield at wood harvest (assuming no interim fodder harvest) should be around 5-8 kg (dry) per tree, or 2-3 T (dry) per year--valuable either as feed or compost.

4-3 Species and Varieties

There are 10 species of leucaena (Brewbaker 1983), of which only two have been field-tested thoroughly; these are L. leucocephala ("leucaena") and L. diversifolia (Schlecht.) Benth., the latter a mid- or high-land species. Leucaena is described in detail in this report; preliminary testing is suggested also for L. diversifolia, which has been introduced on a limited scale in Nepal. L. div. is highly variable, and we have been releasing seed only of "giant" or arboreal varieties that can outyield leucaena in wood at higher, cooler elevations (limited studies)

and are much similar in wood yield at low elevations. Forage yields appear much less, but have not been evaluated.

L. diversifolia and another cold-tolerant species, L. pulverulenta, have been tested in North India, but little has yet been written about them. L. pulv. is long known in Indonesia for its cold tolerance for high elevations there. Both species are largely cross pollinating, while leucaena is selfed; both cross with leucaena, apparently freely. The hybrids are in fact of much interest to us, but are quite sterile and would need to be vegetatively cloned, unless hybrid seed can be produced in quantity.

There are upwards of 1000 varieties of leucaena in various collections, with perhaps 200 well evaluated. We have about 40 of the superior "giant" types in yield trials as fuelwoods. Well known giants include K8 (No. Mexico), K28, K67, and K72 (Salvador), K29 (Honduras), K132 (E. Mexico), and K636 (No. Mexico) from our collections, plus the Australian-bred "Cunningham", a bushy variety excellent for grazing and forage use. Leucaena varieties naturally fall into 3 major types, the bushy and seedy shrubs of the "common type", the arboreal "giant" or Salvador" types, and intermediate Peru types.

4-4 Leucaena Seed Sources

Leucaena seeds are marketed in amounts ranging upward of 30 tons annually (at 20,000 seeds/kg, this is 600 million seeds). India is a primary resource. Major seedsmen are listed below:

(from "LEUCAENA RESEARCH REPORTS", Vol. 3, 1982)

AUSTRALIA

Kingston Rural Management Pty. Ltd., P.O. Box 46, Maryborough 4650, Qld. Varieties; K8

J.H. Williams and Sons Pty. Ltd., P.O. Box 102, Murwillumbah 2484. Vars.; Not specified

BRAZIL

Nuno M. Sousa Costa, EPAMIG, Caiza Postal 295, CEP 35.700, Sete Lagaos, Minas Gerais. Vars.; K8, Peru, plus 22 other accessions in small amts.

INDIA

Bhartiya Agro-Industries Foundation, Kamdhenu, Senapati Bapat Marg, Pune-411016, Maharashtra. Vars.; K8, Cunningham, Hawaiian

Indian Grassland and Fodder Res. Inst., Jhansi, U.P. 284003. Vars.; Not specified

Pratap Nursery and Seed Stores, P.O. Box 91, Panditwari, P.O. Premnagar, Dehra Dun, U.P. 248007. Vars; Not specified

Regional Research Lab (CSIR), Canal Rd., Jammu Tawi. Vars.; K8, K28, K29, K67, Cunningham

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UAS/KDDC Fodder Proj., Univ. Agric. Sciences, Hebbal, Bangalore 560024. Vars.; Not specified

MALAWI

General Mgr., National Seed Co. of Malawi, Ltd., P.O. Box 30050, Lilongwe 3. Vars.; Not specified

MEXICO

Ing. Guillermo Sanchez Rodriguez, Banco de Mex., S.A., Calle 58 #389, Merida, Yucatan. Vars.; K8, K28, Peru, Yucatan (others as small lots for research purposes)

PHILIPPINES

Ms. Belem Abreu, Magsaysay Foundation, 1640 Roxas Blvd., Manila. Vars.; "Hawaiian Giant"

TAIWAN, R.O.C.

Sheng Feng Leucaena farm, 99-4 Tung-an Street, Taipei. Vars.; K8, K28, K29, K67, K72, Peru, Cunningham

Yilin Co., attn. Fu-Hsiung Li, Fu-jen 2nd St., Hualien. Vars.; K8, K28, K29, K67, K72

UNITED KINGDOM

Kings Plants Ltd., Woodcote Grove, Ashley Rd., Epsom, Surrey KT18 5BW. Var.; K67

U.S.A.

Lowe Inc., P.O. 131, Kahaku, Hawaii 96731. Vars.; K8, K28, K29, K67, K72, K132, K341 ("common")

Tree Seeds Internatl., 2402 Esther Court, Silver Springs, MD 20910. Vars.; K8, K28, K67

WEST INDIES

Caribbean Agric. Res. and Dev. Institute, Forage Legume Project, P.O. 1099, St. Johns, Antigua. Var.; Cunningham

4-5 Establishment and Management

Several good references (NAS, 1983; Brewbaker and Hutton, 1979) document the management of leucaena, including forthcoming manuals on leucaena forage and wood production from NFTA (NFTA, 1983). Seeds are readily stored and germinated following scarification. In the field, hot water treatment is most convenient—simply pouring vigorously boiling water over seeds (1 part seeds to 3+ parts water), stirring as it cools for 3-5 minutes, and decanting water. Seeds can be planted directly or following drying.

Rhizobial treatments are usually wise, if often unnecessary; a test can be made in local soil in about 2 months. Inoculant is available from Bhartiya Agro-industries Foundation, India (see section 4-4). Seeds can be planted directly to the soil, or to pots (thin and long preferred; plastic tubes 3 cm dia. and 15 cm long are ideal), for later

transplanting. The seedlings are ready to transplant in about 12 weeks.

Leucaena does not thrive in acid soils (pH below 5); where subsoil is less acid, a small application of lime is advised. Phosphate can be a major limitation in early growth, and should normally be applied, if available, at planting. Nitrogen will accelerate early growth, notably of seedlings in nursery, but is not essential.

Major pest problems in Asia are commonly 4-legged ones, ranging from rats to elephants. Protection of the palatable forage from browsing animals is perhaps the single most serious problem in much of Asia. Few pest or disease problems have proved of concern in leucaena. A bark canker that leads to gummosis occurs under moisture stress on the common leucaenas in India, but is rare on giants; it is caused by Fusarium oxysporum. Weeds are strong competitors with young trees of all kinds, and ring-weeding is advised for 3-6 months after transplanting.

Leucaena can be seeded directly; forage plantings use narrow plant spacings (75,000/ha, or 5-10/m^2), and tree plantings are also quite dense (10,000/ha, or 1-2/m^2). All large plantings should be proceeded one year by a trial planting, to determine some of the local problems to be dealt with. Goats and cattle clearly are the major "problem" in establishment in Nepal.

5. LEUCAENA IN NEPAL

5-1 Current Evaluations

We have provided seeds through the past decade to many people in Nepal, and I have seen only a few examples of these tests. To the South and West in India, leucaena has been very extensively tested, and has been the subject of national symposia (India, 1982) and major exploitation. This experience clearly should be accessed by Nepalese scientists. Among the tests which I have seen or know of (names of collaborators are in Section 7 of this report):

. Inst. Forestry, Hetauda; In collaboration with U. Hawaii, they have planted out a spacing trial at Kamaghiri, around 240 m elevation (1730mm rainfall) on the Terai. At age of 9 months, this trial looks excellent; it needs a fence and guard to keep out the deer and other animals. They also have large plantations of about 10 varieties nearby, with excellent performance considering the human/animal pressures. One planting along the road from Hetauda, at age 2.5 years, is over 10 m in height.

. Inst. Agric. and Animal Sci., Rampur; A few giant leucaenas around campus have performed well, and major fodder/soil stabilization plantings are under consideration for the campus farm. Again, random animal feeding poses problems, and living fences with some barbed wire may be mandated. Growth in this region is expected to be very good.

. GADP Livestock Development Farm, Pokhara; Scattered tests of leucaena here have been made, and performance was not considered good on the rocky Pokhara plain. It is not clear that nodulation was ensured, nor that any detailed tests were made.

. World Neighbors Project, Boudha-Bahanipati; at about 3500 ft, leucaena performing well considering animal pressure. Nursery is working splendidly, seedlings distributed to farmers with some acceptance and much originality in use. It is clearly a preferred animal fodder; it does not stabilize bunds of corn terraces unless planted as a very close hedge on the edge. Where terrace sides are less steep, trees can be planted on the side with a grass like pennisetum. No use is made yet as component of compost, nor as fuelwood, but trees are being grown with the latter use in mind.

. Khumaltar, Livestock Division; Leucaena frost-kills to the ground in winter but grows back well in summer (a casual test, based on seedlings left in a nursery over-winter). They have good seedling production and growth, but have had mixed reception from growers.

. Others; Correspondence indicates a variety of tests with our "giants", primarily as fodder trees, in other parts of Nepal and notably in the Terai and low hills.

5-2 Proposed Management Patterns for Nepal

Leucaena has been adapted into many types of forest and cropping systems, among which the following seem appropriate for evaluation in Nepal:

. HEDGE-MANAGED FORAGE; Wide use is made of leucaena as a low hedge, cut every 8-12 weeks for animal feed; hedges cut to 75 cm in height, planted in rows 75 cm apart, plants 20 cm apart or less; if feral animal grazing is too severe, hedge can be managed to a height of 2 m, for example, allowing some browsing of lower branches.

. FUELWOOD/FODDER BLOCKS; Small block plantings, on marginal areas, harvested every 1-4 years for wood and fodder (or green manure) are common in the tropics, and recommended in Nepal. Trees are spaced 1 x 1m, rarely wider; if boundary/fence plantings are desired, it is better to plant 3-5 rows 50 cm. apart--perhaps linking the outer row with wire or thorny branches to restrict animal ingress. Leucaena firewood is best if 2 or more years old (i.e., drier). It is the rare farm lacking small areas that are difficult to farm, irregular, or otherwise marginal for crops but suitable for trees.

. DOORYARD/SHADE TREES; Leucaena is a common dooryard tree in SE Asia (largely trimmed small as food or feed), and Latin America (largely lopped for animals). Trees are grown 3-5 years before aggressively lopped. "Giant" varieties are essential. Seediness is only a problem if grazing animals are absent.

. SHRUBS OR TREES ALONG TERRACE MARGINS OR BUNDS; Soil stabilization is a major need along rainfed terraces, and research adapted leucaena to this use is needed. Leucaena is widely used (e.g., Indonesia) on modest slopes for hill stabilization, planted solidly along the contour every 3-5 m. Cut annually, forage is fed and wood burned, with small branches lined along the hedge to aid terracing. Nepal's maize terraces could often be stabilized in this manner also, with leucaena densely spaced on

margin of terrace, but cut as short hedge. Goat feeding will be a problem, and cattle in dry season.

. GREEN MANURE; During corn growth, the following green manure management scheme is recommended:

1-Trim leucaena following dry season for fuelwood

2-When corn is knee high, trim leucaena again to 75 cm height, adding foliage as green manure along corn rows

3-When corn achieves tassel, again trim leucaena--this time as fodder, or to add to compost later

4-After corn harvest, again foliage can be harvested to add to the compost or use as fodder

It is in this use as a supplement to compost, to increase N for subsequent corn fertilization, that leucaena and similar plants might have their major role in Nepal, through increased crop yields. Some calculations of expected corn yield gains based on our experience in Hawaii (Evensen and Brewbaker) occur in Section 5-3 of this report.

. ROADSIDE PLANTINGS; Leucaena is not an attractive tree, to be looked at; but as a fuelwood source along roadsides and trails, with 2-4 year wood harvesting, it is excellent. With the animal and fuelwood pressures expected in Nepal, this is to be recommended as District-level or Panchayat-level projects.

. COMMUNITY FORESTS; Assuming social schemes do permit panchayat management and use, Leucaena should be useful at the appropriate elevations. Much of the forest planting of Nepal appears to be on non-agricultural red soils, probably acid and highly P-deficient, and establishment of most trees is difficult, but the pines are well chosen. It would be preferred that community forests involve trees with fodder and fuelwood value, in addition to a prospective income as timber. "Energy forests" of leucaena are being planted in several countries for biomassfueled power plants or gasifiers, but this does not seem appropriate presently in Nepal.

. HILL-STABILIZATION; In lower elevations, leucaena should be considered in any plantings for hill stabilization as a companion tree to non-legumes, or for quick growth while slower trees, e.g., Dalbergia sissoo, are coming along. Its ability to shade out grass and reduce fire damage is of considerable merit; fire will be an increasing menace in Nepal's ravaged hillsides. Spaced at 3x3m, perhaps on contour, leucaena might aid stabilization while native species slowly grow back.

5-3 Agroforestry Project for Nepal

The following agroforestry project is proposed:

TITLE: Fodder Trees in Farming Systems of Nepal

OBJECTIVES:

General--To initiate research on tree plantings as an integral part of small farm cropping systems in Nepal

Specific:

1. Focus on Leucaena for the Low Hills and Terai
2. Introduce L. as a hedge for fodder/green manure and soil stabilizer along terraces
3. Introduce L. as a fodder/fuelwood tree on marginal farmlands, fencerows, and around buildings

BACKGROUND:

Farming systems' research must not ignore, in the future, fuelwood and fodder needs or rural poor; fodder trees like leucaena clearly deserve a place in farming systems' studies for Nepal. What kinds of pragmatic projects can combine such a philosophy with immediate goals in agricultural improvement? Among the needs are:

. An acceptance of the need for agroforestry components in farming/cropping systems' research;

. A definition of woody species that are adapted, locally acceptable, high in performance, and versatile;

. A long-range program of local evaluation, adaption to farmer needs and farm traditions, and extension education

Leucaena for the Low Hills and Terai would appear to be an excellent choice; its value as fodder is quickly recognized, its value as fuelwood should be easily learned, and ultimately the better farmers will be able to see its power as a green manure supplement to compost in Nepal. It should adapt and grow well with minimal inputs. Some hard lessons have already been learned about it in Nepal, and it would not be premature to assemble in 1984 a short Workshop on its use in Nepal.

PLAN:

I favor two major approaches to the introduction of leucaena in cropping systems; both treat it as perennial and as a fodder source:

1. HEDGE MANAGEMENT: L. is planted densely (2 rows 25 cm apart, plants 15 cm. apart in rows directly seeded at beginning of corn plantings) as a narrow hedge along margins or bunds of upland terraces (not for paddy). Use of hedges within the terrace, or as part of the terrace-building process, can be used on wider terraces where they do not interfere with animal-drawn plows; such avenue cropping (or alley cropping) has been researched extensively at IITA and elsewhere. Hedges are trained to acceptable height, depending on animals of the farm area; 1 meter is preferred, but 2 m is acceptable and 3 m possible. Hedge is lopped routinely as fodder or green manure.

1-1 GREEN MANURE USE: Green manure is added to standard compost and compared with unsupplemented compost on corn. Ratios for experimental purposes might be 0:1, 1:3, 1:1 and 1:0 L:Compost. Woody stems are added carefully back along hedge for soil stabilization on slopes. Hedges are lopped carefully at time of corn tasseling to prevent shading of corn leaves above ear, critical to ear dry matter accumulation.

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Some Calculations: assume present corn yield = 1.7t/ha, using 8 T/ha of compost at 50% moisture with .92% N on DM basis (following Mathema and Van Der Veen), thus = 33.8 kg/ha of N. The same amount of leucaena leaves at 50% moisture with 3.5% N on Dm basis provide 140 kg/ha of N. In our trials yield response is linear with N in this range, with regression coeff. of 0.0294 T/ha per kg N (as leaf-derived form) /ha (Evensen and Brewbaker, unpublished); thus we would estimate expected yields of:

0 Leucaena :	100% compost	1.7 T/ha
25% Leucaena :	75% compost	2.5 T/ha
50% Leucaena :	50% compost	3.2 T/ha
100% Leucaena :	0% compost	4.7 T/ha

Care is wisely taken to cover compost from excessive rain, protect it (if leucaena) from browsing; some work at Peradeniya, Sri Lanka, is testing grass-straw covers, a bit like thatched roofs, above the compost (plastic is also being tried).

1-2 Fodder Harvest: It is probable that fodder use will be more immediately acceptable to most farmers than will green manure. However, what has been described as a system in 1-1 can be used directly and solely as animal fodder. Assuming heavy use in dry season, wood production will not be great, but small sticks for fuel are obvious side product. Here, one would work especially to make the hedge an attractive element in soil stabilization, reducing erosion, defining boundaries, filling the little corners of terraces that can't easily be plowed, etc.

2. FODDER TREE MANAGEMENT. Leucaena is grown in small blocks or rows on 50-100 cm center, along margins of land, around buildings, especially around compost areas. Seedlings are grown in plastic tubes (as Livestock people in Khumaltar) during dry season, transplanted at age 3-4 months in monsoon, protected from browse at least the first 9-12 months.

Trees can be managed by lopping, preferably above 2.5 m, with intention to cut for fuelwood in 3-4 yrs. An alternative is to lop trees to 1 m in height at end of each year, providing about equal amts. (DM) of wood and foliage annually (in solid stands in Hawaii, this is about 8T foliage and 12-15 T wood/ha as DM). Trees on 1x1 m spacing become fairly branched (3-8), but they are big and not easily lopped with machete. Such lopping would logically occur into the dry season as fodder needs become acute. We have cut such trees back every year for 8 years now, getting about 8 m height growth annually.

Note: Leucaena diversifolia can be tested for this use at elevations above 1000 m, but we guess it to be much less effective as a hedge. Other species that deserve consideration for similar use are:

Gliricidia sepium; grows easily from cuttings; good feeding and fuel values; lowlands

Robinia pseudoacacia; good fuel and fair fodder; midlands (well studied in Himachal Pradesh, where it gets high marks).

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6. ITINERARY, INSTITUTIONS AND PERSONNEL VISITED

20 Mar.; Kathmandu; arrival
21 Mar.; Kathmandu to Pokhara (with D. Lipinski, PCV)
Hill Food Prod'n Proj.—F. Gorrez, J. Plusje
Pumdi Bhumdi ICP site
Rural Dev. Ctre., United Missions
22 Mar.; Pokhara to Rampur
Livestock Dev. Farm, Lame Patan—J. Von Bargen
Inst. Agric. and Animal Sci., Rampur—M.D. Thorne, W. Combs
Seminar to Faculty and Students, IAAS
23 Mar.; Rampur to Hetauda
Natl. Maize Dev. Program, Rampur—V. Sharma, T. Mishra
Ratna Nagar ICP site
Inst. Forestry, Hetauda—A. Tuladhar, M. Karki, D. Amos, R. Adams
Seminar to Faculty and Students, Inst. For. (U. Trithuwan)
24 Mar.; Hetauda to Tamaghiri to Kathmandu
Tamaghiri Leucaena trials, Inst. Forestry trials—A. Tuladhar
25 Mar.; Kathmandu, Lele
Lele ICP site—Visit of FAO Reg. Dir. Puri
Crops Program—I. Bolo, M. Malla
Comm. Forestry—E. Pelinck, P. Manandhar
26 Mar.; Holiday
27 Mar.; Kathmandu
Dept. Agric.— A.M. Pradhananga, A.N. Bhattarai
Khumaltar ICP; I. Bolo, M. Van Der Veen
Khumaltar Livestock; L.P. Sharma
Peace Corps —M. Frame
28 Mar.; Kathmandu (trekking) to Boudha-Bahanipati
World Neighbors—T. Arens, Gopal Nakarmi, Bir Bahadur Chhetri
29 Mar.; Bahanipati back to Kathmandu
30 Mar.; Kathmandu
Dept. Agric., Ext. Service—F. Moin Shah, Ram Chandra Gupta
Forestry Services, Ltd.—Devendra Amatya
Utd. Mission of Nepal—J. Williamson
31 Mar.; Kathmandu
Nepal - UK Silvic. Res. Unit—Peter Howland, Gerry Neville, Tom Hawkins
Nepal - Swiss Proj.; K.K. Panday
Dept. Agric.—P.P. Gorkhaly, Dir. Gen'l.
Seminar, Dept. of Agric.—Agric., Forestry, Livestock
01 Apr.; Kathmandu
USAID—Gary Alex
Dept. Agric., Livestock Div.—Thir Bahadur Singh (Dir. Gen'l.); Shree Govind Shah, Heraub B. Rajbhandari (Dep. Dir. Gen.)
Departure for Delhi

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June 27, 1983

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