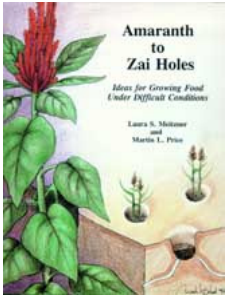


- III. Dry farming practices
- Muscovy ducks for png villages
- Fruit crops
- Fruit vegetables
- Grain crops
- Ground covers and green manures
- Green manure crops
- Industrial crops
- The lablab bean as green manure
- Leafy vegetables
- Leguminous vegetables
- The moringa tree
- Recipes to learn to eat moringa
- Miscellaneous vegetables
- The poor man's plow
- Pulses (grain legumes)
- Rabbit raising in the tropics
- Letter from fremont regier, mennonite central committee, Botswana (and earlier in Zaire)
- Roots and tubers
- Sunnhemp as a green manure
- The sweet potato
- Tropical pasture and feed crops
- The velvet bean as green manure

Amaranth to Zai Holes, Ideas for Growing Food under Difficult Conditions (ECHO, 1996, 397 p.)

28 additional technical notes about tropical agriculture

A few alternate seed sources that we commonly use

- CATIE (Centro Agronomico Tropical de Investigacion Ensenanza), BLSF, Turialba, Costa Rica, Central America. Supplies fruit and forest trees.

- Cornucopia: A Source Book of Edible Plants. Supplies sources for 7000 varieties (see EDN 35-6). From Kampong Publications, 1870 Sunrise Drive, Vista, CA 92084. Incl. postage: $37.50 US; $40.25 surface/$56 air overseas.

- CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), Londres 40, Apartado Postal 6-641, 06600, Mexico. Improved varieties of corn and wheat, including Quality Protein Maize.

- Fruit Spirit, Botanical Garden, Dorroughby, NSW, Australia 2480. Unusual fruit, nut, ginger and other crops.

- Multipurpose Trees and Shrubs: Sources of Seeds and Innoculants. By Peter C. Von Carlowitz, ICRAF, P.O. Box 30677, Nairobi, Kenya.

- High Altitude Gardens, P.O. Box 4619, Ketchum, ID 83340. Some vegetable selections suited to higher elevations.

- Inland & Foreign Trading Co., LTD., Block 79A, Indus Road #04(c)418/420, 0316, Singapore. Legumes, pasture grasses, special purpose trees.

- J.L.Hudson, Seedsman, P.O. Box 1058, Redwood City, CA 94064. Ethnobotanical catalogue of a wide variety of plants.

- National Tree Seed Centre (NTSP), PO Box 373, Morogoro, Tanzania; tel: +255 56 31 NTSP TZ. Provides more than 100 tree species for most purposes.

- Plants of the Southwest, Agua Fria, Rt 6 Box 11-A, Santa Fe NM, 87501. Phone and Customer Service Orders: (9-5 MST M-Fri.) (505)471-2212, Fax: (505)471-2212. Corn, cover crops and vegetables for arid gardens.

- Phoenix Seeds, P.O. Box 94619, Tazmania 7331, Australia. Vegetables, trees, winged beans, jicama.

- Richters Herb Specialists, Goodwood, ONT LOC 1AO Canada. Very complete herb listing.

- SETROPA, P.O. Box 203, 1400 A.E. Bussum, Holland. Trees and forages.

- Shivalik Seeds Corporation, 47 Panditwari, P.O. Prem Nagar, Dehra Dun-248 007 (UP), India. Phone: 91 135 683348. Fax: 91 135 29944. Seeds of a wide range of (agro)forestry, medicinal, horticultural, ornamental plants.

- Tomato Growers Supply Co., P.O. Box 2237, Fort Myers, FL 33902. Wide variety of tomato and pepper varieties.

- Twilley Seed Co., P. O. Box 65, Trevose, PA 19053, USA. Ordinary temperate vegetable and flower seeds.

- University of Hawaii, Seed Program, Dept. of Horticulture, 3190 Maile Way, Rm. 12, Honolulu, HI 96822. Limited range of selected/improved tropical vegetables and papayas.

Amaranth - grain and vegetable

amaranthus hypochondriacus, a. cruentus (grain) & a. tricolor (vegetable) amaranth
Compiled by G. Kelly O'Brien and Martin L. Price

Characteristics

Amaranth is a plant with an upright growth habit, cultivated for both its seeds which are used as a grain and its leaves which are used as a vegetble. Both the leaves and seeds contain protein of an unusually high quality. The grain is milled for flour or popped like popcorn. The leaves of both the grain and vegetable types may be eaten raw or cooked. The amaranths that are grown principally for vegetable use have better tasting leaves then the grain types.

Amaranth has been cultivated for more than 8,000 years, dating back at least to the Mayan civilization of South and Central America. It was a staple of the Aztecs and was incorporated into their religious ceremonies. In 1516 the conquistadores prohibited the growing of amaranth. In that area today only a limited amount of grain is grown, most of which is popped and mixed with honey to make "alegria" candy. However, much of the genetic base has been maintained because amaranth has continued growing in the area as a weed.

Amaranth is considered native to South and Central America, but over 400 varieties are found throughout the world in both temperate and tropical climates. Vegetable amaranth has been used in China for 400 years, and is commonly found in the Caribbean and Africa.

Amaranths are moderately branched from a main stem. Grain types form large loose panicles at the tips of the stems. Vegetable types form flowers and seeds along the stems. They are indeterminate in growth habit, but may set seed at a smaller size during short days. Grain amaranth grown in winter at ECHO (southern Florida) began flowering at less than half of the height of amaranth growing in May. Grain types may grow 1 to 2 meters tall and produce yields comparable to rice or maize. Amaranth has the "C-4" photosynthetic pathway (along with such plants as corn and sorghum), which enables it to be uniquely efficient in utilizing sunlight and nutrients at high temperatures. It is more drought-resistant than corn.

Nutritional value

As can be seen in Table I, amaranth is quite nutritious. Amounts of vitamin C, iron, carotene, calcium, folic acid and protein are especially high. There are reports that the incidence of blindness in children due to poor nutrition has been reduced with the use of 50 to 100 g of amaranth leaves per day. On a dry weight basis, the content of protein in leaves is approximately 30%. The presence of rather high amounts of oxalic acid and nitrates places some limitation on the quantity of amaranth leaves that can be consumed daily. The amount of oxalic acid is roughly the same as that found in spinach and chard. Excessive amounts (over 100 g per day?) may result in a level of oxalic acid that begins to reduce the availability of calcium in humans. This is especially a concern if calcium intake levels are low to begin with. Nitrate in vegetable portions of amaranth is a concern because it is hypothesized that nitrates may be chemically changed in our digestive tracts into poisonous nitrosamines. Evidence for this is lacking at the present time. Nevertheless, over 100 g per day may be an unsafe amount to eat, according to scientists. The levels of both oxalic acid and nitrates are reduced by boiling the leaves like a spinach, then discarding the water.

Amaranth grain has more protein than corn, for example, and the protein is of an unusually high quality. The protein is high in the amino acid lysine, which is the limiting amino acid in cereals like maize, wheat and rice. The protein is also relatively rich in the sulfur- containing amino acids, which are normally limiting in the pulse crops (e.g. beans). The "protein complement" of amaranth grain is very near to the levels recommended by FAO/WHO. It has a protein score of 67 to 87. Protein scores are determined by taking the ratio of the essential amino acids to the level for those amino acids recommended by FAO/WHO, and multiplying by 100. By comparison, wheat (14% protein) scores 47, soybeans (37%) score 68-89, rice (7%) scores 69, maize (9%) scores 35.

Although amaranth is theoretically close to the ideal, combining it with another grain increases the quality to very close to the FAO/WHO standards. Weight gain studies with rats point out, however, that the actual nutritional value is considerably less than would be expected from the above considerations. This is apparently due to certain anti-nutritional factors in raw amaranth. Performance is improved somewhat by cooking. For example, Dr. Peter Cheeke at the University of Oregon compared the rate of weight gain by 120 gram rats fed a corn-soybean diet to rats fed a diet

of corn and seed from A. hypochondriacus, either raw or cooked. The average daily gain for rats on the corn-soybean diet during the first 20 days was 3.9 grams. Rats fed the corn-amaranth diet gained only 0.3 grams per day. The average daily gain for rats fed corn and cooked amaranth was 1.6 grams. Raw amaranth seed is extremely unpalatable to rats (i.e. they will not eat it readily). Cooked seed also does not seem to be very palatable, though it smelled good to Dr. Cheeke.

In another study, Dr. Cheeke found that after 11 days on a corn-amaranth diet, rats (which weighed 120 g initially) "had an unthrifty hunched-up appearance, and exhibited symptoms typical of semi-starvation". We phoned Dr. Cheeke to get his perspective on the seriousness of these negative results. He told us that there are definitely toxins and/or anti-nutritional factors in the raw grain, and that it is less of a problem with cooked grain. He said that a scientist in Australia had been feeding raw amaranth seed to poultry as the major component of the diet. He found that chickens went into spasms, convulsions, and finally died. This unidentified factor causes liver damage. Other problems are caused by saponins, including unpalatability.

But to keep this in perspective, Dr. Cheeke pointed out that there are few raw foodstuffs which do not have problems. Raw soybeans contain 10 kinds of toxins. Raw kidney beans will kill rats, but the problem is eliminated by cooking. The key seems to be to use the grain in moderate amounts, and to cook it. We asked whether we could say that there would be no problem unless people had little other than amaranth to eat. He thought that this was probably a fair statement.

It is our opinion that more research needs to be done before we can recommend amaranth grain as a major ingredient in animal feed. To our knowledge it has not been shown whether these factors decrease the value of amaranth in human nutrition. Until more work is done, however, the feeding trial results must moderate our otherwise enthusiastic promotion of grain amaranth.

Compiled from J.N. Cole, Amaranth: from the Past, for the Future Rodale Press, Emmaus, PA (1979)

Cultivation-vegetable types

There appears to be considerable latitude in choice of plant densities. One approach is to plant dense stands (5-10 cm spacing), and harvest by uprooting when the plants are 5-7 weeks old. Another common approach is to sow less densely (15-30 cm spacing), and harvest by cutting the stem tips and plucking tender leaves periodically beginning when the plants are about 15 cm tall (4-6 weeks old). Seeds may be planted in a nursery for subsequent transplanting or sown directly where plants are to be grown.

Transplanting is a very efficient use of seeds, and allows the growing area to be weeded just before the seedlings are transplanted. The very small size of the seeds, however, means that a few seeds go a long way. The number of seeds saved is probably not a sufficient justification for the extra work involved in transplanting. On the other hand, gaining a two-week jump on the weeds can be significant because amaranth seedlings are not vigorous growers when very young.

Planting in a nursery also reduces risk of loss due to disease such as damping off. Direct seeding involves much less labor, but incurs a greater risk of poor stand due to diseases and predators of young seedlings and to poor competition with weeds in the crucial initial couple of weeks. If direct seeding is used, sowing should probably be in rows to facilitate cultivation.

Whether sown in the nursery or field, seeds need to be planted about 4 mm deep (or covered with 4 mm of soil) for good germination. Because of the shallow depth, special care must be taken to prevent drying out of the soil until plants are established. Tansplanting or thinning may be done in about two weeks when plants should be 5-10 cm tall. Delay in transplanting for even one week can reduce total yield. When harvesting by repeated clippings, a two- or three-week interval is common through the end of the season (usually the shortened days of fall). Both the yield and quality of leaves are higher with more frequent clippings. When the vegetative stage ends and flowering begins, subsequent harvests are lower in both quality and quantity. Flowering may be promoted by short days, water stress or other environmental stresses. The stress that comes with delayed transplanting also can cause the plants to flower more quickly. It is reported that plucking flower heads from the plant may prolong the vegetative phase of growth.

Amaranth is generally considered tolerant of nematodes and is even recommended as a rotation crop to reduce nematode populations for subsequent crops. However, one article reports the presence of root knot nematodes on amaranth roots. Control of nematodes is such a serious problem that it is important to know whether or not amaranth can be used to control them and/or whether it can be planted where nematodes are a problem. We will include this question in our list of research projects that could be done at Christian colleges. It is possible that the discrepancy in reported results is because varieties differ in their suceptibility to nematodes.

Amaranth is susceptible to damping-off disease, root rot, caterpillars and stem borers. It thrives in 30-35o C temperatures. It tolerates poor fertility and drought. However, plant quality is poor under stressful conditions. There is good response to fertilizer.

Cultivation-grain types

Recommendations for plant spacings vary widely for grain amaranth. One recommendation is to space 23 cm between plants and 75 cm between rows. This corresponds to a planting density of 38,000 plants per hectare (15,400 per acre). Seeding rates up to nine times this density have been used successfully! It would seem that if harvesting is to be done by hand the less dense spacings are advisable. This results in fewer but larger heads which can be harvested more quickly. Closer plant spacing may be advisable for mechanical harvesting.

The decision as to whether to transplant or direct seed is subject to the same considerations that were discussed for vegetable amaranth. Cultivation is essential until plants have reached a size where the leaf canopy can shade out weeds. After the plants are about 30 cm tall, it is helpful to mound soil from the centers of the rows up around the plants. This helps to reduce lodging (plants blowing over in the wind), suffocates weeds around the plant, and uproots weeds between rows.

Grain amaranth is grown from tropical lowlands to 3500 m in the Himalayas. In the tropics, altitudes above 1000 m are considered best. Although it tolerates droughts and low fertility, it does much better under conditions that are considered ideal for maize (corn). It may be intercropped with

maize, beans, peppers or squash. In some pure stands it has yielded as well as the world average yields for maize or rice (2000 kg/ha).

Loss of the tiny seeds by shattering before or during harvest can be a problem, especially with mechanical harvesting. (There are approximately 1100 seeds per gram of amaranth.) The seeds are mature when they can be easily separated from the heads upon rubbing between the hands. Seeds can be chewed to test whether they have passed beyond the "dough stage." Heads should be cut from the stalk and side branches as soon as possible after they have reached maturity. Heads should be dried if necessary, keeping green plant parts to a mnimum. Once dry, the seeds are knocked from the heads, fofted through an ordinary window scree, and winnowed to remove chaff.

Although three or four farmers are planting small (around 10 acre) plots in the USA , as of this writing (1982), there appear to remain serious problems with mechanical harvesting. Primary among these problems are the tendency for plants to lodge, and the loss of grain during harvesting. Grain should be dried to about 9% moisture for safe storage. It is reported that grain remains viable for up to seven years. We left heads stacked in a building for 5 summer months (high humidity and temperatures in the 90's). Viability still appears to be high.

Preparation

Vegetable amaranth leaves and stems or entire plants may be eaten raw or cooked as spinach. As discussed earlier, however, cooking and discarding the water will remove potentially harmful oxalates and nitrates. The seeds from grain amaranth can be ground for use as a good quality flour for breads or pastries. It must be combined with wheat flour for a yeast dough. The Organic Farming and Research Center (Rodale) has used a 50:50 ratio successfully, but they sugest that the percent of amaranth could be even greater if desired. They state that "amaranth flour contributes to the sweetness and moistness of a baked good".

Alternatively, seeds can be popped like popcorn. The people at Rodale say that popped amaranth can be used: in confections bound with sorghum, molasses or honey; in high- energy granola and

granola bars; in cheese spreads; to flavor salad dressings; in breadings for chicken and fish; in crackers, pie crusts and breads; and as toppings for casseroles and desserts. Several recipes can be found in the book Amaranth: from the Past, for the Future by Rodale Press.

Other reading material

We found the research results published in Proceedings of the Second Amaranth Conference to be especially helpful. It is available from Rodale Press, Emmaus, PA 18049 for $15.00. For those interested in larger-scale production, Amaranth Grain Production Guide 1982 would be helpful. As far as we know there is no charge. Order it from Rodale Press. Rodale has other material that would be helpful if you wish to pursue the subject in depth.

How do I harvest amaranth?

Basically, you must thrash it like mankind has always done until the invention of the thrashing machine. The three stages include: let the heads dry out, knock the grain from the heads, and winnow the grain. Many of you live where local folks know far more than I about such techniques. For others, here is what we do with small quantities of seed (which must be kept separate from other varieties). Cut the heads when the grain appears to be mature, and put them somewhere to dry. If left too long much of the grain may shatter (fall to the ground). Grain easily shatters from the dried heads. Put a few heads in a burlap bag and beat it against the cement floor a few times to knock it loose, or strike the bags with a stick. Then place the grain in a 5-gallon bucket (many other containers would be suitable).

You will notice that a lot of chaff comes along with the grain. This is where winnowing comes in. Place an empty 5-gallon bucket in front of a fan and, cautiously at first, pour some grain and chaff into the empty bucket. A steady wind will accomplish the same thing as the fan, but a gusty wind will cause problems. The grain is more dense and will fall closer to the fan than the chaff. Quickly one begins to get a feel for how far the buckets should be from the fan, and at what height to hold the one bucket in order for the grain to land in the empty bucket and the chaff to blow far enough to

miss it. Pour the grain back and forth until it appears to be clean. Final cleanup can be done by swirling and shaking the grain around gently. Remaining chaff will "float" to the top like ice in water, and can be removed by hand.

Arid region farming primer

By Franklin W. Martin

Introduction

Why this primer is desirable. In every region of the world it is necessary to find or develop appropriate techniques for agriculture. A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture. Yet, millions of people live in such regions, and if current trends in population increase continue, there will soon be millions more. These people must eat, and the wisest course for them is to produce their own food. Yet, the techniques are so varied that only a very large volume would cover the entire subject. This publication is only a primer, an introduction to appropriate techniques. More extensive treatments are mentioned in the bibliography. In many cases the most suitable techniques for a particular region may be those already developed by the local inhabitants. In some cases it will be difficult to improve on local techniques, but at times even simple and inexpensive innovations may be almost revolutionary. This bulletin suggests that one must begin to improve local agriculture in arid zones by learning what is already there. Then both techniques and plants that may be useful in specific situations are suggested.

Definitions and degrees of aridity. Arid implies prolonged dryness, and is used with respect to the climate itself, and the land below it. In such regions the ability to produce agricultural crops is restricted. Usually on arid lands the potential evaporation of water from the land exceeds the rainfall. The land may be characterized according to the degree of aridity as dry forest, chaparral or brushland, grassland or savannah, or desert. The word, "arid" does not adequately characterize the soils, however, for they may vary in many ways. Often they are alkaline or saline.

Several degrees of dryness must be recognized. The first is where the dry climate is modified by seasonal rainy seasons. In such a region it might be possible to produce a wide range of annual crops during the short rainy season, enough to sustain animals and feed mankind, although few food or feed trees might be feasible without special techniques.

The second situation is a year round aridity, sometimes modified by light or irregular rains, which might make production of crops impossible.

The third situation is where water is brought in by wells, canals, or other means so that normal agriculture can exist, in spite of the aridity of the climate. This primer concerns the first two situations, but not the third. There are techniques suitable for all arid regions.

Principal arid regions of the world. The arid regions of the world are often very extensive, but in the tropics it is common, even on a small island, to find arid regions not far from regions of abundant rainfall. Some of the larger arid regions are:

However, while the above mentioned regions may constitute the most arid regions, nevertheless, there are many more areas, large and small, where aridity is a problem.

PRINCIPAL PROBLEMS OF AGRICULTURE IN ARID REGIONS

Water. Water is absolutely necessary for all plant and animal life. Plants have evolved that are capable of living and reproducing in semi arid, arid, and even desert regions. However, as aridity increases, fewer and fewer species are adapted, and the potential biomass is reduced.

Plants are adapted to aridity by several mechanisms. There are plants with a short life cycle that can germinate, grow, and produce during a very short period of available moisture. There are plants with deep or extensive root systems which have the ability to gather water over a wide area. There are plants which store up water in their tissues and release it very slowly. There are plants that are protected from water loss by wax or other impediments. There are plants with very small or narrow leaves, thus reducing water loss. There are plants in which the tissues themselves can withstand

much desiccation without dying. Crop plants in arid regions may have any or a combination of such mechanisms.

Water that falls in arid regions may be of little use for crop plants because the amount is too small to penetrate the soil sufficiently, or it may run through a porous soil too quickly, or it may run off too quickly. Furthermore, weedy species may be so adept at utilizing scarce water that they rob the water from crops. On the other hand, some soils can store water so efficiently that is possible to grow crops in such soils over an extensive period of drought.

Water from rivers, lakes and wells in arid regions may have problems of quality, especially the presence of excess minerals. The use of irrigation water might lead to the accumulation of salts in the soil resulting in alkalinity or salinity, which might then limit crop production. The removal of salt from the soil is very difficult.

In all arid regions a major challenge is to manage water appropriately. The purpose of such management is to obtain water, to conserve it, to use it efficiently, and to avoid damage to the soil.

Heat and Wind. The major effects of heat and wind are to increase the rate of evaporation of water, and thus to increase the effects of aridity. Wind may also cause mechanical damage to crops. Both are combatted by changing the microclimate. The effects of winds can be reduced by windbreaks (lines of trees perpendicular to the direction of prevailing winds). Some useful tall species are tamarisk, casuarina, and eucalyptus. A windbreak can consist of trees and other plants of varying height. As a general rule, a windbreak is effective over an area two and a half times the height of the tree. One must remember, however, that a windbreak may also rob crops of light, water and nutrients. Thus, the advantages of a windbreak must be weighed against the disadvantages in any particular environment. Windbreaks can also be constructed of non-living materials, which are likely to be expensive.

Heat is received principally from the sun and can be reduced by shading. But, shading also reduces the yields of plants. A light shade such as that below a coconut planting or a protective screen or

lathwork can be useful in reducing heat and retaining moisture, with only a minimum loss of yield.

Soils. Soils of the arid tropics are highly variable, as they are in any climate. Nevertheless, it is possible to make some generalizations about such soils. Because of the low rainfall and consequently reduced plant growth, organic material is produced slowly. Yet, again because of low rainfall, it may be broken down slowly as well. The amount of organic material in the soil, and thus the potential fertility, is likely to be high in semi-arid zones, low in deserts.

Because of low rainfall in desert soils minerals derived from breakdown of rocks are not leached from the soil. In some cases where the soil is periodically flooded or irrigated the soil might be saline as well. Such soils support few crops.

Soils of the semi-arid and arid zones might support few plants on the surface, but a good part of the biomass might be in the soil itself as roots. Shrubby desert plants often have very hard woody roots that may be a physical barrier to agriculture.

Disease and Pest Problems. Arid regions have their fair share of disease and pest problems. However, these may often be quite different from those of wetter regions. Nematodes are often a severe problem in sandy soils. No general rules are useful, and indeed, agriculture anticipates diseases and pests, and their parasites as well.

Agricultural techniques for arid lands

Many of the techniques for agriculture in arid lands are not very different from those in other climatic zones. The unique problems of arid lands are almost entirely related to water or its effects over long or short times. Therefore, the discussion here revolves around two questions, "How to capture existing water", and "how to use water wisely".

How to Capture Existing Water. Much of the water that falls on arid lands is lost by runoff, deep penetration into sands, or by evaporation. Runoff can be captured for later use in natural or nature-

like ways, or in manmade structures. These include the following:

1. Furrows, and diking of furrows, ditches, and pits following contours to slow the runoff of water and permit deeper penetration.

2. Similar structures reinforced by bench terraces, vegetative strips, or trees for alley cropping.

3. Crescent-shaped basins arranged to gather water for one or more trees.

4. Reservoirs of water, such as natural or constructed shallow basins along roads which capture runoff, earth structures that lead water into aquifers (underground streams), rock or clay-lined underground basins.

5. Other man-made structures. These include cisterns (household or community sized clay, stone, or concrete tanks, check dams (small structures that impede water movement in a stream), and conventional dams.

How to Obtain New Water. In many arid regions water can be obtained from wells. The depth of the well necessary to obtain water may vary a few to thousands of feet. Water in wells is either fossil (stored over impermeable layers for thousands of years), or from water that has entered the soil from rain, and is therefore stored rainwater. Both sources of water are limited and can be exhausted.

New water is also obtained by condensation from the air, either onto metal screens or plastic (the principle of the solar still) or onto foliage. Ingenious systems can be developed to capture this condensation. This source of water depends on nighttime temperatures that lower to the point of condensation.

How to Conserve Existing Water. Water that is conserved is just as valuable as water that is obtained, and is one of the best strategies for arid zones. There are many techniques, here

presented only as lists.

Citrus propagation and rootstocks

by dr. Martin L. price, executive director

In response to various questions from overseas, we have tracked down some answers that are of general interest to our readers. These have been published in past issues of ECHO DEVELOPMENT NOTES. This technical note reprints those in their entirety. It also adds a couple of helpful tables that were provided by the Holm Citrus Nursery concerning characteristics of citrus rootstock and varieties of citrus.

FROM ISSUE #5:WHAT VARIETIES OF CITRUS WILL GROW TRUE FROM SEED? Jerry Larson with Double Harvest in Haiti asked us what varieties of citrus might come true from seed. I checked with Dr. Carl Campbell at the University of Florida Extension research center. Carl has given me many in-depth, insightful answers to tropical fruit questions sent by several of our readers. He said that a great number of citrus trees will come true from seed. There is a way that you can tell by examining a few seeds from the tree. Peel off the outer and inner seed coat. It the seed is polyembryonic, i.e. has many embryos, it will come true. I asked what it would look like if it were polyembryonic. Carl said that the various embryos would be convoluted upon each other. If it is mono-embryonic there will be one embryo with two distinct cotyledons. Almost any sweet orange will come true from seed, as well as key limes, grapefruit, tangerine and tangelo. Two varieties that will not come true from seed are temple and pomelo.

What are the advantages and disadvantages of growing citrus from seed when that is possible? One obvious advantage is that it is much less labor intensive to simply sow citrus seeds and eliminate the grafting step. Another advantage is that the seedling will most likely be free from viruses that sometimes get into the budwood that is used for grafting large numbers of trees. I asked Carl about reports that non-grafted citrus trees live longer, up to twice as long, as grafted trees. He said that this can be true, depending on the number and kinds of disease organisms that may be present in

the budwood. If one uses certified disease-free budwood, and if there are no microorganisms present that we don't even know to look for yet, then there should be no difference in the longevity of the trees.

One advantage to grafting is that one can combine the best traits of the above ground part of the tree with the best adapted rootstock for the particular soils and conditions of the area. A seedling will tend to grow upright, tending toward a single trunk, and becoming quite thorny. A grafted tree will be more highly branched. The seedling tree will not fruit for 6-7 years, contrasted to the 3-4 years for a grafted tree. The earlier fruiting of the grafted tree is partly responsible for the more highly branched form of growth. Apparently the weight of the fruit after about 3 years bends the branches and causes new buds to begin growing, resulting in a more highly branched tree. But not all of the reasons for the differences between seedling and grafted trees are known.

If you live in an area where citrus is not a major crop but would like to introduce it, you might consider trying some of the polyembryonic seeds. If you are more adventuresome, in a few years also plant some accepted rootstock varieties for grafting using budwood from the new trees you have introduced. If you prefer to start with a Florida variety rather than a good local variety, and want only a few seeds, we can at times provide them. If you want larger amounts, we have located a supplier, Lawrence Reed at Holm Citrus Seed Co., who routinely ships overseas. Seed currently sells for $30 per pound plus airfreight. He can provide phytosanitary certificates if you so request and include your full address and phone number. I asked about the danger of introducing a new disease. He said this does not appear to be a problem with citrus seed. There has never been an instance where a citrus disease has been proven to have been introduced by seed. They are sending me a one page guide to help select seed for rootstock. I will send you a photocopy upon request. If you have money on deposit with us, we will be glad to place orders for you.

I asked Dr. Campbell to proof-read the above. He added that in some of the polyembyronic citrus, some of the embryos are of gametic origin and therefore do not come true. The percentage varies by species and variety.

FROM ISSUE #7: SUGGESTIONS FOR PURCHASE OF CITRUS SEEDS. Carl Berg, a Peace Corps volunteer in Ecuador, inquired about citrus rootstock and how best to introduce assorted varieties of citrus into his part of the country. I phoned Mr. Reed at Holmes Citrus Nursery for help.

There are five rootstocks that he recommends for anyone, anywhere (though he sells 18). These five are: sour orange, 'Carrizo' citrange, 'Swingle', 'Cleopatra' mandarin and Poncirus trifoliata. If there is no danger of freeze or frost, he would add to the list the following: Citrus macrophylla (for extremely warm climate, but poor fruit quality), 'Rangpur' lime, 'Palestine' lime, 'Milam' and volkameriana. We also sent Carl budwood of superior varieties to bud onto wild citrus. These will be used to bud the new rootstock when it is ready.

The prices per quart range from $30 to $125, so most of ECHO's collaborators would be unable to try more than perhaps one variety. I asked if he would be willing to prepare an assortment in smaller packets. He agreed to the following. You can send him $40 for an assortment of the first 5 mentioned above, all ten mentioned above, an assortment of citrus that will come true from seed (see E D N #5), or any combination of these. He will arrange packet size to make the bill come out to $40. We agreed to allow him some flexibility, as he would not have time for precise measurements, etc. You will receive approximately 1.5 pounds of seed. I would recommend that you add about $20 for airmail postage, as citrus seeds begin to lose viability within a couple weeks after removal from refrigerated storage. Alternatively, you may know someone in the States that is about to visit you. The seeds could be sent to them via UPS. Mr. Holmes is doing this as a favor to help your work and does not assume responsibility for delivery by international mail systems. Send your order, mentioning the ECHO package arrangement, to Mr. Chuck Reed, Reed Brothers' Citrus, P.O. Box 1863, Dundee, FL 33838 (Phone 813/439-1916).

I also asked about susceptiility to Phytophthora root rot. He said that rough lemon is one of the worst root stocks in regions where Phytophthora is a problem. It once was the primary root stock in Florida, but has been totally replaced. All citrus trees are susceptible to Phytophthora root rot to some degree. If a workman injures a root and the organism is in the soil, it can enter and damage

the tree. It can then kill after a few months or just reduce production. Some trees in a row may become infected and others not. Budwood is not infected.

FROM ISSUE #12: ANSWERS TO SOME QUESTIONS ON CITRUS.Two of our readers asked some interesting questions about citrus. We called Larry Reed at Holm Citrus nursery who has so often been helpful. The questions and answers are of general interest, so I repeat them here.

Q. (From William Boykin in Zambia). "The navels, valencias and hamlins do not have the sweet flavors we had hoped. Is there anything we can do, or might it be the rootstock? We budded onto cape lemon."

A. The cape lemon rootstock is your major problem. Lemon rootstocks produce big quantities of fruit, but the quality is always poor. Lemon rootstock is for commercial juice production where they want to emphasize quantity. They then mix with smaller amounts of other juices to get the right taste. An advantage of the lemon stock is rapid growth, it being more vigorous than other stock. However, this also results in poor taste. Climate can also cause inferior taste. It would help if the climate were cooler. I would suggest budding onto either Carizzo or sour orange. They may not allow sour orange into the country because it is so susceptible to Tristeza. For example, Brazil's citrus industry was wiped out some years ago by tristeza. But it depends a lot on how virulent is the strain in your country. It is so good that I would take the risk and not worry too much about tristeza. My third choice would be Cleopatra mandarin. The disadvantage with it is foot rot. This world-wide problem is caused when workers injure the root while cultivating. It is most susceptible during the first 5 years. The safest thing would be to use a combination of rootstocks. Then it will be unlikely that you will be wiped out.

If you wish to plant some true-to-type seeds I would recommend two varieties: ridge pineapple or what is called "old sweet seedling." By the way, any true-to-type seedling [plant grown from seed that will give fruit like the parent tree] is susceptible to foot rot.

Q. (From Peter van Lonkhuyzen in Haiti). I have used budwood from some three year old trees that

are not bearing fruit yet. Someone told me that by using such young trees my grafted trees will start bearing late and never will give good yields. Is this true?

A. A grafted tree will normally start bearing some fruit within a year. The fact that the parent trees you used were not bearing at three years suggests that they were seedlings. If so, you will have to wait about as long as if you had planted the seed.

There is one way you can get some quick budwood. Take budwood from a mature bearing tree and graft onto a rootstock in your area. As soon as this has grown to produce some branches, you can use this to bud other trees. They call this "first generation budwood." However, the second generation of trees should not be used for budding until they have started bearing.

Q. What rootstock should I use that is resistant to both drought and tristeza?

A. Sour orange is drought resistant, but if you want tristeza resistance also I would recommend Carizzo. Of course, even that is only drought resistant to a point. True-to-type seedlings will never tolerate drought as well as the normal rootstocks. I might also mention that a rooted cutting from any variety of citrus will have about half the normal life expectancy of a grafted citrus, due to susceptibility to a range of root diseases.

Q. How is it possible that in some places they have Washington naval trees without thorns while somewhere else the same variety has thorns?

A. There can be some differences in thorniness within a variety. In the one location they must have budded from trees that did not have thorns. You will still have some thorns of course. Alternatively, the thorny ones could be seedlings, as they tend to have more thorns.

Cucurbit seeds

Echo technical note a-2

As possible oil and protein sources for small scale and household use in the hot humid tropics
By Franklin W. Martin Mayaguez Institute of Tropical Agriculture Mayaguez, Puerto Rico

Introduction. Oils are necessary in the diet as a source of non-saturated fatty acids, in order to give flavor to foods, as sources of fuel for the body, and in addition, are used in the kitchen as a cooking medium. The problem of interest here is how to produce the oils needed at the level of the individual household, in the tropical household. This problem has several aspects of interest.

On a small scale, animal fats are more easily obtained from small animals than plant fats obtained from plants. Animal fats are fairly stable, can be used one or two weeks or more even without refrigeration, and are fairly well accepted. They do not contain sufficient non-saturated fatty acid (palm oils, however, are an exception to this rule.) Plant fats are therefore more useful to the body from a nutritional standpoint, but they are less stable, and easily turn rancid. Most plant oils occur as stored materials in seeds. To use the fats it is often necessary or at least desirable to remove the seed coats from the seeds. In order to obtain the nutritional value of the non-saturated fatty acids it is not necessary to extract the oils from the plants. Thus, the kernels can be used in many different ways. A convenient form to use the fats of some seeds is as a vegetable curd. This is prepared by grinding the seeds in water, filtering, and precipitating the protein with an appropriate agent such as lime juice, vinegar, or epsom salts. Most of the oil as well as the protein is extracted and precipitated, the former by occlusion in the protein.

In the hot humid tropics there is often a shortage of oil in the diet, or cooking oil in the kitchen. It is difficult to mature many of the most typical oil crops during the rainy season. While large scale techniques for extracting the oil are available in some cases, they are not necessarily the best for the small scale everyday needs of the tropical household. There is a need for appropriate crop sources of oil in the humid tropics, and for techniques for their use.

A suitable crop for oil production on a small scale should be an annual, or a perennial that produces during the first or second year. The oil-producing fruit or seed should be available year round, or, as

an alternative, the seed should be storable so that oil can be produced year round. It is also very useful if the seeds that are sources of oils are also good sources of protein.

Principal tropical plant oil sources. In the tropics fats are obtained from the seeds of numerous plants, many wild or produced on only a local scale. The most important plant sources of oil in the tropics are given on Table 1. In terms of production per unit area, the oil palm, Elaeis guineensis Jacq. outproduces all other species as an oil source. These oils can be extracted at the household level, and are extremely useful. Palms need space and time to grow, of course, an thus are not convenient crops for the small household.

The soybean, peanut, and possibly the winged bean are suitable sources of high quality cooking oil, but are very difficult to extract on a small scale. They are all excellent as sources of non-saturated fatty acids in the diet. Cotton and okra seeds are other possibilities. Cotton seed is seldom produced on a household scale, but okra seed is often available on the small farm and can be considered a potential source of oil. In both crops the presence of gossypol or related substances in the seeds limits current use. However, lines low or free of gossypol are also feasible.

Cucurbitaceous seeds as oil sources. The uses of cucurbit seeds as sources of oils and proteins have been reviewed by Jacks, et al. (1972). After the hull is removed, cucurbit seeds contain about 50 percent oil and up to 35 percent proteins. Most of their oil is made up of non-saturated fatty acids, thus of high nutritional values. Conjugated fatty acids among some cucurbit oils make them highly useful as drying oils. [I.e. they combine readily with oxygen to form an elastic, waterproof film. Ed.] The proteins, on the other hand, are principally of the globulin type, and are deficient in lysine but also in sulfur-bearing amino acid. Protein efficiency ratios of about 30 to 70 (that of powdered skim milk is 80) have been measured. The PER improves with addition of lysine.

The uses of cucurbit seeds for their high protein and oil content have many precedents. In tropical Africa two species of Telfaria (see Table 2) are used for their large oily seeds. Hodgsonia, a perennial vine with large, fatty seeds, has been domesticated as an oil source in China (Chien, 1963), where it

is known as the lard fruit. Cucurbita mixta was domesticated in pre-Colombian Mexico and Central America chiefly for its seeds, sources of protein and oil. The nutritive value of pumpkin seed is improved when the meal is mixed with soy flour or supplemental lysine (Craveola & Cervantes, 1965). In West Africa, the seeds of Citrullus lanatus are used as commercial sources of oil (Omidiji, 1977). These and seeds of Cucumeropsis edulis and Lagenaria siceraria are used in melon soups for their oil and protein content. Important species used for oil are given in Table 2.

As a general rule, cucurbitaceous plants prefer dry climates, and many are so riddled with disease in the humid tropics that production is impossible. When there is a pronounced dry season it is often possible to grow the vines, produce the fruits, and store the seeds for use as needed. A few species useful for their seeds can be grown in the humid tropics as shown by our experience in Puerto Rico. The most successful species are Benincasa hispida, the wax gourd, and Cucurbita moschata, the tropical pumpkin. If fruits are carefully protected from excess moisture, Lagenaria siceraria, the bottle gourd, can also be grown. In Table 3, experience at Mayaguez, Puerto Rico is summarized.

Benincasa hispida is perhaps the best of the cucurbits as a source of seed oil for the hot, humid tropics. It can be produced at any season of the year. During the rainy season the fruits are susceptible to rotting. They can be protected by growing the vines on trellises or by placing thick but porous supports between the fruit and the wet ground. The fruits are very large, and are very seedy. If the fruits are sound, they can be stored for many months, even a full year, until used. Or, the seeds can be removed and dried, as later discussed. Per hectare yields of these seeds have been estimated in our fields as 500 kg/hectare.

Uses of cucurbit seeds. Seeds of cucurbits can usually be readily separated from the stringy pulp to which they are attached. Sometimes a light fermentation for 24-72 hours of the wetted seeds is useful to clean the seeds of pulp. The cleaned seeds are carefully washed and can then be processed for use or dried for storage.

Fresh, wet seeds sometimes are chewed without further processing. They also can be toasted, with

or without light salting. Or, they can be cooked into soups with or without removing hulls. Naked or almost naked seeds of Cucurbita pepo are especially desirable for such uses because of the lack of seed coat. This means, also that the concentration of oil and protein are very high, and the concentration of fiber is very low in the edible part.

If the seeds are to be stored, they should be carefully dried in the sun or at lowest settings in an oven. Stored seeds retain most of their nutrient content for years and are convenient for rapid later use. The seeds can then be cooked with or without dehulling, or can be ground into a nutritious oily meal.

At our own laboratories we have emphasized the preparation of vegetable curds from cucurbit seeds as an unique method of using the protein and oil. In table 4, the results of tests in Mayaguez, Puerto Rico are summarized.

All of the cucurbits with the exception of the Luffa species produced a very satisfactory vegetable curd, as good as tofu from soybeans. These curds were rich in protein and oil and contained no more than minor and insignificant traces of the seed coat. However, the vegetable curds are usually very fine and difficult to separate from the whey by filtration. In one case, Benincasa, the use of vinegar or lime juice yields a better, more manageable curd.

We consider these results preliminary but very promising. Studies of the protein and oil content of the Benincasa seeds and curd are planned.

Although hand presses can be used to remove oil from cucurbit seed, we consider these and solvent based practices unsuitable for the small household. We have not yet found a satisfactory solution to the need to produce cooking oil from the seed by small scale household processes.

Thus, preliminary consideration of cucurbita seeds as sources of vegetable oils are promising. Extensive further studies are needed to select appropriate species and varieties, and to develop appropriate techniques at the household level.

SOURCE OF FAT LIMITATION NOTE
African Oil palm Awkward for small scale production
Coconut Palm Awkward for small scale production
SoybeanTropical Varieties needed. Suitable in many areas
Peanut Suitable in many areas
Safflower Requires dry climate
Sesame Needs dry climate
Sunflower Pollination often poor in tropics
Flax Not adapted to the tropics
Castor bean Not suitable for household production
Cotton seed Not suitable for household production
Okra Under investigation, probable small to large scale value

SPECIES NOTES
Benincasa hispida Wax gourd. Appears very suitable for the hot, humid tropics. Seeds seldom used for food.
Citrullus lanatus Watermelon, selected varieties. Definite preferences for dry climate, a West African species.
Cucumeropsis edulis Egusi. Definite preference for dry areas. Used in West Africa.
Cucurbita maxima Squash. Domesticated chiefly for its flesh principally temperate zone.
Cucurbita mixta Squash. Domesticated and used for edible seeds. Dry area.
Cucurbita moschata Pumpkin. Seeds edible, but this species is grown chiefly for its flesh.
Cucurbita pepo Squash. Widely used for its fruits and to a lesser extent for its seeds.
Hodgsonia macrocarpa Lard fruit. Recently domesticated in China, subtropical.
Lagenaria siceraria Bottle gourd. Seeds edible, but used chiefly in West Africa, prefers dry conditions.
Luffa acutangula Angled luffa. Seeds and seed oils very bitter, poisonous
Luffa cylindrica Sponge gourd. Seed and seed oils bitter, may be poisonous.
Telfairia occidentalis Oyster nut. Seeds roasted or rendered, wet tropical Africa.

Telfairia pedata Oyster nut. Seeds roasted or rendered, dry tropical Africa.

SPECIES	WINTER	SUMMER
Benincasa hispida	Excellent yields	Excellent yields, fruit rots
Citrillus lanatus	Low yields	Complete failure
Cucumeropsis edulis	Low yields	Complete failure
Cucurbita mixta	Fair yields	Complete failure
Cucurbita moschata	Good yields	Fair yields
Lagenaria siceraria	Excellent yields	Fair yields
Luffa acutangula	Fair yields	Fair yields
Luffa cylindrica	Fair yields	Fair yields
Telfairea occidentalis	Low yields	Low yields

Literature cited

1. Chien, H.S.U. 1963, "Lard Fruit", domesticated in China. Euphytica 12(3): 261-262.

2. Craviota, R. O., & Cervantes, M. 1965, Estudio sobre proteinas y aminoacidos de alimentos mexicanos. Ciencia 24: 83-88.

3. Curtis, L. C. 1948. The use of naked seed in cucurbita pepo as a source of high quality liquid vegetable fat, as a high analysis protein, as a new confection, and as a sandwich spread. Proc. Amer. Soc. Hort. Sci. 52:403-406.

4. Jacks, T. J., Henserling, T. P., and Yatsu, L. Y., 1972, Cucurbit seeds I. Characteristics and uses of Oils and Proteins. A. review. Econ. Bot. 26:135-141.

5. Omidiji, M. O., 1977, Tropical Cucurbitaceous Oil plants of Nigeria. Vegetables of the Hot Humid Tropics, 2:37-39.

Dry farming

Echo technical note a-8

DEFINITION:Dry Farming is the profitable production of crops, without irrigation, of land with a low average or highly variable rainfall.

Fundamental principles

1. Farm practices must conserve and utilize the available rainfall to the fullest extent.
2. Quick maturing, drought resistant crops must be grown.

Requirements

1. Rainfall must be greater than 10 inches per year (250mm).
2. Wind and heat must not cause excessive evaporation at critical stages of plant growth.
3. Soil should be deep (preferably 10 feet - 3 meters) with no clay, sand, or gravel seams to interfere with capillary movement of water. The minimum feasible soil depth is 18 inches (450mm) but water storage capability and drought resistance increases with increasing soil depth.

To obtain maximum storage of moisture under any rainfall condition, the soil must absorb as much water as possible when it rains and losses by evaporation or transpiration must be kept to a minimum.

I. Increase water absorption

A. PREVENT A WATER SEAL AT SURFACE. Probably the greatest deterrent to a high rate of water absorbtion is the tendency for soils to puddle at the surface and form a seal against water intake. The beating action of raindrops tends to break down cloddiness and disperse the soil.

1. By tillage, create a rough, cloddy surface which lengthens the time necessary for the rain to

break down the clods and seal the surface. For seed bed preparation in general, small seeds should have a finer, mellower bed than large seeds.

2. After harvest, create a stubble mulch on the surface. Such material not only prevents raindrops from inpinging directly on the soil, but impedes the flow of water down the slope, increasing absorbtion time.

B. REDUCE THE RUNOFF OF WATER. To the extent that waterlogging is not a problem, the runoff of water and its attendant erosion must be stopped.

1. Cropland should be as level as possible.

2. All tillage and plantings must run across (or perpendicular to) the slope of the land. Such ridges will impede the downward movement of water.

3. For every two feet of vertical drop or 250 feet of horizontal run, the field should either have bunds or contour strips (details of these practices are discussed later).

II. Reducing the loss of soil moisture

A. REDUCING SOIL EVAPORATION. Water in the soil exists as a continuous film surrounding each grain. As water near the surface evaporates, water is drawn up from below to replace it, thinning the film. When it becomes too thin for plant roots to absorb, wilting occurs.

1. Shelter belts of trees or shrubs reduce wind speeds and cast shadows which can reduce evaporation 10 to 30 percent by itself and also reduce wind erosion.

2. Mulching reduces the surface speeds of wind and reduces soil temperatures.

3. Shallow tilling can create a dirt mulch 2 to 3 inches deep which dries out easily but is discontinuous from the subsurface water, preventing further loss. Tillage must be repeated after

each rain to restore the discontinuity. This is most workable where rainfall occurs in a few major rainfalls with relatively long intervals in between.

B. REDUCING TRANSPIRATION. All growing plants extract water form the soil and evaporate it from their leaves and stems in a process known as transpiration.

1. Weeds compete not only for soil nutrients, but water as well and so their control is critical.

2. Selection of crop is significant as well. Dwarf varieties have less surface and so lose less water. Some plants close their stomae when it is hot, reducing their water loss. Others, like corn, curl their leaves during hot afternoon and open them at night, effectively changing their surface area in response to conditions.

3. In dry farming, the number and spacing of plants is reduced so that fewer plants compete for soil moisture. The exception to this occurs when allowances for insect, bird, and rodent loss must be made at planting.

4. Where rainfall is frequently marginal to insufficient, drought "insurance" can be obtained by clear fallowing a sufficient area. An area clear of growing vegetation with a properly maintained stubble and soil mulch can retain 20 to 70 percent of the precipitation received until the next year. Where 5 to 6 acres each year per family have been so set aside in India, the specter of famine due to drought has been eliminated.

5. Post harvest tillage will create stubble and dirt mulches and destroy weeds before the onset of the dry season.

III. Dry farming practices

Dry farming builds upon a knowledge of general agriculture but carries out its practices in the light of the significant probability that this year or next will be a drought. The following agriculture

practices are discussed with this back-ground.

A. BUNDING. The first essential step in dry farming is bunding. The land is surveyed and level contours determined every hundred feet. For unusual slopes, it is recommended that for every fall of two feet, a bund 18 to 24 inches in height be constructed. Even when land is fairly flat, a 12 inch high bund every 250 feet is still found useful. Excess storm water is released by constructing periodic waste weirs with a sill of one-half bund height. This will retain water and minimize the loss of topsoil.

In order to make the bunds, land must be marked by the surveyor with bund lines. A few feet on either side of it, the land should be plowed and harrowed. The bund former should be worked along the bund twice, side by side, leaving a furrow in between. This furrow in the middle should be filled in with soil from the plowed portions on both sides, by means of a scraper. The outlets or "waste weirs" should be constructed of stones.

The natural drainage of the area must not be completely stopped but should be controlled by providing suitable outlets for excess storm water to pass gradually, without carrying much silt with it, and after fully saturating the soil and subsoil. The major natural drains in each village area or watershed must be properly maintained so that all fields have some outlet for the extra storm water.

B. STRIP CROPPING. Strip cropping is a technique that serves to control erosion and increase water absorbtion thereby maintaining soil fertility and plant response. In effect, it employs several good farming practices such as crop rotation, contour cultivation, stubble mulching, etc.

By growing in alternating strips crops that permit erosion and exposure of soil soil and crops that inhibit these actions, several functions are performed:

1. Slope length is maintained.
2. Movement of runoff water is checked.

3. Runoff water is desilted.
4. Absorption of rainwater by soil is increased.
5. Dense foliage of the erosion resisting crop prevents rain from beating directly on the soil surface.

Strips are, of course, planted perpendicular to either the slope of the land or the prevailing wind direction, according to whether water or wind presents the more serious erosion potential. Additionally, crops which do not resist erosion should be rotated with crops which do. Research has shown that:

1. A normal seed rate of groundnut (peanut) is an efficient and suitable crop for checking erosion.

2. The normal seed rate of leguminous crops other than goundnut does not provide sufficiently dense canopy to prevent raindrops from beating the soil surface; is should be raised to three times the normal seed rate.

3. On the average, the most effective width of contour strips for cereals such as sorghum and millet is 72 feet and for the intervening legume, 24 feet. As slopes vary, so do the optimum strip widths, as shown below:

C. SUMMER FALLOW. All of the principles of water conservation and utilization pertaining to dry-farming will not make a crop grow if sufficient rain does not fall. Where the soil depth exceeds 18 inches (450mm), however, it has been shown that it is possible to store water as soil moisture from one year to the next by the use of proper summer fallow techniques. With a soil depth of 10 to 15 feet, up to 75% of the incident water may be retained though 20% to 40% is more normal. Thus, in an area that averages sufficient rainfall for crop growth, it will be rare that the sum of the stored water and incident water will not be sufficient for crop production. Where families in India have faithfully set aside 5 to 6 acres for summer fallow each year, drought-induced famine has been virtually eliminated.

The partial loss of a crop in the year of fallow is offset to a great extent by a very much increased

yield in the year of cropping. Such increased yield in a year of failure of the general crop in the surrounding areas, has a far greater value than a normal crop of a good season.

In order to accomplish this objective, the soil must be loose and permeable to soak up the rainfall and the dirt/stubble and mulch must be maintained to minimize evaporation. The land is worked with a tine-cultivator followed by occasional harrowing, particularly after rainfall, and weeds (which use as much or more water as crops) must not be allowed to grow. Though this expenditure on cultivation is relatively small, neglecting to provide the surface mulch at any time may cause more moisture to evaporate in a few, hot days than would fall during the whole season.

Experience has shown that where rainfall is 10 to 15 inches per year (250 to 375 mm/yr.) a clear fallow every other year is necessary and, at 15 to 20 inches per year (375 to 500mm/yr.), every third year.

D. MULCHES:

1. MECHANISM OF SOIL DRYING. Water easily enters porous soil and, as it seeps downward, becomes absorbed as films of water around the soil grains. These films form a continuous column of water to the surface of the soil. The film tends to remain the same thickness around all the soil grains with which it is in contact. This film of water in the soil is known as the capillary water and is the source of water for the plants.

The sun, wind, and dry air will cause evaporation at the surface, thus reducing the thickness of the film at the surface. The thicker films in the subsoil will rise to equalize the distribution again. This will continue until the films are so thin that the plant roots can draw no further moisture from them. The result is drought.

2. STUBBLE MULCH. Stubble mulching aims at disrupting the soil drying process by protecting the soil surface at all times, either with a growing crop or with crop residues left on the surface during fallows. To be effective, at least one ton per hectacre must cover the surface, and the maximum

benefit per unit residue is obtained at about two tons per hectacre. Benefit may still be obtained at 8 tons per hectacre.

The first benefit of a stubble mulch is that wind speed is reduced at the surface by up to 99%, significantly reducing losses by evaporation. In addition, crop and weed residues can improve water penetration and decrease water runoff losses by a factor of 2 to 6 times and reduce wind and water erosion by factors of 4 to 8 relative to a bare fallow field.

There are two limitations to the advantages of stubble mulch farming:

a. Dead surface vegetative matter can provide a home/breeding ground for plant diseases, insects or rodents. Use of a mulch not related to the succeeding crops will minimize much of the disease and insect effects. Use of stubble mulch only in the dry season will minimize all biological activity.

b. For decomposition, the ideal carbon to nitrogen ratio (C/N) is 25 to 30. Dry, woody, or non-green straw, stalks, etc. have a C/N of 50 to 100. This tends to slow decomposition and deplete soil nitrogen temporarily. Nitrogen is a major requirement for protein synthesis by plants. A stubble mulch during a biologically active period such as the rainy season, should only be used when either:

1. Soil nitrogen is very high.
2. Plant nitrogen needs are very low (such as cassava).
3. A nitrogen-containing fertilizer is used.

To obtain the benefit of mulching on soil structure without causing temporary de-nitrification, the mulch can be composted before adding it to the soil. Rapid bacterial action in the tropics makes composting less beneficial than in temperate climates but may still be worthwhile.

3. DIRT MULCH. Dirt mulching aims at disrupting the soil drying process with tillage techniques that separate the upper layer of the soil from the lower layers, making the soil moisture film discontinuous. In addition the soil surface is made more receptive to water intake.

Principles of dirt mulching:

a. Effectiveness increases with increasing depth to a limit of to 4 inches (75 to 100mm).

b. Increasing the dirt mulch depth decreases the available fertile soil.

c. The effectiveness of dirt mulches decrease with age. Consequently it must be recreated by shallow tillage of harrowing after each rain or each month (whichever is more frequent).

d. The crumb form of dirt mulch (particles greater than 1mm) is more effective and resists wind erosion more than the dust form.

e. Dirt mulches can only be properly made when the soil is moist.

f. For a climate with a "rainy" growing season and a hot, windy, dry season, dirt mulching should only be performed during the rainy season and with a growing crop to slow the wind and water and hold the soil.

The improper use of a dirt mulch presents serious erosion potential. The "dust bowl" condition in the great plains of the U.S. that destroyed or damaged millions of acres of prime cropland was a direct consequence of the abuse of the dirt mulch.

E. PLOWING/TILLAGE PRACTICES. Plowing, when the soil is in the proper condition, wears the soil into thin layers, and forces the layers past each other. If the soil is too wet when plowed (especially if it is heavy), the soil crumbs or granules are destroyed, thus puddling or compacting the soil. When the soil is too dry, the soil tends to pulverize and form dust. Plows with steep moldboards have the greatest pulverizing action upon the soil. The plow with the less steep moldboard has less tendency to puddle the soil and is of less draft.

1. Purposes of Tillage Operations:

a. To produce a rough, cloddy surface that will increase moisture absorption and reduce runoff, as well as erosion from wind and water.

b. To control/destroy weeds that compete with crop for sunlight, nutrients, and water.

c. To destroy or prevent the formation of a hard pan (sole) which can develop after repeated shallow plowing or harrowing. This hard pan can stunt root growth, reduce water storage, and check the capillary rise of water from the subsoil.

d. Promote bacterial activity by aerating soil, encouraging the decay of residues and the release of nutrients.

2. Time of Tillage:

a. Plowing, like planting, is sensitive to moisture and neither should be done when soil is either too wet or dry. In the arid and semiarid tropics, proper moisture conditions are likely to occur only at the beginning of the rainy season and should be done on the same day. If possible, planting should immediately following plowing, with seed rows centered on the furrow slices. A crosswise harrowing will cover seeds and close air spaces, thus creating a dirt mulch and keeping out the drying winds. If the crop is then harrowed/cultivated several times during the season, especially after rains, much moisture will be conserved. The proper soil moisture condition for plowing is indicated by a manual soil test. The usual test is to squeeze a handful of soil. If it sticks together in a ball and does not readily crumble under slight pressure by the thumb and finger, it is too wet for plowing or working. If it does not stick in a ball, it is too dry. When examining soils, samples should be taken both at and a few inches below the surface. Soil that sticks to the plow or to other tools is usually too wet. A shiny, unbroken surface of the turned furrow is another indication of excessive soil moisture. In general, sandy soils and those containing high proportions of organic matter bear plowing and working at higher moisture contents than do heavy clay soils.

b. In semi-arid regions, the soil after harvest time is generally too dry for good plowing. Yet if the

field is left uncultivated, this dry condition may become even worse and weeds will also grow and go to seed. The field should be harrowed (or plowed without moldboard) and crop residues left to form a stubble mulch to absorb/retain moisture and soil until the rains return. Stubble should not be immediately covered and incorporated in the soil unless rodent or insect infestation is heavy (and even then burning should be considered). It has been well demonstrated that it is normally impossible to raise the soil organic matter content in areas where temperatures are high for long 0periods. When moisture is present, the rates of oxidation are extremely high and incorporated organic matter is lost quickly. The benefits thus derived from decomposition, as occurs in the more temperate regions, are not normally experienced. When left on the surface, however, organic matter does not decay so rapidly. Incorporation with the soils will tend to depress the levels of available nitrogen, to the detriment of crops if soil nitrogen is low. If soil nitrogen levels are adequate, the incorporation of residues to the soil may be beneficial if done with spring plowing at the start of the rainy season.

3. Depth of Plowing

a. Variation with Soil Type. Generally speaking, heavy clay soils should be plowed deeper than light, sandy soils, in order to promote circulation of the air and bacterial activity. Deep plowing on sandy soils, which are naturally porous and open, tends to disconnect the seed bed from the subsoil and speeds soil drying by too free a circulation of air in the soil.

b. Depth Affects Moisture Reservoir. In semi-arid climates, the greatest advantage to be gained from deep plowing (5-8 inches) is the development of a comparatively large moisture reservoir. When land is not plowed more than 3 or 4 inches deep for a period of years, a hard plow sole is very likely to form, through which roots and rain can only penetrate with difficulty. A shallow plow sole will saturate quickly with rainwater and increase runoff rates. As a rule, tillage below 5-6 inches also causes increased evaporation rates, losing precious water. This deep plowing need not necessarily be done annually. Depending on soil and rainfall, a deep plowing of 5-6 inches every 2 to 5 years is satisfactory. As noted earlier, the soil mulch attains maximum effectiveness at a depth of 3-4 inches

which can be maintained with a hand harrow/cultivator.

c. Exposure of Acidic Subsoil. Deep plowing in some clay and loam soils will reduce yields for one or two seasons afterward as a result of an acidic subsoil. This may be dealt with by liming the soil (neutralizing the acidity) or by varying the depth of the plowing slowly so that the acidic subsoil is exposed a little at a time. This practice will also eliminate the plow sole.

4. Seed Bed Preparation. In general, smaller seeds require a finer, mellower seed bed than larger seeds. Seeds germinate and plants grow more readily on a reasonably fine, well prepared soil than on a coarse, lumpy one, and thorough preparation reduces the work of planting and caring for the crops. It is possible to overdo the preparation of soils. They should be brought to a granular rather than a powder-fine condition for planting.

F. PLANTING

1. In rows: Planting of crops should be in rows to permit inter-tillage as described later.

2. Planting density: Limited moisture dictates the necessity for wider row spacing and lower rates of seeding (by one-half to two-thirds) than are used in moisture abundant areas. The resulting reduced plant population provides more moisture and nutrients per plant and thus enhances the possibility of the crop reaching maturity before the supplies are exhausted. Cereals should be planted 7 to 14 inches (18 to 35 cm) apart and crops such as millet, sorghum, sesame, safflower, etc. in rows 28 to 42 inches (70 to 105 cm) apart. In some cases, the practice of planting 2 or 4 rows and skipping one is successful in further increasing the efficiency of moisture utilization. In general, with limited rain, higher seed rates produce more straw/stubble at the expense of grain production. (See Table II, below)

G. INTERTILLAGE/INTERCULTIVATION. Crops sown in rows can take advantage of intertillage practices which serve three basic functions:

1. Easy weeding without meticulous hand labor. Weeds compete for moisture and nutrients, thus they should be destroyed while small, before they have grown more than 2 or 3 leaves. If seeds are broadcast, or thickly sown, they can at best only be cultivated manually, a back-breaking task.

2. Increase the formation of nitrates by bacteria. Intercultivation aerates the soil and forms a mulch of dead weeds and stubble on which bacteria operate and form nitrates. Cultivation for this purpose should be undertaken during the early period of plant growth, and should be relatively deep, on the order of 2-3 inches.

3. Intertillage conserves moisture by the formation of a dirt mulch as described earlier. It is imperative that cultivation be performed after rainfalls. Even a light rain can re-form capillary connections between the stored soil moisture and the surface of the ground. After a few drying days like that, it is possible for soil moisture to be lower than before the rainfall.

H. CROP ROTATION AND VARIETIES.

1. UNIQUE ASPECTS OF CROP ROTATION FOR DRY FARMING. One of the first principles of dry farming with regard to cropping practices is that crop rotation as practiced in more humid regions is not necessarily recommended in semiarid lands. The following constitute the chief differences:

a. Only a limited number of crops are adapted to the climatic conditions and the farmer must sow the crop best suited to the moisture conditions encountered at that time.
b. Moisture is so dominantly limiting, that "soil improving" crops are much less effective than in more humid areas.

c. Success with rigid or complex sequences is difficult in the face of widely varying rainfall.

2. REASONS FOR CROP ROTATION. There are five basic reasons why crop rotation should be practiced:

a. Moisture Conservation: Any system of crop rotation should be planned with moisture requirements as the main consideration. For a given set of climatic conditions, a crop may be described as either moisture dissipating or conserving. After harvest of a moisture conserving crop, the soil contains more moisture than at planting. This reserve of moisture can help guarantee the succeeding crop. (see paper on Determining the Water Needs of Plants). Crops which are sown in rows so that intertillage and dirt mulching can be practiced tend to be moisture conserving. Under sowing may also assist in conservation. Moisture may be insufficient to both grow a crop and conserve enough water to ensure the succeeding crop. In such a case it is necessary to utilize the dirt and stubble mulched fallow in the rotation. If annual rainfall is 10 to 15 inches (250 to 375 mm) this will be needed at least every other year; if rainfall is 15 to 20 inches (375-500mm) at least one in every three. In the West African sahel drought may be expected one year in four. Between 1968-1973 the rate was one year in two. In a situation like this, setting aside mulched fallow each year for moisture conservation will significantly aid survival. Where this has been faithfully practiced in similar areas in India, the specter of famine by drought has been virtually eliminated.

b. Pest Control. Where related crops are successively planted in the same place, viruses, molds, blights, and selective insect pests tend to build up in the soil. Crop rotation that leaves at least two years in between subject plants in the same location will eliminate the abnormal buildup of most such pests for most crops.

c. Erosion Control. Plants which are thickly planted or which produce a thick ground cover tend to resist erosion much better than those which are intertilled or tend to be moisture conserving. Loss of soil due to erosion is a significant dry farming problem and erosion controlling crops should be included in a rotation, preferably in a strip cropping mode.

d. Soil Nutrients and Structure. When related crops are successively planted, specific soil minerals and nutrients are withdrawn faster than they can be replaced by decay or subsoil movement. This selective depletion causes a soil to be "worn out" quickly. Simple rotation of crops makes depletion more uniform so that soils "wear out" more slowly. The planting of legumes (such as gram or

groundnut or alfalfa) with their nitrogen fixing capabilities tends to restore soil fertility. The use of green manures (plowing under of a green crop, such as alfalfa, rather than harvesting) can also aid soil nutrients and texture but benefits may be short lived in the tropics and difficult for Third World farmers. The planting of any deep or thickly rooted plants (such as grasses, alfalfa, etc.) tends to improve soil structure and draw subsoil nutrients to the surface like a natural fallow and can increase pasturage during dry periods. Crops like cassava which require relatively little soil nutrients may also be grown for rotation or when soil is almost worn out.

e. Distribution of Labor and Risk. It is generally advisable for the subsistence farmer to grow all crops in the rotation scheme simultaneously, apportioning to each crop the fraction of fields that it requires. This helps the scheduling and distribution of labor at the bottlenecks (planting, harvesting, etc.) so that the entire crop need not be done simultaneously. There is also a reduced risk of total crop failure and increased variety/nutrition in the diet.

3. CROPS AND VARIETIES. Choice of varieties is important. Varieties which have proven excellent in irrigated or high rainfall areas are generally unsuited for dryland conditions. Many attempts at dryland farming have failed, largely due to lack of recognition of the requirements for the variety selection.

a. Variety Requirements For Dry Farming

1. Short-stemmed varieties with limited leaf surface minimize transpiration.

2. Deep, prolific root systems enhance moisture utilization.

3. Quick-maturing varieties are important in order that the crop may develop prior to the hottest and driest part of the year and mature before moisture supplies are completely exhausted.

b. Climatic Requirements of Crops in Brief

1. The TABLES below list favorable conditions for various annual crops.

HIGH TEMPERATURE TOLERANCE
Cotton, Groundnut, Chilies, (favor jute & yams only in humid tropics)

DROUGHT RESISTANCE
Common Millet, Barley, Chickpeas, Safflower (lower temperatures), Sorghum, Bullrush Millet, [Phaseolus] crops, [radiatus] (gram mung bean), Cassava, Castorbean, Sesame, Groundnut (Spanish variety), Pigeon peas, Sunflower

LOWER TEMPERATURES FAVOR
Wheat, Potato, Sugar, Tomato, Safflower

VERY HIGH RAINFALL
Rice, Cassava, Yam tolerance

WIDE CLIMATIC TOLERANCE
Size, Soybean, Groundnut (Valencia & Virginia type), [Phaseolus lunatis,] Kenaf, Hemp, Sweet Potato, Sugar Cane, Tobacco

Muscovy ducks for png villages

Echo technical note b-2

(This is an original manuscript by F. Bauer, Poultry Research Center, Labu, Papua New Guinea. It has merely been retyped by ECHO to make it more compact for airmail.)

Breed description

The Muscovy is a heavy bird, suitable mainly for meat production. Under good management, with proper feeding, the drakes (male ducks) will reach 4.0-4.5 kg and the ducks 2.0-2.5 kg at 16 weeks,

which is usually the age at which the birds are sold to be eaten. Most of the Muscovys are pure white but black ones also exist. There is also a full range between black and white. All the birds develop red flesh around their eyes and at the base of their bills. In older drakes, it may even appear on the back of the neck and wings. With good feed, the ducks will lay about 90 eggs per year and will hatch ducklings very successfully. The breed is very hardy and can get alot of its feed requirement in foraging. Traditionally, the PNG Farmer does not feed its poultry and relies on natural incubation for breeding. The Muscovy duck is ideally suited for the PNG village conditions.

Raising ducklings from 0 to 6 weeks

A. Site of the projects. For a duck project, choose a place:

(1) close to the village, to be able to look after the ducks easily,
(2) where there is good shade (if the ducks stay a long time in the sun, they may get sick),
(3) where there is green fresh grass for the ducks to eat and find insects,
(4) not close to a pig fence (very often, pigs kill and eat ducks),
(5) where hawks do not usually fly,
(6) near a creek or pond, if possible.

Avoid places that are dry, sunny, or covered with kunai grass.

B. Housing. A small house of 3 x 5 m, made out of bush material will be enough for 20 ducklings. Make two windows to give plenty of light inside this house, as ducklings will not grow well in a dark place. Make the house cat and dog proof. In a corner of the house, make a small, covered room (of about .5 x .5 x .3 m) where the ducklings can go and sleep or huddle together out of the wind if they are cold. On the floor, put some deep litter. This can be sawdust, shavings, coffee skin or dry, finely chopped kunai. This deep litter should never become wet.

C. Feeding. Although it is a bit costly, it is recommended to feed the ducklings with a commercial

feed for the first six weeks. Broiler starter, pullet starter, broiler finisher are suitable. Do not use layer mash or crumble, pullet grower or developer as these feeds are too low in protein. A duckling will eat about 3 kg of feed for this period. At the end of the fifth week, start to feed some locally produced feed with the commercial ration. Anything that people eat is suitable for ducklings. Choko, both leaves and fruits is very good for ducks. Cook the feed.

D. Water. Water must be available inside the house all the time. Troughs made out of bamboo are quite good. It is better to have a creek or a pond where the ducks will be able to drink and wash later on, but it is not absolutely necessary. 44 gallon drums cut lengthwise, or a big cooking pot in the ground will be enough, provided that they are refilled regularly.

E. Looking after the ducklings. On the coast, and up to 1000 m, the ducklings can look after themselves very well. For the first five weeks, they must stay inside the house all the time. During the sixth week, they can start to go out, a few hours every day. It would be best to have somebody to check them during that time. In the Highlands (above 1000 m), cold weather might be a problem for the first two weeks. Here are a few possible solutions: (1) Keep the ducklings in a centrally situated brooder for two weeks before distribution. (2) Make a small round enclosure, about one meter in diameter with flat iron, woven bamboo, strong cardboard box, etc. and cover it with old bags, leaving an uncovered strip, about 30 cm wide in the middle. Put a kerosene lamp inside the enclosure, in the strip not covered by the bags. (3) Take a box (beer carton or the like) and make a few holes in it. Every night, or when the weather is very cold, put the ducklings in the box and close it. Let the ducklings out in the morning, or when the weather improves. During the day, do not keep the ducklings inside the box for more than two hours. (A beer carton will be enough for 10 ducklings.)

Raising ducks from six weeks to four months

After six weeks, the ducks can be fed entirely on locally produced feed-sweet potatoes, taro, banana, pumpkin, choko, etc. Anything good for people is good for ducks. The food must be cooked. To know

how much feed to give to the ducks, follow this simple rule: If the ducks eat everything within half an hour and nothing is left, they are still hungry. Cook more next time. If after half an hour, the ducks start to wander away from the feed, and some of it is still left, they have had enough.

Feeding ducks locally produced feed is not enough. Every day, they must be able to graze. It is only in grazing that ducks will get the protein necessary for their growth. These proteins will mainly be insects and grass seeds which are not found on bare ground or in short grass. Even a very big fence will not give enough grazing land because as soon as all the grass is finished, the ground will be laid bare and hard by grazing and trampling of the duck feet. There must be no fence around a duck house. A fenced-in project is a project which will fail. It is better to have a few ducks lost to dogs or other predators than to have the whole flock dying due to protein deficiency. Protein deficiency will result in:

(1) Poor growth-the duck will never be heavy enough to eat,
(2) no feathers-the duck will be cold, sick and will die,
(3) no eggs-the duck will never lay eggs.

The best way to look after ducks after six weeks is to keep them overnight in the house, Let the ducks out at about 8 o'clock in the morning. They will be hungry and active and look for insects and grass. Before sunset, feed the ducks. It will help if the owner always calls his ducks in the same manner (call, bell, etc.). They willcome quickly by themselves and will not need to be rounded up. Lock the duck for the night. Put water in the house. At four months, the ducks will have reached their biggest weight. Under village conditions, it will be about 2.0 kg for the drakes and 1.2 kg for the ducks. They should then be eaten or sold as after that their meat will become quite tough. Do not keep a small duck in the hope that it will grow fatter. It is usually a waste of time and feed.

Breeding ducks
As it is cheaper for a farmer to produce his own ducklings than to buy them from the outside, he should do his own breeding. Only the best ducks and drakes must be kept for breeding. In this way

only, the ducklings hatched on the project will be strong and healthy. Do not keep any birds that have deformed wings, with the tip of wings pointing outside. Otherwise, there will be more and more of them on the project. Do not keep any bird that is smaller than the rest of the flock. Big parent birds produce big ducklings. The ducks kept for breeding will be the heaviest ones, of round appearance and with a belly that is close to the ground. The drake will be the heaviest one, with a belly parallel to the ground. Do not keep any drake which looks like it is standing with the breast much higher than the belly. Do not keep more than 10 ducks for breeding. Otherwise, it is probable that the garden produces will be in short supply to feed the flock and all the birds will do poorly. Keep two drakes for up to five ducks and three for up to ten ducks. Ducks can be kept for up to three years, but drakes should be changed every second year as after that they do not mate regularly and fertility decreases.

Laying

Under village conditions, ducks will start to lay eggs at 8 1/2 - 9 months of age. The first eggs will be small and should not be used for hatching. Small eggs are likely to be sterile (they will not produce a duckling) and even if they hatch, the duckling will be small and weak and will probably die within the first week. An egg is big enough for hatching when it weighs more than 72 g or if its diameter is more than 45 mm. The easiest way to check if an egg is suitable for breeding is to make a hole of exactly 45 mm in a piece of plywood or timber. If the egg passes through the hole, it is too small and must be eaten or sold. If it does not pass through the hole, it must be kept for breeding. The poultry Research Centre at Labu has a few of these measuring holes.

A duck will lay between 10 and 20 eggs. After that it will become broody and sit. If the ducklings are taken away from the mother after hatching, it will start to lay again after two to four months, depending on feeding. There is no laying seasons for ducks in Papua New Guinea. They lay all through the year. If it happens that, in a project, ducks are not laying after 12 months, there is something wrong. Most probably, the ducks are underfed and protein deficient. They will never lay eggs and all the ducks should be eaten or sold and the project terminated. However, it happens that

healthy ducks (fully feathered, weighing more than 1.3 kg) do not lay, for some, yet unknown, reason. If this happens, shift the project to a new site, in a different type of vegetation. If there is no improvement within the next six months, terminate the project. In many projects, it happens that a duck does not lay. It should be eaten or sold as soon as it is noticed. A non-laying duck can be recognised by the following signs: (1) it is heavier than the other birds,
(2) the flesh around the eyes is very red, like a drake instead of being pink or orange,
(3) the space between the two pelvic bones (pointing on both sides of the vent) is about one finger wide instead of 2 or 3.

Nests

Nests should be provided for the ducks to lay their eggs. There should be at least as many nests as there are mothers. Otherwise, they will disturb each other for favorite nests or try to sit two to a nest which is a bad thing. Two mothers in a nest will hatch less ducklings than one alone as more eggs will roll out and more ducklings will be trampled under their feet.

The nests should be about 30 x 30 x 40 cm (12 x 12 x 16") and be covered. This should prevent two mothers sitting together and drakes attempting to mate a sitting mother. Put a strip of timber, about 5 cm (2") wide in front of the nest, to prevent eggs from rolling out and to provide bedding such as sawdust, coffee skin, etc. Keep the nest clean at all times.

Role of the drake
It is widely believed on Papua New Guinea that a male is necessary for a female bird (chicken, duck, turkey, etc.) to lay eggs. This is not true. A female bird will lay as long as it has enough good feed and it is not sick. If a male (rooster, drake, tom turkey, etc.) is present, the birds will mate and the eggs wil be fertile and hatch. If there is no mate, the egg will be sterile, will rot, and will never hatch even if the mother sits. If a duck does not lay, do not blame the drake and try to replace it, but improve feeding or look for disease.

Handling of eggs

Another false belief is that if eggs are handled by people, they will not hatch anymore. Fresh eggs can be picked up and stored in a house for up to seven days. They will still be hatched if given to a duck to sit on. Eggs that are warm because a mother is sitting on them can also be handled but they must be quickly put back under the mother, before they cool off. A warm egg which cools off for a long time will become bad and rot. However, if eggs roll out of the nest during the night, it usually pays to put them back in the nest as most of them will still hatch. This is true at least for the coastal areas.

Hatching

Muscovy ducks have to sit for five weeks (35-37 days) before the ducklings will hatch. It will take between 12 and 24 hours between the first crack on the shell and the times when the duckling is fully out. As a rule, do not try to help the duckling to hatch. The only exceptions are if the duckling's head is already free but the rest of the body is "glued" to the egg shell or if the shell is cracked all around and the duckling does not have the strength to make the complete break through.

Do not enlarge a small crack. Normally, all the eggs should hatch within two days (as the ducklings start to develop inside the eggs only when the mother starts to sit non-stop). If after these two days there are still some eggs left, they should be checked. If the egg looks blue or has blue spots or streaks, or if when it is shaken it sounds like water is inside, it is bad and must be thrown away.

If the egg looks shiny and white, and if it stays warm even if the mother walks away for a while, it is a good one. It will be best to give it to another sitting mother. If there are none, the old mother can keep sitting, but not more than two weeks otherwise it will lose too much weight and might die. When there are no more eggs in the nest, clean it and put some fresh bedding material in it.

Care of the ducklings

It is best to raise the ducklings away from the rest of the flock as quite often drakes or other ducks will pick at and kill day old ducklings as they come out of the nest. Take the ducklings away from the mother as soon as they are completely dry and fluffy and raise them in the way described earlier.

One can either use a part of the old duck house or build a completely new one to raise these new batches of ducklings. Experience has shown that the best results are obtained if commercial feed is used for the first six weeks. Otherwise, mortality will be very high. At the end of the sixth week, the ducklings can go out on their own and join the rest of the flock.

Do not keep more than 40 ducklings at any time. Otherwise, it is most likely that garden produces will be in short supply and the ducks will not grow well. If more than 40 ducklings hatch at about the same time, it would be best to sell some to other interested farmers. Eat or sell the ducks as they reach 4 months unless some are needed to replace older ducks or drakes. When this new stock is mature and starts to breed, eat or sell the older ones. Do not let your breeding stock increase to more than 10 duck and 3 drakes as bigger numbers will not fit with subsistence farming.

Fruit crops

Tropical fruit tree crops are extremely variable in almost all relevant characteristics, including method of propagation, growth habit, use of the fruit, nutritional value, and adaptation. While seldom used as staple foods, their nutritional contribution (frequently vitamin C and sometimes vitamin A), is of great importance. Most fruits contain carbohydrates, frequently in the form of sugars, and often as starch. Relatively easy crops to produce wherever they are adapted, fruit crops are a welcome and useful addition to any small farm.

ECHO has budwood available from some superior varieties of some of these fruit trees. Budwood must be grafted to an appropriate rootstock within a very short time. If it is properly treated, some budwood will last for almost 1 week. If you are interested in obtaining budwood for grafting to trees overseas and you are presently in the U.S. and plan to pass through Florida, ECHO can supply you with scions (budwood) if you drop in just before flying overseas. Budwood may not be available at all seasons. Another option would be for us to send it via overnight express to you. You would need to cover the express charges. (ECHO also has a good video on grafting and also has available rootstock for visitors to practice grafting techniques). Fruit trees for which we only have seed are labeled "S";

those available for budwood cuttings are labeled "BW". Some of the seeds have short viability, and therefore are not kept in the seedbank, but we can put you on a waiting list and send seeds for these in season. We also sell grafted trees, but do not ship these. Some of the best trees in ECHO's collection are the following:

See A Comparison of Selected Tropical Fruit Crops

- Atemoya.Annona squamosa x A. cherimola. (S) Thrives in lowland tropics; seeds will usually become another atemoya but occasionally grows into one of the parents-grafting very common; germination time averages at about 4 weeks; delicious fruit.

- Barbados Cherry.Malpighia glabra. Propagated by cuttings, not by seed. High in vitamin C.

- Black Sapote. Diospyros digyna. (S).

- Carambola. Averrhoa carambola. (S, BW). Available Aug-June.

- Cherimoya. Annona cherimola. (S). This creamy Andean fruit requires close management (hand pollination and careful harvesting). Requires >1500 m elevation at equator and >1200 mm rain during growing season.

- Jaboticaba. Myciaria cauliflora. Available late fall/spring. (EDN 32-2, 34-2).

- Loquat. Eriobotyra japonica. (S, BW). Seeds viable for 8 days, available Feb-Mar.

- Papaya. Carica papaya (S). Sunrise, Waimanalo, Malaysia exotica. New Cariflora var. (EDN 15-4, 26-3, 32-1, 41-3).

- Passionfruit. Passiflora edulis. (S). Purple. Yellow produces a large oblong fruit with great juice yield; hand-pollinate to collect pure seed. (EDN 29-3).

- Soursop (Guanabana). Annona muricata.

- Surinam Cherry. Eugenia uniflora.. High in vitamin A.

- Jujube. Ziziphus sp. Burmese 'Salay Zee Thee'. Prolific bearer; thorny; cold, drought and flood tolerant.

Fruit vegetables

Crops in the category of fruit vegetables are a group of species almost entirely from two families, Cucurbitaceae and Solanaceae, which have little in common except that they are fruits. Most are of modest nutritional value, but all contain useful dietary fiber. Few are highly valuable as fruit vegetables, including the tropical pumpkin, the pepper, and the tomato. Others could be exploited for their seeds, which are especially rich in proteins and oils. However, others contain poisonous seeds (e.g., Luffa). Some produce edible leaves or shoot tips. Some species, especially tomato and pepper, are used as condiments and may contribute useful amounts of nutrients to the diet in this form. Some may have one or many improved varieties, which should be compared to local varieties for best results.

See A Comparison of Fruit Vegetables

- Achuffa (Pepino de Comer).Cyclanthera edulis. Fruits like hollow cucumber, may also be stuffed before cooking or pickling. Temporarily out of stock.

- Bottle gourd.Lagenaria siceraria. (Calabash or Birdhouse gourd). Edible only when very small. (EDN 8-3). Gourds used as containers/vessels; very prolific in subtropics. Buffalo gourd. Cucurbita foetidissima. Roots used for firewood; seed rich in oil and protein; requires long periods of warm dry weather; edible oil made from crushed seeds; native Americans used fruit, pulp, and vines as soap.

- Cucuzzi (Italian squash).Lagenaria sp. Does well in very hot weather; fruits harvested when 18"

long; can be used as a container when dried.

- Eggplant.Solanum melongena. Selected varieties of purple, white and striped available. (EDN 14-4).

- Loofah (sponge gourd). Luffa acutangula. Preferred as a vegetable; ridged fruit eaten when young. Luffa cylindrica. Smooth fruit, edible when young. Both species are vigorous climbing vines. Seeds toxic.

- Okra. Hibiscus esculenta. African type; likes the hot weather, but will produce in winter, unlike most okras.

- Pepper, Ensalada. Capsicum chinense. Perennial; produces small fruits that are usually not hot but have the taste and smell of hot peppers. Leaves can be cooked like spinach. Also available is Capsicum frutescens.

- Pumpkin. Cucurbita moschata. Tropical or Calabaza varieties: La Primera, Brian, CBDE, Trinidad, and Tropical mix. Seminole varieties: Acorn, Ingram Billie, Hardy, and Seminole mix. Vigorous, productive vines. (EDN 8-3, 18-2, 37-3).

- Snake gourd. Trichosanthes cucumerina. Young fruits eaten cooked; climbing vine.

- Tamarillo or Tree tomato.Cyphomandra betacea. Red Andean fruits used raw, in juice or jams. Requires high altitudes. Low-germination seeds available only.

- Tomato. Lycopersicon esculentum. Varieties with high vitamin A: Alcobaca-Beta (in breeding, its hybrids have high betas and extended shelf life), Floradade-Beta, Kewalo-Beta. Disease-resistant varieties offered individually or as a variety trial: Hayslip, Florida MH1, Tropic, Walter, Floradade. Others (can bear in summer): Open-pollinated-Matlinka, Saladette; Hybrids-Solar Set, Heatwave: not very disease-resistant but are able to set fruit at higher temperatures. Seed cannot be saved, as

they are hybrids. (EDN 24-1, 32-1, 36-4).

• Wax gourd or Chinese wintermelon. Benincasa hispida. Best cucurbit for seed oil in hot humid tropics; flesh eaten as a summer squash; the fruit can be stored for many months. (EDN 2-5, 8-3).

Grain crops

Grain crops are those that produce an edible dry seed which can be stored for a long period of time. The seeds of grain crops are normally milled to produce a flour, but sometimes they are softened by cooking and/or chemical treatment. The majority have high protein content accompanied by a good content of B vitamins. Some have fair to high oil content and/or Vitamin E. In addition, most have good quantities of carbohydrates, usually as starch. As a group, the grains are used chiefly in the production of breads. Grain crops are literally the staff of life for billions of people. The three most important food crops in the world are wheat, rice, and corn. Somewhat similar grasses include pasta wheat, barley, sorghum, pearl millet, rye, and triticale (a potentially important hybrid between wheat and rye).Teff is a major grain crop in Ethiopia. Buckwheat is an important grain crop from China, but it is not a grass. Amaranth, kaniwa, and quinoa, used extensively in the past by American Indians, are highly nutritious non-grass grains (called pseudo-cereals). Varietal differences are important ingrains. Individual cultivars often have particular seasonal and climatic adaptations. As a rule, crops are planted during a wet season and must mature during dry weather.

See A Comparison of Grain Crops.

• Amaranth.Amaranthus cruentus: Mexican R104 (Rodale). Manna: good producer. Amaranthus hypochondriacus: low growth habit, easy to harvest mechanically (Rodale). HH4/HH5-large yellow heads, excellent yields (USDA). (EDN 3-1, 4-1, 16-5, 23-6).

• Buckwheat. Fagopyrum esculentum. Cool, humid climates. Harvest two months after planting. Short season high altitude nurse crop used to shade ground; green manure; seed high in lysine; used in honey production ;wide soil tolerance; not for hot areas; needs good soil moisture

throughout growing season; frost-intolerant. (EDN 10-3, 38-2).

• Corn. Zea mays. Blue-100 day, large full ears, dark blue kernels, drought tolerant and disease resistant; Posole-100 day, large plump ears, drought tolerant flour corn. Papago-80 day, small slender cream-colored ears, drought tolerant flour corn. Rio Grande Red-110 day, 7 ft stalks, 1-2 ears of dark red kernals, this is a drought tolerant flour corn. Larger quantities available from Plants of the Southwest. [Sweet corn: see Miscellaneous Vegetables.] (EDN 16-1, 20-3,4,5, 21-3, 23-6, 28-2).

• Kaniwa. Chenopodium pallidicaule. High protein (16-19%), with well-balanced amino acids; does well on poor, rocky soils at high elevations; also survives frost; temporarily out of stock but would appreciate any sources or information on this plant.

• Millet. Echinochloa turnerana. (Channel Millet)-temporarily out of stock.

• Eleusine coracana (Dragon's Claw or Finger Millet). Less susceptible to bird damage than other millets listed below, low protein, long storage life, sea level to 2500 meters, cool moist climate; tillers.

• Pennisetum americanum (Candlestick Millet). Similar to Pearl millet.

• Pennisetum glaucum (Pearl Millet). Grain not as susceptible to Striga as other species, but very bird susceptible. Plant residue used for livestock feed, house building, fencing, and fuel. Harvesting may be irregular.

• Setaria italica (Foxtail Millet). Cooked whole, or made into meal, plant is used for hay or silage. Highly drought tolerant. Sea level to 200 m.

• Panicum sp. (Proso or Hog's Millet) Used as human and animal food, much the same as rice, or in flour. Short season, high in amino acids and carbohydrates. Wide soil variety, not frost tolerant, low

water requirement, but not as drought resistant as other grains, due to shallow roots.

- Oats, Naked. Avena nuda. An oat that has no hull.

- Quinoa. Chenopodium quinoa. High protein; seeds eaten like rice; grows well at high elevations on poorly drained lands, in cold areas and in drought. Day-neutral and equatorial varieties available (EDN 4-4, 11-3, 46-1,2,3). 'Ingapirca' has very low saponins requiring only light washing; best for very high altitudes, 3000-3600 m on equator; wind, frost and drought tolerant; 400-800 mm rain/yr; not tolerant of humidity. 'Tunkahuan' also has low saponins requiring only light rinsing; 2200-3400 m on equator; 600- 1200 mm rain/year, humidity-tolerant. 'Appelawa', 'Kaslala' are our Bolivian types, and 'Colorado 407' is a Chilean type.

- Sorghum. Sorghum bicolor. Giza 114-stalks also burned as fuel (Egypt). Bird-resistant-dwarf variety low in tannins; do not roast (EDN 46-5)(EDN 25-1, 32-6). Sweet Sorghum and Striga-resistant varieties available.

- Teff. Eragrostis tef. Red and White types. Ethiopian staple in bread. Small seeds, self-pollinated, 3' tall, matures in 4 months.

Ground covers and green manures

This group includes any rapidly growing crop that covers and protects the soil and that can be left as a mulch or plowed under to enrich the soil. Legumes are emphasized because of their ability to fix nitrogen and the large amount of foliage (and thus organic matter) produced. As a group, these crops are adapted principally to the hot, somewhat moist, tropics, but some are adapted to all tropical climates. They can all be established by seed, but some root at the nodes and can be established from cuttings. ECHO does not provide inoculants; see Agroforester, Liphatec, and BNF in listing at back for sources.

- Butterfly pea. Clitoria ternatea. Very drought tolerant, but does not compete well with weeds.

- Cowpea. Vigna unguiculata, V. vexillata. See Pulses.

- Hairy Indigo. Indigofera hirsuta. Summer cover crop in Florida; reseeding annual; nematode-suppressant; prefers well drained and droughty sites; for hay and grazing.

- Jack bean. Canavalia ensiformis. Drought tolerant; see under Leguminous Vegetables. (EDN 12-1, 20-2).

- Kudzu, tropical. Pueraria phaseoloides. Not the weedy temperate kudzu (EDN 12-6, 42-5).

- Lablab bean. Dolichos lablab . White, Rongai, and Highworth are excellent field varieties. Choose one or a variety trial; see under Leguminous Vegetables. (EDN 12-1).

- "Lee" or American Joint Vetch. Aeschynomene americana. Green manure and forage good for low areas or drainage ditches, >1000 mm rain.

- Sword bean. Canavalia gladiata. Drought tolerant; see under Leguminous Vegetables.

- Sunnhemp. Crotalaria juncea is becoming popular in East Africa. Crotalaria ochroleuca is an upright, non-vining legume; good for intercropping. Not poisonous to livestock, unlike most Crotalarias (EDN 26-5). C. ochroleuca may have poisonous seeds, forage before it goes to seed.

- Tephrosia. Tephrosia vogelii. Used as green manure and insect control. (EDN 42-5).

- Velvet bean. Mucuna deeringiana. Vigorous, drought resistant; see under Pulses. Tropical and 90-Day. (EDN 12-1,33-1).

- Winged bean.Psophocarpus etragonolobus. See under Leguminous Vegetables.

Green manure crops

Updated February 1993
by ECHO Staff

Tremendous advantages to the small farm in the third world
Taken from EDN 12, written by Roland Bunch, World Neighbors

Jack bean. Canavalia ensiformis.

Velvet bean. Mucuna deeringiana.

Lablab bean. Dolichos lablab.

Sunnhemp. Crotalaria juncea.

A Poor Man's Plow.

Green manure crops are crops which are grown to be turned under to increase soil fertility. Leguminous green manure crops, i.e. those which can make nitrogen fertilizers from atmospheric nitrogen, can offer small-scale Third World Farmers a tremendous number of advantages:

1) They provide large quantities of nitrogen for the soil.

2) They add many tons of organic matter to the soil, thereby improving topsoil depth, water- holding capacity, nutrient content, friability, and texture of the soil.

3) Inasmuch as the green manure crop grows in place, it presents no transportation problems, in contrast to either compost or chemical fertilizers.

4) Green manure crops require absolutely no capital outlay after the initial purchase of a handful of seed. Because they require no chemical inputs, dependency on outside sources of fertilizer, nutrients, and pesticides is reduced.

5) Green manure crops can shade the soil up to eleven months out of the year, a factor extremely important in tropical climates for preservation of soil moisture and organic matter.

6) The cover they provide for the soil protects the soil from wind or water erosion.

7) Green manure crops provide generous amounts of high protein fodder for animals, which can be especially valuable if it is available during the last months of the dry season (inasmuch as fodder at this time of year is the limiting factor in traditional animal-raising in much of the Third World).

8) Some green manure crops provide human food, including various kinds of edible beans, peas, and pods.

9) Green manure crops can provide a cash income, by selling firewood, food or feed (and maybe seed).

10) They often provide an incentive for people to abandon harmful traditional practices, such as burning crop residues or letting animals loose in the dry season to devour everything in sight.

11) Some green manures, when intercropped with basic grains, can control most weeds, thereby eliminating costly weeding operations.

Something like 30% of all the increases in harvests achieved by small farmers in the third World during the last three decades has been achieved through the use of chemical fertilizers. Should petroleum prices shoot up once again, as could easily happen sometime in the next decade, prices of chemical fertilizers could easily become too expensive to be economically feasible for use with traditional basic grains. Almost overnight, Third world basic grain production could plummet, causing famines the extent of which would make the present situation in Africa seem mild by comparison. Widespread use of green manure crops could avert much of this impact.

Comparison with Compost

Inasmuch as composting is a technology that is often recommended for Third World development programs, it might be useful to compare composting with the use of green manure crops.

1) Compost merely decomposes the organic matter one already has, whereas a green manure crop can often add over 40 tons of additional organic matter per hectare. Inasmuch as organic matter is often in short supply on villagers' farms (or is already being recycled), this is an important consideration.

2) At best, compost will return to one's field about 98% of the nitrogen one started out with. A green manure crop, however, will add considerable quantities of new nitrogen to the system.

3) A compost heap takes a tremendous amount of work, as anyone who has personally made one can attest. Though compost will often pay in a vegetable garden, it is not economical when used on basic grain crops such as corn or millet. On the other hand, although a green manure crop takes a bit of labor to plant (using a dibble stick) and a fair amount of labor to incorporate, it takes nowhere near the labor a compost heap does. And in some cases where the green manure crop is intercropped among traditional crops (such as corn, sorghum, or millet), it covers the ground so well that one or even two weeding operations can be eliminated, thereby actually bringing a net savings in labor.

4) A compost heap requires water. This often means it is made near a water supply but at a fair distance from where it is to be applied. Green manure crops are planted to take advantage of available rain water, and are planted right where they will be used.

5) Compost cannot be used as a food source, either for animals or humans.

A Few Ideas About What to Look For The major problem with green manure use around the Third world is that village farmers cannot afford to give up land in order to just grow a soil amendment. Or when they have the land, they cannot spare the labor. However, there are three ways in which these objections can be overcome. In many situations only one of these will be appropriate, in

others two. Experience so far seems to indicate that only rarely is none of them appropriate.

1) Green manure crops can often be planted amount traditional row crops, especially corn, sorghum, and millet, without decreasing the production of the main crop at al the first year, and usually with major increases in the major crop in succeeding years. The major instance in which this is not possible is when people are already intercropping two or three other crops with their major grain.

2) Green manure crops can often be intercropped with basic grains toward the middle or end of the growing season, with the idea that their major growth would occur during the dry season, thereby using land that would not ordinarily be under cultivation.

3) Wherever multiple-year fallows and/or shifting agriculture is used, green manures can be planted on land the first year it is to go fallow. Thus the period of fallow can be cut to one year instead of three to fifteen years.

What characteristics should we look for, then, in a legume that will be useful under these circumstances?

1) It must be a non-woody annual with vigorous growth.

2) It should grow well in the poorest of soils in the area, without needing any kind of fertilizer.

3) One must be able to plant it in local fields with no special soil preparation, and either with a dibble stick or, preferably, by broadcasting the seed.

4) The plant must have few enough natural enemies that it will grow vigorously without the use of any pesticides or major labor requirements.

5) The legume should either be very shade- resistant (for intercropping) or drought-resistant (for growing into or through the dry season).

6) If possible, it should first cover the ground well, then climb any stalks that remain in the field.

7) If possible, the green manure crop should be edible by animals and/or humans.

Some Already Known Possibilities

Although a good deal of research still needs to be done in finding adequate plants (far too much of the extant research has been done on fertile experimental stations or with the use of chemical fertilizers, thereby making it virtually useless to small farmers), there are a few species that seem to fit most of these conditions admirable well in certain parts of the world:

1) Canavalia ensiformis(jackbean, etc.) is highly shade and drought-resistant covers the soil, climbs extremely well, and is edible by animals. It does well from sea-level to about 1,800 m. It has almost no natural disease or insect pests. It can be dibble-sticked (at 2 seeds/sq.m.) or broadcast (at 4 per sq.m.) in among other crops. I have seen it grow vigorously on soil so badly eroded and depleted that no weeds would grow there at all. A high-protein fodder, the pods and beans can also be eaten by humans if certain precautions are taken.

2) Stizolobium spp. (velvetbean) covers the soil and climbs much like the jackbean. It grows even more vigorously than the jackbean under less harsh conditions (in Yucatan, where droughtiness is always a problem the jackbean does better in years of low rainfall, whereas the velvetbean does better when rain fall is higher than normal, but still scarce). Be sure to use a variety that does not have the irritating itchy powder on the pod (we have such a variety from Honduras). It grows from sea-level to 2,000 m. So far no natural diseases or pests have been observed in Central America, where it is native. It can be dibble-sticked (2 seeds/sq. m.). A high-protein fodder, the beans can also be toasted and ground to make a tasty high-protein "coffee", or used to "stretch" real coffee.

3) Clitoria ternatea is even more drought- resistant then the Canavalia, although being small-leafed, it does not cover the soil well. We really do not have much experience with this plant yet. It grows well at sea-level.

4) Dolichos lablab etc. (lablab bean) also covers the soil and climbs, much like the velvetbean. On semi-fertile soils around 1,200 to 1600 m., it grows very well with good shade-resistance, and so fast that it should not be planted in corn until at least 2 months after corn is planted. I do not have wider experience with this plant yet. It produces good forage.

[Ed: Young pods of some varieties are quite tasty when cooked. Dr. Andrew Duncan recently told me that he saw a variety with an exceptionally wide pod growing on sides of village houses in Bangladesh.]

Miscellaneous Observations

1) What can be done in areas where animals are let loose during the dry season while the green manure crop is still growing? One approach is to first show people the results of the green manure plant on an enclosed piece of land. Next get a good number of people to try it out, perhaps timing the planting to get a good start before the animals are let loose. Those who experiment first can often be motivated to spread the word to others with the idea that the destruction for each person will be less if more people plant it. Eventually, if enough people plant it, community pressure will make everyone keep his animals locked up (except in cases where the person with all the animals is a large landowner).

2) On very steep hillsides, something must be done to keep the organic matter from washing away. Piling crop residues along roughly contour lines can help, as can contour ditches. Another possibility is incorporating the green manure immediately after cutting it, but this is hard work before the rains come (if soil is a heavy one), and once the rains have come, people generally do not have extra time.

3) On flatter land, the green manure should usually be cut and allowed to dry for a couple of weeks before incorporating it (if during the dry season). The labor saved in incorporating it will be worth more to the farmer than the small amount of fertility lost. In one case farmers cut holes in the Canavalia cover to plant corn when the rains came, cut down the Canavalia entirely about two

weeks later and replanted the Canavalia. Then, two weeks later, they incorporated the dead Canavalia vegetation. In this manner, they avoided both weeding operations in their cornfields!

4) Where weather is unreliable, a combination of similar plants, one of which is more drought-resistant (e.g. jackbean and velvetbean) reduces risk of total loss, yet assures a vigorous crop if rains are plentiful.

5) In West Africa, we are trying a system of planting a perennial every sixth row (pigeon pea), and then gathering the corn or millet residues under the pigeon pea plants at the end of the year, to be distributed six months or so later when well-mixed with better C:N pigeon pea leaves. The presence of the pigeon pea trees (already known as a cash crop) will also prevent burning of residues.

6) On South and Southeast Asian hillside areas, Leucaene leucocephala is planted as a contour barrier and constantly pruned, thereby providing erosion protection, some green manure, and firewood (see the booklet produced by World Neighbors called Leucaene-based Farming). This produces less green manure than other systems, but can be sued where green manure cannot be intercropped among traditional crops.

7) We certainly would welcome any experience yo have in this subject. Much more information and experimentation must be done. We readily admit we are just getting started at this, but the positive response from hundreds of villagers and dozens of other programs has made us decide to share what little we know as soon as possible so we can all work together to learn more about it. I would think that, right now, the most important subjects we need to learn more about are:

a) What legumes will work above 1,800 m.?

b) What additional plants will work at any elevation?

c) Do adaptive research to see what of these technologies will work outside the Southern Mexico/Central American habitat that this information comes from.

d) Which legumes can be broadcast rather than planted with a dibble stick?

e) Which of these green manure crops provide the best yield increases with which basic grain crops?

f) What green manure crops would be best under high rainfall conditions?

g) Where can I get seed?

Thanks a million Rolland! (Martin speaking now). We have a modest amount of one vigorous variety of velvet bean that we can share. We will fill seed requests for Rolland's variety of velvet bean as well as Clitora ternatea, sword bean and jack bean in January if it does not freeze this year. We have plenty of lablab beans, pigeon peas and leucaena, including a variety that is hopefully less toxic because it is low in mimosine. If we cannot supply seed, we will see if Rolland can help, though note that he cannot meet the local demand. Please note that seeds for jackbean, swordbean, and velvetbean are quite large. We will send approximately 6 seeds of these, which will come in a very bulky envelope or a small package (if such packages do not get through to you, perhaps someone will be visiting that can bring them in). This will give you a few plants to begin increasing your own seed. Do not ask for pigeon pea if it is an important crop in your area, as you do not need it and we want to minimize risk of diseases of established crops. If you want more than 6 seeds of the larger seeded varieties, please send a couple dollars to help with postage. Some of you have ideas and experience with groundcovers. Let us hear from you.

A comment on green manure from zaire

Pete Ekstrand just visited us and had this account from the Paul Carlson Medical Program in Zaire. They have found that Pueraria phaseoloides (tropical kudzu or puero) grows vigorously and can even smother the vigorous native imperata grass if the grass is manually bent over. This is not the same kudzu that took over so much land in Alabama and elsewhere. They then cut circles perhaps 2 meters wide and plant fruit trees, coffee, etc. in the middle. It had not rained for 60 days when he visited and the ground in the circles was hard and dry. But one arm length under the ground cover

the soil was moist and could be molded with the hand! We have not succeeded in harvesting our own seed, so let me refer you to the Yates Seed Co., P.O. Box 117, Rockhampton, 4700 Australia. Yates is an excellent source for a large number of tropical pastures.

update: what we have learned to date about green manure crops for small farmers
Taken from EDN 20, written by Roland Bunch, World Neighbors

In spite of the advantages of green manures, their use has seldom become common among farmers in the Third world. They cannot afford to give up scarce cropland just to grow a soil amendment. If they do have the land, they cannot afford the labor. Nor are they generally willing to spend money to improve crops grown for subsistence, because they earn no money to improve crops grown for subsistence, because they earn no money from them with which to replace what they have spent. World Neighbors/Central America has found a number of ways to overcome most of these problems to the extent that farmers have accepted green manures faster than any other agricultural technology with which we've worked through the years. One program sold 65 pounds of seed last year to local farmers and 1500 pounds this year in the same area with minimal promotion. There are six ways to produce green manure without reducing at all the land used for other crops.

(1) Plant among traditional row crops.

(2) Intercrop near harvest of the first crop timed so green manure will grow primarily during the dry season.

(3) Where shifting agriculture is practiced, plant during the first fallow year to shorten the fallow period.

(4) Alley cropping.

In Central America our work has used the first four possibilities. We have had the most success with jack bean and velvet bean.

Industrial crops

These crops are unrelated in terms of botanical relationship, growth habit and uses, although all are well adapted to some season of the tropics. These crops are not important in most small farm situations. ECHO does occasionally carry a few.

See A Comparison of Industrial Crops

- Jojoba. Simmondsia chinensis. Oil can be extracted from the seeds; drought tolerant. (EDN 3-4,5).
- Sunflower. Helianthus annus. Rustov variety. Edible seeds high in oil.
- Vernonia. Vernonia glamensis. Contains a naturally epoxidized oil useful in paints. (EDN 27-1).
- Kenaf. Hibiscus cannabinus. Fiber/paper pulp crop, frost intolerant; photoperiod sensitive; well drained soils, no flooding; ample rain during growing periods. 'SF459' resistant to southern rootknot nematode and soil-borne fungi.

The lablab bean as green manure

The Lablab Bean (Dolichos lablab or Lablab purpureus) is a legume very similar in appearance to the velvet bean, but even faster growing where soils are fairly fertile. It has not been as valuable to us because of its need for somewhat more fertile soils and occasional insect problems, but may well be important to us later on when the other green manures have raised fertility sufficiently. The lablab bean is almost as drought-resistant as the jack bean, is very shade- tolerant, and is among the most palatable of legumes for animals (definitely preferred over velvet bean or jack bean). Lablab beans grow well from sea level up to about 1500 meters. They require well-drained soils. Lablab beans start flowering after 3 months and continue most of the first year, producing seed as well as remaining green. If soils are deep enough and other conditions permit, it will grow right through the dry season. I have seen plants that survived 3 years in droughty areas of the central plateau of

Haiti. [Ed: in the sandy soils at ECHO lablab beans get nematodes so badly that it is difficult to keep them alive an entire year]. It nodulates profusely, producing mostly white nodules. Whereas the velvet bean growth is reduced if it has nothing to climb, plants in thick stands of lablab beans will begin to climb up each other. Another difference from the velvet or jack bean is that the lablab bean can be cut off nearly at ground level and will grow again, although with somewhat less vigor. Lablab beans are traditionally planted toward the end of the agricultural cycle in come villages in Honduras to provide dry-season pasture for animals. It is also edible, and in some places, such as Haiti and West Africa, is widely appreciated as a regular food. Young pods or immature beans can be eaten green (beans taste similar to a sweet pea - a white seeded variety is best for this). Dry lablab beans can be substituted for dry beans in most recipes. Where it grows well, the lablab bean has produced a phenomenal 11 kg per square meter (110 T/Ha) of above ground organic matter (wet weight). Though we have had problems with insect attacks, its growth is so vigorous that it still usually grows as fast as the velvet bean. Because animals prefer it to almost anything else, lablab beans cannot be grown where animals run free. In pure stands, lablab beans should be planted about 10/square meter. We have not found a good system yet for planting in corn fields because of its rapid growth, but it should be possible with heavy pruning (which it withstands well). The lablab bean requires either a recently cultivated or a sandy soil. Continuing research needs. If you have been experimenting with green manures, please send me whatever information you have put together [Ed: Please send a copy to ECHO too]. I think the most important subjects we need to learn more about are:

- (1) What legumes will work above 1,800 meters?
- (2) What additional plants will work at any elevation?
- (3) What green manures will work best under wet tropical conditions?
- (4) In what ways must these recommendations be modified for areasoutside of the caribbean basin area from which they have come?

Martin speaking now ... Thanks a million Rolland. ECHO will send a small packet of any seed mentioned in this article. If you want to buy larger quantities we will try to find a source. We also have the "90" day " velvet bean that was grown in the southeastern part of the USA 50 years ago. At the time of the last corn cultivation farmers would plant this velvet bean. Both corn and beans were left in the field. Cattle were allowed to feed in the fields a couple of hours each day in the fall and winter, reportedly getting very fat. This variety is not sensitive to day length so produces 3 months after planting. The tropical kind only produces when days are short (flowering starts in November at ECHO). The 90 day kind has some of the itch-producing hairs Rolland refers to, but not nearly as many as I have seen on the wild "pica-pica" in Honduras.

Leafy vegetables

Leafy vegetables are among the easiest to obtain in the tropics and are of great importance in the diet. They contain protein, vitamins A and C and B complex, and minerals, especially calcium and iron, but also magnesium and phosphorus. All contain large amounts of dietary fiber and are low in carbohydrates and fat. Dark green leaves are usually more nutritious than lighter or yellowish leaves. Loose leaves are better than leaves in heads. Young leaves are more nutritious and easier to digest than old leaves.

Leaves often contain toxic substances, of which the most common are oxalic acid, nitrates, glycosides of hydrocyanic acid, and alkaloids. Most leaves should be cooked to reduce toxicity. Leaves should be boiled about 20 minutes, and the cooking water should be discarded. A cup of cooked leaves will give the body as much fiber as it needs. It is wise when eating leaves to vary the species used as food. Only the leaves known to be edible raw should be eaten raw. These include moringa, katuk, lettuce, edible hibiscus, and false roselle.

Many tropical leaf vegetables are perennials. They yield a maximum amount of useful food with a minimum amount of labor. Leaf vegetables respond favorably to rich growing conditions, especially lots of nitrogen fertilizer, for this leads to lush, soft growth. But well fertilized vegetables may

contain excess nitrates, harmful to babies and other small children.

See A Comparison of Vegetable Leaves

- Amaranth. Amaranthus tricolor. Greenleaf R108-green with white stripes (Rodale). Tigerleaf-green with red stripes (Rodale). Calliloo-Jamaican; productive, prolific; weed potential; less sensitive to day length. Tasty stems. (EDN 3-1, 4-1).

- Bush okra (Jute mallow, Egyptian spinach). Corchorus olitorius. Only leaves and growing tips eaten; must be cooked; fibers used in twine and burlap sacks; likes heat and water, but is tolerant of drought and humidity. (EDN 21-5).

- Chaya. Cnidoscolus chayamansa. Spineless variety; cuttings only; must boil leaves 5 minutes, discard water, repeat. (EDN 18-2).

- False roselle. Hibiscus acetosella. Tangy, deep maroon leaves eaten raw or cooked; flowers blended with lemonade or in teas give a bright purple color.

- Moringa. Moringa oleifera. Leaves, flowers, and young pods edible; young roots blended with vinegar as horseradish; seeds used to purify water. Moringa stenopetala: larger leaves than M. oleifera providing more shade; stockier, bushier, more vigorous tree; leaves have milder taste when eaten rare; more drought-resistant and has bigger seeds; only occasionally available. (EDN 10-1, 11-7, 21-5, 22-6, 32-5, 35-2, 37-4, 42-2, 43-2).

- Indian (tropical) lettuce. Lactuca indica. Prolific, productive; leaves bitter (serve with vinegar or cooked). (EDN 4-5, 8-4). Available fall of 1996 if harvest goes well.

- Malabar Spinach or Ceylon. Basella alba-White stems; climbing vine; tender stems and succulent leaves edible; likes heat and lots of moisture. Basella rubra-Red stems, large leaves, vigorous; suited for humid regions; easy to cultivate; requires trellis. Boil and discard water to prepare.

- Kale (Ethiopian). Brassica carinata. Unlike most kale, will produce seed in the tropics.

- Katuk. Sauropus androgynus. Cuttings in U.S. only; seed availability highly variable; young stem tips eaten.

- Lettuce. Lactuca sativa. Montello (North American), Maioba (Brazilian-high in vitamin A, resists acidic soils) seeds available fall of 1996 if harvest goes well, Anuenue (Hawaiian), and Queensland (Australian)-slower to bolt in hot weather. (EDN 14-3, 34-4, 41-5).

- Quail grass. Celosia argentia. Upright growth, three varieties available: red leaved, green leaved, and cockscomb (var. cristata). Boiled leaves of all three are tasty. Flowers dry nicely. (EDN 8-2).

- Sweet potato. Ipomea batatas. Leaves and shoot tips eaten boiled. SEE DESCRIPTION UNDER 'ROOTS AND TUBERS'.

Leguminous vegetables

Immature legume pods and green seeds are used as vegetables. The green pods contain good quantities of most nutrients, especially protein, vitamins, and minerals, but little of oils and carbohydrates. They also add useful fiber to the diet. They can be adequately prepared by boiling for 20 minutes. The immature seeds contain similar nutrients to the mature seed with some Vitamin A and C, and are easier to digest than dried, cooked seeds. A few leguminous vegetables contain toxic substances. All should be well cooked before eating. Good production requires the appropriate variety and season. However, they need not mature during dry weather. As can be seen by comparing the charts (order from ECHO) concerning pulses (grain legumes) and leguminous vegetables, many species are used for both purposes.

See A Comparison of Leguminous Vegetables.

- Bush bean, green podded. Phaseolus vulgaris. 'Contender'- 55 day. Grows to 6 1/2" flavorful,

stringless, and fleshy beans. Resistant to powdery mildew and bean mosaic virus; does better than most at ECHO, but we have never found a bush bean that will produce during our hot, humid summers.

- Chickpea (Garbanzo). Cicer arietum. Cool season crop, very drought tolerant; immature beans used as a vegetable.

- Cowpea. Vigna unguiculata. Thailand longbean (catjang). See Pulses.

- Fava or broad bean. Vicia faba. Cool season crop suitable for high altitudes. 'Quitumbe' is a smaller seed preferred for making flours; 2800-3400 m on equator; 800 mm rain in growing season; pH 5-6.

- Jackbean. Canavalia ensiformis. Ideal pH 5-6. Very young pods edible; mature bean HIGHLY TOXIC; very drought tolerant.(EDN 20-2,25-2).

- Lablab bean.Dolichos lablab. Ideal pH 5-6.5. Red-best variety for eating young pods because even relatively large pods are still tender. Field varieties(mix available): Highworth, White, Rongai-edible but pods become fibrous at a young stage. (EDN 20-5, 30-1).

- Pigeon pea. Cajanus Cajan. "Vegetable" types have larger green seeds than pulse varieties. Very adaptable to many soils. A mixed variety trial and a short-duration variety are available (EDN 29-4,5, 38-6).

- Soybean. Glycine max. AVRDC Tropical vegetable soybean variety trial.

- Sword bean.Canavalia gladiata. Only very young pods edible; mature beans HIGHLY TOXIC; drought tolerant.

- Winged bean. Psophocarpus tetragonolobus. Bogor-very vigorous vine, short pods. Square-

produces edible tuber. Chimbu-long, crimson pods, moderate vigor. Flat-remains flexible even when long; transports better because pods lay flat. Siempre-good yields. Day-neutral-tuber-producing, recommended for longer days and higher latitudes (EDN 9-1, 11-6).

• Yardlong bean (Asparagus bean). Vigna sesquipedalis. Purple-podded-productive; attractive color; shorter than green-podded. Green- podded yard-long bean. Guilin-from China; long and thin.

The moringa tree

by Dr. Martin L. price, executive director
Updated 2/93 by echo staff

THE MORINGA TREE, MORINGA OLEIFERA, IS CALLED "MOTHER'S BEST FRIEND". That is one way they sometimes refer to this tree in the Philippines where the leaves of the malunggay, as they call it, are cooked and fed to babies. Other names for it include the benzolive tree (Haiti), malunggay (Philippines), horseradish tree (Florida), and drumstick tree (India). I believe it is one of the most exciting plants that we have in our seedbank. The leaflets can be stripped from the feathery, fern-like leaves and used in any spinach recipe. Small trees can be pulled up after a few months and the taproot ground, mixed with vinegar and salt and used in place of horseradish. Very young plants can be used as a tender vegetable. After about 8 months the tree begins to flower and continues year round. The flowers can be eaten or used to make a tea. They are also good for beekeepers. The young pods can be cooked and reportedly have a taste reminiscent of asparagus. The green peas and surrounding white material can be removed from larger pods and cooked in various ways.

Seeds from mature pods (which can be 2 feet long) can be browned in a skillet, mashed and placed in boiling water, which causes an excellent cooking or lubricating oil to float to the surface. The oil reportedly does not become rancid and was once sold as ben oil. The wood is very, very soft, though the tree is a good living fencepost. It makes acceptable firewood but poor charcoal. It is an extremely fast growing tree.

Roy Danforth in Zaire wrote, "The trees grow more rapidly than papaya, with one three month old tree reaching 8 feet. I never knew there would be such a tree." The tree in our organic garden grew to about 15 feet in 9 months, and had been cut back several times to make it branch out more.

It is well to prune trees frequently when they are young or they will become lanky and difficult to harvest. Where folks begin breaking off tender tips to cook when trees are about 4 or 5 feet tall, the trees become much more bushy.

The folks to whom we have sent the tree in Africa have been pleased at its resistance to dry weather. Rob Van Os rated its growth, yield and potential as exceptional and added that it "can be planted after the other crops, even near the end of the rains." He has introduced it into several villages already.

The first plants grew so well for Gary Shepherd in Nepal that he had us arrange for 1,000 of the large seeds. He reports that at five months one was 12 feet tall and most were 6 feet.

There is more good news. The edible parts are exceptionally nutritious! Frank Martin says in Survival and Subsistence in the Tropics that "among the leafy vegetables, one stands out as particularly good, the horseradish tree. The leaves are outstanding as a source of vitamin A and, when raw, vitamin C. They are a good source of B vitamins and among the best plant sources of minerals. The calcium content is very high for a plant. Phosphorous is low, as it should be. The content of iron is very good (it is reportedly prescribed for anemia in the Philippines). They are an excellent source of protein and a very low source of fat and carbohydrates. Thus the leaves are one of the best plant foods that can be found." In his Edible Leaves of the Tropics he adds that the leaves are incomparable as a source of the sulfur-containing amino acids methionine and cystine, which are often in short supply.

Dennis Rempel in Burkina Faso reported on seed we had sent. "Folks loved the leaves. In fact it is supposedly found locally, though I have yet to be shown any. They say it is rare but highly prized to be added to sauces. Everyone wants more."

We have found that it responds well to mulch, water and fertilizer. It is set back when our water table stays for long at an inch or two below the surface. We planted one right in the middle of our vegetable garden for its light shade. The branches are so brittle that I would hesitate to climb it, though Roger Magliore in the Dominican Republic says that children readily climb the trees. It is not harmed by frost, but can be killed to the ground by freezes. It quickly sends out new growth from the trunk when cut, or from the ground when frozen. I understand that living fences can be continually cut back to a few feet.

We learned of another unexpected use from Dr. Samia Al Azharia Jahn with the Deutsche Gsellschaft fur Technische Zusammenarbeit in Germany. Suspensions of the ground seed of the benzolive tree are used as primary coagulants. They can "clarify Nile water of any degree of visible turbudity." At high turbid- ities their action was almost as fast as that of alum, but at medium and low turbidities it was slower. The doses required did not exceed 250 mg/l. Coagulating the solid matter in water so that it can be easily removed can remove a good portion of the suspended bacteria. "River water is always faecally polluted. At our sampling site the total coliforms ammounted during the flood season to 1600-18,000 per 100 ml. Turbidity reductions to 10 FTU were achieved after one hour, reducing the coliforms to 1-200 per 100 ml". "Good clarification is obtained if a small cloth bag filled with the powdered seeds of the benzolive is swirled round in the turbid water"

The material can clarify not only highly turbid muddy water but also waters of medium and low turbidity which may appear milky and opaque or sometimes yellowish or greyish. During the cool season complete clarification, which takes only one hour in hot water, may take two hours unless the water is left in the sun for some time to raise its temperature." "In the case of the Blue Nile, for example, water of low turbidity in the initial and final flood season needs doses equivalent to about one quarter of a seed per liter, water of medium turbidities needs half a seed per liter and at high turbidities the dose should be 1-1.5 seeds per liter.". Water from a different river will require different quantities of clarifier because of variable characteristics of suspended material. Simple experiments in a jar will determine the best dose.

To prepare the seed for use as a coagulant, remove the seed coats and the quot;wings". The white kernel is then crushed to a powder, using a motar or placing in a cloth on top of a stone and crushing. The powder should be mixed with a small amount of water, stirred in a small cup, then poured through a tea strainer before being added to the turbie water. It is even better to spread a thin piece of clean cloth on the strainer. "The milky white suspension has to be added to the turbid water and stirred fast. If a wooden soup whisk is used, the nails sometimes present in these gadgets should be replaced by small wooden sticks. Continue fast stirring for at least half a minute. After that the floc will not form unless it is stirred slowly and regularly (15-20 rotations per minute) for about five minutes." "After stirring the treated water should be covered and left to settle for at least an hour." If moved or shaken before then, clarification will take much longer or fail to reach completion. The GTZ is planning implementation projects with counterparts in Indonesia and Kenya. You may write to him at GTZ, FB 332; Dag-Hammarskjold-Weg 1-2; Postfach 5180; D-6236 Eschborn 1 bei Frankfurt/Main, West Germany.

CULTIVATION

I quote Alicia Ray, who wrote a booklet on the benzolive in Haiti some time ago. "It seems to thrive in impossible places - even near the sea, in bad soil and dry areas. Seeds sprout readily in one or two weeks. Alternatively one can plant a branch and within a week or two it will have estab- lished itself. It is often cut back year after year in fence rows and is not killed. Because of this, in order to keep an abundant supply of leaves, flowers and pods within easy reach, "topping out" is useful. At least once a year one can cut the tree off 3 or 4 feet above the ground. It will readily sprout again and all the valuable products will remain within safe, easy reach.".

Beth Mayhood with Grace Mountain Mission wanted to establish a model vegetable garden on a small piece of land. "It was windswept and sunbaked with no natural barriers or trees in the area. Soils were poor and very alkaline. The salt content was also high. We started in January to prepare large quantities of compost. In April holes were dug in the poor soil and filled with compost. Benzolive trees planted in seedbeds germinated in 3-4 days. In 9 weeks they were transplanted in

between the garden beds, around the edge of the 200 x 250 ft area and in a double row about 5 ft apart in the middle. The trees protected against the prevailing inds." I saw slides of this spot later. It was impressive. The light shade of the tree is a considerable help to most vegetables.

I cannot emphasize enough how important it is to use pruning of some sort. If left to itself the tree becomes quite tall and lanky. This method of cutting it back to 4 feet each year sounds good. One method I tried with some success was to cut each branch back a foot after it had grown 2 feet until it was a multibranched shrub. Alternatively, normal harvesting can have the same effect if begun while the tree is young.

Beth Mayhood wrote, "We liked them so much we began picking the growing tips to boil as a spinach several times a week. This picking of the growing tips caused the tree to branch. Our constantly pruned trees became thick-limbed and many-branched." I am told that when grown for its roots, the seeds are sometimes planted in a row like vegetables.

COOKING THE LEAVES. Alicia Ray writes, "Of all parts of the tree, it is the leaves that are most extensively used. The growing tips and young leaves are best. [However, we sometimes pull the leaflets off in our hands and cook them without regard to age]. Unlike other kinds of edible leaves, benzolive leaves do not become bitter as they grow older, only tougher. When you prepare the leaves, always remove them from the woody stems which do not soften. [We did not know this the first time we served them. It was almost like having wire in the dish]. "The leaves can be used any way you would use spinach. One easy way to cook them is this: Steam 2 cups freshly picked leaves for just a few minutes in one cup water, seasoned with an onion, butter and salt. Vary or add other seasons according to your taste. In India leaves are used in vegetable curries, for seasoning and in pickles. Let your imagination be your guide."

COOKING THE PODS. Alicia Ray writes, "When young, horseradish tree pods are edible whole, with a delicate flavor like asparagus. They can be used from the time they emerge from the flower cluster until they become too woody to snap easily. The largest ones usable in this way will probably be 12

to 15 inches long and 1/4 inch in diameter. At this state they can be prepared in many ways. Here are three:

1. Cut the pods into one inch lengths. Add onion, butter and salt. Boil for ten minutes or until tender.

2. Steam the pods without seasonings, then marinade in a mixture of oil, vinegar, salt, pepper, garlic and parsley.

3. An acceptable "mock asparagus" soup can be made by boiling until tender, the cut pods seasoned with onion.

Add milk, thicken and season to taste. "Even if the pods pass the stage where they snap easily they can still be used. You can cut them into three inch lengths, boil until tender (about 15 minutes), and eat as you would artichokes. Or you can scrape the pods to remove the woody outer fibers before cooking."

COOKING THE PEAS. Alicia Ray writes that the seeds, or "peas," can "be used from the time they begin to form until they begin to turn yellow and their shells begin to harden. Only experience can tell you at what stage to harvest the pods for their peas. "To open the pod, take it in both hands and twist. With your thumbnail slit open the pod along the line that appears. Remove the peas with their soft winged shells intact and as much soft white flesh as you can by scraping the inside of the pod with the side of a spoon. Place the peas and flesh in a strainer and wash well to remove the sticky, bitter film that coats them. (Or better still, blanch them for a few minutes, then pour off the water before boiling again in fresh water). Now they are ready to use in any recipe you would use for green peas. They can be boiled as they are, seasoned with onion, butter and salt, much the same as the leaves and young pods. They can be cooked with rice as you would any bean.

"In India the peas are prepared using this recipe:

12-15 horseradish tree pods
1 medium onion, diced
4 cups grated coconut
2 bouillon cubes
2 inches ginger root
4 T. oil or bacon grease
1 clove garlic
2 eggs, hard boiled salt, pepper to taste

"Blanch both peas and pods flesh, drain. Remove milk from 2 1/2 cups grated coconut by squeezing water through it two or three times. Crush ginger root and garlic, save half for later. Mix peas, flesh, coconut milk, ginger and garlic together with onion, bouillon cubes, oil, salt and pepper. Bring to a boil and cook until the peas are soft, about 20 minutes. Fry remaining coconut until brown. Fry remaining half of crushed ginger root and garlic in 2 T. oil. Dice eggs. Add coconut, ginger, garlic and eggs to first mixture, heat through. Serves 6.

THE DRY SEEDS. The dry seeds are apparently not used for human food, perhaps because the bitter coating has now become hardened. They are used for their oil, which is about 28% by weight. The oil can be removed by an oil press. I have heard reports that the residual cake is not safe to feed to animals, but I have not seen the results of any studies. Write to me if you have details. If an oil press is not available, seeds can be roasted or browned on a skillet, ground, then added to boiling water. The oil floats to the surface. Alicia Ray says that roasting is, however, not necessary.

THE FLOWERS. A visitor who had spent time in the Pacific area told me recently that the flowers are eaten there. Unfortunately, I do not recall details. Perhaps our readers can help. Alicia Ray says they are used in Haiti for a cold remedy. Water is boiled, then a cluster of flowers is placed to steep in it for about 5 minutes. Add a little sugar and drink as needed. It is very effective!

THE ROOTS. The tree is uprooted and the roots grated like horseradish. Alicia Ray says to one cup

grated root add 1/2 cup white vinegar and 1/4 t. salt. "Chill for one hour. This sauce can be stored for a long time in the refrigerator." The following caution appeared in EDN 35. It begins by quoting from a recent review by Dr. Julia Morton in "Economic Botany." "The root, best known in India and the Far East, is extremely pungent. When the plant is only 60 cm tall, it can be pulled up, its root scraped, ground up and vinegar and salt added to make a popular condiment much like true horseradish. ...The root bark must be completely removed since it contains two alkaloids allied to ephedrine - benzylamine (moringine), which is not physiologically active, and the toxic moringinine which acts on the sympathetic nerve endings as well as on the cardiac and smooth muscles all over the body. Also present is the potent antibiotic and fungicide, pterygospermin. The alkaloid, spirachin (a nerve paralyzant) has been found in the roots.... Even when free of bark, the condiment, in excess, may be harmful." The key words are "in excess."

I worked one summer in the laboratory of forage scientist Dr. VanSoest at Cornell University. He said we should learn a lesson from the deer. Deer can eat plants with no ill effect that are poisonous to cattle. The difference is that deer are browsers. They eat a small amount of one thing, then move on to many other things during the course of the day. In contrast, when a cow likes something it keeps eating. "The body is capable of detoxifying small amounts of a great many things." I have thought of that many times since working with so many kinds of plants at ECHO. No doubt a steady diet of some would be harmful, as is the case with many common foods like cassava which contains cyanide or spinach with oxalates. There is a comforting degree of safety in "browsing" among a large selection of foods. Not only will your body more likely be able to detoxify the small amounts of any particular toxin, but it is more likely to find at least a minimal amount of the various nutrients it requires. All the more reason to work to bring diversity to the diets of people with whom we work.

USE AS AN ANTIBIOTIC. A study at University of San Carlos in Guatemala was summarized in EDN 37. Herbal applications are commonly used to treat skin infections in developing countries, although few investigations are conducted to validate scientifically their popular use. A previous study had showed that moringa seeds are effective against skin infecting bacteria Staphylococcus aureus and Pseudomonas aeruginosa in vitro (i. e. in a test tube). This study showed that mice infected with S.

aureus recovered as quickly with a specially prepared aqueous extract of moringa seed as with the antibiotic neomycin. This study proves only the effectiveness of moringa as they prepared it. That preparation could be done in any country, but not with just household untensils. It was prepared by infusing 10 g powdered moringa seeds in 100 ml of 45C water for 2 hours. The part that is a bit more complicated is reducing the 100 ml down to 10 ml by placing it in a rotavaporator. This is a very common piece of laboratory equipment which continually rotates a flask containing the liquid. An aspirator attached to a faucet produces a modest vacuum when the water is turned on. A rubber tube from the aspirator is connected to the rotavaporator, reducing the pressure and causing the water to evaporate rather quickly without boiling it. The ointment was prepared by placing 10% of the extract in vaseline. (We can send a copy of the article to medical personnel).

Are you in a situation where there is a shortage of antibiotics? This ointment could be prepared for use in the local community anyplace where there is electricity and running water. I would not be surprised if much simpler methods, better suited to preparation as needed in the home, might not also be effective. I hope someone will devise and test such preparations.

OTHER SPECIES. Over the years Moringa oleifera has been the number one seed in our seedbank, in terms of number of requests and positive reports. When we learned that Moringa stenopetala, a species native to Ethiopia had larger edible leaves, more drought resistance, and larger seeds (important for those using moringa to purify water) we were eager to learn more. When Dr. Samia Jahn, sent a modest supply of seeds for us to share with with those in our network we mentioned it in ECHO Development Notes issue 32.

It has been our experience that M. stenopetala produces a stockier, bushier, more vigorous tree. The trunk is considerably thicker at the base and the leaves are noticably larger. Reports from Africa tell us that this species does much better under drought conditons than M. oleifera, but by the end of a long dry season they may still loose their leaves. In Kenya trees have reached 10-12 meters in height. In Sudan trunk diameters are at least 2-3 times as thick as those of M. oleifera In Ethiopia it is cultivated as high as 1800 meters (5400 feet). Reports are consistent that M. stenopetala trees

are not as quick to set flowers as M. oleifera. In Sudan the first flowers appeared after 2 1/2 years, compared to 11 months for M. oleifera. At ECHO, our 4 year old trees have yet to set flowers, but they have also been dama ged by two freezes.

Both species will start from cuttings. M. stenopetala leaves taste similar to M. oleifera when cooked and milder if tasted raw. One interesting difference is that it is the roots of M. oleifera are used as a condiment similar to horseradish. With M. stenopetala it is the bark that is used.

While our trees have not produced to date, we are occasionally sent a fresh shipment from Ethiopia. Those in our overseas network can request to be placed on a waiting list for a free packet. We cannot take U.S. orders at this time. (See EDN 32-5 and 36-8 for more discussion of this plant). ECHO can usually provide trial-sized quantities of Moringa oleifera ($2.75 per packet; free to Third World development organizations) from the trees on our farm.

For those seeking other potential sources we can recommend the following:

- Christas Cactus, 529 W. Pima, Coolidge, AZ 85228, p: 602/723-4185
- Greenleaf Seeds, P.O. Box 98, Conway, MASS 01341, p: 413/628-4750 (No telephone orders)
- Of the Jungle, P.O. Box 1801, Sebastapol, CA 95473
- Peace Seeds, 2385 S.E. Thompson Street, Corvallis, OR 97333, p: 503/752-0421
- Peter B. Dow & Co., P.O. Box 696, Gisborne 3800, NEW ZEALAND, f: (079) 78 844
- Ellison Horticultural PTY.Ltd., P.O. Box 365, Nowra, N.S.W. 2541 AUSTRALIA p: 6144-214255
- Kumar International, Ajitmal 206121, Etawah, Uttar Pradesh, INDIA.
- Samuel Ratnam, Inland & Foreign Trading Co., (Block 79A, Indus Road #04-418/420, SINGAPORE,

p: 0316 p 2722711, f: 2716118)

Recipes to learn to eat moringa

Vegetable Rolls

1 c pigeon or Congo pea, boiled and 1 loaf sliced bread
mashed 3 eggs, beaten
1 c young buko*, chopped 1/3 c all-purpose flour
1/2 c moringa leaves 1/2 c winged bean (optional)
1/4c red pepper, chopped 1 c squash, grated
1/4 c carrots, chopped 5 tbsp margarine
1/4 c peanut, boiled 2 T salt
1/2 c green papaya, chopped 1/2 c pork, ground
1 bulb garlic, chopped (optional) 1 head onion, chopped (optional)
Mix all ingredients above. Wrap in banana leaves, and steam for 45 minutes.

Pigeon Pea or Congo Pea, Papapa, Moringa and Winged Bean Rice

1 c young pigeon or Congo pea, 1/2 c shrimp, shelled & diced
boiled 1 medium onion, chopped
1/2 shredded green papaya 5 segments garlic
1/4 c strips of winged bean Oil for frying
1/2 c chicken, boiled & sliced Salt to taste
into cubes Accent or MSG
Saute the garlic and onions. Add chicken, shrimp, peas, green papaya, and winged beans. Add salt and Accent or MSG. Cook the papaya and winged beans until tender. Remove, and let cool. Wrap in rice paper. Fry in deep hot oil. Serve hot with sweet and sour sauce.

Sauted Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean with Liver

1-1/4 c pigeon or Congo pea 1/2 c liver
3 quarts water 3 T salt
3/4 c cooking oil 2 c rice washings
4 segments garlic 1-3/4 c winged bean
1-1/4 c tomatoes 2 cup moringa leaves
Boil peas until cooked. Set aside. Saute garlic, onion and tomatoes. Add liver. Cover and cook until liver is tender. Season. Add rice washings. Add winged bean and papaya. Cover and cook 10 minutes. Add cookoed peas and moringa leaves. Serve hot.

Pigeon Pea or Congo Pea with Pork and Banana Blossom

1 c peas 1 c winged bean
1 pc banana blossom 1/2 moringa leaves
1 leg pork Ginger
1 c roselle Salt to taste
Smoke pork until golden brown. Remove from fire, and cut into cubes about 2 inches in size. Boil peas and pork leg until tender. Add ginger and salt to taste. Add banana blossoms and winged beans. When tender, add roselle and onions.

Broiled Milk Fish with Pigeon Pea or Congo Pea

21 medium size milk fish (broiled with Green onions scales)
2 tomatoes
2 c fresh peas medium size green papaya
1 bunch winged bean Salt, MSC or Accent to taste
2 cups moringa leaves
Boil fresh peas until soft. Add tomatoes and salt to taste. Add broiled fish. When done, add winged beans and green papaya. Add moringa, and garnish with green onions.

Chicken with Pigeon or Congo Pea, Papaya, Moringa and Winged Bean

1"1 medium size chicken 1 onion
1-1/2 c boiled pigeon or Congo pea 1 tomato
2 pcs green medium size papaya 3 cloves garlic
1 c winged bean Salt, MSC or Accent to taste
1 c moringa leaves
Saute garlic, onion and tomatoes. Add sliced chicken, boiled peas, and boil for 20 minutes. Then add papaya and winged bean, and boil another 10 minutes. Add MSC or Accent and salt to taste. Put in moringa leaves before removing from fire. Serve hot.

Pigeon or Congo Pea, Papaya, Moringa and Winged Bean with Dried Minnow and Coconut Milk

1 c dried minnow 1 c green papaya, cubed
1 T fish sauce 1 c winged bean, cut into 2" length
1-1/4 t salt 1/4 c red pepper
1 c cubed squash 1 c coconut milk (second extraction)
2 c fresh pigeon or Congo pea 1/4 c sliced tomatoes
Heat second extraction of coconut milk with dried minnow and fish sauce. Cook for 10 minutes. Season with salt. Add squash and cook for 3 minutes. Add fresh peas, green papaya, red pepper, winged beans, and tomatoes; cook for 4 minutes. Add coconut milk and moringa leaves. Remove from fire, and serve hot.

Vegetable Ukoy*

1 c shredded green papaya 1 or 2 eggs, beaten
1 T green onion leaves, chopped 2 T flour
1 T sweet pepper Vegetable oil to fry
1/2 c pigeon or Congo pea (fresh or MSG or Accent, salt, and white
dried), boiled & mashed pepper to taste
Mix all ingredients. Drop by spooonful into hot oil. Fry until brown. Serve with calamansi* juice.

Pork's Leg with Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean

1 whole pork leg 1 c moringa leaves
2 c pigeon or Congo pea 2 pcs tomatoes
1 bunch winged bean 1 pc onion
1 medium green papaya Salt to taste
Boil porkk leg until tender. Add garlic, tomatoes and onions. Add peas and cook until soft. When done, add winged bean and green papaya. Add moringa leaves. Season to taste.

Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean Sweet Potato Ring

1 yellow cassava 1 c coconut milk (second extraction)
1 c peas, boiled 1 c shrimp juice
1 c shelled shrimp 1/2 c coconut milk (first extraction)
1 c cubed green papaya 1/4 c tomato, sliced
Boil the yellow cassava cubes, and drain; set aside. Boil the peas, shelled shrimp, shrimp juice, tomatoes, green onion bulbs, ginger, coconut milk (second extraction). Season it with soy. Add winged beans and payapa cubes, and cook for 3 minutes. Add pure coconut milk and cook for 2 minutes. Add moringa leaves, and cover. remove from fire. Arrange the cooked yellow cassava along the side of the container to make a bedding, and place the peas, papaya, moringa and wing bean mixture at the center; garnish with green onions. (I wonder if this is the correct procedure for this recipe.)

Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean in Nest

1/2 c peas 1/2 c moringa
1/2 c papaya 8 pcs winged bean
1 c cassava, boiled 10 pcs shrimp
1 small onion 1/2 c squash (thinly sliced)
Mash the cassava with margarine; set aside. Saute galic, onion and ginger. Add shredded papayas,

squash, winged bean and boiled peas. Boil until the vegetables are cooked. (I wonder if this is the correct procedure for this recipe.)

Binulay (Binalot Na Gula)*

1 c ground beef and pork 1/2 c flour
2 tsp salt 1 tsp white pepper
1/2 MSG or Accent 1 tbsp full onion
1 egg, unbeaten 1/2 c winged bean, chopped
1/4 c carrots 1/4 c papaya
1/2 c pigeon or Congo pea
Mix thoroughly all the above ingredients. Wrap in banana leaves, and steam until cooked. Let it cool, and slice thinly. Then fry.

Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean Hamburger

1 c boiled peas, mashed 1/2 c papaya, chopped
1/2 c string beans, chopped 1/2 c flour
1/2 c moringa 2 eggs
1 big size onion, chopped 2 segments garlic
Oil to fry; salt to taste
Saute garlic, onions and tomatoes. Add mashed peas, papaya, winged beans, and set aside. Beat eggs and add flour. Add moringa leaves to sauted ingredients, and mix with beaten eggs.

Pigeon Pea or Congo Pea Guinat-An*

3 pcs tomatoes 6 pcs winged bean
1 medium papaya 5 pcs moringa
1 c coconut milk 1 tsp fish paste
1/2 c punao (forage grass) 1 tbsp salt

Boil pigeon or Congo peas until soft. Add salt and fish paste; continue boiling. Add papaya, winged beans and punao. Boil until soft and done. Add moringa, coconut milk, and the rest of the ingredients.

Lawot-Lawot*

1/2 c pigeon or Congo pea seeds 1 c moringa
1 c kalabasa* 1 c bitter melon
3 young taro leaves 1 spinach (purple)
1/2 c winged bean 2 regular size sweet red pepper
1 tsp sliced ginger 1 tsp iodized salt
2 stalks green onions 1 c thick coconut milk
1 stalk lemon grass 2 c thin coconut milk

Select fresh tender vegetables that are free from blemishes. wash whole and slice to desired sizes; set aside. Bring to boil1 c thin coconut milk. Add pre-cooked pigeon or Congo pea, squash, and young taro leaves. Boil for 5 minutes. Add remaining 1 c thin coconut milk, winged beans, bitter melon and spices. Boil for 2 minutes. Add thick coconut milk and leafy vegetables. Allow to boil. Remove from fire. Serve while hot.

Pochero a la Berding Gulay

1 c peeled & sliced unripe papaya 3 stems green onions
1 c moringa leaves 1 small pc ginger (thinly sliced)
1 c green beans or winged beans 1 tbsp cooking oil
3 pcs ripe tomato 5 black pepper, whole
3 pc ripe banana (gardaba) 3 c rice water, strained
1 c dried minnow Salt to taste
1 clove garlic

Saute the garlic and ginger in cooking oil until slightly brown. Add the rice water and bring to a boil. Add the banana, beans and black pepper. Cover, and continue to boil. When half-done add the sliced papaya, dried minnow, tomatoes, green onions, and salt to taste. Lastly, add the moringa leaves. Remove from fire when done, and serve while hot. 8 servings.

Masquadilla Torta*

1/2 moringa leaves 1/4 c powdered dried dried minnow
1 c winged bean pods, finely 3 pcs tomato, sliced
chopped 3 eggs, beaten
1/2 c shredded papaya 1/2 c onion, sliced
3/4 c shredded squash 5 segments garlic
1/2 c powdered mung bean Salt & pepper to taste

Mix moringa pods, leaves, shredded papaya, squash, powdered dried minnow, powdered mung bean, tomatoes, beaten eggs, onion, garlic, salt and pepper to taste. Place one piece of 5 by 5 banana leaf on a plate, and pour the mixturer on it. Then fry in hot fat until golden brown. Garnish with sliced tomatoes, onions and calamansi*. 8 servings.

Pigeon or Congo Pea, Papaya, Moringa, Winged Bean Chicken Guinat-An*

3 pcs tomato 8 pcs winged bean
1 small papaya 1 c coconut milk
1 c boiled pigeon or Congo pea 1 c palm heart
2-1/2 c sliced chicken 3 pcs garlic
1 c moringa leaves 1 small ginger
3 c water 1 onion
Salt to taste

Saute garlic, onions, tomatoes and ginger in hot oil. Add the sliced chicken and boil with salt. Then

add thewater, and boil until the chicken is soft. Add the papaya, palm heart, winged bean and pigeon or Congo pea. Lastly, add the moringa and coconut milk. Season to taste.

Sauted Vegetables with Cassava

2 c boiled pigeon or Congo pea shells* 1 c mongo bean, yard-long
1/2 c moringa 1 c green bean or cowpea
3 c water 1 c papaya
1 c cubed cassava Oil, garlic, tomatoes, onions and salt

Saute garlic, onion, and tomatoes, with green shells. Add beans, peas, papaya and cubed cassava. Add water and salt to taste. Boil until tender.

Pigeon Pea or Congo Pea, Papaya, Moringa and Winged Bean Lampirong*

3 c lampirong 1/2 c peas or mung beans, boiled
1 c winged bean 1/2 c moringa
2 c yam or potato bean 1 tsp fish paste
1 c kalabasa

Saute lampirong in tomatoes, oil, garlic and onion. Add fish paste, and cook until tender. Add boiled mung bean or pigeon pea, winged bean, and squash. Lastly, add yam bean and moringa. Season with salt and pepper to taste.

Vegetable Delight

1 c pure coconut milk 1 small pc ginger
1/3 c pure coconut milk reserve 3 pcs bell pepper, green& red,
5 pcs fish, preferably tilapia quartered
1 onion bulb, sliced 1-2 tbsp cooking oil

1 head garlic, crushed 1 tsp crushed black pepper
3 pcs tomatoes, quartered 1/2 c pigeon or Congo pea
8-10 winged beans or string beans, 1 c cubed yellow sweet potato
quartered 2"1/2 moringa leaves

Saute garlic in oil until brown. Add onion. Transfer to unglazed cooking pot, then add 1 cup pure coconut milk, winged beans, pigeon or Congo pea, yellow sweet potato, fish, and ginger. Let it boil until half-done. Add bell peppers and tomatoes. Season with salt and crushed pepper. Add the rest of the coconut milk and moringa. Boil for 5 minutes, and serve.

Patalbog*

1 red papaya 4 c water
1 c moringa leaves 1 tsp salt
1 c winged beans Ginger and seasoning to taste
1 c pigeon or Congo pea
Wash peas and papaya (which has been sliced ito elongated pieces). Remove young moringa leaves from stems, and place in a cup. Slice winged beans to desired size, and wwash. Pare ginger, and pound. Place all ingredients in a casserole accordingly. Cook for 15 minutes or until all vegetables are tender. Serve hot. 4 servings.

Pigeon or Congo Pea, Papaya, Moringa and Winged Bean with Dried Fish

2 c sliced winged bean 1 c thick coconut milk
1/2 c mature peas 2 medium size dried fish (marabara-an)
1 c sliced green papaya 1 c young moringa leaves
1 medium size dried yellow sweet 1 tsp soy sauce
potato 1 c thin coconut

Boil 2 cups thin coconut milk with peas, camote, and papaya. Add dried fish and winged beans. Cook

for 5 minutes. Add thick coconut milk and soy sauce. Cook until it boils. Add moringa leaves, and cover. Remove from fire. Serve hot.

Sauted Young Pigeon or Congo Peas

2 c dried minnow 2 tbsp oil
2 c moringa leaves 2 tsp soy sauce
1 c young pigeon or Congo pea 1 medium size onion
1/2 c slided tomato 3 cloves garlic
1 c sliced squash Salt to taste

Saute garlic, onions and tomatoes. Add fish, squash and peas, and cover. Cook for 10 miinutes. Add moringa leaves, and continue cooking for 3 minutes. Remove from fire and serve hot.

Dinengdeng

1 c pigeon or Congo pea, boiled 1 tbsp fish paste or salted fish
1 c green papaya, sliced into small pieces 1 pc ginger
1 c moringa leaves 2 medium tomatoes, sliced
1 c winged beans, sliced into strips

Roasted walking catfish or mullet P>Boil 2 cups water in a casserole. Add the fish paste, ginger, and roasted fish for 15 minutes. Then add the previously boiled peas, green papaya, and winged beans. Cook until tender. Add the moringa leaves last, and cook 2-3 minutes more. Add a pinch of MSG or Accent, and salt to taste. Serve hot. 4 servings.

Pinamilit Na "Haluwan" (Dalag)*

1 c tinapa (roasted fish) 1 head onion
4 cups coconut milk 1 small ginger

2 cups water 1 pc papaya
1 cup moringa leaves Black pepper to taste

Boil the coconut milk with water. After boiling, mix the fish with the spices for 5 minutes. Add the papaya and let it boil for 5 minutes, then add the moringa leaves. Cook for 5 minutes more. Remove from fire. Serve hot. 4 servMSG or Accentings.

Papaya Pancit*

Papaya, unripe Cooking oil
Onion Garlic
Cabbage Soy sauce
Shrimp or dried fish Salt to taste
Pepper, red & green MSG or Accent
1/2 c shrimp paste

Saute the garlic untilk golden brown. Add the sliced onion, pepper, and shrimp orOnion dried fish. Add 1 c of water. Add sliced caggage, shredded papaya, and soy sauce. Cook until tender. Add salt and MSC or Accent to taste. Serve hot.

3-in-1 Recipe

1/2 c coconut milk, diluted 1/2 c shrimp paste
1 c dried shrimp 2 pcs green pepper, (cut into strips)
1/2 papaya, unripe, cut into strips 1 segment garlic, minced
3 c moringa leaves Onion

Boil coconut milk, shrimp, garlic, and onions for 10 minutes. Season with shrimp paste, and continue stirring. Add cooked peas, papaya, green pepper, and moringa leaves. Cook 5 minutes longer. Serve h ot. 6 servings.

Pigeon or Congo Pea, Papaya, Moringa and Winged Bean Chop Suey

2/3 c mashed boiled peas 1/4 c chopped onion
1/4 c blanched moringa leaves 1-1/2 c rice washing
1/3 c chopped shelled shrimp 2 tbsp flour
1 pc beaten chicken egg 1/2 c edible oil
1/2 c shell meat* 2 segments garlic
1 small half-ripe papaya, sliced thinly 1/2 c shrimp juice
3 pcs winged bean, sliced crosswise Salt to taste
2 pcs sliced red & green pepper Pinch of white pepper

Combine mashed peas, winged beans, shrimp, one-half of the beaten egg, 1 tbsp flour, half of the bulb onion; season with white pepper and salt to taste. Mix well and form into small balls and fry./ Saute garlic, remining onion and shell meat. Add salt and shrimp juice. Let it simmer for 2 minutes. Add fried pea balls, papaya, winged bean and rice washing. Bring to boil for 3 minutes. Beat 1 tbsp flour to the remaining beaten egg, and pour in; add red and green pepper, then salt to taste. Sprinkle with white pepper and serve hot for 6 persons.

Pigeon or Congo Pea with Blanched Dried Minnow

2 c pigeon pea seeds, fresh or dried 6 c rice washing
1 c blanched dried minnow 1 medium size onion
4 medium sizie tomatoes 1 tbsp salt

Peel and slice onion. Wash tomatoes, and cut into cubes. Add to the rice washing together with the pea seeds. Add salt and boil until peas are tender enough. Then add the blanched dried minnow, and boil for 5 minutes. Serve hot. Good for 6 servings.

Notes

1 The flower of this wild banana is extensively used as a vegetable, as are those of other bananas.

2 The meat from a young unripened coconut that has a jelly-like consistency.

3 Yams may be used as a substitute.

4 Coconut milk is extracted by squeezing the meat of a freshly grated coconut. The first squeezing is called kakang gata. A second squeezing is used after water is added to the remaining coconut meat, and this is called gata or coconut reserve.

5 Unknown at this time. Further inquiries are being made to the Food and Nutrition Research Center of the Philippines, and this information can be obtained by writing to the author at a later date.

6 Lumpia wrappers are made from rice or wheat flour dough and are paper-thin, and pliable when dampened.

7 See Section I, "Introduction".

8 The green pods of moringa can be used as a substitute for okra.

9 What portion of this plant (leaf or grain) is used is unknown at this time. It is a common forage grass. Further inquiries are being made to the Food and Nutrition Research Center of the Philippines, and this information can be obtained by writing to the author at a later date.

10 Rice washing is the water used to wash the rice the second or third times after the dirt and insects have been washed out. It contains a powder from the rice, and is thought to preserve some of the nutritional value of the rice.

11 The leaves of this plant are used as a spinach substitute; fruit are used to make wine, jellies, and a variety of other products (with a flavor similar to cranberries), and used in drinks because of its bright red coloring.

12 Saba is both a term for a specific species of banana, as well as a generic term for wild and cultivated bananas and for plantains. Wild or cooking bananas or plaintains are used both as a vegetable (green), and as a fruit (ripe), and the flowers are used as a vegetable.

13 Sitaw (sitoa) is a generic name for a number of green beans (including green cowpeas), as well as for dried cowpeas.

14 The heart of almost all palms can be cooked and eaten as a vegetable.

Miscellaneous vegetables

Miscellaneous vegetables do not fit conveniently into other classifications. These are often popular vegetables in the tropics, and some are especially nutritious and/or well adapted to a specific, harsh environment.

See A Comparison of Miscellaneous Vegetables

- Buffalo gourd. Cucurbita foetidissima. Vigorous perennial; seeds are high in protein and oil; roots are an excellent fuel crop; does well in dry areas with low humidity. (EDN 25-1).

- Egusi.Citrullus lanatus ssp. colocynthoides. Only the seeds are used, with 30% protein and 50% oil; FLESH TOXIC; very drought tolerant. (EDN 7-1, 41-4).

- Onion. Allium sp. Tropical variety trial; produces bulbs during short days; not for sale in the US. (EDN 39-1,2) When available.

- Rhubarb. Rheum rhaponticum. Can be grown from seed (not roots) as an annual in Florida. (EDN 26-2).

- Roselle.Hibiscus sabdariffa. Also "sorrel"; sour-flavored calyx used in drinks and sauces; edible leaves.

- Sweet corn.Zea mays. Hawaiian Supersweet #9A. Buhrow's white desert sweet-does well in dry areas (temporarily out of stock). See Grain Crops for other corn varieties.

The poor man's plow

by Lewis Baker

The plow is used to prepare the land for planting. The plow does several things, but most importantly it removes from the surface of the soil the vegetation that would interfere with planting, such as weeds and residues of previous crops. The plow requires a lot of energy to turn over the upper layer of soil, and so a powerful tractor is used to pull the plow. But tractors cannot be used on steep slopes; and even if they could, they are very costly to buy and operate. Therefore, farmers with scarce economic resources have to use other means to prepare their land for planting.

In some areas farmers use oxen to pull their plows, or they use heavy hoes powered by human energy to prepare the soil; however, most poor farmers use fire to prepare the land for planting. Fire is the poor man's plow because it, like the tractor or ox-drawn plow, removes from the surface of the soil the vegetation that would interfere with planting. The tractor-drawn plow does this by turning over the upper layer of soil and covering and mixing with the soil, the weeds, and residues of previous crops. But the use of fire converts them all to ashes and smoke.

Although fire clears the surface of the land to facilitate planting, it also does a lot of harm because it destroys the organic materials. (The organic materials of rotted leaves, branches, and stems add nutrients to the soil and help it to hold the moisture that the growing plants need.) Fire also destroys many of the beneficial microbes of the soil, which are very necessary for its fertility. And, then, fire leaves the land bare and defenseless when the heavy rains come. On hilly land the rains wash away the bare earth, and carry much of the good soil to the creeks and rivers where it is lost forever.

Thus it is that the poor farmer, by using fire, is destroying the health and wealth of the land that

God has been preparing for thousands of years. But God is very great and very wise. God has given to humankind-to the poor farmer-some plants that fertilize the soil, and these same plants also protect the soil from eroding when the heavy rains come. These plants cover the soil and choke out the weeds, but once they are cut they dry up and rot very quickly. In other words, God has given to the poor farmer another plow that improves the soil and does not harm it as fire does. There are several kinds of these plants, all of them legumes, which can be used as the poor man's plow, and God has arranged things in such a way that beneficial microbes which fertilize the soil can live and multiply in the roots of the leguminous plants.

One of these plants is called Velvet Bean (Mucuna deeringiana), but you may know it by some other name. It is a spreading and climbing vine with many leaves similar to those of ordinary beans, but larger. The pods appear at the beginning of the dry season and they form in bunches. They look something like bean pods, but they are much thicker, and they are covered with fuzz when they are immature. This fuzz does not irritate the skin as does the fuzz on the pods of some similar plants. The mature pods turn black, and the seeds are round. They may be black, white, gray or mottled. The velvet bean is very easy to grow and once established it will cover the ground, and in a very few months it will smother out all the weeds. After the weeds are gone it is relatively easy to chop up the lush growth of the velvet bean. Since it rots very quickly it presents little difficulty to the farmer who plants by hand. Without burning, one can then plant corn, rice, or any other crop in the soil which is protected by the mulch formed from the velvet bean. The plants of velvet bean which sprout up after a different crop is planted can be pulled out quite easily, so they do not present a serious problem.

Another plant not quite so well known is called Tropical Kudzu (Pueraria phaseoloides) (not the same species as found in southern USA). It is also a vigorously growing vine that covers the ground, fertilizes it, protects it against erosion, and chokes out the weeds. The leaves are very similar to those of the velvet bean, but the pods and the seeds are quite different. The pod is long and very thin-almost as thin as the lead of a pencil. Each pod has about 30 small round seeds, brown in color, and very hard. When the pods are mature they turn black, and with the heat of the sun they spring

open to scatter the seeds.

Another leguminous plant native to some forested areas is known variously as Ox's Eye or Deer's Eye (We at ECHO are unfamiliar with this species). It has similar properties to the velvet bean and kudzu, in that it fertilizes and protects the soil and smothers out the weeds. The vine is heavier than either of the other two plants mentioned, and the leaves are larger but with the same general shape. The seeds are less numerous, but they are very large. Each pod usually has from two to four of these black seeds shaped something like large checkers. They remind people of the eye of an ox, cow, or deer- hence, the popular name.

It may be necessary to experiment with different ways and times of planting to learn how to obtain the greatest benefits from any of these plants. For example, in one area a person could try planting velvet bean with corn when the corn is knee-high, using three seeds per hill, with the hills two meters apart. In other areas, different times, different densities, and different distances could be tried with a view to comparing the results. The goal would be to have the legume well established when the corn is harvested, without the corn having suffered. After the corn is harvested, the velvet bean should be given enough time to cover the ground and smother out the weeds. Also, enough velvet bean seed should be harvested for replanting before cutting it down to plant another crop of corn.

God has made these leguminous plants-velvet bean, kudzu, cow's eyes, and others-to help maintain and increase the fertility of the soil. But farmers must cooperate with God by gathering the seed and planting it at the appropriate time in the appropriate place. With God's guidance we can learn to use these marvelous plants that He has given us, and farmers rich and poor can have a better life-a life that glorifies Him who has placed us as stewards over the earth and all that is in it.

Pulses (grain legumes)

Pulses are legumes which produce seeds that are harvested when dry, then cooked for human food. They are high in protein and can substitute for meat in the diet. Oil content ranges from almost

none to high. They also provide good quantities of B vitamins. Carbohydrate contents vary, but often include long chain carbohydrates that are difficult to digest and lead to flatulence (gas). Most grain legumes contain antinutrients or poisonous substances and need to be thoroughly cooked before eating. Under proper conditions they can be stored for many years.

Some grain legumes are commonly used for other purposes, as edible leaves or leguminous vegetables, in which case the same species will be mentioned in more than one section of this publication. Most tropical grain legumes are annuals, but some are weakly perennial. Their climatic adaptation varies, and some have severe insect and disease problems which limit their use. Variety trials are desirable, as there may be considerable variation within a species. ECHO's varieties represent a small proportion of those available, and there are many minor species not in ECHO's collection.

See A Comparison of Pulses

- Bush bean. Phaseolus vulgaris. 'Contender'-see Leguminous vegetables.

- Chickpea (Garbanzo). Cicer arietum. Cool-season crop; drought tolerant; immature beans used as a vegetable.

- Cowpea. Vigna unquiculata. Thailand long bean (catjang)-very productive climbing or trailing vine; 8-10" pods; must be harvested before it becomes stringy; tasty, disease-resistant. Yardlong beans. (EDN 23-6).

- Cowpea. Vigna sinensis. Cowpea (black-eyed pea).

- Fava or broad bean. Vicia faba. See Leguminous Vegetables.

- Hopi Red Lima bean. Phaseolus lunatus. Very drought tolerant.

- Horse gram. Dolichos biflorus. Tolerates drought and poor soils; small seeds; rarely attacked by insects or disease; eaten boiled or fried.

- Lablab bean. Dolichos lablab. (See Leguminous Vegetables.) All varieties (Red, White, Rongai, and Highworth) can be used as pulses. (EDN 20-5, 31-3).

- Lentil. Lens culinaris. Crimson variety of drought-resistant Middle Eastern pulse. Early blooming date. (EDN 40-7).

- Marama bean. Tylosema esculentum. Drought-resistant bean from Kalahari desert; roast in the shell to get a hickory-smoked cashew taste. (EDN 42-2).

- Moth bean. Vigna acontifolia. Yellow brown-annual vine; small seeds; mat-like growth that protects soil surface; adapted to poor soils but needs good drainage; needs short days; highly drought tolerant; 22-24% protein.

- Mung bean (Green gram). Phaseolus aureus. Early-maturing bush or slightly vine-like herb; high-yielding, widely adaptable.

- Nuna (Popping bean). Phaseolus vulgaris. Requires short days to flower.(EDN 29-1).

- Pigeon pea. Cajanus cajan Khaki-indeterminate, large seeds, from Puerto Rico. 2-B Bush-determinate, from Puerto Rico. Peruvian. Black-seeded. Martha White/Goya. Short duration. Gray. (EDN 29-4,5, 38-6).

- Rice bean. Vigna umbellata. Slender twining vine; drought resistant; needs well-drained soils; intercropped, often with rice.

- Soybean Glycine max.Duocrop-tropical. Braxton and Wright-temperate. Davis-subtropical. (EDN 15-2, 24-3, 25-5). Temporarily out of stock.

- Tarwi.Lupinus mutabilis. High in protein and oil, does well on marginal soils. High altitude crop; does not produce seed in Florida. (EDN 29-1).

- Tepary bean. Phaseolus acutifolius. Intolerant of frost and standing water; requires low humidity; very drought tolerant; yields variable and generally low. Only virus-free seed is sent overseas. Also may select a disease-resistant variety trial; select best colors for your area: white, black, yellow/tan, gray, red speckled (EDN 2-2, 11-3, 34-6). Note: many people groups are particular in what color of bean they will eat.

- Urd bean, yellow. Phaseolus mungo. Also called black gram; differs from mung bean in that urd beans have erect pods, longer hairs and longer seeds; more drought resistant than mung beans.

- Velvet bean. Mucuna deeringiana. All varieties vigorous, somewhat drought tolerant; good green manures; beans used in various recipes, or roasted and ground as a coffee substitute, although they may be dangerous to eat. Tropical-requires short days (long nights) for flowering and pod production. 90-day-day length neutral, but less vigorous than the tropical type; has irritating hairs, so cover arms during harvest. NOTE: IT MAY NOT BE SAFE TO EAT THE BEANS, THOUGH SOME DO. EXERCISE CAUTION AND WATCH FOR ANY SIDE EFFECTS. (EDN 20-3, 24-4,5,6, 31-6, 37-1,2, 43-5).

- Winged bean.Psophocarpus tetragonolubus Request TN for cooking information. See under Leguminous Vegetables.

Rabbit raising in the tropics

Echo technical note # b-1

Compiled by Martin L. Price, Director of ECHO

Some development workers in the third world are very enthusiastic about rabbit raising projects.

Others are equally negative. Why do they have such different opinions? The following began when I wrote to Fremont Regier in Botswana and presented this perplexing question to him. Fremont had been mentioned to me a couple of times as a person who enthusiastically and successfully used rabbits in development projects.

This is not a treatise on all you need to know to raise rabbits in the tropics. Rather you should view it as a "conversation" with some experienced people about certain aspects of raising rabbits. This collection may be expanded in the future, so I welcome suggestions and ideas from your own experience, pro or con. When writing, specify whether I can (1) use your name and (2) identify your organization and country when quoting you.

Letter from fremont regier, mennonite central committee, Botswana (and earlier in Zaire)

I find your question concerning why rabbits catch on in one place or with one person and fail to do so in another place or with another person quite interesting. I've given this question a good deal of thought. There are some givens which must be present for rabbit raising to go in eveloping poorer countries in rural villages. Let me list a few of them which may seem very simple and obvious, but nevertheless critical.

Adequate source of cheap roughage. To be economically feasible a rabbit project cannot depend on expensive purchased commercial rations (unless a very high degree of management is available along with good transport and marketing facilities). To go well, rabbits must be raised by village farmers in areas where climate and other conditions permit the farmer to cut free, or nearly free, green roughage in large quantities. This cuts down on the need for grain. Though neither production nor weight-for-age will be as great, the gains will be inexpensive. The beauty of the rabbit in this situation is that it converts cheap roughage unfit for human consumption into meat of very high quality.

Proper housing. A large variety of forest and other materials can be used to build rabbit hutches. But a decent hutch is required to provide healthy surroundings, adequate light and protection from

dogs and thieves. It must be made from inexpensive local materials, with the possible exception of wires mesh floors. Rabbits must be kept properly apart to control breeding. Hutches must last long enough that the farmer does not become discouraged at constantly having to repair them.

Management. Rabbits are very forgiving. You can get away with a lot. But certain minimum standards must be kept. Breeding, feeding, housing, record keeping,weaning and health maintenance must be done to keep the project operating. A man can have a flock of chickens, throw them a bit of grain occasionally, shut them up in his kitchen at night and get away with it. Much more is required of the rabbit raiser. We found that it is best to start with a farmer who has had no experience with rabbits and help him get started. The man who has "raised" rabbits before under improper methods of letting them run around the house and not in proper cages is less likely to succeed than the one who starts from scratch and "does it right". Extension work is essential here. Farmers need regular visits to their farms to encourage, train, support, trouble-shoot, give new ideas, etc. Occasional seminars, tours, field trips to visit other farmers' rabbit projects and other group activities serve to encourage and maintain interest.

Labor. As said earlier, a flock of chickens can take very little time under the traditional "scavenger" method of husbandry, but rabbits, each one in its cage, take much more work. In questioning many one-time rabbit raisers who later abandoned the work, I got many reasons why they had stopped. Some said their rabbits died, others that they couldn't sell them, or that they had no food. In questioning other raisers who had continued to raise them, I was told that rabbits do not die for no reason (hunger or ill care or dirty cages cause it), that they had no trouble selling all that they had for sale and that feed was available. I surmised that what it boiled down to in many cases was that it just takes too much time and work for some people. I'm not saying this is bad. If a person doesn't want to be that tied down to a set amount of labor daily, that is O.K. To many it just is not worth it. But you can't raise rabbits with no work or with as little work as would be required for an equal number of chickens. We learned to be wary of the would-be rabbit raiser who had a hard time staying at home. One of our extension agents would refuse to help set up anyone in rabbits who was unmarried or owned a motor bike! His theory was that such young men ran around too much and

would not be at home with the project on a regular basis. At the same time I've seen fathers teach their sons to care for their rabbits in their absence and a beautiful family project developed giving occasion to teach the value of honest labor, discipline and husbandry.

Yes, some people are very negative about rabbits and others enthusiastic. Rabbit raising is not for everyone. In the same given area some will take to it, others not. And areas differ. One village will have a good group of interested raisers, others none. One development project with volunteer American extension agents will be successful in promoting rabbit raising, another similar project with similar extension agents in similar programs will be unsuccessful and become discouraged. I've even seen some of those volunteer agents from America unsuccessful in their own rabbitry. I don't know the secret. But I feel it lies in interest, real desire, sincere joy at farming and animal husbandry, willingness to work hard, determination to hang in there until it pays off, horse sense, a "feel" for animals.... and I suppose some mystery factor we can't put our fingers on.

In areas where the traditional "scavenger" method of animal husbandry has been practiced (where the animals are largely left to find their own livelihood) a fundamental change in attitude or educational process must take place for rabbits to be practical and successful. To cage and regularly feed the animal is very foreign. Especially when the farmer and his family may be hungry. We must not underestimate the significance of this educational process and fundamental change that must occur here. Very important in this all is discipline of thinking and living which has been traditional for some people.

You might find some assistance in the materials available on rabbits from World Neighbors, 5116 Portland Ave., Oklahoma City, OK 73112. I am enclosing a copy of a letter about rabbit raising that I wrote to someone else recently. It goes into more detail on some of the management questions. If I can be of further assistance, don't hesitate to contact us again. [Ed: See p.6 on World Neighbors material.]

Letter from fremont responding to someone's questions about management of rabbits

Thank you for your letter. I am very much interested and excited about rabbit raising. We have just started again after our move to Gaborone, raising rabbits for the family. We have had litters of 10, 13, 14, and 10 as our beginning! Though I cannot answer all of your questions, I will make an attempt on some of them.

1. How do you penetrate the villages with the practical helps of rabbits and the gospel?

To properly respond to this would, of course, involve volumes on anthropology, rural sociology, Christian love and patience and theology. But I'll mention several points.

I'm not quite comfortable with the word "penetrate" in the question, and would prefer a softer word such as "enter" or "present" or "approach". We need to come humbly, as learners and fellow travellers on life's road.

To be of significant service in effectively sharing the good news of the Gospel one needs to be accepted in a given village. An entry is needed. I'm most excited about working through the local church if one exists. I like the approach that God cares for His people and is concerned with every fact of their daily life: spiritual, social, political, economic, etc. These are all parts of the Gospel good news. God created the world. We are His husbandry people. We have esponsibility to care for, conserve and replenish the earth, to practice stewardship and Biblical ecology and to share the produce God's world will give us if properly tended, in cooperation with His laws of nature, with others in the community. These are all parts of the Good News of the Gospel.

If a local church exists in the village, working through its leadership/members provides a good entry, as one endeavors to facilitate their work and become assistant to their work.

Other points of entry through which it is necessary to work are the local chief or headman, school teachers, government agricultural agents, health workers, family welfare workers and other leadership/service types who may be present. In all cases initiative and bottom-up participation must be sought at all costs. Top-downing will not, in the long run, produce real on-going

development nor is it Christian or consistent with Christ's examples. One must participate in village life and learn the language, customs, etc. to the extent of being accepted as a trusted friend before one can expect to make much impact or initiate change.

In our work in Zaire we were known in most villages as workers of the Mennonite Church which had been there for many years. Therefore we needed no introduction. Had the church not been there, our introduction would have taken longer. Our approach was, as extension workers, to visit the local clan chief and other leaders mentioned above. On initial visits to given villages we tried to come as learners to hear what their problems were. Some of their requests we could refer to other departments of the church or to other agencies. We would try to get people to think together on what they locally could do about it, looking at their resources and others available to them. It is unwise to do for anyone something that person can do for him/her self.

In the small livestock program specifically we would come to know those who were interested in rabbit raising. We would suggest materials from the forest needed to build hutches and promise to be back in a month to help any farmers who had their materials cut ready to build the hutches. These hutch building times became real community endeavors. Others would gather around to help, thus learning how to build their own hutches. After they had obtained breeding stock at the center from others already in rabbit production, we'd do follow-up extension work on care, feeding, management and financial record of rabbit keeping.

Each of the village visits was a beautiful opportunity to share with farmers and their families around the campfire at night about the issues mentioned above of God's involvement in His creation and our life. Occasional seminars of one or two days on rabbit raising in a central village and group tours to visit each others' projects increased interest and proficiency. We also imported wire mesh to sell to those who wanted it for floors for greater efficiency and life of the hutch. A cooperative was formed for marketing.

2. What possibilities do you see in raising rabbits in Nigeria?

The Nigerian government in the early seventies was pushing backyard rabbit production. I'm not sure of the present state of the program. Basically I do not think the weather is adverse there. Rabbits can stand a wide range of weather and climatic conditions if properly housed and cared for. To be practical for rural villagers cheap sources of greens must be available. Purchased prepared rations as pellets , etc. are so expensive and hard to come by in many cases that extremely fine management is needed to make it profitable. This level of management as well as the marketing and transportation infrastructure is often lacking in rural village situations. therefore, one needs to depend on such items as wild greens, (e.g. palm branches and various weeds) those leaves from field crops like cabbage and lettuce that are not used for human consumption, corn plants after the corn is harvested for roasting ears, planted crops like Stylo santhis, peanut vines, etc. These free or cheap sources of greens form the bulk of the diet and smaller amounts of grains are necessary. However some rain is necessary, especially for nursing does and growing fryers. If not using prepared portions, salt will be a necessary supplement as well. If there is sufficient rain for greens to grow and some grain is available, feed is no problem.

Culturally, some people do have taboos or are unaccustomed to eating rabbit meat, but with proper information on raising, slaughtering and preparation we've found this to not be too much of a problem.

3. Would raising chickens be complimentary to raising rabbits?

We used to call rabbits the "poor man's project" as opposed to chickens. To be profitable, chickens need more sophisticated diets, veterinary medicine and more frequent marketing of highly perishable produce (eggs) than rabbits. These inputs are often too expensive or unavailable to the rural village farmer. (That is if one wants to go with improved breeds on a commercially viable basis). An improved cock with local native hens running in the village is a good little sort of thing, but not too much of a commercial venture. However, where these necessary poultry inputs are available to a farmer, we have found that chickens and rabbits go well together. In fact, I like to run chickens under my rabbit hutches part of each day to clean up on the grain or pellets the rabbits

inevitably spill. Other than this, I don't suppose there is too much complimentarily between rabbits and chickens. Rabbits don't compete with humans for grains as strongly as do chickens, another advantage for rabbits.

Rabbits do compliment well with vegetable raising, however. As extra greens are available they are fed to rabbits, the manure goes back on the plots, etc. A good cycle is possible there.

4. Would you consider any vegetables or plants that could be preventative measure for diseases?

In case of rabbit or poultry feed, I know of no plants that could be used as preventative measures for disease other than the normal dietary components necessary to provide health and strong resistance to disease.

Letter from gary shepherd
Sometimes one of our readers will take time to write to us, quite on his own initiative, about something he has learned from personal experience. A timely example of this is this letter from Gary Shepherd in Nepal which arrived soon after the letter from Fremont. Gary's letter follows.
"About 8 years ago I tried raising rabbits in the village, but nearly all the 80 young died and I gave up. Last fall I got a few tips and raising rabbits has caught on like wildfire now. The important points were:

(1) Clean the pen daily, i.e. throw out all old grass etc.

(2) Keep feed off of the bottom of the pen by either building a feed rack or tying it up.

(3) Make sure villagers build pens with bottom slats of bamboo or wooden rods so that it is as self-cleaning as possible.

(4) Avoid giving grass that is wet during the hot season. Though you might get away with it for a month or more, one day you will find that a bunch have died overnight. Cut grass in the morning

and spread it out to dry excess moisture in a sheltered place (on top of the pen) and feed it in the evening. In the evening you can cut grass again and dry it overnight. Rabbits do OK on a 90% banana leaf diet, but prefer a mix of foliage, weeds, etc.

(5) Some books say not to give salt. I put it in with a little ground grain made damp with water. Our villagers feed their rabbits a lot of mustard cake. They are far more profitable than chickens and require comparatively little grain."

Fremont's reply to my second letter
I wrote to Fremont a second time with some additional questions that were not addressed in his first letter. His reply follows:

Dear Martin,

Thanks for your kind letter of 25 August, 1982. It is very gratifying to realize my letter and other information I sent was useful. Yes, you may go ahead and include my address in what you send out to people in this connection. [Editor: You may write to him at P.O. Box 33, Gaborone, Botswana] Let me attempt to answer your other questions.

1.) Too many rabbits die from heat in hot climates to make them profitable: We never had rabbits die from the heat in Zaire or in our short experience in Botswana, though some other countries would have even higher temperatures. Higher temperatures do lower growth rates as feed consumption goes down and does are also harder to breed when it is very hot.

2.) You can't feed a rabbit very much green matter or it will bloat and die: I have heard that fresh green matter with dew still on it will cause rabbits to bloat. For that reason some farmers would cut their greens in the morning when they were fresh, crisp and sweet and then hold them for evening feeding which works well since rabbits are night feeders. I've also heard that changing kinds of greens feed suddenly can cause trouble, but I've never had trouble with that. Farmers in Zaire fed a tremendous variety of greens with no ill effects. I have heard that Paw-paw tree leaves cause

diarrhea but in moderate amounts they have never caused any problems for me. Just now we are feeding our rabbits enormous amounts of cabbage, lettuce and cauliflower leaves that we get from grocery stores in the city and we have no problems. And it saves us a lot on expensive commercial pellets. Basically, it is safe to say that practically anything from the garden, forest or kitchen can be run through the rabbit hutch - banana and paw-paw peels, pineapple cores, palm branches, corn stalks, peanut and sweet-pea vines, weeds, alfalfa, stylo-santhis. If they eat it, fine; if not, it goes on out to the compost pile with the manure.

3.) The danger of escaped rabbits is too great. They could end up being another Australia: I've heard this argument before also, but actually it is a rather ridiculous one, I think. The Australia thing was caused by the introduction of wild rabbits, not of domestic rabbits. J.E. Owen in "Rabbit Production in Tropical Developing Countries : A Review." Tropical Science, 1976, 18 (4), pages 203-210, on pages 207-208 says: "One aspect of rabbit keeping which causes concern to many developing countries is the potential threat of escaped domestic stock and their effects upon other agricultural enterprises. The unfortunate experience in Australia is probably responsible for this. It should be pointed out, however, that in Australia in the mid-19th century domestic rabbits were kept in almost every town and city. Those which were liberated or known to have escaped gave little or no trouble, except around Sidney where they became established and merely constituted a local nuisance (Fenner and Ratcliffe, 1955). However, this problem paled into insignificance compare with the damage caused by wild rabbits which were introduced later on. All successful mainland invasions, of England, Australia, New Zealand, and South America have developed from the introduction of wild stock (Flux, 1974,1975, 1976, personal communication), but even in Australia wild rabbits have not spread into the tropical parts of the country.

There are many instances of escaped domestic rabbits multiplying on small islands, to the detriment of the vegetation, in both tropical and non-tropical climates (Watson, 1961; O'Farrell, 1965; Flux, 1974, 1975, 1976, personal communication). The burrowing habit has undoubtedly helped them to withstand periods of very high temperature and water shortage in warm countries (Hayward, 1961) On large land masses, such as Africa, escaped domestic stock are extremely unlikely to cause

serious problems. On small islands with no natural predators, however, the situation may be very different, although the island of Malta has both wild and domestic rabbit population and has suffered no such problems. In these situations expert advice from ecologists who are familiar with local circumstances should be sought." Incidentally, if you don't have Owen's Article, it would be a valuable one to get. It is a good summary and his reference list is helpful.

No, I've not had experience with the feeding of leaves of leguminous trees, but it does sound like a workable idea if such trees were available in abundance. Rabbits can eat large volumes of green material and care would have to be taken in harvesting leaves to avoid killing the trees.

Some planning ideas to remember when considering rabbit production as a church development project to help village farmers by fremont regier

Introduction. Rabbits have a number of valuable advantages that make their production quite inviting. One doe can produce 4-6 litters of 6-8 young each per year. That means one doe can easily give you 25 or more young per year. Multiply that number by the number of does you may have to arrive at your annual production given proper husbandry and management practices. Multiply this number then by 1 or 2 kilograms and you see the potential of meat production in rabbits.

Rabbits consume large amounts of forage - greens of many types - which people do not eat. They convert this forage into meat which people do eat. Anyone with fields or a garden will have maize stalks, sweet potato vines, fruit peelings, peanut vines, cabbage or lettuce leaves, carrot tops or any number of other greens in addition to lots of wild plants and kitchen garbage on which rabbits thrive. Many of these greens would otherwise go to waste. They would need, however, a bit of grain each day.

These animals produce a highly acceptable, very nutritious meat. When slaughtered, they give meat for a family-size meal. They are easy to prepare in a number of ways. The pelts can be used for clothing, hats, to cover bicycle seats, etc. and their use could spark a village industry/crafts project.

To start a rabbit project one does not need a large initial investment. One can begin with home-built hutches and 1 or 2 does plus the breeding buck which all together represent a small outlay of cash. They respond well to good management but are surprisingly forgiving of poorer management. They give good returns for the inputs invested. Any size of project can be profitable depending upon the resources of time, money and materials the individual rabbit farmer may have.

Rabbit raising makes an excellent family enterprise. Children in the family learn about life, production, the joy and value of hard work, and cooperation in caring for their rabbits. My three children each owns one doe in our family rabbitry and are saving money for college with the returns from their doe's offspring. They are learning about the possibilities and joy of working in harmony with God and His creation to increase food production.

Rabbits fit well into a balanced farming scheme. Their manure is very valuable for vegetable gardening to fertilize the soil. Unlike poultry manure, it will not burn the plants and can be applied directly to the plant or its roots. Excess and waste from the vegetable gardening project goes to feed the rabbits, setting up a profitable cycle and aiding the balance of nature.

A rabbit farm takes little space. Rabbit production is very adaptable. The farmer can be as inte nsive or extensive as his condition, materials, possibilities and wishes dictate.

Some Suggestions:

1. Keep the production unit at your center simple and small. You will want to save all your resources of energy, time, and money possible for the more important extension phase of your program. A small production unit will allow you this time, while still giving valuable experience in learning to raise rabbits. A unit of 5 to 10 does will give you lots of breeding stock to sell to beginning farmers. Very soon new farmers wanting to start new projects can buy their initial breeding stock from other farmers. In a short time, then, your center will become less and less important in selling breeding stock and village farmers will sell to each other, thus increasing their income.

2. Use breeds locally available and adapted. Don't worry about getting some sort of exotic stock from far away. Locally successful rabbit breeders can provide you with good stock. Several does from one breeder and a buck from an unrelated herd will be a good start. Then select replacement stock from the mothers producing the largest, fastest growing litters. Both you and the village farmer can improve your stock better this way than by trying exotic imports.

3. Be innovative. Use local materials as much as possible for hutch construction. Maybe stone hutches with stone floors, using deep litter will work for you. You may prefer to use woven wire mesh for the floors, but materials like bamboo for the rest of the hutch. Thus you will save money, but even more importantly you will be giving a practical example to the village farmers wishing to start their own projects.

NOTE: If you use the deep litter method it will always be dry. Mothers will make their nests to kindle babies right in the litter. If you use wire mesh floors, you will need to supply nesting boxes for your does.

4. Read all you can get on rabbit production. There are a number of books on rabbit production in available. If you write to World Neighbors, Oklahoma City, Oklahoma USA, they will send you an English copy of the rabbit production manual village level, for Zaire conditions, but it has a lot of material applicable anywhere.

5. Base your whole rabbit project on extension. An aggressive extension program will be the most important part of your project. Get out where the people are! You can follow up farmers who purchase starting stock from you or elsewhere or who are already raising rabbits. You can give them on-the-farm assistance in husbandry, nutrition, management. The most wonderful production center will be of little value to your project if it is not made valuable to village farmers through extension services. Visiting rabbit farmers on extension tours give you a chance to get the pulse of what's going on in the village. This awareness will help you to orientate your whole project to village needs and actualities.

Very basically, an extension program will give excellent opportunities for your staff to communicate their faith in God to people in a natural atmosphere under conditions conducive to discussion. Many meaningful relationships can be built through extension work, giving witness to Christ through natural channels which farmers understand. God in His care for us created the world for our husbandry. He is interested in how we use it and our welfare on the earth. Man is not only physical or economic. Man is also social and spiritual. Faith in Christ and eternal values can be built on relationships built through good extension work.

6. Use short, intensive courses for training in rabbit raising. Farmers can come to your production center for one or several days to study together the essentials of rabbit raising. Rabbits do require lots of work, proper technique, sanitation, etc., so training is essential. But don't plan courses that take farmers away from their homes and fields for months at a time and alienate them from their communities. Follow-up seminars or short courses can also be held in villages where farmers come together for learning about rabbits. Training can thus be part of your extension program. Learning farmers can also work as apprentices with more experienced rabbit raisers to learn very practical lessons to put to work on their own farms. You can hold recurring training sessions. Repetition is helpful. New things come up as farmers share their experiences, and they learn a lot from each other.

7. Don't do anything for the village farmer which he could do for himself. We are thinking here of hutch construction, breeding of does, weaning, cleaning hutches, feeding, marketing, etc. This is to help save your time, and even more importantly to help the farmer to become a good rabbit raiser soon. Rather than doing it for him, help him to do it himself through extension on his own farm.

Comments on world neighbors material

In light of Fremont's reference to their material on rabbits, I phoned Karen Shallenberger at World Neighbors. They have one formal publication on rabbits. Ask for "Learning to Raise Rabbits". This is a back issue of their quarterly newsletter, World Neighbors in Action. Each issue is dedicated to one

topic. Subscriptions cost $3.00, and back issues are 75 cents (airmail included). If you already have a good book on raising rabbits I do not believe you will find much new information. But it is a very good 8-page condensation of how to raise rabbits.

The other material consisted of photocopied typewritten manuscripts. Because of expense of postage (they are bulky), you should order these only if seriously interested. One of these is "Housing of Rabbits in Africa". This is a summary of the different housing in which rabbits are raised in Africa and some of the basic criteria to keep in mind when designing housing for rabbits. An appendix reports on a project in northern Ghana where construction material is so limited that the project relied on round mud huts with rabbits on the floor.

I found the most new ideas in a manuscript called "Commercial Rabbitry Handbook". It is written by Lovelace and Divine Odonicor, who appear to be entrepreneurs in the Volta region of Ghana. The most unusual idea (based on what I have read) is their method of reducing labor and number of cages by housing rabbits in large groups which they call intensive gangs. They call the system of having each producer buck and doe in separate cubicles "subsistence rabbitry" because they cannot make enough with that system to expand. Even does who are about ready to kindle are paired two per cage. Here does must be of similar size and due about the same time. They should also be the same breed and be of similar physical fitness. They found that the does do not discriminate so much in milking bunnies, so when one doe is weak the other helps in feeding all of the bunnies.

They feed a variety of greens. In addition, "dry groundnut tops and guinea grass (Panicum) are of remarkable importance alongside wheat bran, corn chaff, sorghum or dried brewers mash mixed with 5% fish meal and 25% ground dry cassava peels, and salted to taste".

Their system of "rotary crossing" was especially interesting, though I found it hard to follow. This system ensures that production of bunnies will be uniform each week. With large numbers of rabbits it could become difficult to remember when to do what. The best way to explain this system is to consider what they would be doing at different days of the week. In the diagram below you can see

that they have divided the rabbits in their "production" area into 11 groups. There are 12 sections, but one of these is empty at all times. Light does are those ready to breed, and heavy does are pregnant.

Schematic diagram of the production section
If you visited early Monday morning you would find one of the light doe sections occupied by a number of rabbits (let's randomly say L-2 was filled). The other section, L-1, is empty. All four heavy doe sections are filled. One section contains rabbits that are 1 week pregnant, another 2 weeks, etc. For convenience, let us say that H-1 is due to bear this week, H-2 next week, etc. Likewise, all six kindling sections are filled with does and bunnies. One section contains bunnies that are six weeks old, another 5, etc. Let us say that bunnies in K-1 were born six weeks ago, K-2 five weeks, etc.

The first thing Monday morning, bunnies in K-1 are weaned and transferred to a "bunnies section". The does are transferred to the empty section L-1, and are now considered light does. Newly emptied cages are cleaned up. On Tuesday, the heavy does that are about due are transferred from H-1 to the newly emptied section K-1. On Wednesday (and through the rest of the week, if needed), the light does in L-1 are bred and transferred to the newly emptied section K1. Note that when these does are transferred to the kindling sections in four weeks they will be 28 days pregnant (less, if bred later in the week). This assures that they will have been in their new quarters a few days before giving birth.

The following Monday the whole cycle is repeated. Bunnies are transferred from K-2 to bunnies section, and does to L-1. On Tuesday, heavy does are transferred from H -2 to K-2 in preparation for kindling. Light does in L-1 are bred starting on Wednesday, and transferred to H-2. Twelve weeks (one quarter) elapse between the time of breeding, passing through each of the 12 sections, and the next breeding.

Miscellaneous comments
In the past month both Dr. Frank Martin, with USDA in Puerto Rico, and Fred Harder, with Heifer

project, have commented favorably about rabbits. Both added that for really efficient meat production, though, we should consider Muscovy ducks. If you have had experience with Muscovy ducks in the third world, please let me hear from you.

Fred Pettit told me that he raised angora rabbits in Ecuador. Twice a day he would feed them fresh alfalfa just as it was going into flower, enough so a little would be left over at the time of the next feeding. Very occasionally, if it was available, he would give them a little corn. Every couple of weeks he threw in a mineral supplement with a little grain. He never watered the rabbits! Apparently they got enough water from the fresh feed. (But before you try that, remember that his temperatures never rose about 78o F.)

Roots and tubers

The root and tuber crops are all perennials or biennials by virtue of the storage root. The perennials contain large amounts of starch-their chief contribution to the diet-while the biennials contain very little. The perennials contribute some protein to the diet as well as starch, but this varies among the species. All roots and tubers also contain vitamin C, but only carrots and sweet potatoes contain useful amounts of vitamin A. Many roots and tubers contain toxic substances or antinutrients. As a general rule, it is best to cook them before eating. However, some cultivars of cassava may be acutely or chronically poisonous even after cooking.

Roots and tubers are extremely important crops on a worldwide basis and should be included on every farm. ECHO's collection contains a few selected cultivars of some of the best.

See A Comparison of Roots and Tubers

- Carrot.Daucus carota. Beta 3 (hybrid)-over 300 ppm carotene (Standard U.S varieties contain 60-80 ppm). Uberlandia-Brazilian; sets seed in the tropics in one season. (EDN 8-4, 12-1, 16-3, 31-3,4, 43-1, 44-4).

- Jicama. Pachyrrhizus erosus. Eat tuber raw; also remains crunchy like water chestnuts when cooked; low nutritional value; requires short days for tuber production; leaves and seeds contain the poison rotenone. (EDN 6-1).

- Sweet potato. Ipomoea batatas. ONLY SHIPPED OVERSEAS WITH IMPORT PERMITS; PHYTOSANITARY INSPECTION IS REQUIRED ($30 PER ORDER). Write with your needs and for instructions. We do not ship outside of Florida within the USA. Varieties: 'Topaz'-orange and sweet, closest to typical US varieties but 50% higher yields; somewhat less uniform. 'Ivoire'-non-sweet, "Irish" potato substitute; very dry if harvested after 12 weeks. 'Viola'-purple skin, white flesh, sweet, good flavor, has done well everywhere. 'Colorette'-low in sweetness, high yielding, light orange flesh, light purple outside. 'Suabor'-large, sweet, smooth, early maturing, yellow when cooked. 'Toquecita'-large, white flesh and skin, non-sweet, excellent for processing. (EDN 4-2, 22-2, 25-3, 28-6, 33-1).

- Wild Mung beans.Vigna vexillata. Cowpea relative with edible tubers.

- Winged beans.Psophocarpus tetragonolobus. Almost all varieties produce high protein edible tubers.

Special purpose trees

In addition to the more conventional crops, many trees are used around the small farm for a wide variety of purposes. These trees have little in common except that many of them are legumes. Leguminous trees are exceptionally valuable for the nitrogen they add when their leaves fall off, or their roots die back. A single species of tree often serves multiple purposes and if a legume is frequently called a multiple purpose legume. The potential uses of trees on the small farm are many, including the production of food, feed, industrial raw materials, lumber, and fuel; living fences, alley cropping, shade, source of nutrients for the soil, and erosion control. Altitude ranges (in meters) are given as a guide. We have a Technical Note on the Principles of Agroforestry if you are interested in this area.

NOTE: Our tree seed inventory changes frequently. Most are added when we purchase or are given some seeds, and are deleted when that runs out. Moringa and leucaena are the only ones we always try to have on hand. We recommend the suppliers on the last page for most of your tree seed needs.

See Comparison Chart for Special Purpose Trees.

- Acacia angustissima (Prairie acacia). Large shrub. Pods eaten in Mexico. Provides fuel wood. Used in tanning.(EDN 34-5).

- Acacia auriculiformis. Widely adaptable to harsh climates (pH 3-9). Used for eradication of Imperata grass. Acacia mangium. To 720 m. Very fast growing on acidic degraded soils, needs full sun. Good timber and fuel wood, high quality charcoal. Quickly suppresses aggressive weeds. Not drought, flood, or wind tolerant; not good for fodder or coppicing.

- Albizia lebbek. aka Woman's tongue; for reforesting dry alkaline soil.

- Albizia lucida. Fast-growing, nitrogen fixing tree.

- Azadirachta indica . Neem. Seeds viable <1 month; available seasonally. To 1500 m. Extremely drought resistant, grows quickly to yield fuelwood, excellent charcoal, and durable timber. Seeds used to make insecticide; twigs as toothbrushes. Various medicinal uses with caution.

- Bursera simaruba (Gumbo limbo). To 1000 m. Used as a living fence, for timber and fuelwood. Coppices well, tolerates salty conditions. Poor drought resistance.

- Calliandra calothyrsus. To 1900 m. Vigorous, bushy, fast-growing reforestation tree; leaves used as fodder; excellent coppicing, fuelwood production. Moderate drought resistance; good for humid tropics. Prolific flowering for honeybees. Some weed potential.

- Erythrina berteroana. Small tree used as living fence, living trellis, forage. Dense foliage; soft

wood; poor drought resistance.

- Flemingia macrophyla. 'Wild Hops' Woody, leguminous, deep-rooting shrub. Grows up to 2,000 m and needs 1-200 mm of rain per year. Tolerates droughts, poor drainage, acid soils, and high aluminum. Useful for fodder, alley farming, fuelwood, and green manure.

- Gliricidia sepium. Fast growing, living fences, green manure, fodder, beekeepers.

- Grevillea robusta. Silky Oak. From 1000-2400 m in tropics. Excellent timber; for high altitudes and wide climatic range. Requires medium soil fertility. Moderate drought resistance; windfirm. Some weed potential. Temporarily out of stock.

- Leucaena. Leucaena diversifolia.. Better than L. leucocephala for 500-2000 m and higher rainfall levels. Not drought tolerant. Fodder quality lower than L. leucocephala but lower in mimosine. Hedgerows, intercropping, alley cropping. Varieties K156; K784- low/mid-altitude; growth superior to K156; psyllid-resistant.

- Leucaena leucocephala. To 1000 m. pH 4.3-8.7, ideal 6.1-8. Moderate drought tolerance. Fast growth, coppices well. Leaves a fodder supplement (small amounts only). Salvador (Hawaiian giant) varieties. K28, K67[high seed production]-tall and tree-like. Peruvian K6-tall with extensive branching; good forage. Cunningham K500-excellent forage. K4-low in mimosine, a toxin when fed to animals in quantity. K636-resistant to the defoliating psyllid.

- Moringa. Moringa oleifera. To 1000 m. Drought resistant. Grows well on infertile, dry soils. Coppices well. Light crown density good for intercropping with many crops. Does not fix nitrogen. Multi-purpose: see under Leafy Vegetables. Moringa stenopetala. Larger leaves and seeds, more drought resistant than M. oleifera. (EDN 32-5).

- Sapium sebifarum. Chinese tallow. To 2000 m. Seed oil and fat used for soaps and candles. Not drought resistant. Frost tolerant; insect and disease resistant. Tolerates a range of soils. Used in

erosion control. May have weed potential.

• Sesbania grandiflora. To 800 m. Perennial tree with rapid early growth even on flooded/waterlogged sites; good fodder, green manure, pulpwood; edible leaves and flowers. Not drought tolerant. Prune lightly; does not coppice well.

• Sesbania rostrata. Annual shrub legume which grows to 5 meters in height and is exceptional at fixing nitrogen (forms nodules on stems). Green manure. Grows in hot rainy season, mostly in low-lying flooded and waterlogged soils. pH range of 2-4.8. Short days may induce flowering.

• Sesbania sesban. From 300-1800 m. Fast-growing perennial with moderate drought resistance, good coppicing ability(EDN 17-2).

• Tagasaste. Chamaecytisus palmensis (TN). Temperate counterpart of leucaena. Used in alley cropping in upland tropics. Tolerant of marginal soils, drought, and wind. Palatable high-protein fodder. Harvest regularly for best production.

Sunnhemp as a green manure

Based on EDN issues 26 and 36. Fr. Gerold Rupper in Tanzania reports that sunn hemp (Crotalaria ochroleuca) is receiving widespread acceptance as a versatile green manure in East Africa. The jack bean, velvet bean and lablab bean are all vines. Sunn hemp is a vigorous upright legume growing 2 meters tall. When planted in narrow rows, mature plants tend to fall over. When planted in the field plants tend to hold each other up. While sunn hemp has a different growth habit than most of the green manures we have featured, the uses are much the same, including: weed control, livestock feed, and erosion control. Sunn hemp is especially suited for weed control in fruit groves because, unlike vining ground covers, continual vigilance to keep it from covering the trees is not necessary. It is being used with banana, plantain, citrus, and coconut. It can be cut at any time and left in the field as mulch. If it is cut one foot (30 cm) from the ground it will grow a second time. Fr. Ruber stresses that not less than 10 kilo of seed per acre must be planted.

Fr. Rupper wrote, "In Hanendi, sunn hemp was planted in an orchard affected badly by insects. When it had grown a bit, the insects left the trees and started to live on the sunn hemp. When the sunn hemp was cut for mulching, the insects returned to the orange trees." "Just this week we were informed that insects which attacked the freshly planted maize moved to inter-cropped sunn hemp, ate the roots and are perishing." Crotalaria is known to contain toxins, but this variety is free of toxin, except perhaps the seed. It is cut about 3 months after planting. It is best cut in the morning, but keeps until evening. Later in the season cattle can be allowed to graze in the sunn hemp field. One farmer noted that after first spending an hour in a grass field, his cows even ate the dry stems.

Fr. Ruper mentions that cattle must not be allowed to spend more than about one hour in the area. [He does not say why.] He also says that the seeds should not be stored in a closed room where people are working. Sunn hemp seeds are used to keep weevils from stored rice and maize. Sunn hemp seeds are spread over the ground and bags put on top of the seeds. This procedure is continued, layering sunn hemp seed and bags of stored grain. After about 9 months, the process must be repeated.

When we asked our EDN readers for suggestions on how to keep monkeys out of the garden, Fr. Rupper wrote: "Early in the campaign for planting sunn hemp (also called zanziberica), we got a report from a youth group that monkeys had been afraid to traverse a belt of sunn hemp around their field of maize. I could not ask the monkeys why they did so. But one can imagine that first of all it is a strange sight to see sunn hemp growing together and forming a barrier.

Secondly, the husks give a clattering sound, which may disturb the monkeys. [Editor: The genus for rattle snake is crotalus coming from the Greek root crotal meaning a rattle or castanet].

Thirdly, if they are caught stealing maize, it is almost impossible to flee through the sunn hemp field as the branches form a rather strong network like wire. In the case of maize [corn] there is some synchronization between the crop and sunn hemp. The husks of both crops form about the same time (depending on the variety of maize). People like to let the corn dry in the fields, at which time

the barrier effect of sunn hemp becomes important....

Meanwhile we have developed a new method of planting sunn hemp. Two rows of maize alternate with one row of sunn hemp. Here the maize is well protected against monkeys." As with velvet bean, farmers are especially appreciative of its usefulness in controlling weeds and improving the texture of the soil. He tells farmers, "If you have no chemical fertilizer when the season starts, plant sunn hemp between your food crops. If fertilizer arrives you may still be able to use it. If not, use sunn hemp and you will at least get a modest crop." According to Fr. Rupper sunn hemp will completely kill striga. A simple alley cropping system has been developed for controlling this important weed. When a field is ploughed and sowed to corn or sorghum, sunn hemp is sown along with the grain at a rate of 10 kilos (mixed with 20 kilos of sand) per acre. At weeding time, sunn hemp is left standing in every third row, knowing that it will kill the crop.

After seven or eight months sunn hemp seeds are harvested and the dry stems are placed in the furrows and buried. If this is practiced each year you have a sustainable system free of striga. Other uses for sunn hemp include: applying the dry stems and any husks to trees or gardens as mulch, or as bedding for livestock. The seeds, about the size of millet, are mixed with two parts of coarse sand and broadcast by hand. They do not need to be covered, although it might be well to draw a branch across the newly planted field. They sprout after a few days and develop a strong root. Growth is rather slow until they reach about one foot, then they quickly grow to 2 meters or more. Sunn hemp is fairly drought resistant, recovering well when rains return. Plants bare seed after 3-4 months and die after 6 months. However, if they are cut back to about one foot (30 cm) above the ground, they again develop new leaves. If planted densely in a well-prepared field, no further work is needed (except to keep out animals).

Sometimes sunn hemp is interplanted with maize. Some species of Crotalaria are also useful in suppressing nematodes, but we do not know if this is one of them. ECHO also carries another species of sunn hemp, Crotalaria juncea.

Variety 'Tropic Sun', released by the University of Hawaii, is included in rotation with vegetables, ornamentals and others to add nitrogen, organic matter, suppress weeds, control erosion and reduce root-knot nematodes. In 60 days it can produce 145 pounds of nitrogen and 3 tons of dry matter per acre. Seed should be broadcast at the rate of 40-60 pounds per acre and covered 1/2 inch deep. High populations make the stems more succulent and hence better for incorporation into the soil. If allowed to grow too tall, stems become fibrous and difficult to deal with. Seeds can be inoculated with cowpea inoculant to maximize nitrogen fixation [presumably not needed where cowpeas are commonly grown]. It also lacks the poisonous alkaloids that make some species of crotalaria poisonous to livestock.

The sweet potato

by Franklin W. Martin

Why grow sweet potatoes?

Sweet potatoes are already the 6th or 7th most produced food crop in the world, surpassed only by wheat, rice, corn, potato, barley, and possibly cassava. Among the reasons that sweet potato is a great crop is that it is relatively easy to grow, relatively free of pests and diseases, has relatively high productivity, and is always good food, principally starch, some protein and vitamin C, and, in orange varieties, rich in vitamin A. In addition, the young leaves, rich in protein and most vitamins, are also good food. Furthermore, the sweet potato is an excellent animal food. Its ability to produce in poor soils makes the sweet potato an especially good crop for poor tropical soils where fertilizer is not available. If the leaves are also used as food, sweet potato will probably produce more nutrients per acre than almost any other crop under those conditions. (The other tropical crop which produces well on poor soils and also has both edible roots and leaves is cassava. It has an advantage over sweet potato in drought tolerance, but sweet potato has the advantage in nutrients. That is because substances called polyphenols in the cassava leaf combine with protein during cooking and reduce the amount of protein that is digestible.) Nevertheless, like all crops the sweet potato must be

produced with understanding in order to obtain maximum yields. It should never be treated with neglect.

Principle uses of sweet potatoes, and techniques

Leaves. The sweet potato plant can be harvested for leaves during the 2nd and 3rd months of production. Only the tender stem and young, not fully developed leaves, which constitute the distal 2-4 inches of the growing stem, should be taken. The leaves and stems are boiled for 15-20 minutes, washed, seasoned, and served.

Boiled sweet potato. The sweet potato is washed, peeled and trimmed, cut into 1 inch thick slices or cubes, and boiled 18-20 minutes. The boiling water is then discarded. The sweet potato can then be served as is, mashed, or combined in many dishes (casseroles). The mashed pulp can be used as a partial substitute for wheat flour in baked products such as pancakes, cakes, flat breads, cookies, fritters, or even bread.

Baked sweet potato. The entire sweet potato is wrapped and then baked in a modern or primitive oven until soft (one hour at 350 degrees C). During baking of most sweet potatoes, part of the starch is converted to the reducing sugar, maltose, thus increasing sweetness.

Osmotically modified boiled sweet potato. The peeled and trimmed sweet potatoes can be cut into thin (1/8") slices, placed in water 2 hours (moved once in a while) and then boiled. The products will be clearer, less sweet, and milder than those made from untreated sweet potatoes. (What is happening chemically is that the enzymes and substrates responsible for polyphenolic oxidation are partially lost, as well as some of the sugars).

Sweet potato flour. The flour of sweet potato is much more difficult to make than that of potato because the reducing sugars readily released from the starch combine with free amino acids to produce disagreeable colors, odors, and flavors. To avoid this the peeled sweet potato can be shredded, and the shreds immersed in water 2 hours. This process works better if the water is

changed 2-3 times. The shreds are drained and then dried, first in the shade (with air movement or wind) and later in the sun (in some cases, drying over the stove or in an oven will be necessary). The brittle shreds are easily crushed to flour, or this can be done rapidly in a household blender. The flour can be stored for 6 months or more in sealed containers. It can be used as a substitute for wheat flour in the following amounts: 100% in white sauces, 25-50% in cookies, cakes and flat breads, and 15-20% in breads. From the water, starch can be recovered (see below).

Starch production. The peeled sweet potato is ground in a mill or blender as finely as possible, and mixed with 5-10 times its weight in water. The starch settles out, and the water is carefully poured away (can be used as pig feed). The starch is then mixed with water 1-3 times more and the process is repeated. After the last settling the water is carefully drained and the starch is dried on a metal surface in the sun. It can be used as is any starch, such as corn or potato starch, and can be stored in sealed containers for a year or more.

Breakfast cereal. A breakfast food similar to "cereal" can be made from any sweet potato. The sweet potato is grated (not as finely ground as for starch), suspended in water, and filtered through a cloth. The liquid is saved for starch, the residue is suspended 1-3 times more in water, and filtering is repeated. The portion of the sweet potato that does not

Tropical pasture and feed crops

A wide variety of plants can be used as pasture and feed in the tropics. Over the years a limited number have become of great importance because of their adaptation, ease of growth, high yields, and nutritional value. Most of these are either grasses or legumes. Most of the grasses are highly suitable for permanent pastures, although a few are usually cut and carried to the animals. Unfortunately, there are few legume and grass combinations that are compatible in pastures of the tropics; however, we have recently added several new legumes suitable for mixed pastures and are eager to hear how they grow in various areas. In the case of leucaena and grass as a combination, an appropriate diet consist of 1/3 of the legume to 2/3 of the grass. Some of the legumes in our

seedbank are trees. During drought or in the arid areas, the tree leaves are sometimes the only feed available.

See A Comparison of Tropical Pasture and Field Crops

- Alfalfa 'Alfagraze'. Medicago sativa. High-yielding, graze-tolerant alfalfa developed for Florida; soil pH>6.5 (EDN 40-6).

- Buckwheat. Fagopyrum esculentum. See Grain Crops.

- Centrosema pascuorum 'Cavalcade'. Prostrate annual legume for seasonally dry tropics; extremely drought-tolerant. Survives seasonal flooding. Wide soil adaptation, pH 5-8.5 and sand to heavy clay. Requires high growing season temperatures.

- Clover, Cherokee Red. Trifolium pratense. Warm [not hot]-climate clover suitable for tropical highlands; N-fixing legume that can be multiple cut, producing high biomass; likes loams with good moisture; is root-knot nematode tolerant.

- Clover, Crimson. Trifolium incarnatum. Cold-tolerant legume sown in autumn for overwintering and harvest in spring; grows fast; fixes N.

- Clover, Osceola White. Trifolium repens. Perennial warm [not hot]-climate clover suitable for tropical highlands. Can not tolerate long dry seasons and remain a perennial.

- Cratylia argentea.A shrub legume well adapted to very acidic soils of low fertility, grows and establishes quickly, drought tolerant; palatable forage if leaves are wilted for a few hours after cutting.

- Desmanthus virgatus. A browse shrub which is palatable, aggressive, persistent, non-toxic to livestock, tolerates heavy grazing, and fixes nitrogen.

- Desmodium intortum, Greenleaf. Perennial legume which grows well in cool temperatures; frost susceptible; produces seed in short days. Tolerates acid conditions and poorly drained or waterlogged soils. Not for areas with less than 890 mm rain.
- Desmodium rensonii. Highly preferred for SALT technique in the Philippines (EDN 14-1). ECHO is looking for more information on this plant; please write to us if you have experience to report.

- Forage peanut, Arachis hypogea 'Pintoi'. Persistent perennial for well-drained soils of moderate fertility and >1000mm rain. Our seeds have exhibited very low germination-ask for large amounts.

- Glycine. Neonotonia wightii. Perennial vining legume for areas with 760-1525mm annual rain. Requires moderately fertile soils, good drainage; not tolerant of waterlogged or very acidic soils. High nitrogen production. Often intercropped with grasses, but can be slow to establish. 'Cooper' is early flowering, vigorous, drought resistant. 'Malawi' is slower to establish but withstands heavy grazing and adverse weather conditions in poor soils.

- Hairy Indigo. Indigofera hirsuta.See Ground Covers and Green Manures.

- Jack bean. Canavalia ensiformis. Not preferred by livestock, but they will eat it when other choices disappear in the dry season. See under Leguminous Vegetables.

- Joint Vetch, American. Aeschynomene americana. Short-lived perennial for wetland areas (>1000mm annual rain), including low-lying ditches with seasonal flooding. Regenerates well naturally in pastures. Also used as a green manure. Aeschynomene evenia also availablle.

- Kudzu, tropical. Pueraria phaseoloides. Not the weedy temperate kudzu; vigorous ground cover. (EDN 12-6).

- Lablab bean. Dolichos lablab.. (see above). Highworth and Rongai make excellent feed crops. Very vigorous annual; grows well in warm, humid conditions but is also drought resistant. Cool tolerant. Palatable; produces much high-protein feed. See Leguminous Vegetables.

- Leucaena. Leucaena diversifolia. Better than L. leucocephala for 500-2000 m and higher rainfall levels. Not drought tolerant. Fodder quality lower than L. leucocephala but lower in mimosine. Varieties K-156 and K-784 are good for hedgerows, intercropping, and alley cropping. Leucaena leucocephala. To 1000 m. pH 4.3-8.7, ideal 6.1-8. Moderate drought tolerance; not for acid soils. Fast growth, coppices well. Leaves a fodder supplement (small amounts only). Salvador (Hawaiian giant) varieties. K28, K67 [high seed production]-tall and tree-like. Peruvian K6-tall with extensive branching; good forage. Cunningham K500-excellent forage. K4, K743 [hybrid]-low in mimosine, a toxin when fed to animals in quantity. K636-resistant to the defoliating psyllid.

- Siratro. Macroptilium atropurpureum. Deep-rooted perennial for areas with 760-1780mm annual rain. Withstands heat and drought on a wide range of soils. Establishes quickly; persistent even under heavy grazing. Seeds viable in soil to 5 years.

- Sorghum (Forage). Sorghum bicolor. Stalks can at times cause cyanide poisoning in livestock.

- Stylo. Common Stylo, Stylosanthes guianensis 'Cook': suited to warm humid zones with >1525mm annual rain; tolerant of low fertility, acidic, and poorly drained soils; varies in palatability to animals. This cultivar is of highlands origin, vigorous, high yielding. Caribbean Stylo, Stylosanthes hamata 'Verano': suitable for 600-1700mm annual rain; heat-loving plant; cold impairs growth. Shrubby Stylo, Stylosanthes scabra 'Seca': hardy perennial; very drought tolerant; thrives on infertile soils.

The velvet bean as green manure

Velvet bean (Stizolobium pruriens orMucuna deeringiana) is the most promising green manure that we have worked with in Central America. It covers the soil completely and then climbs as high as its support allows (up to well over 6 meters). It is highly palatable to animals and has gained wide acceptance in our Honduras program areas as a coffee substitute. Especially encouraging is that there are at least 4 large areas where velvet bean use has spontaneously spread from village to village without any outside intervention (in Mexico to shorten fallows and in Honduras to intercrop

with corn). Velvet beans first cover the ground almost completely, then climb vigorously. Where corn stalks are present, it will eventually form a mat of leaves at about the top of the stalks, with little more than stems and pods underneath. Stems remain thin and nonwoody throughout the plant's life. The plant dies after it has set seed.

[Ed: Seeing velvet bean growing to the tops of pine trees at ECHO prompts many to ask if it might not take over like kudzu in the southeastern USA. This might happen were it not that the plants die after seed set. It was a major US crop for years, and I never heard of such problems.]

Sometimes velvet bean roots produce solid clusters of dark red nodules that are 4 cm in diameter. We think that heavy nodulation occurs most frequently in infertile or sandy soils.

Like jack bean, the velvet bean will volunteer heavily the second year if seed is allowed to mature and fall on the ground. In fact, farmers in Chiapas get growth each year in their corn fields without bothering to reseed it. They harvest 4 T/Ha. of monocroppped corn planted year after year on the same land under typical jungle conditions, using chemical fertilizer plus velvet bean.

About the only soils in which velvet bean has not done well for us are those that are waterlogged or have a ph of 4.5 or less. Like the jack bean, it needs to be planted in a field that is either sandy or has been cultivated within the last 3 years. Velvet bean will take a bit cooler climate than jack bean, but still does best at sea level and does poorly over 2,000 meters. In cool climates it will grow 3-4 months into the dry season, but is not as drought-resistant as jack bean.

The velvet bean is presently our species of choice, in most cases, for growing in corn fields, rehabilitating depleted land, and weed control. It has been used in Guatemala and parts of Honduras to eliminate serious weeds such as nutgrass (Cyperus rotundus), Bermuda grass (Cynodon dactilon) and imperata grass (Imperate cylindrica). I am not aware of what is required to do this, though I would guess that the grass must be cut back and the velvet bean then allowed to grow a full 6 months in order to choke out the weeds. It is an extremely good, fairly palatable high- protein fodder for most animals, especially cattle, and is eaten by virtually all animals except, sometimes,

chickens. Thus, like the lablab bean, it can be an important source of high protein fodder well into the dry season, when many domestic animals are losing weight for lack of food. We were taken off guard by the degree of acceptance of the dry beans as a coffee substitute. Having introduced it as a coffee stretcher (to be used 50-50 with coffee), we found that people were soon drinking it straight. Use is so widespread after just one year that a group of women is roasting and grinding the bean and selling some 40 pounds a week under the name "nutricoffee".

Like the jack bean, velvet bean is native to Central America. However, there are two kinds. The more common one has an extremely irritating itchy powder on the mature pod. Villagers who know this plant will not want to plant the non-itchy-powder varieties until they've been shown that the pods are harmless. We would under no circumstances recommend that anyone use the irritating kind with small farmers. Slugs damage velvet bean in warm climates (though much less than regular dry beans). Rabbits, leaf-cutter ants (its only serious insect pest here) and iguanas are other pests.

In some locations rats used the velvet bean stems to climb up and eat the corn. Planting the beans later or cutting its tendrils when it gets too large has helped with this problem. It must be watched and cut back if planted near trees. Everything said above about planting jack bean also applies to velvet bean. However, fine tuning is needed to determine when to plant velvet bean in local corn fields. This is affected by speed of growth of the native corn, climate, soil fertility and existence of problems with rats. One should plant as soon after the corn as possible to get maximum velvet bean growth and weed control, but not so soon that the velvet bean outgrows the corn or causes rat problems. Especially in fertile or heavily fertilized soils, the velvet bean grows very rapidly and may even need to be pruned once to retard its progress.

Corn crops growing where velvet bean or jack bean have been incorporated can often do extremely well without any initial fertilization with chemicals, but will often show signs of nitrogen deficiency by tassling time. Farmers in our programs in Honduras almost always add a side dressing or urea to these crops. In general we recommend this practice where fertilizer is available and affordable. Over

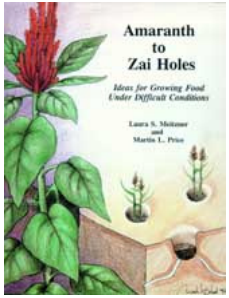
the long run, one would think phosphorous would also be needed, but in the short-run neither visible symptoms nor level of yields would indicate much problem with this element. Quite likely the increased organic matter is increasing the availability of soil phosphorous enough that deficiencies just are not a problem.

In corn fields, the velvet bean produces an average of about 6-7 pounds of above-ground organic matter (wet weight) per square meter (30 T/Ha), but has produced twice that. The effect on subsequent plantings is roughly equal per pound to that of cow manure or half that of chicken manure, although this varies from field to field. When incorporated into the soil, the velvet bean often approximately doubles subsequent corn yields and when used as a mulch increases yields by about 35%. Even dry bean yields following velvet beans have shown yield increases of over 100%.

Farmers in areas with enough moisture for two crops of corn or sorghum have recently started doing the following. The green manure (velvet bean or jack bean) is intercropped with the first grain crop. After harvesting the grain they cut the residue and green manure down, leaving this on the surface as a mulch. The second crop is planted 20 days later with a dibble stick right through holes cut in the mass of dead velvet bean. There is usually a net saving of labor because planting and cutting of the green manure requires less work than the two weeding operations that are thus saved with the second crop. This is the sort of technology one dreams of, but rarely finds: net savings of labor, zero cash cost, decreased risk (the mulch gives some protection from erosion and drought), increased productivity, increased soil fertility and increased protein intake for animals or people.

In Togo velvet bean grew well and was incorporated into the soil 5 months before planting corn. There was virtually no response to the green manure. Our hypothesis is that the green manure was burned or leached out. We are now testing whether under such conditions a green mulch (jack bean for instance) throughout the dry season will be able to reduce surface temperatures sufficiently to maintain organic matter. We have serious doubts about the claims that organic matter in tropical soils are impossible to maintain. Recently villager nutrition groups have discovered that by toasting the velvet bean somewhat less than they do to make coffee, they have been able to produce a really

passable hot chocolate. By grinding the flour finely, they have even been able to use a recipe for soybean cake to make "velvet bean cake".



Related echo publications
Related resources and organizations

Amaranth to Zai Holes, Ideas for Growing Food under Difficult Conditions (ECHO, 1996, 397 p.)

Principles of agroforestry

ECHO Basic Document # 4

PRINCIPLES OF AGROFORESTRY
by Franklin W. Martin and Scott D. Sherman

Introduction

What is agroforestry?

In simplest language, agroforestry is the production of trees and of non-tree crops or animals on the same piece of land. The crops can be grown together at the same time, can be grown in rotation, or can even be grown in separate plots when materials from one are used to benefit another. However, this simple definition fails to take into account the integrated concepts associated with agroforestry which makes this system of land management possibly the most self-sustaining and ecologically sound of any agricultural system.

Thus a second definition of agroforestry would be the integration of trees, plants, and animals in conservative, long-term, productive systems. Agroforestry can be considered more as an approach than as a single finished technology. Although several finished systems have been devised and tested, such technology may require adjustment for particular situations. The flexibility of the agroforestry approach is one of its advantages.

Why agroforestry?

Agroforestry systems make maximum use of the land. Every part of the land is considered suitable for plants that are useful. Emphasis is placed on perennial, multiple purpose crops that are planted once but yield benefits over a long period of time. Furthermore, systems of agroforestry are designed for beneficial interactions of the crop plants, and to reduce unfavorable interactions. They are designed to reduce the risks associated with agriculture, small scale or large, and to increase the sustainability of agriculture.

Agroforestry practices normally help conserve, and even improve, the soil. Agroforestry includes a recognition of the interactions of crops, both favorable and unfavorable. The most common interaction is competition, which may be for light, water, or soil nutrients. Competition invariably reduces the growth and yield of any crop. Yet competition occurs in monoculture as well and this need not be more deleterious in agroforestry systems. Interactions may be complementary, as in the case of trees, pasture, and foraging animals, where trees provide shade and/or forage, and animals provide manure.

Agroforestry systems are designed to produce a range of benefits including food, feed, fuels, often fibers, and usually renewed soil fertility. Agroforestry systems take advantage of trees for many uses, to hold the soil, to increase fertility through nitrogen fixation, or through bringing minerals from deep in the soil and depositing them by leaf-fall, to provide shade, construction materials, foods and fuel. Agroforestry systems may be thought of as principle parts of the farm system itself, which contains many other sub-systems which together define a way of life.

Summary of benefits of agroforestry (see definitions)

Improved year-round production of food and of useful and salable products.
Improved year-round use of labor and resources.
Protection and improvement of soils (especially when legumes are included) and of water sources.
Increased efficiency in use of land.
Short term food production offsetting cost of establishment of trees.

Furnishing of shade for vegetable or other crops that require it or tolerate it.
Medium and long term production of fruits.
Long term production of fuel and timber.
Increase of total production to eat or to sell.

Land

Agroforestry is not a system of pots on the balcony nor for the greenhouse. It is a system to manage the agricultural resource, land, for the benefits of the owner, and the long term welfare of society. While this is appropriate for all land, it is especially important in the case of hillside farming where agriculture may lead to rapid loss of soil. Normally land will be what the farmer owns (farmers that rent land may have little interest in the long term benefits of agroforestry), and thus farmers must think conservatively, how the land can be maintained over long periods of time.

The trees

In agroforestry, particular attention is placed on multiple purpose trees or perennial shrubs. The most important of these trees are the legumes because of their ability to fix nitrogen and thus make it available to other plants. The roles of trees on the small farm may include the following:

Sources of fruits, nuts, edible leaves, and other foods.

Sources of construction material, posts, lumber, branches for use as wattle (a fabrication of poles interwoven with slender branches etc.), thatching.

Sources of non-edible materials, including sap, resins, tannins, insecticides, and medicinal compounds.

Sources of fuel.
Beautification.

Shade.
Soil conservation, especially on hillsides.
Improvement of soil fertility.

In order to plan for the use of these trees in agroforestry systems considerable knowledge of their properties is necessary. Desirable information includes the uses described above, the climatic adaptations of the species, including adaptations to various soils and stresses, the size and form of the canopy as well as the root system, and the suitability for various agroforestry practices. Some of the most common uses of trees in agroforestry systems are:

Individual trees in home gardens, around houses, paths, and public places.

Dispersed trees in cropland and pastures.
Lines of trees with crops between (alley cropping).
Strips of vegetation along contours or water ways.
Living fences and borderlines, boundaries.
Windbreaks.
Improved fallows.
Terraces on hills.
Small earthworks.
Erosion control on hillsides, gullies, channels.
Woodlots for the production of fuel and timber.

Non-tree crops

Any crop plant can be used in agroforestry systems. The choice of crop plants in designing such systems should be based on those crops already produced in a particular region either for marketing, feeding animals, or for home consumption, or that have great promise for production in the region. In keeping with the philosophy of agroforestry, however, certain other values should be pursued in the choice of crops, including:

Crops for making money.
Crops for feeding the farmer.
Crops for good nutrition.
Crops for self sufficiency.
Crops for feeding the animals.
Crops for protecting the soil.

Thus, selection of crops requires a judgement based on knowledge of the crops, adaptations, production uses, as well as family needs, opportunities for barter, and markets. Any farm animal can be used in agroforestry systems. The choice of animal will be based on such values as:

Animals for making money.
Animals for feeding the farmer.
Animals for supplying labor.
Animals for non-food products.
Animals for using crop residues.
Animals for furnishing manure.

Getting started with agroforestry systems

Decide whether agroforestry systems are appropriate.

Describe family and community needs.

Find the limiting constraints in agriculture, including markets and marketing.

List the potential benefits of an agroforestry system in the region in question, and their relative importance. Then decide if it is worth the effort to develop one.

Consider whether the people of the region are willing or capable of adopting a system.

Design asystem.

Select the area.

Characterize it (describe it, its strengths, weaknesses) with respect to existing soil, water, and crops.

List the needs that could be met with an agroforestry system.

Characterize the crops desired by minimum space requirements, water and fertilizer needs, and shade tolerance.

Select the trees, shrubs, or grasses to be used.

If the system is temporary:

Plan the features of soil erosion control, earthworks, and gully maintenance first.

Plan spacing of fruit trees according to final spacing requirements.

Plan a succession of annual or short-lived perennials beginning with the most shade tolerant for the final years of intercropping.

If the system is permanent:

Plan the proportion of the permanent fruit and lumber trees on the basis of relative importance to the farmer.

Plan the spacing of long-term trees on the basis of final space requirements times 0.5.

Plan succession of annual and perennial understory crops, including crops for soil protection and

enrichment.

As large permanent trees grow, adjust planting plan to place shade tolerant crops in most shady areas.

In temporary and permanent systems:

Keep all ground in crops or protective covers at all times.

Try the system on a small scale first.

Measure the inputs and outputs of the system.

Evaluate whether the benefits expected have been achieved.

Look for the desired plant materials or for suitable substitutes locally (Table 5).

Expand or extend any new system cautiously.

Source abbreviations

ATSC	Australian Tree Seed Centre
CATIE	Centro Agromomico Tropical de Investigacion y Esperanza
ECHO	Educational Concerns for Hunger Organization
FKNN	Florida Keys Native Nursery
ILCA	International Livestock Center for Africa
KFSC	Kenya Forestry Seed Centre
KI	Kumar International
SFF	Southern Florida Forests

SFI	Southern Florida Forests
SSC	Shivalik Seeds Corporation
TBAIF	The Bharatiya Agro Industries Foundation
TSP	Tree Seed Program
UH	University of Hawaii

Definitions

Alley Cropping:	Growing annual crops between rows of trees.
Beautification:	Planting trees for ornamental purposes.
Boundary Plantings:	Trees planted along boundaries or property lines to mark them well.
Dispersed Trees:	Trees planted alone or in small numbers on pastures or otherwise treeless areas.
Earthworks:	Constructions made of earth, usually to conserve or control water.
Improved Fallows:	Areas left to grow up in selected trees as part of a trees-crop rotation system.
Individual Trees:	Trees occurring alone, whether spontaneously or planted.
Living Fences:	Fences in which the poles are living trees, or in which all of the fence consists of closely-spaced trees.
Nectar Crop:	Trees valuable as a source of nectar for honey bees.
Terraces:	Level areas constructed along the contours of hills, often but not necessarily planted with trees.
Vegetative	Long, narrow areas of any type of vegetation, usually planted along contours for

Strips:	erosion control; may include trees.
Woodlot:	An area planted to trees for fuel, or timber.

Bibliography and useful publications

Buck, L. 1988. Agroforestry Extension Training Sourcebook Cooperative for American Relief Everywhere. (CARE) International New York, N.Y., 540 pp.

Fernandez, Pamela G., guest ed. Sustainable Agricultural Newsletter, September 1990, dedicated to agroforestry seeds with an extensive listing of suppliers around the world. CUSO, 17 Phaholyothin, Golf Village, Phaholyothin Road, Bangkhen, Bangkok 10900 Thailand. free

Folliot, Peter F. and Thames, John L. 1983. Environmentally Sound Small-Scale Forestry Projects, Guidelines for Planning. Volunteers in Technical Assistance (VITA). Arlington, VA, 109 pp. $9.75 (see CODEL below)

Forestry/Fuelwood Research and Development Project. 1992 Growing Multipurpose Trees on Small Farms. Bangkok, Thailand: Winrock International. 195 + ix pp. (including 41 species fact cards). To order in the USA, call: 703/351-4006 and request book order no. PNABR667.

IITA (no date) Alley Cropping, A Stable Alternative to Shifting Cultivation. International Institute of Tropical Agriculture, Ibadan, Nigeria, 25 pp. (available for $1.00 from NFTA, see resources).

IIRR, 1990, Agroforestry Technology Information Kit. The International Institute of Rural Reconstruction, 475 Riverside Drive, Room 1270, New York, NY 10115 ($20.00). Kits are probably available as well from their office in the Philippines: IIRR, Silang, Cavite 4118, PHILIPPINES. Nitrogen Fixing Trees for Wastelands. FAO Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok, THAILAND.

NAIR, P.K.R. Classification of Agroforestry Systems. Agroforestry Systems 3: 97-128.

National Academy of Sciences. 1980, Firewood Crops, Shrub and Tree Species for Energy Production, Vol I, Washington, D.C., 236 pp. (available free to those actively working in development: BOSTID (JH-217D), National Research Council, 2101 Constitution Avenue, Washington, D. C. 20418, USA).

National Academy of Sciences. 1983, Firewood Crops, Shrub and Tree Species for Energy Production, Vol II, Washington, D.C., 92 pp. (see vol I).

Rockeleau, D., Weber, F. and Field-Juma, A. 1988. Agroforestry in Dryland Africa. International Centre for Research in Agroforestry (ICRAF). Nairobi, Kenya, 311 pp. $31.00

Save The Children/US, Thailand. 1992, Collection, Storage, and Treatment of Tree Seeds: A Handbook for Small, Farm Tree Planters. The FAO Regional Wood Energy Development Programme in Asia, Bangkok, Thailand.

Shankarnarayan, R. A. (Ed.) 1984. Agroforestry in Arid and Semi-arid Zones. Jodphur, India, ICAR Central Arid Zone Research Institute, 295 pp.

Teel, W.A., 1984. A Pocket Directory of Trees and Shrubs in Kenya. Kenyan Energy Non-Governmental Organization (KENGO). Nairobi, Kenya, 151 pp.

Thuvesson, D. (Ed.) Forests, Trees and People Newsletter, Swedish University of Agricultural Sciences/IRDC, Box 7005, S-750 07 Uppsala, Sweden. (Quarterly publication distributed to those interested in and/or working with community forestry activities). free

USAID 1987. Windbreak and Shelterbelt Technology for Increasing Agricultural Production. United States Agency for International Development, Washington, D. C. 219 pp.

Liegel, Leon H.; Venator, Charles R. A technical guide for forest nursery management in the Caribbean and Latin America, Gen. Tech. Rep. SO©67. New Orleans, LA: U.S. Department of

Agriculture, Forest Service, Southern Forest Experiment Station; 1987. 156p.

von Carlowitz, P. 1986. Multipurpose Tree and Shrub Seed Directory. International Center for Research in Agroforestry, Nairobi, Kenya. 265 pp. $24.00

VSO (no date). If a Tree Falls: A VSO Guide to Raising and Planting Trees in Kenya. Voluntary Services Overseas

Wesley, S.B. (Ed.) Agroforestry Today, ICRAF. Nairobi, Kenya, quarterly. (Subscriptions for development workers and scientists are free (see ICRAF below).

Related echo publications

ECHO Crop Production Bulletin: Coconuts Bananas & Bread Fruit ($2.00)

ECHO Technical Notes: Comments on Citrus($2.00) Honey Producing Trees Suitable for Multiple Use ($1.00)Insecticidal Properties of Neem ($1.50) Living Fences ($1.50) Moringa: It's Many Uses ($2.00)

Articles: Australian Suppliers of Tree Seed ($1.00)IFAS Citrus Publications ($1.00)Jojoba: How to Grow it ($1.00)Key to Mango Flowering ($1.00) Learn to Eat Malunggay ($3.00)Leucaena and Growing Giant Leucaena ($1.50) Paulownia: China's Wonder Tree ($1.50) Fruit Tree Seed Characteristics Table ($1.50) Sesbanias: A Treasure of Diversity ($1.50)Sloping Agricultural Land Technology ($3.00) Tagasaste ($1.00)

Related resources and organizations

Agroforestry Seed Information Clearing House (Pamela Fernandez, Department of Agronomy, University of the Philippines at Los Banos, College, Laguna 3720, PHILIPPINES) Information

ATSC (Australian Tree Seed Centre, CSIRO Division of Forestry and Forest Products, PO Box 4008

Queen Victoria Terrace, Canberra, ACT 2600, AUSTRALIA) Seeds

CARE (660 First Ave., New York, NY 10016, USA) Information

Carter Seed Co (475 Mar Vista Drive, Vista CA 92083, USA) Seeds

Centro Agromomico Tropical de Investigacion y Esperanza (CATIE, Turrialba, Cartage, COSTA RICA, 56-6431/56-0169). Information & Seeds

Centro de Mejoramiento Genetico y Banco de Semillas Forestales de Nicaragua (Magaly Urbina M., Director, Km. 12 1/2 Carretera Norte, Managua, Nicaragua, phone; 505-2 31622, fax: 505-2 31623). Seeds

DANIDA (Forest Seed Centre, Krogerupvij 3A, DK-3050, Humleback, DENMARK). A project of the Danish International Development Agency offering information and library service, publications and training to countries which Denmark renders support. Information

Florida Keys Native Nursery Inc, 102 Mohawk St., Tavernier, FL 33070. Seeds Forestry Fuelwood Research and Development Project (F/FRED, Winrock International, 1611N. Kent St. Suite 600, Arlington, VA 22209, USA). Information

Forestry Support Program (International Forestry, USDA Forest Service, P.O. Box 96090, Washington, DC 20090©6090). Provides technical assistance in forestry and natural resources to USAID and U.S. Peace Corps.

Henry Doubleday Research Association (Dr. Phil Harris, Overseas Projects Coordinator, HDRA, Ryton-on-Dunsmore, Coventry, CV8 3LG, UK). Information & seed for groups working in Africa and the Indian sub-continent, especially drought tolerant Prosopis species.

Inland & Foreign Trading Co. (Block 79A, Indus Road #04-418/420, SINGAPORE, 0316. Information

& Seeds

Institute of Tropical Forestry (P.O. Box 25000, Rio Piedras, PR 00928-2500, USA). Information

International Centre for Research in Agroforestry (ICRAF, P.O. Box 30677, Nairobi, KENYA, e mail: icraf@cgnet.com) Newsletter, Information & Seeds

International Livestock Center for Africa (ILCA, P.O. Box 5689, Addis Ababa, ETHIOPIA). Information and Seeds

International Society of Tropical Foresters (ISTF, 5400 Grosvenor Lane , Bethesda, MD 20814, USA). Newsletter and Information

J.R. Palmer, IUFRO (International Union of Forest Research Organizations, A-1131, Wien-Schonbrunn, Austria KENGO (P.O. Box 48197, Nairobi, KENYA) Information

Kenya Forestry Seed Centre (Kari, P.O. Box 74, Kikuyu, KENYA). Seeds

Kimseed (Australian Revegetation Corporation Ltd., 51 King Edward Road, Osborne Park 6017, Western Australia), extensive inventory of arid land trees & shrubs and equipment for planting, harvesting etc.

Kumar International (Ajitmal 206121, Etawah (UP), INDIA). Seeds

The New Forests Project (731 Eighth Street, SE, Washington, D.C. 20003). Seeds & Information.

Nitrogen Fixing Tree Association (c/o Winrock International, Petit Jean Mountain, Morrilton, AR 72110-9537, Ph 501/727-5435, Fax 501/727-5417). Newsletter, Information

NifTAL Project (Department of Agronomy and Soil Science, University of Hawaii, P.O. Box 0, Paia, HI 96779, USA). Rhizobia

Oxford Forestry Institute, Plant Science Department, South Parks Road, Oxford OX1 3RB, UK. Seeds

Peace Corps (Information Collection and Exchange, 1990 K Street NW, Room 808 Washington, DC 20526, USA). Information

Petawawa National Forestry Institute (Chalk River, Ontario K0J 1JO). Seeds for research purposes.

Roy Danforth (Imeloko Agroforestry Project, B.P. 1377, Bangui, Central African Republic). Working to promote agroforestry as an alterative to "slash and burn" farming in Africa. Seeds (375+ species of tropical fruit trees)

RWEDP (Regional Wood Energy Development Programme in Asia, FAO/RAPA, 39 Maliwan Mansion Phra Athit Road, Bangkok 10200, THAILAND. Information

SETROPA (P.O. Box 203, 1400 AE Bussum, HOLLAND). Seeds

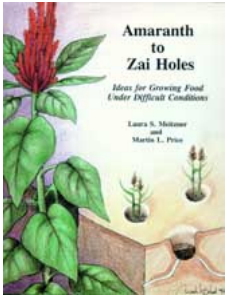
Shivalik Seeds Corporation (Panditwari, P.O. Prem Nagar, Dehra Dun - 248007 (UP), INDIA). Seeds

The Bharatiya Agro Industries Foundation (´Kamdhenu', Senapati Bapat Marag, Pune-411 016, INDIA). Seeds

Tree Crops Centre (PO Box 27, Subiaco, WA 6008, AUSTRALIA). Information

Tree Seed Program (Ministry of Energy & Regional Development, P.O. Box 21552, Nairobi, KENYA). Seeds

University of Hawaii at Manoa (Department of Agronomy & Soil Science, U. of H. at Manoa, 190 East-West Road, Honolulu, HI 96822, USA). Seeds



Amaranth to Zai Holes, Ideas for Growing Food under Difficult Conditions (ECHO, 1996, 397 p.)

Good nutrition on the small farm

A beginners guide

ECHO Basic Document # 5

GOOD NUTRITION ON THE SMALL FARM A BEGINNERS GUIDE
by Franklin W. Martin and Scott D. Sherman

Why Nutrition?

Human beings are so much alike! Yet, probably in no one characteristic are we as alike as in our nutritional needs. It is easy to forget that eating is more than just a pleasure. It is the act of replenishing ourselves with what we need to build and repair our bodies, to keep us vigorous and healthy, and to fuel us for the activities of life.

Good nutrition is perhaps the most basic factor associated with health, a prerequisite to happiness, basic for a sane spirit. Furthermore, the facts of good nutrition are already well known and very little has been done in the last 25 years to enhance our knowledge. Simple rules can be learned by anyone and followed without attention to counting calories. It is not necessary to know the details of the nutritional content of foods in order to create a balanced diet.

What is a balanced diet?

It is a diet that gives one all of what one needs in more or less the quantity that is needed. This bulletin permits you to balance the diet with only a few simple rules. You need only learn the 5 common food groups (all foods will fit into them) and about the amount you will need of each food group each day. Yet this bulletin attempts to educate you further, to give you sufficient knowledge to be able to resist food fads and irrational diets, and to interpret the "nutritional" advertisements one is surrounded by today.

Furthermore, you may be interested in the spiritual well being of others. How can you help them spiritually if they suffer from hunger or malnutrition? You may owe your people the knowledge given here. Finally, although all people need the same foods, they may need them in different

amounts due to special conditions of the moment. This bulletin will help you interpret individual differences and special needs.

Why the small farm?

The truth is that nutritional needs are the same everywhere. But on the small farm one may have the opportunity to produce food not only to sell, but to fill his own needs. To raise the right crops and animals requires an understanding of nutritional needs, as shown here. Furthermore it may require the special knowledge of how to preserve foods during times of plenty, to be used later in times of scarcity. However, this knowledge is not covered in this bulletin.

Nutrients in foods

The nutrients in food can be divided into major and minor classes. Major, as used here, only signifies that a nutrient is needed in large quantities. The major nutrients are water, carbohydrates, fats, and proteins.

Water makes up to 80% of the body's weight. Lack of water will kill in 4-5 days.

Carbohydrates are of three types: Sugars (easily digested), starches (more slowly digested) and fiber (not digested, but necessary). The first two sources are a source of energy. The third is important in elimination of body waste.

Fats are a very concentrated source of energy common in plant and animal foods. As a general rule, plant fats (except palm fats) are more healthy to the body than animal fats.

Proteins are necessary for the building of the body (growth) and for repair of the normal and injured body.

Minor nutrients are the vitamins and minerals, very essential to health. There are 13 essential

vitamins, the fat soluble (A,D,E, and K) and the water soluble (C and the various B's). Minerals are needed in small amounts (calcium, phosphorus, potassium, sodium, chlorine) and those needed in minute amounts (iron, iodine, zinc, and several others). To balance the diet (make the diet adequate) it is not necessary to know the uses of the individual vitamins or minerals. However it does require a wide variety of foods that contain them.

Recommended daily allowances

While each person needs a different amount of nutrients according to size, age, sex, state, and lifestyle, nevertheless an average can be calculated as follows:

NUTRIENT	AVERAGE AMOUNT NEEDED DAILY
Protein	45- 65 grams
Carbohydrates	200-260 grams
Fats	27- 60 grams
Water	According to thirst

FAT SOLUBLE VITAMINS:

A	5000 International units
D	400 International units
E	30 International units
K	0.4 milligrams

WATER SOLUBLE VITAMINS:

B-1 Thiamin	1.5 milligrams

B-2 Riboflavin	1.7 milligrams
B-3 Niacin	20 milligrams
B-6	2 milligrams
B-12	6 micrograms
Biotin	0.3 milligram
Pantothenic acid	10 milligrams
C	45 milligrams

MAJOR MINERALS*

Calcium	1 gram
Phosphorus	1 gram
Magnesium	400 milligrams
Potassium	1 gram

MINOR MINERALS:

Iron	18 milligrams
Zinc	15 milligrams
Copper	2 milligrams
Iodine	150 micrograms

* It is generally assumed that sodium and chlorine requirements are easily met during eating normal foods. The more frequent problem is too much.

The amounts required of some nutrients can be higher under certain circumstances, as follows:

Under nutrition	requires more food or better balance of food
Fatness	requires less sugars, starches, and fats
Pregnancy	requires a richer diet
Lactation	requires a richer diet
Heavy work	requires more foods rich in calories
Growth	requires a higher proportion of proteins
Old age	requires careful watching of diet, especially vitamins and minerals

Heart problems require reduction in total fat, animal fat, and salt

Natural foods and products made from them contain irregular amounts of nutrients. No one food contains all nutrients. Therefore, to obtain a balanced (adequate) diet, one has to eat a variety of foods. This can be done in two ways:

1. Knowing all the nutrient contents of all foods and calculating the nutrients of the foods eaten (a very difficult method).

2. Classifying foods in nutrient categories, and then using the recommended number of servings of each group (a relatively easy method).

Five natural food groups

1. Milk and dairy products: milk in any form including yogurt, ice milk, ice cream, cottage cheese, cheese

2. Meat, eggs, fish, dry beans (cooked)

3. Grains and their products including products made from corn or wheat flour, rice and oats.

Includes whole wheat and enriched white bread, breakfast cereals, biscuits, muffins, waffles, pancakes, pasta, grits, tortillas.

4. Green and yellow fruits, including tomatoes, leafy vegetables, pumpkin, mango, papaya, citrus.

5. Sweets (including sugar, candies, jams, jellies, syrups, soft drinks, some toppings), fats (butter, margarine, lard, salad dressing, mayonnaise, cooking oil) and roots and tubers (yams, sweet potatoes, cassava, taro, potatoes).

Balancing the diet with the five food groups

To balance the diet, try to obtain daily the number of servings indicated of each food group. Interpret one serving as the amount that might be served at one meal consisting of five equal servings of food.

Milk and dairy products	3 servings
Meat, eggs, legume seeds	3 servings
Grains and cereals	4 servings
Vegetables and fruits	4 servings
Fats and sweets	May be unnecessary in most diets. Use to fill the appetite or give extra calories when needed.

When milk is missing

Milk and dairy products furnish good quantities of calcium, vitamin A, B vitamins, and protein to the diet. Milk is practically a complete food, especially for children. Fortunately, there is some overlapping in the nutrient contents of foods, and therefore, when milk and its products are not

available, substitution is possible. The best food to substitute would be dark green leafy vegetables, especially chaya, moringa, cassava leaves, katuk, Pacific spinach (Abelmoschus), celosia and amaranth. Also useful are increased amounts of green pods, especially of legumes, soy milk (can be made at home), shellfish, and fish in general.

Potential Sources for Information on Nutrition

Dr. Clive E. West, Dept. of Human Nutrition, Wageningen Agricultural University, De Dreijen 12, 6703 BC Wageningen, The Netherlands (put out a good Food Composition Table of foods commonly eaten in East Africa).

Janet Glassman, Rodale Press Information Services, 33 East Minor Street, Emmaus, PA 18098, USA (publish "The Vitamin A+ Sieve").

Dr. D.S. McLaren, International Centre for Eye Health, 27©29 Cayton Street, London EC1V 9EJ, U.K., Fax: 903 206770 (Publish "Xerophthalmia Club").

Family Food Production & Nutrition Project, UNICEF Pacific Operations, c/o UNDP, Private Mail Bay, Suva, FIJI

Outreach, c/o UNEP Information Service, United Nations Environment Programme, P.O. Box 30552, Nairobi, KENYA

S.M. Mohd Idris, Coordinator, People's Health Network, Third World Network, 87 Cantonment Road, 10250 Penang, MALAYSIA

Program in Appropriate Technology in Health, 4 Nickerson St., Seattle, WA 98109©1699, Phone: 206/285-3500

Medical Assistance Program International, 2200 Glynco Parkway, P.O. Box 50, Brunswick, GA

31521-0050, Phone: 912/265-6010.

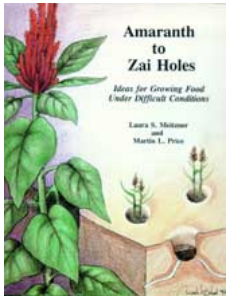
The Medical Benevolence Foundation, 320 Highway 190 W. Woodville, TX 75979-9717.

Medical Ambassidors International, P.O. Box 6645, Modesto, CA 95357-6645.

Health Development International, P.O. Box 40294, Pasadena, CA 91114, Phone 818/797-1200, FAX 818/398-2491

TEAR Fund, 100 Church Road, Teddington, Middlesex TW11 8QE, U.K.

World Health Organization, UN Liaison Office, Room DC2-0956/0976, United Nations, New York, NY 10017, Phone: 212/963-6004.



- 2: Vegetables and small fruits in the tropics
- 3: Staple crops
- 4: Multipurpose trees
- 5: Farming systems and gardening techniques
- 6: Soil health and plant nutrition
- 7: Water resources
- 8: Plant protection and pest control
- 9: Domestic animals
- 10: Food science
- 11: Human health care
- 12: Seeds and germplasm
- 13: Energy and technologies
- 14: From farm to market
- 15: Training and missionary resources
- 16: Oils
- 17: Above-ground (urban) gardens
- 18: What is ECHO?
- Additional ECHO publications
- ECHO development notes - issue 52
- ECHO development notes: issue 53
- 28 additional technical notes about tropical agriculture
- Principles of agroforestry
- Good nutrition on the small farm

About this book

This is a book of practical ideas. It is written for people who help those who live and make their living under difficult conditions in the tropics and subtropics. What should a development worker do to assist a community? There are no simple answers, but there are many possibilities-plants, techniques, and technologies-which hold potential. For fifteen years, ECHO has sought out information on these ideas for the quarterly networking bulletin ECHO Development Notes (EDN). Many people have contributed their insights to share with our network of over 4000 people in 140 countries. If you are interested in improving the lives of small farmers, we welcome your active participation in our network.

This book is based on the first fifty-one issues of EDN. The ideas in EDN come from questions or experiences of field workers, the scientific research done in support of their work, and many newsletters from around the world which ECHO's staff monitor for worthy items. This collection is not intended to be a complete handbook. There are important topics which are not mentioned, and in many cases you are referred to other resources for background information or specialized details.

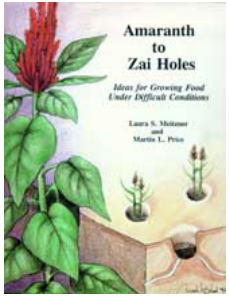
Since no innovation can be guaranteed success in any location, ECHO encourages development workers to be experimenters. Trying ideas which have worked elsewhere and testing plants which are appreciated in another part of the world are first steps toward discovering something valuable for your own situation. As you read these chapters, some ideas will strike you as promising for your region, while others will not be applicable in your site. What is accepted in one area will be rejected in another. Keep in mind that the world is a very, very large place, and often discovering the right niche for a new plant or technique can make a big difference. Visionary open-mindedness and a critical eye can together help you define which ideas to consider for experimentation and adaptation.

ECHO's primary focus in the field of agricultural development is with little-known tropical plants or improved varieties of common plants. Our seedbank has selected vegetables, fruits, grains, cover crops, and trees with potential to produce well in challenging environmental conditions. EDN also includes information on other topics of importance to the small farmer. This book lists many organizations which specialize in various areas, and we can direct you to them with questions

related to their fields of expertise.

All organizations, publishers, and many individuals mentioned in this text were contacted during 1995 and 1996 to confirm current addresses, prices, and services. Every effort was made to update the information wherever possible. However, books go out of print and prices change, so after 1996 you should confirm availability and prices before ordering any items mentioned. Please let us know of any changes you find so we can stay updated.

We sincerely hope that this information will assist you in your work, and we encourage you to write ECHO with your questions and experiences. If you are not already a member of ECHO's network, write for an application for ECHO Development Notes. We look forward to hearing from you!



- 3: Staple crops
- 4: Multipurpose trees
- 5: Farming systems and gardening techniques
- 6: Soil health and plant nutrition
- 7: Water resources
- 8: Plant protection and pest control
- 9: Domestic animals
- 10: Food science
- 11: Human health care
- 12: Seeds and germplasm
- 13: Energy and technologies
- 14: From farm to market
- 15: Training and missionary resources
- 16: Oils
- 17: Above-ground (urban) gardens
- 18: What is ECHO?
- Additional ECHO publications
- ECHO development notes - issue 52
- ECHO development notes: issue 53
- 28 additional technical notes about tropical agriculture
- Principles of agroforestry
- Good nutrition on the small farm

Acknowledgements

ECHO is a networking organization. Many people have contributed their insights and experiences, or

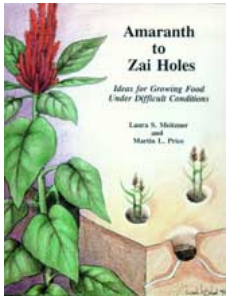
called to our attention relevant materials, or provided us with seeds. This book would not have been possible without them. Keep writing to us!

Christi Sobel is the primary illustrator of this book, designing the cover and most of the artwork. We appreciate her fine talent, versatility, flexibility, and service. An Eastern College graduate with degrees in studio art and biology, her work combines her love of art and fascination with the intricacies of nature. Christi works in several art media and can be contacted for freelance work at 219 White Church Road, Brooktondale, NY 14817, USA.

We appreciate Dr. Frank Martin's willingness to share his expertise by writing numerous technical documents, several of which are included in this book. It is also a pleasure to thank Herb Perry for his faithful help in editing each chapter, and all the staff and interns at ECHO who offered encouragement and assistance.

Some pictures were also taken from the copyright-free books Clip Art for Development and The Copy Book. These resources are reviewed on page 363. We thank Ann Winterbotham and the other artists who also donated their work.

Amaranth to Zai Holes, Ideas for Growing Food under Difficult Conditions (ECHO, 1996, 397 p.)
1: Basics of agricultural development



- *(introduction...)*
- Background in agricultural development
  - *(introduction...)*
  - Nature of small-scale tropical agriculture
  - Some common problems
  - Steps toward improving small-scale agriculture
  - Summary
  - Book reviews
- Selecting suitable tropical crops
  - *(introduction...)*
  - Technical note: selecting the right crop for your location in the tropics or in the subtropics
    - *(introduction...)*
    - Introduction
    - Principal factors determining crop potential
    - Prediction of suitable crops
    - Table I. Ecological or life zones of the tropics, sub tropics, and warm temperate zones
    - Table II. Annual crops (or perennial crops grown as annuals) - climatic needs crop : rainfall - temperature - other considerations
    - Table III. Important perennial and tree crops climatic needs
    - Table IV. Suggested crops for specific climatic zones
    - Discussion
    - Appendix I. Maximum ecological amplitudes for some tropical crops
  - Technical note: Comparison charts of tropical crops

Amaranth to Zai Holes, Ideas for Growing Food under Difficult Conditions (ECHO, 1996, 397 p.)

1: Basics of agricultural development

There are certain basic and important questions we receive which are so encompassing that we cannot answer them in a personal letter. One such question is, "I have just begun work in this country. My degree is not in agriculture, but I want to help local farmers. They know much more than I do about farming in this area, but there must be some ways to make improvements. Where do I begin?" This chapter gives a framework of theories and ideas on getting started in agricultural development, guidelines for selecting crops and innovations, some resources to assist you in the field, and a model for experimental work in your community.

Background in agricultural development

TECHNICAL NOTE: A GUIDE FOR BEGINNERS IN SMALL-SCALE TROPICAL AGRICULTURE by Dr. Franklin W. Martin, a researcher and consultant on small farming systems in the tropics.

You want to help people in the tropics. Beautiful! The tropics are waiting for you. No matter what your abilities, you can offer your service to others in the tropics. Your concern for the physical and spiritual well- being of people can be translated into fruitful work. Your first asset is your goodwill, your willingness to serve.

As you begin to get acquainted with the tropics, you will find that common problems include the production and use of food. Among the poor, those that most need your help, obtaining one's daily

bread is a constant concern. This is not only a question of eating. It is first a matter of production, second of distribution and storage, and third of preparation of meals and balancing of the diet. It is highly probable that when you arrive in the tropics you will not have all the knowledge you need of food production and use in order to help tropical people with their priority needs. It does not matter what experience and training you may have had in your temperate homeland; you cannot be fully prepared in advance. This is normal, and do not let it discourage you. Frequently, however, to accomplish your purposes you will need to help others with their needs to produce and use food better.

The tropics are different from the temperate zones. While in theory it might be possible to produce food crops all year round, in reality a wide range of biological and social factors determine what crops are produced and during which seasons. The soils are formed by different processes than those of the temperate zone. They tend to be acidic and heavy, with low natural fertility; but there are numerous exceptions. Day length is short during part of the year, but never as short as in the temperate zone during the winter. Day lengths are longer 6 months later, but never as long as in the temperate zone during the summer. Many tropical plants are very sensitive to length of day, and flower in response to small differences.

Time and length of the rainy season vary, making some climates very dry while others have regular rains almost all year. The most common weather pattern in the tropics is the monsoon, characterized by drought during short days and rain during long days. Tropical crops are often distinctive from the crops of the temperate zone, but even when they are the same, the varieties are almost always different. The methods of producing them are highly varied, but usually include small-scale techniques. Even the layout of the garden is different, often an irregular and undisciplined mixing of trees and vines with mostly perennial vegetables. Add to these differences those due to local custom, food preferences, and personal preferences and you will quickly understand that the tropics are not like home.

This is a problem only if you make it so. If you try to teach in the tropics the patterns and customs

that you are familiar with, you will almost always fail. Therefore, your task will be first to learn the techniques that local people are already using. In so doing your respect, understanding, knowledge and abilities will grow, and you will pave the way towards improvement of the local techniques. It can help you become a small-scale food production expert.

Nature of small-scale tropical agriculture

The scale of agriculture in the tropics ranges from the small household farm to very large farms. Tropical agriculture is usually labor-intensive, seldom machinery-intensive. Large farms, sometimes called plantations, are often concerned with production of crops that can be exported. Large and medium-sized farms are always concerned with sales and making a profit.

On the other hand, small-scale agriculture has a double purpose: subsistence (feeding the family) and marketing (cash or barter). Food which is produced on the subsistence farm is itself a savings in that income need not be expended. However, subsistence is more than just a way of life. It is often the only alternative that a family has. The food produced on the small farm is often not just a financial matter, but also a matter of life or death. This is the reason that some small farmers seem to follow traditions rigidly and resist change. The price of a mistake may be too high.

The crops grown on the small tropical farm are usually basic subsistence crops: grains, legumes, roots and tubers. These crops often are the best crops to grow to sell, for they are the crops used in great amounts by others. Often very little attention is paid to fruits and vegetables. Fruits are often neglected because they are so abundantly produced, at least during their season, that they are available to most and surpluses are difficult to sell. Their value in the diet, chiefly in terms of vitamins but sometimes carbohydrates and oils, is seldom appreciated. Vegetables, as known in the temperate zone, are produced even less than fruits, but there are many exceptions to this rule. European vegetables are often unadapted, but can be produced in the highlands, during the cool season, or when varieties adapted to heat or other specific conditions are available.

There are many tropical vegetables that are seldom if ever seen in the temperate zone. Newcomers

to the tropics do not recognize them and may wrongly assume that the local people do not grow vegetables. Many of these are the young and tender leaves of shrubs and trees. Some are wild but protected, and others are conscientiously planted. Any one of them is likely to be many times more nutritious than civilized lettuce. Some tropical vegetables have many edible parts including young leaves, shoot tips, flowers, tender pods, immature seeds, dried seeds, and roots or tubers. People often know these other uses of local vegetables, while they may be unaware of many uses of introduced plants.

When starting out, experimentation with very obscure tropical plants is not advisable. The properties of most plants that have a great deal of potential for the small farm are known and described somewhere (though often in hard-to-find publications). The first place to start is always by learning from local people. Then you may also look for plants which may be unknown in your location, but are important in other parts of the world. You can learn about many of these plants through ECHO Development Notes, and seeds for many of them are available from ECHO's seedbank. But remember, learning from local people is always the best way to start.

Small-scale tropical agriculture is also characterized by small amounts of available resources, especially purchased inputs. While labor tends to be abundant, it might be committed to other tasks. Purchased fertilizer or pesticides might be out of the reach of the small farmer. Some small farmers may lack even the most elementary hand tools. Techniques you introduce should ideally be capable of reaching the people with few resources, and yet afford opportunity to those who can take advantage of more advanced technology.

It is appropriate here to discuss what some consider a resource: credit. Indeed, there are many places where agriculture is deemed impossible without credit. As a general rule, the larger the farm, the more easily credit can be obtained. Yet, credit implies an obligation. Farmers, small or large, assume an obligation every time they accept credit. The obligation is hard and absolute, while the ability to pay is soft and full of risks. Small farmers are usually better off when they do not resort to borrowing. Without borrowing the farming risk is the same, or less, and the profit is the same or

greater. You must decide whether credit is a resource or liability.

Tropical agriculture on a small scale is an adaptation. In many respects it is the result of an evolutionary process, the growth and change of small farmers in response to the physical and social environments they face. Change is a never-ending process. Agriculture may need to change rapidly sometimes, or not at all at other times. The techniques of small-scale agriculture should not be considered primitive, but as adaptations to reality. They should not be considered sacred and unchangeable either, because change is inevitable. Change represents opportunity: for innovation, for experimentation, for winning cooperation, and for bettering life physically and spiritually.

Finally, small-scale tropical agriculture represents an integration. In the sense used here, integration is the use of one resource to stimulate the production of an "unrelated" output. As simple examples, integration might be the use of crop residues to increase animal production, and the use of manures to increase crop production. Integration is a way of maximizing outputs (food for the family, farm products for sale, etc.) and minimizing inputs (purchase, labor). Integration on small tropical farms is often lacking even when possible. Integrating is one of the easiest ways to contribute to the welfare of the farm family, and may cost no more than some thought and discussion or demonstration.

Some ideas for integrating activities include:

1. Use of moveable cages where animals might feed on and destroy weeds, scratch the soil, and deposit manure in garden areas. This can be done with moveable cages on tethers.

2. Restraining chickens from household gardens.

3. Use of crop residues as litter in animal cages, and subsequent use as compost.

4. Weed control with mulches that are later incorporated into the soil as compost.

5. Off-season green manuring with appropriate species.

6. Disposal of human waste in deep pits, later planted to trees.

7. Use of crop residues as fuel, as building material (roofing, etc.), and as clothes.

8. Use of animal furs or skins as clothes and shoes.

9. Location of small animal cages and outbuildings under fruit trees.

10. Use of ashes as fertilizer and in soap making.

11. Use of trees with edible products as fence posts. Rat control with poisonous seeds of fence trees (Gliricidia sepium).

12. Uses of crop plants for a variety of compatible uses.

13. Location of farming facilities to permit labor saving.

14. Planting crops taking into account the amount of family labor that will be available later.

In most cases farmers have integrated many aspects of their operations. However, on almost all farms there are still opportunities to be discovered. Integration cannot be practiced until all elements of the farmers' systems are understood!

Some common problems

Water. Water is almost always a problem with small-scale agriculture in the tropics. The availability of water will determine what crops can be grown and at what seasons. However, availability of water to the plant is conditioned by many factors, especially the nature and treatment of the soil. Water management is complex, and therefore only generalities can be given in this publication.

Excess water can damage crops by flooding (excluding oxygen from the soil), loosening roots followed by lodging (falling over) of plants, leaching away nutrients, eroding soil, stimulating weed growth, and making work in the fields difficult. The first solution to excess water is to reduce its effects by providing better systems of drainage (ditches, furrows, or planting mounds).

Lack of water is a constant problem. One solution is to use irrigation. If this cannot be done, loss of water is partially controlled by plowing, terracing, use of pits to capture runoff, mulching, incorporating organic material in the soil, etc. Drought requires the use of appropriate crops (millet is more drought resistant than sorghum; sorghum more than corn). Some crops have drought-resistant varieties. Some soils retain water so well that certain crops can be planted and grown to maturity after rain ceases, without addition of more water. You can expect that small farms will need water management systems to maximize production.

Weeds. Weeds are a major problem on every tropical farm, large or small. As living plants they compete with crop plants for space, light, water and nutrients, and thus reduce yield. Furthermore, they usually produce their seeds before cultivated crops do, and thus assure their future. Seeds of many species live for years in the ground, and cultivation to destroy existing weeds brings previously buried seeds to the surface where they can germinate. Weed control is a major subject. A brief guide to weed control has been printed by ECHO and is available by request.

The major goal of weed control is to reduce the competition with cultivated crops. The elimination of weeds from a field is impossible. Often when one pesky species is controlled, another arises to fill its niche. Practical control is achieved through one or a combination of methods, which might include reduction of germination, reducing the growth rate, or killing the weed during its growth.

It is almost always possible to improve weed control on the small farm. Better weed control will almost always improve yields. Yet, you should be aware that weeds can be tolerated in some situations. It may be uneconomical to control them, especially if they are few in number, not very competitive, or only present as the crop is maturing. A good rule for the time of control is as early

as possible.

Soil Fertility. Problems with the fertility of the soil almost always occur on the small tropical farm. Only on those farms of exceedingly rich soil where primary or secondary forest has been cut does one occasionally find fertility that cannot be improved. Soil fertility problems vary in terms of nutrients that are lacking. A soil analysis may be helpful, but is often not adequate. It will not measure other equally important factors such as the availability of nutrients that are present (this is determined in part by the form in which they are held), or the texture of the soil. It appears that the field is very complicated, and it is! The best analysis of the soil may be a small-scale trial of its ability to support crops.

Nevertheless, some very important generalities can be made. No matter what the nutrient problem of the soil, improvement can be made by the addition to the soil of organic material (any refuse from dead plants and animals). This material is best if first composted (rotted by fermentation, producing heat). This is feasible in the home garden, but may not be feasible on the farm. Useful results can be obtained when the organic material is mixed into the soil, or even when it is applied as a deep layer on top of the soil. For best results large amounts are needed. It is difficult to apply too much. The most useful organic material is animal manure. Crop refuse often contains abundant carbon, but little nitrogen. Applying some nitrogen in the form of manure or as chemical fertilizer is desirable. Growing of a crop that can later serve as organic material (green manure crop) is often good practice. The best of such crops are legumes, including the vigorous velvet bean and lablab bean.

Where sufficient organic material is not available, mineral fertilizer will almost always improve yields. When no guidelines are available, equal parts of nitrogen, phosphorus, and potassium can be used. The first 100 kg/hectare gives the most dramatic response. Since crop growth may be limited by factors other than fertility, very high rates (e.g. 1000 kg/hectare) are seldom economical on the small farm. Too much mineral fertilizer, especially nitrogen, may even reduce crop yields. It will result in crops that are too soft, have few roots or tubers, or are susceptible to drought.

Appropriate Species and Varieties. Newcomers in a rural area often try to help local people by quickly introducing something that they know to be useful through their previous experience elsewhere. This is such a common error that each would-be reformer or teacher must be on guard for this mistake. Techniques developed elsewhere often do not work out when transferred to another area. New crops are often ill-adapted or not culturally accepted. New varieties of an acceptable crop may fail for numerous reasons. Nevertheless, often the introduction of a better variety of an already commonly used crop will dramatically improve the welfare of the people. It is appropriate to look for innovations. Just remember that all innovations must be carefully tested in the immediate area.

The testing of a new variety can be very complicated or very simple. The simplest approach is to grow the new variety alongside the old, using the same techniques for both, and to harvest, eat, sell, and store both with the farmer, who will rapidly discover which is better. A more advanced approach is to become familiar with what other agencies are testing or developing, and test these materials first.

An even more complicated task is to describe the deficiencies of the existing varieties with the production systems, and to seek the advice of an expert. Often a newcomer will see a problem without understanding it. Low yields, for example, can be caused by a large number of factors. Very high yields are utopian, and may be achievable only when all growing conditions are maximized or all limiting factors are controlled. You may never achieve the maximum, but with improved techniques and better varieties, you should be able to improve yields. What should you do? Proceed cautiously. Find out what has been attempted. Find the rationale behind existing varieties and techniques, and then proceed with caution. Look for new crop varieties first from the agricultural experiment stations and departments of agriculture in the region or country, and from your colleagues in similar situations.

Finally, crop adaptation is often very location- and technique-specific. Changes of area and of technique may change the variety desired. There is no end to the development of new techniques or the testing of new varieties. Don't expect to reach perfection, but strive for improvement.

Pests and Diseases. Every crop plant has its pests and diseases. While the crops, their pests, and diseases may be different in the tropics, the principles of control are about the same. These are mentioned in ECHO's document "Control of Weeds, Insects and Diseases on the Small Farm or Home Garden." Pests and diseases may limit the production of a given crop in a particular region. When resistant varieties are available, their use is usually the most satisfactory and least expensive control. However, resistance cannot be obtained for many crops.

The use of chemical controls has many disadvantages: danger to the user and to others, possible contamination of the farm, killing of beneficial insects, and increased costs. Very often partial control can be achieved by changes in the method of production or cultural practices. Usually farmers know something about these conditions, but may not have developed an integrated approach in which all knowledge available is incorporated into the system of control. There is great opportunity for progress on the small tropical farm through control of diseases and pests. Quite often the disease or pest problem occurs after harvest; thus special knowledge of appropriate harvesting and post-harvesting practices is important.

Interaction of Agriculture and Human Welfare. Agriculture on the small tropical farm is intimately related to the health of the farm families. Both ignorance and custom, as well as lack of food or facilities, may interact with farming plans, food produced and methods of use. A knowledge of good nutrition and good hygiene is desirable if farm families are to be helped. A newcomer who chooses to accept local customs uncritically may literally die. By example and by teaching, families can be taught the basics of nutrition and hygiene.

Nutrition. Farm families often fall far short of eating balanced diets of the four basic food groups (meats and eggs, milk and milk products, breadstuffs, and vegetables and fruits). In the third world, three kinds of malnutrition are evident, often combined: protein, carbohydrate, and vitamin and mineral. Ample information is available in this field and often is printed in the local language and is related to local custom. Publications are usually available from local government agencies.

Attacking only part of the nutritional problem is seldom the solution. An integrated approach is almost always necessary, including growing the right foods, producing animals, and using the foods rightly. Sometimes good nutrition involves introducing foods into the diet that are not customarily used. This is often difficult because people do not change their preferences easily. Sometimes the new food can be incorporated into traditional dishes. Sometimes acceptance begins first with the children.

Some of the crops or foods with great nutritional promise are high-lysine corn (also called hard endosperm opaque-2 corn) which is useful for its balanced amino acids, leaves of many kinds for vitamins A and C, new legumes for protein (including white in place of colored beans), soybeans for soybean milk, seeds of heavy- seeding squashes and their relatives for protein and edible oil.

On the other hand, rural peoples of the third world often eat more than enough starches, and thus might consume too many calories in relation to oil, protein, vitamins, and minerals. This is often because such foods are readily available. These people may need to adopt new dietary habits for a healthier diet.

Hygiene. The life span of rural people is often shortened due to poor hygiene. Dehydration of babies due to diarrhea is a major problem in the third world. Some of the basic problems in hygiene are the following: Pigs and chickens distribute their excrement throughout the yard, and thus parasites and intestinal infections are common. Personal hygiene (use of toilet or latrine, bathing, washing before eating) may be difficult, impossible, or neglected. Proper precautions may not be used for preparation, storage, or consumption of food. Water for drinking and bathing may be contaminated. Disease-bearing pests may be present.

In advanced countries, the normal practices followed for good hygiene are so common that their essential nature is overlooked. It is dangerous to assume that rural conditions are equally valid alternatives. Good hygiene is always desirable and often will make a life-or-death difference.

Family Economy. Farm families, like many others, need money. The lack of money often leads to

poor nutrition. A pig on a small farm may be saved to sell when there is great need. The eggs are collected not to eat, but to sell. Crops are grown which have a market, not for their nutritional contributions.

A good farming system integrates crop production (food, feed, fuel), animal production, and making money, with preserving and improving health. (Growing vegetables for a cash crop can sometimes increase on-farm vegetable consumption because there are so many nutritious but not marketable culls.)

Steps toward improving small-scale agriculture

As with many good things in life, improvement of small-scale agriculture is not easy. Since every region (and indeed every farm) is distinctive, there are no automatic solutions to the improvement of agriculture. Nevertheless, from the experience of many persons, a few principles can be instilled as follows:

Literature. Agriculture requires information. Follow this document with other publications that teach principles. Be sure to obtain a subscription to ECHO Development Notes (free for those who work overseas with small farmers) and your own copy of this book, plus back issues after EDN 51. Enrich your library with publications of the country or region in which you will serve. Be cautious with information developed for other regions or countries with different soils, climates, and social-economic conditions. Do not believe that miracle solutions can be found or that any publication will solve your problems. Information is like a set of tools to be used judiciously.

Diagnosis. The first step in improving rural agriculture is to ask the right questions so as to arrive at a diagnosis. These may include the following, and others: What land is available, and what are its limitations? What crops are grown, during what seasons, with what techniques, and with what results? How are the crops harvested, stored, transported, and used? What crop residues remain, and what is done with them? What animals are produced on the farm, using what techniques? What is done with the animals and their by-products? What do people eat? How is food prepared and

stored? What parts of the diet are inadequate? How does this change with time of year? How does animal production interact with human welfare? What do people buy, trade or share? Where do they get the money? What markets exist for new products? What purchased inputs are available (tools, mineral fertilizers, fungicides, etc.)? What is the health of the people? What are the social and economic factors influencing distribution and marketing? What is the infant mortality rate and the life expectancy? Does the diet appear balanced? From what diseases do people suffer? As answers are compiled, you will form an impression of the fundamental problems in the community. In addition to general problems faced by everyone, there will be idiosyncratic problems belonging to specific families or persons. Some decisions will need to be made about the most important problems to be attacked as well as their root causes. The fundamental problems may not be agricultural.

Selection of Alternatives. From this point, the discussion will concern only agriculture, the theme of this article. While other problems are too numerous and complex to be discussed here, they merit equal or perhaps greater concern.

From the diagnosis of the agricultural situation, plan several alternatives. The closer the alternatives are to current practices, the more likely they will succeed. Select rational alternatives, based on knowledge and previous experience if possible. They may have experimental aspects (in the sense that one can never be sure of the results). By organizing alternatives that address real problems as the people perceive them, chances for success are enhanced. Some of the alternatives may be...

A new crop, a new variety
An improved system of soil preparation
A different season of planting
A changed physical arrangement of the plants
A better way of fertilizing
A better nursery (if the crops are transplanted)
A new way to control weeds or pests

Improved harvest or storage
Better ways of food preparation
New uses of crop residues

Similarly, additional alternatives may be sought for the animal component of the farm.

Testing Alternatives. Try selected alternatives first in plantings completely managed by the innovator. These plantings could be in schools, churches, backyard gardens or rented fields. Test alternatives alongside plantings which use the farmers' technology. As soon as possible, involve farmers in testing alternatives alongside their own plantings. The same principles are applicable if the alternatives include storage or cooking techniques or any other aspect of production and use of food. Trials should be made for comparisons before new technology is introduced to farmers or cooks. If the alternatives require new markets or marketing techniques, these should also be worked out before the alternatives are presented to farmers.

In normal practice, a foreign innovator is closely watched. It is a serious error to introduce a technology that is not a significant improvement. (However, you should expect some disappointing results along with successes on your personal trial plots!) On the other hand, successful aspects of a technology (successful alternatives) will be watched and tried by others.

Verification in Farmers' Situations. Even when new alternatives have been demonstrated to be successful they must be verified in the hands of the farmers. Farmers will put them into use in their own way and will find strengths and weaknesses not obvious to the innovators. These verification trials allow farmers to adapt and adopt innovations useful for them. A grassroots approach is the most useful in the spreading of innovations; but as acceptance becomes generalized, new doors may be opened for more formal training in agriculture, food processing, nutrition, and hygiene.

Relating to Local People. While learning about a new culture it is not necessary and may, in fact, be undesirable to practice wholehearted local rural ways. You may wish to dress, eat, and balance the diet, practice hygiene, and comfort yourself in your own way. But, private and personal practices

which are so important to you may not be appropriate for the people around you. The virtues of tolerance, understanding, and appreciation ought to be your guidelines at every step of the way. You will undoubtedly find that those you work with are loveable and will love you.

Summary

The Best Ways To Help A Small Farm: Become acquainted with what people do, diagnose first, select alternatives, try them out in small experiments-first under your control and then progressively with farmers. Promote that which proves to be better. Never give up, because improvement is always possible.

THE CHALLENGE OF AGRICULTURAL MISSIONS: Notes from ECHO's staff. Doing agricultural missions is not an easy task. Many mission agencies with projects in evangelism, health, education, water, sanitation etc. hesitate to add agricultural projects to their program. Why? Because it is often much less clear what they should do to have a major impact in agriculture than it is in these other areas. It has been said that if you can provide clean drinking water and build latrines you take care of up to 80% of a village's health problems. Likewise, medicines already exist to treat most of the diseases in the developing world. But, if a community is "sick" due to the poverty of farmers, it is much less clear what should be done.

Requirements for a satisfactory agricultural project include the following: It must involve only minimal risk to local farmers who are already living on the edge. It must be something they are not already doing. The plants or innovations should be suited for local conditions, culturally appropriate, and address a felt need among the people. It should not exceed realistic labor and time investments for the users. It should make such a major difference that farmers will readily adapt the innovation on their own. And, it must have a ready market (or be liked as food locally) if it involves sale of a product.

It is almost impossible to meet all of these criteria and some projects have failed miserably. But, there have been successes and well-prepared agricultural missionaries are still needed. Below are a

few ideas to keep in mind for designing a successful agricultural project. The list is not all-inclusive, but these are points that come up over and over again.

Be committed to the people and the work. Effective change takes time. Get to know the people and understand their needs. Live with them, learn their language and culture. Earn the right to help them. Cultivate your powers of observation; keep your eyes open. Go as a learner, see why people do things the way they do (most things are done for a reason, even if it seems foolish to you at first). Practice humility and listening. Admit when you are wrong, and expect good ideas to come from local counterparts. Be flexible, as you may become involved in more than you expected. You may find yourself involved in agriculture, regardless of your background in food production or skills and responsibilities in other areas.

Nationals, the people from the communities, must own the project. If they are not involved in every aspect from start to finish, your work will not effect lasting improvements. Use local resources and technologies which are appropriate. Do not do for the farmers what they can do for themselves. As far as possible, they should provide the labor and materials needed. Teach folks to teach others and do not make yourself indispensable. You will not be there forever. All this helps people keep their dignity, avoid dependency, and assure sustainability. Whenever possible work with the government and leadership, not against it.

Identify a few important technologies and test them. There are a lot of technologies which have already been proven in a particular setting. These are well worth a trial in similar circumstances, but nearly everything will require some adaptations to the local situation. A good approach might be to start by promoting a good idea from one area of the country or world in a new area, and work with it until it is recognized as an improvement. Be patient. We visited missionary Bob Ekblad in Honduras who rented the worst piece of land on a very visible hillside along a well-travelled road. People thought he was crazy to try to farm such poor, steep land, but after watching the contour ditches and other soil improvement processes work effectively, they adapted and adopted these practices and soon enjoyed reduced soil erosion and much-improved yields. Even some abandoned

fields were brought back into production.

Sometimes you may be called upon to develop a new technology from scratch. If so, be prepared and committed to adapting and promoting the idea over the long term. Joshua Tsujimoto, who developed a raised bed mini-greenhouse system for out-of-season vegetable production in Bangladesh, tells how farmers laughed at him and suggested that they would benefit more if he were sent home and his missionary support divided among the people. But after many years of trials and errors, he developed a very workable system for people to produce vegetables in the rainy season when no one else can, thus greatly increasing their incomes. Persevere.

Expect frustration. We once read that a farmer in the Philippines was able to multiply his cash income 15 times by planting disease-resistant tomatoes. But he declined to plant them again because of social pressures from his less successful family and neighbors. Resist the temptation to become cynical or overly critical when reactions to your efforts are not as you had hoped. We have also heard over and over of plants which succeed brilliantly in one area or season but fail miserably in another. Anticipate such problems.

Start small and be an experimenter. Identify naturally innovative farmers in your area and work with them. Do not be overeager to convince many farmers to implement ideas you have not tried personally or locally; in doing so, you may inadvertently do more damage than good and lose respect in the community. Keep things simple. Truly good ideas will often spread themselves without elaborate promotion.

ECHO's role is to help you find technical ideas to try. You must evaluate which innovations hold potential for your area, and weigh the risks and benefits of introducing these ideas in your community. This book will not teach you the process of community development; it is meant as a resource for people seeking ideas with potential to improve the life of small farming families. But this process of development is essential, and we encourage you to consider the social, cultural, and spiritual aspects of your work alongside the technical part. A few books which deal with the

development process are highlighted below.

Book reviews

TWO EARS OF CORN AND OTHER WORLD NEIGHBORS MATERIALS. We have had countless occasions to recommend Two Ears of Corn: A Guide to People-Centered Agricultural Improvement (250 pp.) by Roland Bunch since it was published in 1982. Those of you with minimal experience and reading in the area of community development could find it revolutionary. The rest will find it helpful, as well as a good introduction for those coming to work with you. If you have not read a book such as this I would put it in the must read category. The needs around you are too great to ignore them just because you are not an "expert." But there is great wisdom in learning what you can before moving ahead. We arranged for a copy to be sent to John Douglas in Zambia after he asked our comments on some interesting agricultural projects that he was beginning. He wrote back, "I don't think I have ever read anything that had such a practical grasp of both village problems and solutions. I can already see that the book will make a difference in the way we carry out our program."

The book is divided into 5 sections: (1) General orientation (2) Getting started (3) Choosing and using technology (4) Administration and (5) Expansion and Consolidation. Here are some selected chapter headings: The program goals; the program area; planning; start slowly, start small; limit the technology; choosing an appropriate technology; small-scale experimentation; teaching the technology; employees; supporting services; evaluation and phase-out; multiplying our efforts; building institutions; integrated programs. I especially appreciated the chapter on small-scale experimentation because this is at the heart of much that ECHO does. The author shows that it is possible to find new and better methods or resources with your own experiments and by involving the farmers in experimentation.

You can order the book in English, French, or Spanish for $7.95 each plus $7.50 airmail postage from World Neighbors, 4127 NW 122 St., Oklahoma City, OK 73120-8869, USA; phone 800/242-

6387 or 405/752-9700; fax 405/752-9393. Orders for 10 or more receive a 20% discount. Other organizations have also translated it into Indonesian, Vietnamese, and Portuguese; while these languages cannot be ordered from World Neighbors, they can give you the addresses to contact.

World Neighbors also has an excellent catalogue of filmstrips, videos, and printed materials designed to be easily understood by village audiences. The materials are practical and relevant for communities, and can be used for training extension workers. Many of the filmstrips are available in English, French, Spanish, Portuguese, and Hindi. Topics include specific areas in community development, health and nutrition, family planning, small animal raising, and agriculture, trees, and soil conservation. A few filmstrip titles from the latter category are "Planting cultivated pastures," "Fodder trees," "In-row tillage," "New dryland farming technology," "How to take soil samples," "Using the A-frame," "Quinua: protein for the highlands," "Growing mushrooms in tropical climates," and "The use of velvet bean to improve cropping land." A few projectors and accessories are available through them as well. Order the catalog from the above address.

PEOPLE IN RURAL DEVELOPMENT (228 pp.) by Peter Batchelor, veteran agricultural missionary in Africa, is an excellent, thoughtful book on Christ-centered agricultural development. Chapter titles include: People First, Getting Started, The Church and the Rural Poor, Good Stewards, Classroom and Fields, On the Job Training, Health the Key, An Appropriate Response, Whole Families, Workers, Ownership, Working Together, and God and Development. Contact the Paternoster Press/STL, P.O. Box 300, Kingstown Broadway, Carlisle, Cumbria CA3 0QS, UK; fax 0228 51 49 49.

PARTNERS WITH THE POOR (158 pp.) by Jerry Aaker is subtitled "An emerging approach to Relief and Development." The author writes a personal journey through 25 years of international service with church agencies, tracing different trends in assistance, education, relief, and transformation. It is a fine resource for those who wish to examine different theories and issues in development. Order from Friendship Press, P.O. Box 37844, Cincinnati, OH 45222-0844, USA ($12.95).

SOYBEANS AND THE KINGDOM OF GOD: AN APPROACH TO HOLISTIC MISSION (159 pp.) by Sharon

Soper recounts her work with developing and promoting soybean flour while serving as a nurse in Bolivia. She discusses how holistic theology of God's kingdom, culture change, and value differences related to the technology of introducing soybeans into the diet. Available from Evangelical Mennonite Mission Conference, Box 52059, Niakwa P.O., Winnipeg, MB, CANADA R2M 5P9; fax (204) 256-7384; Cnd$13 in Canada, US$11 in USA, and US$13 International, postage included.

"COMMUNITY DEVELOPMENT AND CHRISTIAN DISCIPLESHIP: The Wedding of the Great Commandment and the Great Commission" by Gary Hipp offers a brief introduction to an effective relationship of Christian faith and works in a development situation. Contact Mission: Moving Mountains, P.O. Box 1168, Burnsville, MN 55337-1168, USA.

Selecting suitable tropical crops

THE MOST-ASKED QUESTION. What question do we receive the most frequently from ECHO's network? Easily it is some variation of, "What crops can people consider for the region where I work?" This is usually followed by some description of climate, soils, etc. Often some especially difficult condition is outlined-too much or too little rain, farms that are too small, steep, rocky, hot, infertile, swampy, or remote.

This is also one of the most frustrating questions to try to answer. We asked Dr. Frank Martin to put together something that would help you answer the question for yourself. He found it the most difficult assignment we have given him. "It should be possible to characterize soil and climate so that areas that are similar, even though widely scattered, could use the same technology. In practice this has proven very difficult." He knows of two large projects which tried to accomplish this, but neither turned up anything that appears to be useful. "The old- fashioned technique of a variety trial is still the best method to determine the value of a particular crop for your region."

The article that follows contains three levels of complexity. In one table, the most complex, he pulls together 140 crops, including both annuals and perennials, and vegetable, field and fruit crops. It will be useful as a rough screen to chose or eliminate crops you might consider. Other tables list

several plants based only on rainfall amount and distribution and on temperature. No attempt was made to prepare an exhaustive list. For each of these climates, he has chosen several useful and probably familiar plants that would be well worth a try.

Technical note: selecting the right crop for your location in the tropics or in the subtropics

by Dr. Franklin W. Martin

Introduction

"What crops can I grow?" Consultants in tropical agriculture often receive letters from Peace Corps volunteers, teachers, missionaries, students, and those who have followed their careers to the tropics, with the question, "What crops can I grow?" Leaders and literate farmers often look for new alternatives to basic crops that do not bring in the income desired and write, "What other crops can I grow?" Conscientious persons from the developing world, and even from academic institutions in the United States ask the same question. Choosing the right crop or crops for a particular place is a common problem, and the information necessary for answering the question is not widely available or easily found. Knowledge of agriculture tends to accumulate in regional pockets that represent ecological zones. While the majority of those that write may understand their own area quite well, they are much less familiar with the broader situation or the whole of the tropics and subtropics.

Improvement of Local Agriculture. Quantity and quality of agricultural produce, and usually the diversity as well, can always be improved. However, it is a mistake to assume in any situation that improvements are easy. Agricultural systems represent biological, socio- economic, and technical evolutionary adaptations to particular ecological systems. Agricultural systems are followed because they work under the local circumstances, or at least they work better than easily visualized alternatives.

It is sometimes relatively simple to improve the technology of third world agriculture, yet investigators are often puzzled why the technology is not readily adopted by farmers. Usually the

answer is in the socio-economic aspects of the system, which are frequently overlooked. In highly technical systems, yields and quality might already be high. Improving such agriculture is like shooting at a moving target, hard to achieve a hit.

Traditional approaches to answering the question. The most obvious and useful technique to answering the question, "What crops can be grown?" is to observe and talk with local farmers. They are wealthy in appropriate technology with deep and sometimes almost poetic understanding of their particular crops and production systems. Following farmers' techniques, especially those of farmer-leaders or farmer-innovators, one is practically assured of a crop. Yet, farmers have their roots in tradition. Even excellent farmers may be unaware of what farmers do in an adjacent valley or region. They may not know of improved varieties or technological advances. They will seldom be aware of the world situation, or at times even the local market, and how it affects their crops. Thus, the expertise of farmers is valuable but limited.

A second source of information is that of agricultural statistics. While few countries have as extensive a system as that found in the United States, all countries maintain some records of production, and these clearly show what crops are grown, and usually what acreage and what yield. If a crop is already grown in substantial quantity in a region, then you can be sure it is a crop that not only can be grown, but that can also make money-and that it can be improved.

A third technique is to talk to the local agricultural agent, or, if possible, the nearest agricultural extension office or experiment station. The structure of the system developed to help local agriculture varies, but these people have some knowledge of the crops of the region. They will know which crops the government emphasizes (usually the money makers) and often the improved varieties and technology. Do not underrate them and their potential answers to your queries. While the above traditional sources of information may not be adequate, it would be foolish to start any serious long-term endeavor without consulting these sources.

A fourth technique is to observe the wild plants on the land as an indication of what crops can be

successfully produced. This technique has not been developed to the extent that it would be a useful tool, and has as a disadvantage the requirement of special knowledge of the flora. Furthermore, in some regions the original native flora has been destroyed.

An integrated approach. This kind of approach tries to use local, national, and internationally available information to answer the question. The ecological situation is emphasized here. If one can learn to distinguish ecological zones and learns the ecological requirements and preferences of crops of the world, then one can match crops with zones with a high degree of confidence that a given crop can be grown in a given locality. But, even so, always remember that there are other questions to be asked.

Principal factors determining crop potential

The principal factors that determine crop potential are both internal (genetic) and external (environment). Not only do species of plants vary with respect to their genetic potentials and responses to environment, but even within a given species different varieties or different individuals are distinct in adaptation.

Availability of water. Water occurs everywhere, including in the driest desert. Nevertheless, not all water is available for plant growth. For example, water in the air is not available to most plants. Since almost all crop plants grow in the soil, water availability for practical purposes is the water available to plants in the soil. When excess water falls on the soil, a part may run off even before it can enter, and part of that which enters will be held in the soil by physical and chemical forces. In dry climates runoff can be reduced by contour planting, by furrows oriented crosswise to rain-carrying winds, by plowing, and other treatments on the soil surface. Plants can also be planted at the bottom of furrows or in pits to increase their chance to obtain water. The remainder of the water will move deeper into the soil attracted by gravity until it comes to rest on an impenetrable basin or joins an underground stream or aquifer.

Water is lost from the soil not only by percolation downward but also by evaporation on the surface.

The rate of evaporation depends on the water-holding capacity of the soil, and also on environmental conditions, chiefly temperature, relative humidity, and wind. In general, sandy soils hold the least available moisture, clay soils and soils of high organic matter hold the most. The water-holding capacity of the soil can be increased, for practical purposes, chiefly by the addition of organic material to the soil. Plants can remove water from the excess flowing through the soil, from basins or aquifers, and from the water that is physically and chemically held in the soil, up to a limit. From a practical standpoint, water availability to a plant is determined also by its ability to retrieve water, with a large and efficient root system. Competing plants (other crops or weeds) also reduce the water available to a particular plant.

Seeds may need water almost continuously in order to germinate, and seedlings may need extra water to grow. The growing plant needs large quantities of water, but may be very adept at getting water because of its root system. The plant that is maturing seeds, fruits or tubers often needs less water. A plant that matures in a short period may avoid drought by its ability to mature when water is available.

Life zones (as defined by Holdridge, see Table I) depend in part on the amount of water received annually. The yearly average rainfall, much more than the extremes, dictates the kinds of woody perennial plants that can be grown without irrigation in a particular zone. The suitability of an annual crop plant for growth in a particular region, however, depends not only on life zone, but also on the water availability through irrigation and through water conservation methods. Distribution of rainfall must also be taken into account in interpreting the life zones. If rainfall occurs over a relatively short period, followed by a dry season, some annual crops might not be able to mature.

Temperature. Temperature affects plant growth directly and indirectly. As temperature increases, chemical activity increases and thus over a certain range, higher temperatures increase growth. However, protoplasm cannot survive excessively hot temperatures. At the other extreme, many plants cannot survive temperatures below freezing. Special organs may be more susceptible to heat (reproductive organs, flowers) or to cold (succulent organs). Some organs, particularly some seeds,

may resist both heat and cold. Furthermore, loss of water from plants and soil is increased by high temperatures (as well as by low humidity and wind).

Plants are adapted to particular climates in part by their ability to grow and reproduce at certain temperatures. Among vegetable crops one can distinguish cool season crops (cabbage, lettuce) from hot season crops (corn, squash). Some crops grow best where days are hot and nights are cool (tomato). Life zones as defined by Holdridge depend not only on annual rainfall but also on mean annual temperature.

Altitude and Latitude. Altitude influences temperature and in this way affects plant growth. As altitude increases, temperature decreases. Latitude influences temperature by influencing the amount of light intercepted by a unit area. It also influences daylength. Daylength influences plant growth through hormonal mechanisms which are part of a plants adaptability. For example, short-day plants require or flower best in short days. Long- day plants often flower best only during long days. Some plants are day-neutral and their flowering is not influenced by day length.

Thus, life zones are influenced chiefly by annual rainfall and mean annual temperature. Some of the world's life zones as defined by Holdridge are given in the table. In any region of the earth a person should be able to determine the life zone by weather records. It may now be impossible to do so from the vegetation. Agricultural zones, however, are determined also by availability of irrigation water.

Soil acidity. The acidity of the soil, defined in terms of pH, is a third important factor determining crop potential. While almost all crops grow well in soils with slightly acid pH (6.5), nevertheless crops differ in their tolerance of acidic (low pH) and alkaline (high pH) conditions. The acidity of the soil can be increased with the use of acid forming fertilizers (such as sulphates) and organic materials, or decreased with the addition of lime. These are common agricultural practices. Usually soils of the humid tropics are acid and those of the dry tropics alkaline, but there are exceptions.

Prediction of suitable crops

Use of Table I and the Appendix.

As a first step in determining whether a particular new crop (old crops are obviously suitable) may be suitable for your region, determine the life zone for the region from annual rainfall and temperature. Determine the normal pH of the soil of the region. Consult Table I and the Appendix.

A second step. Classify your environment in a less formal manner than that of Holdridge. First, classify the environment during the period of maximum rains as follows: cool (C), intermediate (IT), or hot (H). Then consult Table II for annual crops and Table III for perennial crops.

Note in Table II that irrigation changes everything. If temperatures are favorable, all vegetables can be grown in a dry climate where water is added. This is probably true of fruits as well. Note also the other considerations in the case of some of the other crops.

Finally, you can use Table IV if your region falls into one of the following categories: hot humid tropics; tropical monsoon; dry tropics; beach climate; wet, cool highlands; and dry, cool lowlands. Consult the portion of the table which corresponds to your climate and find the grains, legumes, vegetables and other crops most likely to be a success.

Table I. Ecological or life zones of the tropics, sub tropics, and warm temperate zones

TABLE I. ECOLOGICAL OR LIFE ZONES
OF THE TROPICS, SUB TROPICS, AND WARM TEMPERATE ZONES.

Ecological Zones [1,2]	Mean Annual Temperature (°C)	Average Annual Rainfall (mm)	Symbol
Tropical Desert Scrub	24 or more	125 - 250	Tx
Tropical Thorn Steppe	24 or more	250 - 500	Tt
Tropical Very Dry Forest	24 or more	500 - 1000	Tv
Tropical Dry Forest	24 or more	1000 - 2000	Td
Tropical Moist Forest	24 or more	2000 - 4000	Tm
Tropical Wet Forest	24 or more	4000 - 8000	Tw
Tropical Rain Forest	24 or more	8000 or more	Tr
Subtropical Desert Scrub	18 - 24	125 - 250	Sx
Subtropical Thorn Woodland	18 - 24	250 - 500	St
Subtropical Dry Forest	18 - 24	500 - 1000	Sd
Subtropical Moist Forest	18 - 24	1000 - 2000	Sm
Subtropical Wet Forest	18 - 24	2000 - 4000	Sw
Subtropical Rain Forest	18 - 24	4000 or more	Sr
Warm Temperate Desert Bush	12 - 18	125 - 250	Wx
Warm Temperate Woodland	12 - 18	250 - 500	Wt
Warm Temperate Dry Forest	12 - 18	500 - 1000	Wd
Warm Temperate Moist Forest	12 - 18	1000 - 2000	Wm
Warm Temperate Wet Forest	12 - 18	2000 - 4000	Wd
Warm Temperate Rain Forest	12 - 18	4000 or more	Wr

NOTE: In the Appendix you will see life zone symbols of more than two letters. For example, okra grows in life zones Wdm and Txm. The capital letters refer to tropical, subtropical or warm temperate climates. The small letters are for types of vegetation as determined by the life zones. Using the chart below you can see that okra will grow in warm temperate dry forests, warm temperate moist forests, tropical dessert scrub and tropical moist forest climates.

T = Tropical	d = dry forest
S = Subtropical	m = moist forest
W = Warm temperate	r = rain forest
C = Cool temperate	t = thorn steppe (if tropical) or woodland (if warm temperate)
B = Boreal	v = very dry forest
	w = wet forest
	x = desert scrub (if tropical or subtropical) or bush (if temperate)

Table I. Ecological or life zones of the tropics, sub tropics, and warm temperate zones.

T = Tropical
d = dry forest
S = Subtropical
m = moist forest
W = Warm temperate
r = rain forest
C = Cool temperate
t = thorn steppe (if tropical) or woodland (if warm temperate)
B = Boreal
v = very dry forest
w = wet forest
x = desert scrub (if tropical or subtropical) or bush (if temperate)

NOTE: In the Appendix you will see life zone symbols of more than two letters. For example, okra grows in life zones Wdm and Txm. The capital letters refer to tropical, subtropical or warm temperate climates. The small letters are for types of vegetation as determined by the life zones. Using the chart you can see that okra will grow in warm temperate dry forests, warm temperate moist forests, tropical dessert scrub and tropical moist forest climates.

Table II. Annual crops (or perennial crops grown as annuals) - climatic needs crop : rainfall - temperature - other considerations

TABLE II. ANNUAL CROPS (OR PERENNIAL CROPS GROWN AS ANNUALS)

CROP	CLIMATIC NEEDS RAINFALL	TEMPERATURE	OTHER CONSIDERATIONS
Amaranth	S	H	DM
Arrowroot	L	H	
Bean (common)	S	IT	DM
Cantaloupe	L	C-IT	NG
Carrot	IR	C	
Cassava	S-IR	H	
Chayote	L	IT	NT

Chickpea	S	C	
Corn	IR	IT-H	DM
Cowpea	S	H	DM
Cucumber	IR	IT	
Eggplant	IR-L	H	
Lablab bean	S-L	IT-H	SD
Mungbean	S	IT	SD
Okra	IR	H	LD
Onion	IR	C-IT	
Peanut	S-IR	H	DM
Pearl millet	S	H	DM
Pepper	IR	IT-H	
Pigeon pea	S	H	DM-SD
Potato	S-IR	C-IT	
Pumpkin	IR-L	H	
Rice	IR	IT-H	
Scarlet runner bean	IR	C	
Sorghum	S-IR	H	DM
Soybean	S-IR	H	SD
Sweet corn	IR-L	IT	
Sweet potato	L	H	
Tomato	S	IT	DM
Watermelon	IR	H	
Winged bean	L	H	SD
Yam	L	H	MC
Yardlong bean	IR	H	NT

Key:
Rainy season: S = short; IR = intermediate; L = long
Temperature: C = cool; IT = intermediate; H = hot
Other considerations: SD = most varieties bloom or produce during short days; MC = suitable for monsoon climate, with rains during long days; DM = dry weather required during maturation; NG = not usually grown in the tropics; NT = needs trellis; LD = produces best in long days.

Table II: . Annual crops: climatic needs

CLIMATIC NEEDS

crop:

rainfall

temperature

other considerations

Amaranth

S

H

DM

Arrowroot

L

H

Bean (common)

S

IT

DM

Cantaloupe

L

C-IT

NG

Carrot

IR

C

Cassava

S-IR

H

Chayote

L

IT

NT

Chickpea

S

C

Corn

IR

IT-H

DM

Cowpea

S

H

DM

Cucumber

IR

IT

Eggplant

IR-L

H

Lablab bean

S-L

IT-H

SD

Mungbean

S

IT

SD

Okra

IR

H

LD

Onion

IR

C-IT

Peanut

S-IR

H

DM P

earl millet

S

H

DM

Pepper

IR

IT-H

Pigeon pea

S

H

DM-SD

Potato

S-IR

C-IT

Pumpkin

IR-L

H

Rice

IR

IT-H

Scarlet runner bean

IR

C

Sorghum

S-IR

H

DM

Soybean

S-IR

H

SD S

weet corn

IR-L

IT

Sweet potato

L

H

Tomato

S

IT

DM

Watermelon

IR

H

Winged bean

L

H

SD

Yam

L

H

MC

Yardlong bean

IR

H

NT

Key: Rainy season: S = short; IR = intermediate; L = long Temperature: C = cool; IT = intermediate; H = hot Other considerations: SD = most varieties bloom or produce during short days; MC = suitable for monsoon climate, with rains during long days; DM = dry weather required during maturation; NG = not usually grown in the tropics; NT = needs trellis; LD = produces best in long days.

Table III. Important perennial and tree crops climatic needs

TABLE III. IMPORTANT PERENNIAL AND TREE CROPS CLIMATIC NEEDS

CROP	RAINFALL	TEMPERATURE	OTHER CONSIDERATIONS
Avocado	S-IR	IT-H	
Banana	I.	H	
Black pepper	I.	H	NT
Breadfruit	IR-L	H	
Cacao	IR-I.	H	NS
Cashew	S	H	DF
Cherimoya	IR	C	
Coconut	IR-L	H	
Coffee	IR-L	IT	NS
Fig	S	IT	
Guava	IR	H	
Macademia nut	IR	IT	
Mamey sapote	IR-I.	H	
Mango	IR	H	DF
Mangosteen	L	H	
Moringa	S	H	
Oil palm	IR-L	H	
Papaya	S-IR	H	NT
Peach palm (pejibaye)	IR-I.	IT	
Passion fruit	IR	IT-H	
Pineapple	IR	IT-H	
Plantain	L	H	
Soursop	S-I.	H	
Sugar cane	L	H	
White sapote	IR	C-IT	

Key:
Rainy season: S = short; IR = intermediate; I. = long
Temperature: C = cool; IT = intermediate; H = hot
Other considerations: NT= needs trellis; NS = needs shade; DF = needs dry weather during flowering

Table III: Important perennial and tree crops climatic needs

crop	rainfall	temperature	other considerations
Avocado	S-IR	IT-H	
Banana	L	H	
Black pepper	L	H	NT
Breadfruit	IR-L	H	
Cacao	IR-L	H	NS
Cashew	S	H	DF
Cherimoya	IR	C	
Coconut	IR-L	H	
Coffee	IR-L	IT	NS
Fig	S	IT	
Guava	IR	H	
Macademia nut	IR	IT	
Mamey sapote	IR-L	H	
Mango	IR	H	DF
Mangosteen	L	H	
Moringa	S	H	
Oil palm	IR-L	H	
Papaya	S-IR	H	NT
Peach palm (pejibaye)	IR-L	IT	
Passion fruit	IR	IT-H	
Pineapple	IR	IT-H	

Plantain	L	H	
Soursop	S-L	H	
Sugar cane	L	H	
White sapote	IR	C-IT	

Key: Rainy season: S = short; IR = intermediate; L = long Temperature: C = cool; IT = intermediate; H = hot Other considerations: NT= needs trellis; NS = needs shade; DF = needs dry weather during flowering

Table IV. Suggested crops for specific climatic zones

GRAINS, LEGUMES, VEGETABLES, FRUITS, AND OTHER

TABLE IV. SUGGESTED CROPS FOR SPECIFIC CLIMATIC ZONES

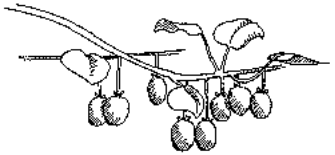
HOT HUMID TROPICS (LONG RAINY SEASON, NO COOL WEATHER)

GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
PADDY RICE	WINGED BEAN	ARROWROOT DASHEEN & TANNIER PUMPKIN SWEET POTATO TARO YAM (ASIAN)	BANANA & PLANTAIN BREADFRUIT JACKFRUIT PEACH PALM	BLACK PEPPER CACAO OIL PALM SUGAR CANE OTHER SPICES

Suggested crops for HOT HUMID TROPICS (Long Rainy Season, No Cool Weather)

TABLE IV. TROPICAL MONSOON (STRONGLY ALTERNATING WET AND DRY SEASONS)

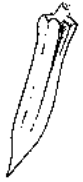
GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
CORN	COWPEA	ARROWROOT	AVOCADO	CACAO
PADDY RICE	PEANUT	DASHEENS	BANANA & PLANTAIN	COCONUT
SORGHUM	PIGEON PEA	EGGPLANT	BREADFRUIT	COFFEE
UPLAND RICE	SOYBEAN	OKRA	CACAO	OIL PALM
	WINGED BEAN	PEPPER	CITRUS	SUGAR CANE
	YARDLONG BEAN	PUMPKIN	GUAVA	
		SWEET CORN	JACKFRUIT	
		SWEET POTATO	MACADAMIA NUT	
		TOMATO	MAMEY SAPOTE	
		YAMS	MANGO	
			MANGOSTEEN	
			PAPAYA	
			PASSION FRUIT	
			PINEAPPLE	
			SOURSOP	



Suggested crops for TROPICAL MONSOON (Strongly Alternating Wet And Dry Seasons)

TABLE IV. DRY TROPICS (A LONG, HOT DRY SEASON WITH A SHORT OR IRREGULAR RAINY SEASON)

GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
AMARANTH	COW PEA	CANTALOUPE	AVOCADO	SISAL
CORN	LABLAB BEAN	CASSAVA	BREADFRUIT	COTTON
MILLET	MUNG BEAN	CUCUMBER	CITRUS	
SORGHUM	PEANUT	EGGPLANT	GUAVA	
UPLAND RICE	PIGEON PEA	OKRA	MAMEY SAPOTE	
	SOYBEAN	ONION	MANGO	
	YARDLONG BEAN	PEPPER	PAPAYA	
		PUMPKIN	PASSION FRUIT	
		SWEET CORN	SUGAR APPLE	
		SWEET POTATO	TAMARIND	
		TOMATO		
		WATER MELON		



Suggested crops for DRY TROPICS (A Long, Hot Dry Season With A Short Or Irregular Rainy Season)

TABLE IV. BEACH CLIMATE (DRYISH, INTERMITTENT RAINS)

GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
CORN	COWPEA	CASSAVA	AVOCADO	COCONUT
SORGHUM	LABLAB BEAN	EGGPLANT	CASHEW	OIL PALM
	PEANUT	OKRA	GUAVA	
	PIGEON PEA	PEPPER	MAMEY SAPOTE	
	SOYBEAN	PUMPKIN	MANGO	
		SWEET POTATO	PAPAYA	
			PASSION FRUIT	

Suggested crops for BEACH CLIMATE (Dryish, Intermittent Rains)

TABLE IV. CONTINUED:

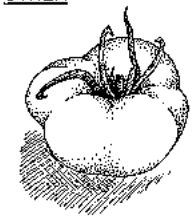
HIGHLAND CLIMATE, WET AND COOL

GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
CORN	CHICK PEA	BEET	AVOCADO	COFFEE
	SCARLET RUNNER BEAN	CARROT	PAPAYA	
		CHAYOTE	PASSION FRUIT (PURPLE)	
		COOL SEASON VEG'S (ESP. CRUCIFERS)	PERSIMMON (JAPANESE)	
		LEEKS		
		LETTUCE		
		ONIONS		
		SWEET POTATO		

Suggested crops for HIGHLAND CLIMATE, Wet And Cool

TABLE IV. CONTINUED:
HIGHLAND CLIMATE, DRY AND COOL

GRAINS	LEGUMES	VEGETABLES	FRUITS	OTHER
AMARANTH	CHICK PEA	BEET	AVOCADO	
MILLET	COMMON BEAN	CARROT	FIG	
QUINOA		COOL SEASON VEG'S (ESP. CRUCIFERS)	PAPAYA	
SORGHUM		LEEKS	PERSIMMON (JAPANESE)	
		LETTUCE	WHITE SAPOTE	
		ONIONS		
		POTATO		
		TOMATO		



Suggested crops for HIGHLAND CLIMATE, Dry And Cool

Discussion

In principle, it should be possible to characterize soil and climate so that areas that are similar, even though widely scattered, could use the same technology. In practice this has proved very difficult. As the number of factors increases sufficiently to carefully characterize sites, those that are similar become smaller and smaller in number. Researchers often refer to "site-specific technology." This simply means that any particular technology is specifically suited only to the site for which it was designed. This is true whether the technology is cultural techniques or pest control methods.

Two very large projects were specifically designed to overcome the problems of site-specific technology. In one of these the technology was to be developed at specific sites and demonstrated to be useful at similar sites. This project was unable to fulfill its objectives. In a second project years of experimentation at distant locations finally came through with a mathematical model to predict the yield of a crop at one location based on its performance at other locations. All test locations had to be thoroughly characterized. This has been done with only one crop, corn (maize). The technique is too cumbersome to be of practical value, and the old-fashioned technique of a varietal trial is still the best method of determining the value of a particular crop or technology.

There are no final answers to the questions, "What crop should I grow?" and "How should the crop be grown?" Superficially, agriculture is simply crops, climate, and land. But in reality each is extremely complex, requiring knowledge, experience, and judgment. On the other hand, the crop production potentialities are revealed by trial and error. There is no substitute for hard work and a sharp eye.

Some logical questions follow "What crop can I grow?" The answers may require considerably more study. What are appropriate varieties? Where can seed be obtained, and how can it be maintained? What are the appropriate seasons for planting? How can it best be fertilized? What insects, other pests, and diseases may occur, and how can they be controlled? When and how is the crop to be harvested? How can it be stored, processed and utilized? Will people accept it? Will it be economical in terms of energy, time, and money? Part of ECHO's work is to give you perspectives on these issues to equip you to answer such questions.

Appendix I. Maximum ecological amplitudes for some tropical crops

APPENDIX I. MAXIMUM ECOLOGICAL AMPLITUDES FOR SOME TROPICAL CROPS

CROP			TOLERANCES			
Scientific Name	Common Name	Length[3]	pH	Rainfall(cm)	Life An. Temp.[1]	Lifezones[5]
Abelmoschus esculentus	Okra	A	5.1-7.8	30-250	13-27	Wdm,Txm
Agave fourcroydes	Henequen	P	7.3-7.8	70-250	15-27	Wd,Tlm
Agave sisalana	Sisal	P	5.1-8.3	20-260	15-27	Cm,Ttw
Aleurites fordii	Tung Oil	P	5.3-7.3	60-250	13-25	Wdm,Tdw
Allium ampeloprasum	Leek	B/A	5.2-8.3	40-270	7-23	Bu,Td
Allium cepa	Onion	B/A	4.5-8.3	30-410	6-27	Bu,Tvw
Allium sativum	Garlic	P/A	4.5-8.3	30-260	6-27	Bm,Tvw
Alocasia macrorrhiza	Giant Taro	P/A	5.8-7.3	70-420	15-27	Wd,Tm
Aloe vulgaris	Common Aloe	P	6.0-8.0	60-400	19-27	Wdw,Ttd
Amaranthus hypochondriacus	White Amaranthus	A	5.2-7.5	70-270	8-27	Cm,Tdm
Anacardium occidentale	Cashew	P	4.3-7.5	70-410	19-28	Sdw,Tvw
Ananas comosus	Pineappte	P	3.5-7.8	70-410	16-28	Wm,Tvw
Annona cherimola	Cherimoya	P	4.3-7.3	80-400	16-27	Wdm,Tmw
Annona muricata	Soursop	P	4.3-8.0	60-420	17-27	Wd,Tvw
Apium graveolens	Celery	B/A	4.2-8.3	30-460	5-27	Bw,Sdw
Arachis hypogaea	Peanut	A	4.5-8.3	30-410	10-27	Cm,Ttw
Areca catechu	Betel Nut	P				

Areca catechu	Betel Nut	P	4.8-6.8	70-420	15-27	Sdw,Tvw
Arenga pinnata	Sugar Palm	P	5.8-8.0	70-400	19-27	Sd,Tm
Arracacia xanthorrhiza	Arracacha	P/A	6.3-6.8	70-130	15-25	Cd,Sdm
Artocarpus altilis	Breadfruit	P	5.9-8.0	70-400	17-27	Sdw,Tdw
Asparagus officinalis	Asparagus	P	4.5-8.2	30-400	6-27	Csw,Tvm
Averrhoa carambola	Carambola	P	4.3-8.3	70-410	18-27	Sdw,Tvw
Bactris gasipaes	Peach Palm	P	5.8-8.0	70-400	19-25	Sdw,Tmw
Bertholletia excelsa	Brazil Nut	P	4.5-6.5	110-410	19-27	Sm,Tdw
Boehmeria nivea	Ramie	P	4.3-7.3	70-410	15-27	Wdm,Tvw
Brassica chinensis	Pakchoi	B/A	4.3-7.5	60-410	6-27	Bw,Tdw
Brassica oleracea	Cabbage	B/A	4.3-8.3	30-460	5-27	Bmw,Tdw
Brassica pekinensis	Chinese Cabbage	B/A	4.3-6.8	70-410	7-27	Cmw,Tdw
Brosimum alicastrum	Ramon	P	6.0-8.0	30-400	19-25	Sm,Tdw
Butyrospermum paradoxum	Shea Butter	P	4.9-5.2	130-140	26-27	Tdm
Cajanus cajan	Pigeon pea	P/A	4.3-8.3	30-400	15-27	Wmw,Txw
Calamus rotang	Rattan	P	4.2-5.5	170-420	19-27	Sm,Tw
Camellia sinensis	Tea	P	4.5-7.3	70-310	14-27	Wdw,Tvw
Canarium indicum	Canary Nut	P	7.1-8.1	110-230	25-27	Tdm
Canavalia gladiata	Swordbean	P/A	4.3-6.8	70-270	16-32	Wm,Tmw
Canna edulis	Edible Canna	P/A	4.3-6.8	70-400	7-26	Cm,Tdm
Capsicum annuum	Bell Pepper	A	4.3-8.3	30-460	9-27	Csw,Txw
Carica papaya	Papaya	P	4.3-8.0	70-420	17-29	Wm,Tvw
Casimiroa edulis	White Sapote	P	5.7-8.0	50-400	16-26	Wd,Tdw
Ceiba pentandra	Kapok	P	4.3-8.0	70-420	19-29	Sdm,Tvw
Ceratonia siliqua	Carob	P	6.2-8.6	30-400	13-26	Wd,Sdm
Chrysanthemum cinerariifolium	Pyrethrum	P	5.2-7.5	70-260	8-27	Cmw,Sdm
Cicer arietinum	Chickpea	A	5.5-8.6	30-250	6-27	Wdm,Txm
Cinnamonum verum	Cinnamon	P	5.8-8.0	150-390	20-27	Sdw,Tdw
Citrullus lanatus	Watermelon	A	5.3-8.0	30-400	11-29	Cw,Txw
Citrus aurantium	Sour Orange	P	4.8-8.3	20-400	13-28	Wd,Txw
Citrus limon	Lemon	P	4.8-8.3	30-410	11-28	Cw,Tvw
Citrus paradisi	Grapefruit	P	4.8-8.3	30-410	13-28	Wm,Tdw
Citrus sinensis	Sweet Orange	P	4.3-8.3	30-410	13-28	Wmw,Tdw

[3]Life length: A = annual; B = biennial; P = perennial; P/A = perennial grown as an annual; B/A = biennial grown as an annual.

Table: Maximum ecological amplitudes for some crops (1)

Scientific Name	Common Name	Length	pH	Rainfall(cm)	An. Temp.	Lifezones
Cocos nucifera	Coconut	P	4.3 & 3	70-420	11-27	Sdw,Tvw

Cocos nucifera	Coconut	P	4.3-8.3	70-420	11-27	Sdw,Tvw
Coffea arabica	Coffee	P	4.3-8.0	80-460	11-27	Wdr,Tvw
Coffea canephora	Robusta Coffee	P	4.3-6.8	80-370	20-27	Sdw,Tdw
Cola nitida	Kola Nut	P	4.3-4.8	140-270	23-27	Sm,Tdm
Colocasia esculenta	Taro	P/A	4.3-7.4	70-410	11-29	Cw,Tvw
Crocus sativas	Saffron	P	5.7-7.8	50-110	6-19	Bm,Stm
Cucumus melo	Canteloupe	A	4.3-8.3	20-400	7-27	Csw,Txw
Cucumus salivus	Cucumber	A	4.3-8.3	20-460	6-27	Bmw,Txw
Cucurbita moschata	Pumpkin	P/A	4.3-8.3	30-280	7-32	Cmw,Tdm
Curcuma domestica	Tumeric	P/A	4.3-6.8	70-420	18-27	Sdw,Tdw
Cymbopogon citratus	Lemongrass	P	4.3-7.3	70-410	18-27	Wdw,Tvw
Daucus carota	Carrot	B/A	4.5-8.3	30-460	3-27	Bmw,Tdw
Dioscorea alata	Winged Yam	P/A	4.8-8.0	70-420	15-29	Wdm,Tvw
Dioscorea rotundata	African Yam	P/A	5.1-5.8	140-280	23-27	Sm,Tvm
Diospyros digyna	Black Sapote	P	5.1-8.0	70-420	19-27	Sdm,Tdw
Diospyros kaki	Japanese persimmon	P	4.3-8.3	30-460	13-27	Wdr,Tvw
Durio zibethinus	Durian	P	4.3-6.8	210-410	18-27	Ww,Tdw
Elaeis guineensis	African Oil Palm	P	4.5-8.0	70-400	21-27	Sdw,Tdw
Elettaria cardamomum	Cardamom	P	4.8-7.4	70-420	21-27	Sdr,Tvw
Eriobotrya japonica	Loquat	P	5.5-8.0	50-400	15-26	Wdm,Tm
Euphoria longana	Longan	P	5.8-8.0	70-400	19-27	Sdw,Tvm
Ficus carica	Fig	P	4.3-8.8	30-400	9-32	Cmw,Txw
Fragaria sps.	Strawberry	P/A	4.5-8.3	30-260	5-21	Bmw,Sdm
Garcina mangostana	Mangosteen	P	4.3-8.0	110-420	21-27	Smw,Tmw
Glycine max	Soybean	A	4.3-8.2	40-410	7-29	Cmw,Tvw
Gossypium barbadense	Sea Island Cotton	P	4.3-8.3	50-400	9-26	Csm,Tvm
Gossypium hirsutum	Common Cotton	A	4.3-8.3	30-270	7-32	Cmw,Tvm
Helianthus annuus	Sunflower	A	4.5-8.3	20-400	6-27	Bmr,Tvw
Helianthus tuberosus	Jerusalem Artichoke	P/A	4.5-8.3	30-280	7-27	Csw,Tm
Hevea brasiliensis	Rubber	P	4.3-8.0	110-420	23-28	Smw,Tdw
Hibiscus cannabinus	Kenaf	A	4.5-7.4	50-400	13-27	Wtm,Tvw
Ilex paraguariensis	Yerba Mate	P	5.7-7.3	60-100	14-16	Wdm
Ipomoea batatas	Sweet Potato	P/A	4.3-8.3	30-460	9-27	Csw,Tvw
Kerstingiella geocarpa	Kersting's Groundnut		4.9-5.2	130-140	26-27	Td
Lablab purpureus	Lablab Bean	P/A	5.9-7.8	20-250	9-27	Wdm,Txw
Lactuca sativa	Lettuce	B/A	4.2-8.3	30-410	5-27	Bmw,Tdw
Leucaena leucocephala	Leadtree	P	4.3-8.0	70-410	16-29	Wdm,Tvw
Linum usitatissimum	Flax	A	4.8-8.3	30-130	6-25	Bmv,Tv
Luffa aegyptiaca	Smooth Luffa	A	4.3-8.3	30-420	13-27	Wm,Tvw
Lycopersicon esculentum	Tomato	P/A	4.3-8.3	30-460	6-27	Bmw,Tvw
Macadamia cultivars	Macadamia Nut	P	4.5-8.0	70-260	15-25	Wd,Tm
Mammea americana	Mamey Apple	P	4.3-8.0	70-400	19-27	Sdm,Tdw
Mangifera indica	Mango	P	4.3-8.0	20-420	17-29	Wm,Txw
Manihot esculenta	Cassava	P/A	4.3-8.0	50-400	15-29	Wdm,Tvw
Maranta arundinacea	Arrowroot	P/A	6.3-6.8	70-400	17-29	Sdm,Tdw
Medicago sativa	Alfalfa	P	4.3-8.3	20-250	5-25	Bmw,Txd
Moringa oleifera	Moringa tree	P	5.7-7.4	70-400	19-29	Sdm,Tvm
Mucuna deeringiana	Velvetbean	A	5.1-6.8	70-310	17-27	Wdm,Td
Musa cultivars	Banana	P	4.3-8.3	70-260	18-27	Ww,Tvw
Myristica fragrans	Nutmeg	P	4.3-6.8	70-410	15-27	Wd,Tdw
Nicotiana tabacum	Tobacco	A	4.3-8.3	30-400	7-27	Csw,Tvw

Olea europaea	Olive	P	5.3-8.6	30-170	13-23	Wtm,Tvd
Opuntia ficus-indica	Indianfig	P	5.8-8.3	20-170	13-25	Wtm,Td
Oryza sativa	Rice	A	4.3-8.3	50-420	9-29	Csw,Tvw
Pachyrhizus tuberosus	Yambean	P/A	4.3-7.3	150-410	21-27	Sdm,Tdw
Passiflora edulis var.flavicarpa	Yellow Passion Fruit	P	4.3-8.0	70-420	15-29	Wdw,Tvw
Paullinia cupana	Brazilian Cocoa	P	5.0-7.5	110-230	21-27	Sm,Tmv
Pennisetum americanum	Pearl Millet	A	4.5-8.3	20-260	9-27	Wdw,Txd
Persea americana	Avocado	P	4.3-8.3	30-410	13-27	Wdm,Tdw
Phaseolus acutifollus	Tepary Bean	A	6.8-7.3	70-170	17-23	Wdm,Tv
Phaseolus lunatus	Lima Bean	A	4.3-8.3	30-420	9-27	Csw,Tvw
Phaseolus vulgaris	Common Bean	A	4.3-8.3	30-460	5-27	Csw,Tvw
Phoenix dactylifera	Date Palm	P	5.1-8.3	20-400	13-28	Wtd,Txm
Pimenta dioica	Allspice	P	6.3-8.0	70-370	21-26	Sdm,Tdw
Piper nigrum	Black Pepper	P	4.3-7.4	70-420	20-27	Sdw,Tvw
Pistacia vera	Pistachio	P	5.7-7.8	30-70	15-19	Wd,Std
Pouteria campechiana	Canistel	P	6.8-8.0	70-260	21-25	Sm,Td
Pouteria sapota	Mamey Sapote	P	6.3-6.8	150-400	23-26	Tm
Psidium guajava	Guava	P	4.3-8.3	20-420	15-29	Wdw,Txw
Psophocarpus tetragonolobus	Winged Bean	P/A	4.3-6.8	70-410	23-32	Sdw,Tvw

Table: Maximum ecological amplitudes for some crops (2)

Scientific Name	Common Name	Length	pH	Rainfall(cm)	An. Temp.	Lifezones
Punica granatum	Pomegranate	P	4.3-8.3	30-420	13-27	Wtm,Tvw
Saccharum officinarum	Sugarcane	P	4.3-8.3	50-420	16-27	Wdm,Tvw
Sechium edule	Chayote	P	5.2-8.0	50-260	15-27	Wdw,Tdm
Simmondsia chinensis	Jojoba	P	7.3-8.2	20-30	17-20	Wt,Td
Solanum hyporhodium	Cocona	P	6.5-7.3	70-310	21-22	Sdw
Solanum melongena	Eggplant	P/A	4.3-8.3	20-420	7-27	Csw,Txw
Solanum quitoense	Naranjilla	P/A	5.8-8.0	70-310	11-25	Cw,Smw
Solanum tuberosum	Potato	P/A	4.3-8.3	30-460	4-27	Bmw,Tvw
Sorghum bicolor	Sorghum	P/A	4.5-8.3	40-310	8-27	Csw,Ttw
Syzgium aromaticum	Clove	P	6.8-7.3	70-400	24-26	Sd,Tm
Tamarindus indica	Tamarind	P	4.3-8.0	60-420	20-29	Sdw,Tvw
Telfaerea pedata	Oyster Nut	P	5.7-8.0	80-250	19-27	Sm,Td
Theobroma cacao	Cacao	P	4.3-7.4	70-420	18-28	Sdw,Tdw
Vanilla planifolia	Vanilla	P	4.3-8.0	70-420	19-28	Sdw,Tmv
Vigna radiata	Mung Bean	A	4.3-8.3	40-410	8-27	Cm,Ttw
Vigna unguiculata	Cowpea	A	4.3-8.3	30-410	13-27	Wtm,Ttw
Vigna unguiculata	Yardlong Bean	A	5.5-7.3	70-280	16-27	Wdm,Tdm
Vigna unguiculata	Catjang Cowpea	A	5.6-6.0	150-170	17-23	Wdm,Td
Vitis viniffera	Grape	P	4.3-8.6	50-330	7-27	Cmw,Tvw
Xanthosoma sagittifolium	Tannier	P/A	5.1-7.5	70-400	17-29	Wm,Tdw
Zea mays	Corn	A	4.3-8.3	30-400	5-29	Bmw,Txw

Table: Maximum ecological amplitudes for some crops (3)

Technical note: Comparison charts of tropical crops

by Dr. Franklin W. Martin and Michael P. Fennema

Introduction to the charts :

The question of what crops should be grown and how they should be used are never completely answered. Furthermore, there is no document or person that can provide all the answers desired. Agriculture always involves trial and error, experimenting and risking, learning and adjusting. These charts supply you with information to help you in making choices about which crops to try in your location. Crops are compared by categories to permit selection based on knowing how the crop can tolerate the conditions in your area. These comparison charts complement ECHO's catalog of "Seeds Available from ECHO," although the charts include a broader range of crops than offered in the catalog. It serves as another basic source of information on the most important crops of the tropics.

A COMPARISON OF GRAIN CROPS [*All these grain crops are annuals and are propagated by seed.]
Chart 1

Common Name	Species Name	Growth Habit	Edible Parts, and Uses	Principal Nutrients	ADAPTATION				Negative Facto
					Temp.	Daylength	Flood	Dry	
Amaranth	A. cruentus A. hypochondriacus	rapid, upright branched	seed in flour, popped	protein, starch	warm to hot	neutral	no	some	tiny seeds, som heads shatter
Barley	Hordeum vulgare	branched grass	seed in flour, cereal, malt, grits	protein, starch	cool to warm	neutral	no	no	
Buckwheat	Fagopyrum esculentum	herbaceous bush	seed in flour, cereal, green manure	protein, starch	warm	neutral	no	no	high altitude c
Corn, Maize	Zea mays	upright grass	cereal, starches, oil, seed in flour	protein, oil, starch	warm to hot	neutral to short	no	no	
Kaniwa	Chenopodium pallidicaule	broadleaf herb	seed in flour	protein, starch	warm	neutral	no	some	small seeds, high altitude
Pearl Millet	Pennisetum americanum	upright grass	seed in flour, cereal	protein, starch	warm	neutral	no	yes	

Quinoa	Chenopodium quinoa	broadleaf herb	seed in flour	protein, starch	warm	neutral	no	some	tiny seeds, high altitude
Rice	Oryza sativa	branched grass	seed as staple food, flour, starch	starch, low protein	warm to hot	neutral	yes	no	relatively low protein
Rye	Secale cereale	branched grass	seed as flour, cereal	starch, high protein	warm	neutral	no	no	
Sorghum	Sorghum bicolor	upright grass	seed in flour, cereal	protein, starch	warm to hot	neutral	no	some	birds eat best varieties
Tef	Eragrostis tef	branched grass	seed in flour, flat bread (injera)	protein, starch	cool	neutral	no	some	small seeds, high altitude
Triticale	Hybrid, Triticosecale	branched grass	seed in flour, cereal, bread	starch, high protein	cool to warm	neutral	no	no	experimental, hard to get
Wheat, bread	Triticum aestivum	branched grass	seed in flour, cereal, bread	protein, starch	warm	neutral	no	no	
Wheat, pasta	Triticum durum	branched grass	seed in flour, cereal, pasta	protein, starch	warm	neutral	no	no	lower protein above

Chart 1 Comparison of Grain Crops

A COMPARISON OF LEGUMINOUS VEGETABLES [* All are propagated by seed; winged beans may also be propagated by tubers.]
Chart 2

Common Name	Species Name	Annual/ Perennial	Growth Habit	Edible Parts and Uses	Principal Nutrients	Adaptation				Negative Factor
						Temp.	Daylength	Flood	Dry	
Bean, Common	Phaseolus vulgaris	annual	vine or bush	pod, dry seeds	general nut., starch	warm	mostly neutral	no	no	
Chickpea, garbanzo	Cicer arietinum	annual	bush	undried and dry seeds	protein, starch	cool to warm	mostly neutral	no	some	
Cowpea	Vigna unguiculata	annual	bush or vine	undried and dry seeds	protein, starch	hot	mostly neutral	no	some	
Fava bean	Vicia faba	annual	bush	pod, dry and undried seed	protein, starch	warm	mostly neutral	no	some	consumption re to a disease
Jack bean	Canavalia	annual	mostly	small young pod	protein,	hot	neutral/ short	some	yes	poisonous and

	ensiformis		bush		starch		day			use when older
Lablab bean	Dolichos lablab	weak perennial	vine; bush -short day	dry and undried seed, pod	protein, starch	hot	short day	some	some	excessive vining summer
Lima bean	Phaseolus lunatus	annual	vine or bush	undried seeds	protein, starch	warm to hot	mostly neutral	no	some	
Pea	Pisum sativum	annual	weak vine	pod, dry and undried seeds	protein, starch	cool to warm	neutral	no	no	strictly tempera
Peanut	Arachis hypogaea	annual	bush	dry and undried seed	oil, high protein	hot	mostly neutral	no	some	wet seeds becon poisonous
Pigeon Pea	Cajanus cajan	weak perennial	tall bush	dry and undried seed	protein, starch	hot	neutral/short day	no	yes	
Soybean	Glycine max	annual	bush	dry and undried seed	oil, starch, high protein	warm to hot	short day	no	no	often needs rhiz innoculant
Sword bean	Canavalia gladiata	annual	vine	young pod	protein, starch	hot	neutral	no	no	pods and beans slightly poisono
Winged bean	Psophocarpus tetragonolobus	weak perennial	vine	young pod, leaf, root, flower	oil, starch, high protein	hot	mostly short day	some	no	
Yardlong bean	Vigna unguiculata	annual	vine	pod	general nutrients	hot	mostly neutral	no	no	

Chart 2 Comparison of Leguminous Vegetables

COMPARISON OF PULSES (DRIED LEGUMES USED FOR COOKING) [* All are propagated by seed, the scarlet runner may also be propagated by roots.]
Chart 3

Common Name	Species Name	Annual or Perennial	Growth Habit	Edible Parts and Uses	Principal Nutrients	Adaptation				Negative Factors
						Temp	Daylength	Flood	Dry	
Bambara groundnut	Voandzeia subterranea	annual	compact, bushy herb	seeds ground or boiled, pods boiled	protein	hot	mostly neutral	no	yes	hard seed
Bean, common	Phaseolus vulgaris	annual	bushy herb or vine	boiled seeds, mashing and refrying, pods	protein, starch	warm	mostly neutral	no	no	limited adaptation to the
Chick pea, garbanzo	Cicer arietinum	annual	bushy herb or vine	boiled seeds	protein, starch	cool to warm	neutral	no	yes	temperate climate only
Cowpea	Vigna unguiculata	annual	bushy herb or vine	boiled seeds, immature pods, leaves	protein, vit.B	hot	mostly neutral	no	some	diseases and insects

Faba bean	Vicia faba	annual	bushy	boiled seed, roasted, ground meal	protein, starch	cool to warm	mostly neutral	no	some	Fabism (a disease) is link bean
Horse gram	Macrotyloma uniflorum	annual	bush or weak vine	boiled seeds	protein, starch, oil	hot	mostly short day	no	some	small seeds
Lablab	Dolichos lablab	annual	climbing vine	boiled seeds, mature seeds and pods	protein, starch	warm	mostly short day	some	some	excessive vine growth du days
Lima bean	Phaseolus vulgaris	annual	bush or vine	boiled seed or green pod	protein, vit.B, starch	hot	variable	no	some	foliage contains HCN
Moth bean	Vigna aconitifolia	annual	low trailing vine	seed boiled, ground or fried, forage	protein, starch	mostly hot	neutral, short day	no	yes	difficult to harvest
Mung bean	Vigna radiata	annual	small bush or vine	boiled and sprouted seed, edible pods	protein, starch	cool to warm	neutral, short day	no	yes	rhizobium inoculation n some soils
Popping bean	Phaseolus vulgaris	annual	vine	popped before eating uncooked	protein, starch	cool to warm	short day	no	some	adapted to Andes mount
Pea	Pisum sativum	annual	weak vine	boiled seed, ground meal	protein, starch	mostly hot	mostly neutral	no	no	temperate climate only
Peanut	Arachis hypogaea	annual	small bush	dry nuts, boiled seed	oil, protein	hot	neutral, short day	no	some	diseases
Pigeon pea	Cajanus cajan	annual or weak perennial	tall bush	boiled seed, mature seed	protein	warm to hot	neutral, short day	some	yes	insect susceptibility
Rice bean	Vigna umbellata	annual or weak perennial	small vine	boiled seed, edible pod, leaves	protein, starch	warm to hot	mostly short day	no	yes	poor yields
Scarlet runner bean	Phaseolus coccineus	annual or perennial	vine	boiled seed, mature seed, leaves, roots	protein, starch	cool to warm	mostly neutral	no	no	adapted to cool or temp climate
Soybean	Glycine max	annual	mostly bushy	boiled, ground, extracted, processed	oil, high protein	hot	short day	no	some	rhizobium inoculation n some soils
Tarwi	Lupinus mutabilis	annual	bush	boiled seeds	oil, high protein	cool to warm	mostly neutral	no	some	seed contains poisonous must boil seed
Tepary bean	Phaseolus acutifolius	annual	bush or weak vine	seeds boiled or ground	protein, starch	warm to hot	mostly short day	no	yes	adapted only to desert c
Urd, bean	Vigna mungo	annual	bush	boiled or ground seed	protein, starch	very hot	neutral, short day	no	some	adapted only to dry con
Velvet bean	Stizolobium/ Mucuna spp.	annual or weak perennial	climbing or trailing vine	roasted seed as coffee sub., or in tempeh	protein, oil	warm to hot	mostly short day	yes	some	seeds contain poisonous must be boiled

Chart 3 Comparison of Pulses

A COMPARISON OF FRUIT VEGETABLES
Chart 4

Common Name	Species Name	Annual/ Perennial	Growth Habit	Edible Parts and Uses	Principal Nutrients	Adaptation			Negative Factors

						Temp	Flood	Dry	
Angled luffa	Luffa acutangula	annual	climbing vine	young fruit	low nutritional value	hot	no	no	poisonous seeds
Bitter gourd	Momordica charantia	annual	climbing vine	young fruit, leaves	vit. C	hot	no	yes	very bitter
Bottle gourd/ Cucuzzi	Lagenaria siceraria/ Lagenaria sp.	annual	climbing vine	young fruit, seed	low nutrit. value, seeds high in oil and protein	warm \hot	some	no	low nutrit. value
Chayote	Sechium edulis	perennial	climbing vine	mature fruit, vine tips, roots	tips high in vitamins, minerals	warm	some	no	needs cool nights
Eggplant	Solanum melongena	weak perennial	bush	young fruit	low nutrit. value	warm \hot	some	some	low nutrit. value
Melon	Cucumis melo	annual	trailing vine	mature fruit	low nutritive value	hot	no	no	many diseases
Okra	Abelmoschus esculentus	annual	bush	young fruit, dried seed	fair source of most nutrients	hot	no	some	summer only
Pepper	Capsicum annuum	weak perennial	bush	yng\mature fruit, leaves	vitamins A,C	warm \hot	no	some	virus susceptible
Pumpkin, tropical	Cucurbita moschata	weak perennial	trailing vine	yng\mature fruit, buds, seeds, vine tips	vit A,C., seeds high in oil and protein	hot	some	no	mildew
Snake gourd	Trichosanthus cucumerina	annual	climbing vine	young fruit	low nutrit. value	hot	no	no	poor quality
Sponge gourd	Luffa cylindrica	annual	climbing vine	yng fruit, mature sponges	low nutrit. value	hot	no	no	low nutrit. value
Tomato	Lycopersicon esculentum	annual/ weak per.	bush or wk vine	yng\mature fruit	vitamins A,C	warm	no	no	many diseases
Wax gourd	Benincasa hispida	annual	climbing vine	young fruit, seed for oil	low nutrit. value, seeds high in oil and protein	hot	no	no	low nutrit. value

* All plants listed are daylength neutral and are propagated by seeds; chayote, pumpkin and tomatoes can also be propagated by cuttings.

Chart 4 Comparison of Fruit Vegetables

A COMPARISON OF VEGETABLE LEAVES
Chart 5

Common Name	Species Name	Annual/	Propaga-	Growth	Edible Parts and Uses	Relative	Relative	Adaptation	Negative Factors

		Perennial	tion	Habit		Yield	Quality	Temp.	Daylength	Flood	Dry	
Amaranth	Amaranthus sp.	annual	seed	herb	leaf and whole plant, cooked	high	high	hot	mostly short day	no	some	Short life span, insects
Belembe	Xanthosoma brasiliense	perennial	offshoot	herb	leaf and stem, cooked	low	very high	hot	neutral	yes	no	low production
Bok choi	Brassica rapa B. chinensis	annual	seed	herb	leaf and head, raw or cooked	medium	medium	cool to warm	neutral	no	no	
Bush okra	Corchorus olitorius	annual	seed	herb	leaf and shoot, cooked	high	medium	hot	neutral	no	some	weedy
Cassava	Manihot esculenta	perennial	cutting	bush	leaf and shoot, cooked	medium	medium	hot	neutral	no	some	needs cooking or is toxic
Chaya	Cnidoscolus chayamansa	perennial	cutting	bush	leaf and shoot, cooked	very high	high	warm to hot	neutral	some	yes	somewhat toxic
False roselle	Hibiscus acetosella	weak perennial	seed	bush	leaf and shoot, cooked	medium	medium	warm to hot	short day	no	some	weedy nature
Moringa	Moringa sp.	perennial	seed, cutting	tree	leaf, young fruit, flower, root	very high	high	hot	neutral	no	yes	excessively vigorous
Indian lettuce	Lactuca indica	annual	seed, cutting	tall herb	leaf, raw	high	high	warm to hot	short day	no	no	excessive height
Kai choi	Brassica juncea	annual	seed	herb	leaf and head, raw or cooked	medium	high	warm	neutral	no	no	
Kale, Ethiopian	Brassica carinata	annual	seed	herb	leaf, raw or cooked	high	medium	warm	neutral	no	no	
Katuk	Sauropus androgynus	perennial	seed, cutting	bush	leaf and shoot, cooked	medium	high	hot	neutral	no	no	lowers blood sugar
Lettuce	Lactuca sativa	annual	seed	herb	leaf and head, raw	medium	medium	cool to warm	short day	no	no	
Malabar Spinach	Basella rubra (B. alba)	perennial	seed, cutting	climbing vine	leaf and shoot, cooked	high	low	hot	short day	no	no	fruits during short days
Pacific Spinach	Abelmoschus manihot	perennial	cutting	tall bush	leaf and shoot, cooked	high	medium	hot	short day	no	no	mucilaginous when cooked
Quail grass	Celosia argentea	annual	seed	herb	leaf and shoot, cooked	high	medium	hot	short day	no	yes	weedy
Sweet potato	Ipomoea batatas	perennial	cutting	trailing vine	shoot, cooked	medium	medium	hot	short day	no	no	weevils are hard to control
Watercress	Nasturtium officinale	perennial	seed, cutting	trailing	entire plant	high	high	warm	neutral	yes	no	strong flavor
Water Spinach	Ipomoea aquatica	perennial	cutting, seeds	trailing vine	leaf and shoot, cooked	high	hot	warm to hot	short day	yes	no	weedy in canals

Chart 5 Comparison of Vegetable Leaves

A COMPARISON OF ROOTS AND TUBERS
CHART 6

Common Name	Species Name	Annual, Bi\Per-ennial	Propa-gation	Growth Habit	Edible Parts, Uses	Principal Nutrients	Adaptation				Negati Factors
							Temp.	Daylenth	Flood	Dry	
Beet *	Beta vulgaris	bi., grown as annual	seed	herbaceous	Roots, leaves cooked	roots-low nutrients	cool	neutral	no	no	temper climate
Carrot *	Daucus carota	bi., grown as annual	seed	herbaceous	roots, raw or cooked	high in vit. A	cool\ warm	neutral	no	no	temper climate
Cassava	Manihot esculenta	per. grown as annual	stem cutting	bush	tuberous root, leaf, cooked	starch	hot	short day	no	some	some v posion untreat
Dasheen	Colocasia esculenta	per. grown as annual	off-shoot	herbaceous	corm, cooked	starch, vit. C	hot	short day	some	no	
Edible Canna *	Canna edulis	per. grown as annual	off-shoot	upright herbaceous	rhizome, cooked	starch	hot	neutral	some	no	poor quality vegetal
Jicama *	Pachyrrhizus crosus	weak per. used as annual	seed	vining	tuberous root, cooked	starch, protein	hot	neutral	no	some	pods,le poison
Potato	Solanum tuberosum	per. grown as annual	tuber cutting	herbaceous	tuber, cooked	starch, vit. C	cool\ warm	neutral	no	no	not tropica
Sweet Potato	Ipomoea batatus	per. grown as annual	stem cutting	trailing vine	vine tips and tuberous root, cooked	starch, vit. C, vit. A	hot	mostly short day	no	no	insect proble
Tanier	Xanthosoma spp.	per. grown as annual	off-shoot	herbaceous	corm, cooked	starch	hot	mostly short day	some	no	disease proble
Taro	Colocasia esculenta	per. grown as annual	off-shoots	herbaceous	corm, cooked	starch, vit. C	hot	mostly short day	yes	no	needs paddy culture
Yam	Dioscorea spp.	per. grown as annual	tuber cutting	climbing vine	tubers, cooked	starch, protein	hot	mostly neutral	some	no	very seasona

*Not a dietary staple

Chart 6 Comparison of Roots and Tubers

A COMPARISON OF MISCELLANEOUS VEGETABLES
Chart 7

Common Name	Species Name	Annual/ Perennial	Propagation	Growth Habit	Edible Parts and Uses	Principal Nutrients	Adaptation				Negative f
							Temp	Daylength	Flood	Dry	
Asparagus	Asparagus officinale	perennial	seed, offshoot	bush, large rhizomes	young tender shoots, cooked pickled	vit. C	cool-warm	neutral	no	some	needs 3-5
Bamboo shoots	Several spp.	perennial	offshoot	tall woody grass	young culm		warm to hot	time dependent	often	often	very large
Buffalo gourd	Cucurbita foetidissima	perennial	seed	bush/vine	seeds for oil and flour	oil, high protein	warmt o hot	long day	no	yes	
Bunching onion	Allium fisulosum	perennial	seed, offshoot	herb w/ bulb	entire plant as condiment	vit. C	cool warm	short day	no	no	
Chestnut, water	Eleocharis dulcis	perennial	corm	reed in mud	corm	starch	warm to hot	long day	yes	no	
Chinese chives	Allium tuberosum	perennial	offshoot	herb	green foliage as spinach	vit A,C	warm hot	short day	no	no	
Coconut sprout	Cocos nucifera	perennial	seed	tall tree	root ball after germination		hot	neutral	some	some	
Egusi	Colocynthus citrullis	annual	seed	trailing vine	roasted seeds as snacks or ground	high protein	warm to hot	neutral	no	yes	
Izote	Yucca elephantipes	perennial	seed, cutting	large woody bush	mature bud and flower raw or cooked, heart must be cooked	flower- vit.C, calcium in heart	warm to hot	neutral	no	no	chiefly for uses, ineffi production
Onion	Allium cepa	perennial	seed, bulbs	herb	bulb as condiment	vit. C	warm	short and long day varieties	no	no	specific va planting d needed
Pacaya	Chamae-dorea spp.	perennial	seeds	small palm	young inflorescence	protein	hot		no	no	inefficient production
Palm heart	Many spp.	perennial	seeds	branched palms	tender growing tip	protein, vit. B	hot	neutral	some	some	inefficient production
Pit pit	Saccharum edulis	perennial	cutting	large grass	bottled up flower cooked as vegetable	protein	hot	short day	some	no	inefficient production

Rhubarb (as annual)	Rheum rhaponti	perennial	seed, offshoot	large herb	petioles cooked	vit. C	cool warm	neutral	some	no	mostly ten
Roselle	Hibiscus sabdariffa	annual	seed	large woody herb	calyxes of pod as fruit	vit. C	warm	short day	no	some	
Sweet corn	Zea mays	annual	seed	tall herb	immature ear	carbohydrate, P, niacin	warm	neutral to short day	no	no	

Chart 7 Comparison of Miscellaneous Vegetables

A COMPARISON OF SELECTED TROPICAL FRUIT CROPS
Chart 8

Common Name	Scientific Name	Propagation	Growth Habit	Edible Parts and Uses	Principal Nutrients	Adaptation			Negative Factors
						Temp.	Flood	Dry	
Atemoya	Annona hybrid	grafts	small tree	fruit, raw	vit. C	warm	no	some	irreg. shape
Avocado	Persea americana	seeds, grafts	med. tree	fruit, raw	oil	warm-hot	no	some	disease
Banana	Musa sp.	offshoots	large herb	fruit, raw, cooked	starch, potassium	hot	some	little	dark color
Black Sapote	Diospyros digyna	seeds, grafts	med. tree	fruit, cooked	carbohydrate	hot	some	none	
Breadfruit	Artocarpus elastica	root cuttings	med. tree	fruit, cooked	starch	hot	some	some	
Canistel	Pouteria campechiana	seeds, grafts	small tree	fruit, raw, processed	starch, vit. A,C	hot	no	some	
Carambola	Averrhoa carambola	seeds, grafts	small tree	fruit, raw	vit. C	hot	some	no	
Cherimoya	Annona cherimola	seeds, grafts	med. tree	fruit, raw	vit. C	hot	no	no	
Citrus	Citrus spp.	grafts	med. tree	fruit, raw	vit. A,C	warm-hot	no	some	
Coconut	Cocos nucifera	seeds	tall palm	fruit, many uses	protein, oil	hot	some	some	
Date	Phoenix dactylifera	seeds, offshoots	tall palm	fruit, dried	carbohydrate	very hot	no	yes	
Durian	Durio zibethinus	seeds, grafts	large tree	fruit, raw	protein,carbohydrate	hot	some	no	odor of fruit
Guava	Psidium guajava	seeds, airlayers	small tree	fruit, raw, cooked	vit. C	hot	some	some	
Jaboticaba	Myrciaria cauliflora	seeds, grafts	small tree	fruit, raw	vit. C	warm	some	no	needs cool winter
Jackfruit	Artocarpus heterophyllus	seeds, grafts	med. tree	fruit, raw	vit. A,C	hot	some	no	
Lansium (Langsat)	Lansium domesticum	seeds	med. tree	fruit, raw		hot	some	no	
Lychee	Litchi chinensis	seeds, airlayers	med. tree	fruit, raw	vit. C	warm	some	no	needs cool winter
Loquat	Eriobotrya japonica	seeds, grafts	med. tree	fruit, raw, cooked	vit. A,C	warm-hot	no	no	cool days to set fruit
Mango	Mangifera indica	grafts	tall tree	fruit, raw, cooked	vit. A,C	hot	some	some	

Mamey sapote	Pouteria sapote	seeds, grafts	med. tree	fruit, raw	vit. C	warm-hot	no	some	
Mammee apple	Mammea americana	seeds, grafts	large tree	fruit, raw, cooked	vit. A,C	hot	some	some	somewhat poisonous
Papaya	Carica papaya	seeds	large tree	fruit, raw	vit. A,C	hot	no	some	fruit too soft
Passion fruit	Passiflora edulis	seeds, cuttings	vine	fruit, raw juice	vit. A,C	warm-hot	some	some	
Peach palm	Bactris gasipaes	seeds	tall palm	pulp and kernel of seeds	oil, starch, vit. A	hot	no	no	spiny trunk
Prickly pear	Opuntia spp.	seeds, cuttings	shrub	fruits, new pads	carbohydrate	warm-hot	no	yes	spiny plant
Rambutan	Nephelium lappaceum	seeds, grafts	med. tree	fruit, raw	vit. C	hot	some	no	
Salak	Zalacca edulis	seeds, grafts	small palm	fruit, raw		very hot	yes	no	
Tamarind	Tamarindus indica	seeds, offshoots	large tree	fruit, raw juice	vit. C	hot	no	yes	
White sapote	Casimiroa edulis	seeds, grafts	med. tree	fruit, raw	vit. C	warm	no	some	

Chart 8 Comparison of Selected Tropical Fruit Crops

A COMPARISON OF NUT CROPS
Chart 9

Scientific Name	Common Name	Propagation	Edible Parts	Principle Nutrients	Tolerant of	
					Flood	Drought
Anacardium occidentale	Cashew	seeds, grafts	nuts	protein	no	yes
Areca catechu	Betelnut	seeds, offshoots	seed - chewed	alkaloids	yes	no
Artocarpus altilis	Breadnut	seeds, offshoots	seeds	carbohydrate	yes	no
Artocarpus heterophylla	Jackfruit	seeds, grafts	seeds, pulp	carbohydrate	yes	no
Bactris gasipaes	Peach palm	seeds, offshoots	pulp, seeds	carbohydrate	yes	no
Brosimum alacastrum	Mexican breadnut	seeds	seeds		yes	no

Canarium indicum	Canary nut	seeds	seeds	protein	no	yes
Canarium ovatum	Pili nut	seeds, grafts	seeds, pulp	protein	yes	no
Cocos nucifera	Coconut	seeds	seeds, other	protein	yes	no
Coula edulis	African walnut	seeds	seeds	protein	yes	some
Erythrina edulis	Basul	seeds	seeds, foliage		no	no
Inga paterno	Paterno	seeds	seeds	carbohydrate	no	some
Inocarpus edulis	Tahiti chestnut	seeds	seeds		some	
Gnetum gnemon	Joint fir	seeds	seeds	protein	some	no
Lecythis elliptica	Paradise nut	seeds	seeds	protein	some	no
Macadamia sp.	Macadamia	seeds, grafts	seeds	protein	some	some
Pachira aquatica	Malabar Chestnut	seeds	seeds	oil	yes	no
Pouteria sapote	Mamey sapote	seeds, grafts	pulp, seeds	protein	no	some
Terminalia catappa	Indian almond	seeds	seeds	protein, oil	yes	no
Terminalia kaernbachii	Okari nut	seeds	seeds	protein, oil	yes	no
Treculia africana	African Breadfruit	seeds	seeds	protein	yes	no

Chart 9 Comparison of Nut Crops

A COMPARISON OF INDUSTRIAL, PLANTATION, OR BEVERAGE CROPS
Chart 10

Common Name	Species Name	Annual or Perennial	Growth Habit	Adaptation				Supplementary Uses
				Temp.	Daylength	Flood	Drought	
SPICES								
Allspice	Pimenta officinalis	perennial	small tree	hot	neutral	no	no	

Cloves	Syzygium aromaticum	perennial	small tree	hot	neutral	some	no	
Ginger	Zingiber officinale	perennial	herb	hot	long day	some	no	
Nutmeg + Mace	Myristica fragrans	perennial	tree	hot	neutral	some	no	
Pepper	Piper nigrum	perennial	vine	hot	neutral	some	no	
Vanilla	Vanilla fragrans	perennial	vine	hot	neutral	some	no	
BEVERAGES								
Cacao	Theobroma cacao	perennial	small tree	hot	neutral	no	no	household
Coffee	Coffea arabica Coffea robusta	perennial	small tree	hot	neutral	no	no	household
Guaraná	Paullinia cupana	perennial						
Mate	Ilex paraguariensis	perennial						
Tea	Camellia sinensis	perennial	shrub	warm	neutral	no	no	household
OIL								
Coconut	Cocos nucifera	perennial	tall palm	hot	neutral	some	some	multiple
Oil palm, African	Elaeis guineensis	perennial	palm	hot	neutral	some	some	
Oil palm, American	Corozo (=E.) oleifera	perennial	palm	hot	neutral	no	some	food
Olive	Olea europaea	perennial	tree	warm-hot	neutral	no	yes	many
Peanut	Arachis hypogaea	annual	herb	hot	long day	no	some	as food
Sesame	Sesamum indicum	annual	herb	warm	long day	no	some	as food
Soybean	Glycine max	annual	herb	hot	short day	no	some	as food
Tung	Aleurites sp.	perennial	tree	hot	neutral	no	some	
FIBER								
Abaca	Musa textilis	perennial	large herb	hot	neutral	some	no	cord
Cotton	Gossypium sp.	annual	large herb	hot	neutral	no	no	stuffing
Jute	Corchorus capsularis	annual	herb	hot	neutral	no	no	cord
Kapok	Ceiba pendandra	perennial	tree	hot	neutral	no	no	stuffing
Kenaf	Hibiscus sp.	annual	herb	hot	long day	no	no	cord, leaves

Ramie	Boehmeria nivea	annual	herb	hot	long day	no	no	cord
Sisal	Agave sp.	perennial	herb	hot	neutral	no	yes	cord
OTHER								
Sago palm	Metroxylon sagu	perennial	palm	hot	neutral	yes	no	starch
Sugar cane	Saccharum edulis	perennial	grass	hot	neutral	yes	some	food
Sugar palms	Many species	perennial	palms	hot	neutral	some	some	many
Tobacco	Nicotiana tabacum	annual	herb	hot	long day	no	no	insecticide

Chart 10 Comparison of Industrial, Plantation, or Beverage Crops

A COMPARISON OF GROUND COVERS AND GREEN MANURES

Chart 11

Common Name	Scientific Name	Annual or Perennial	Growth Habit	Uses
Butterfly pea	Clitorea ternatea	annual	climbing vine	ground cover
Beggarweed	Desmodium gyroides	annual	shrub	ground cover
Beggarweed	Desmodium heterophylla	annual	shrub	ground cover
Beggarweed	Desmodium salicifolium	annual	herb	ground cover
Calapo	Calopogonium mucunoides	either	trailing vine	green manure
Centro	Centrosema pubescens	perennial	climbing vine	ground cover
Indigo	Indigofera hendecaphylla	perennial	herb	green manure
Jackbean	Canavalia ensiformis	annual	bush	green manure
Kudzu, trop.	Pueraria phaseoloides	perennial	climbing vine	ground cover
Lablab bean	Dolichos lablab	annual	climbing vine	food, ground cover
Perennial peanut	Arachis sp.	perennial	trailing	ground cover, feed
Spanish	Desmodium triflorum	perennial	trailing vine	ground cover

clover				
Spanish clover	Desmodium uncinatum	perennial	trailing vine	ground cover
Sunn hemp	Crotalaria juncea	annual	shrub	green manure, fiber
Velvet bean	Stizolobium/ Mucuna spp.	annual	trailing vine	ground cover
Winged bean	Psophocarpus tetragonolobus	annual	climbing vine	food, green manure
Vigna	Vigna hosia	perennial	vine	ground cover
Vigna	Vigna lutea	perennial	vine	ground cover
Vigna	Vigna unguiculata	annual	climbing vine	food, green manure
Vigna	Vigna vexillata	perennial	trailing vine	ground cover

Chart 11 Comparison of Ground Covers and Green Manures

All of the plants mentioned in this chart 11 can be used as feed for animals. However, cutting them for feed limits their effectiveness as green manures and cover crops. The distinction between green manures and cover crops is minimal, and often the two words are used interchangeably. The following definitions show the difference in emphasis of the two terms. Green manure crops are those grown for the purpose of incorporation when the plant is fresh and green (thus high in nitrogen), resulting in soil enrichment and a greater water holding capacity. Ground cover crops grow vigorously to outcompete weeds and provide a good soil covering and mulch. These crops are also good for soil improvement and erosion prevention.

A COMPARISON OF TROPICAL PASTURES AND FIELD CROPS
Chart 12

Common Name	Species Name	Annual or Perennial	Growth Habit	Propagation	Adaptation

					High temps.	Flood	Drou
FEED LEGUMES							
Acacia, Apple-ring	Acacia albida	perennial	tree	seeds	yes	no	some
Centro	Centrosema pubescens	perennial	vine	seeds	yes	no	some
Jack bean	Canavalia ensiformis	annual	bush	seeds	yes	no	some
Kudzu	Pueraria phaseoloides	perennial	vine	seeds	yes	some	some
Leucaena	Leucaena spp.	perennial	tree	seeds	yes	no	yes
Mesquite	Prosopis spp.	perennial	tree	seeds	yes	no	yes
Mother of cacao	Gliricidia sepium	perennial	tree	seeds, cuttings	yes	some	some
Prickly sesban	Sesbania bispinosa	perennial	shrub	seeds	yes	yes	some
Spanish clover	Desmodium uncinatum	perennial	vine	seeds	yes	no	some
St. John's bread	Ceratonia siliqua	perennial	tree	seeds	yes	no	yes
Umbrella thorn	Acacia tortilis	perennial	tree	seeds	yes	no	yes
FEED GRASSES							
Napier	Pennesitum purpureum	perennial	tall grass	seeds, cuttings	yes	yes	no
Sudan	Sorghum sudanense	annual	tall grass	seeds	yes	no	some
Guinea	Panicum maximum	perennial	clump grass	seeds, cuttings	yes	some	some
Pangola	Digitaria decumbens	perennial	spread grass	cuttings	yes	some	some
Bermuda	Cynodon dactylon	perennial	spread grass	cuttings	yes	no	some
Star	Cynodon nlemfluensis	perennial	spread grass	cuttings	yes	no	some
Kikuyu	Pennesitum clandestinum	perennial	spread grass	cuttings	no	no	some

Chart 12 Comparison of Tropical Pastures and Field Crops

A COMPARISON OF SPECIAL PURPOSE TREES
Chart 13

Species Name	Common Name	Nitrogen Fixing	Principal Uses	Secondary Uses	Adaptation
Acacia albida	Apple-ring acacia	yes	MPL*	camel feed	hot, dry tropics
Acacia mearansii	Black wattle	yes	MPL		hot, dry tropics
Acacia nilotica	Nile acacia	yes	MPL, alley cropping		hot, dry tropics
Boscia senegalensis		no	emergency food		hot, dry tropics
Bursera simaruba	Gumbo limbo	no	living fence	industrial gum	hot, dry tropics
Calliandra calothyrsis	Calliandra	yes	MPL	fuel	wet tropics
Chaemaecytisus palmensis	Tagasaste	yes	alley cropping	MPL	upland tropics
Cassia siamea	Siamese acacia	yes	fuel, hard wood	MPL	hot tropics
Casuarina sp.	Casuarina	yes	fuel, lumber	windbreak	hot tropics
Erythrina berteroana	Coral bean	yes	living fence	MPL	intermed. tropics
Gliricidia sepium	Mother of Cacao	yes	living fence	MPL	intermed. tropics
Hibiscus tiliaceus	Mahoe	no	living fence	erosion control	hot, dry tropics
Leucaena leucocephala	Leucaena	yes	alley cropping, feed	MPL	intermed. tropics
Moringa pterygosperma (formerly M. oleifera)	Moringa	no	food	living fence	intermed. tropics
Moringa stenopetala		no	food	living fence	wet tropics
Sapium sebiferum	Tallow tree	no	useful oils	erosion control	intermed. subtropics
Sesbania grandiflora	Sesban	yes	food, alley cropping	MPL	intermed. tropics
Swietenia mahogani	Mahogany	no	timber		wet tropics
Tamarisk sp.	Tamarisk	no	windbreak	lumber	dry subtropics
Yucca elephantipes	Bulbstem yucca	no	living fence	edible flowers	hot and intermed. subtropic

*MPL refers to multipurpose legume

Chart 13 Comparison of Special Purpose Trees

What seed would you take to an uninhabited tropical island?

Dr. Frank Martin is the author of several books and articles on tropical subsistence farming and a frequent consultant to ECHO. We received from him the following interesting note:

"If I were to go to an uninhabited island in the hot, humid tropics, taking with me the seeds with which I think I could best provide myself food, I think I would take the following.

Roots and Tubers: (1) sweet potatoes-the variety 'Gem' (orange-fleshed) and some white-fleshed types, (2) yams-Dioscorea alata and D. esculenta, selected varieties, (3) cassava-some true seed to start my own, (4) Queensland arrowroot (Canna edulis), very easy to grow and productive.

Grains: (1) corn, (2) okra, for edible seed and well as green fruit, (3) wax gourd (Benincasa hispida) for edible seed as well as squash-like fruit.

Legumes: (1) Catjang cowpeas (climbing, disease resistant forms), (2) winged bean, (3) Dolichos lablab beans, (4) asparagus beans.

Leafy Vegetables: (1) chaya, (2) sunset hibiscus, (3) Tahitian taro (Xanthosoma brasiliensis), (4) Tropical or Indian lettuce (Lactuca indica).

Fruit Vegetables :(1) tropical pumpkin, (2) okra, (3) small-fruited, indeterminate tomatoes, (4) hot pepper, (5) ensalada pepper, selected for its edible leaves.

Trees :(1) bananas, (2) breadfruit, (3) limes (West Indian, from seed), (4) tamarind, (5) papaya, (6) mangoes (from seed, turpentine type but selected)."

Several of Dr. Martin's publications (co-authored by Ruth Rubert) are available from ECHO. We are reprinting their book Edible Leaves of the Tropics (see chapter on Tropical Vegetables). Techniques and Plants for the Tropical Subsistence Farm (see below) is an excellent introduction to a wide variety of food plants adapted to hot, humid regions.

How can I garden in the hot humid tropics?

Letters from EDN readers often contain questions similar to this. Even experienced gardeners can get discouraged when they move to the humid tropics from a temperate country and plant the vegetables they know from home. Others of you have not had gardening experience in any climate, but now face the need to learn quickly. The approach of the two books described below is so different that they complement each other very well.

The best way to begin gardening in hot humid regions is to try those plants that God has clearly made for such climates. However, temperate crops are often in demand because of the increased variety that they add to the diet and their value as a cash crop to replace imported vegetables. Techniques and Plants for the Tropical Subsistence Farm is oriented toward plants that are adapted to the tropics. Growing Vegetables in Fiji is more oriented toward growing temperate vegetables, with some discussion of other vegetables.

Dr. Frank Martin and Ruth Rubert with the USDA's Tropical Agriculture Research Station in Puerto Rico wrote a 56-page book called Techniques and Plants for the Tropical Subsistence Farm. (It is now out of print, but ECHO sells a photocopied version in a binder for $5 plus postage.) It is an excellent introduction to a wide variety of foods that are adapted to hot, humid regions. Its scope is a bit broader than only gardening, as the title implies. The table of contents lists: overall planning; vegetables and cereals (leaves, legumes, roots and tubers, fruit vegetables, cereals); trees (fruit trees, vegetable trees, leguminous trees, trees for wood); forage crops (site selection & preparation, planting, management, grazing, storage, selecting forages, grasses, legumes, misc. forages). Their approach to insect control is less specific with an emphasis on organic methods. (It is quite likely

that insect control is less of a problem with the native tropical plants.) Here are some excerpts.

"Phosphorous is an essential, limiting element in tropical soils as often as nitrogen. It is important in stimulating root development and is necessary for fruit and seed development. Although it is common enough in the soil, most of it is insoluble, unavailable for plant use. Manure, compost and cover crops do not add enough phosphorous to the soil" and tend to become insoluble when they are added. He then discusses deficiency symptoms. Commercial fertilizers are one source. "Bonemeal is a useful additive though much of its phosphorous is insoluble. Marine organic materials (seaweeds, fish) are other good sources. There does not seem to be an easy solution to the problem, but a soil with adequate humus and good aeration slowly releases soluble phosphates from the insoluble forms."

"Indian or tropical lettuce (Lactuca indica) from Southeast Asia is considered by some to be the best lettuce for the hot humid tropics. Like all lettuces, it requires a fertile soil. Seeds are small and seedlings require careful attention. [Ed: So many plants come up wild we no longer need to replant, however.] The plants grow rapidly and produce large succulent leaves. These may be harvested individually, or the tops may be snapped off... [to be] replaced rapidly by new growth. Once flowering begins, it cannot be suppressed, but leaves may be harvested until exhausted. Year-round production is easily achieved by planting every 3-4 months. Yields are excellent and the plants can be grown in pots. The lettuce is somewhat bitter in taste, but its flavor and texture are perfect for mixed salads." [Ed: It is also excellent as a cooked green. ECHO has seed.]

Kirk Dahlgren worked as the Rural Development Director for the Peace Corps in Fiji. He wrote a 123-page book for the Peace Corps called Growing Vegetables in Fiji. This book is an excellent general introduction to gardening in the tropics (or elsewhere for that matter). We think so much of the book that we have reprinted it (US$5 plus postage). As mentioned earlier, a special emphasis is placed on growing temperate vegetables. The climate is hot and humid in much of the country, similar to conditions faced by many of you. His writing is clear and choice of subjects excellent. He has an unusual ability to get right to the most important points and to explain them clearly in as few

words as possible. The table of contents lists: the Fiji vegetable crop environment; building and maintaining soils; cultural methods of vegetables; the garden crops of Fiji; growing vegetables under plastic; composting and mulching. Some examples follow.

"The culture of many of these new crops required the learning of a totally foreign propagation method-the use of seeds." Traditional Fijian crops are propagated vegetatively, i.e. a piece of the plant other than a seed is used to produce new plants. "The vegetable crops the missionaries brought evolved in temperate zones where plants needed to produce resistant bodies, i.e. seeds, to survive the harsh winters." Crops the Indians brought had a similar need to survive dry months. Because in Fiji the weather is always just right for the plants to grow, it is often advantageous for plants to reproduce through means other than seeds.

Here is an excerpt from the discussion of carrots. "Fiji relies largely on carrot imports to satisfy local demand. Carrots do well in Fiji, however. ...Carrots are small-seeded, slow-germinating, and slow to establish so require a steady supply of moisture and a high measure of weed control. Quick growth produces better carrots. Carrots are high in vitamin A and have good keeping qualities." He then gives recommended varieties and detailed cultural procedures. "Show extra attention to weed control. Weeds in carrots can be controlled by spraying with kerosene at the three-true-leaf stage. The rate is 450 liters/ha (45 ml/square meter). Spray on a sunny day for best control." Diseases, pests and their control [usually chemical rather than organic] are discussed for each vegetable. He lists three common problems: cavities caused by calcium deficiency, galls caused by nematodes, and split root tips caused by excess soil nitrogen.

Resource centers for agricultural development

SUMMARY OF TRAINING OPPORTUNITIES IN AGRICULTURE FOR MISSIONARIES. A number of organizations are responding to the need for training of those going to work in third world agriculture and/or appropriate technology. ECHO has a Technical Note which summarizes the offerings of many of the programs that we know about. Write ECHO for "Where Can I Get Training

for Agricultural Missions?"

WHAT HAS BEEN YOUR EXPERIENCE WITH THE INTERNATIONAL RESEARCH CENTERS?

Many of you are aware of the network of international agricultural research centers that have been responsible for much of the green revolution. They are usually known by abbreviations: ILRI in Ethiopia and Kenya, CIAT in Colombia, ICRISAT in India, IRRI in the Philippines, IITA in Nigeria, etc. Each center focuses on just a few areas of agriculture and maintains the international germplasm (seed or other propagative material) for a few "mandate crops." This enables them to avoid duplication of effort and develop an unusual depth of expertise in those areas. (Universities, in contrast, typically cover all areas of agriculture but in less depth.)

How can we extract the most ready-to-use information from the centers? (We appreciate it when those of you who work at these centers call items to our attention or give feedback to items in EDN). These centers work primarily through governmental extension networks, but they seem quite open to helping "small" groups too.

We are interested in how these international centers can help folks in ECHO's network, typically a hands-on person in the field with a private voluntary organization (PVO). If you have approached one of the centers and found them helpful in a particular way, drop ECHO a line with details. I would also like to know if you tried to get information or seeds and were not successful. Many government agencies are increasingly recognizing the valuable role PVOs play in development. Most scientists at these centers are eager to see their discoveries implemented. On the other hand, they are very busy with their primary task of research and cannot write lots of letters. We would like to have a practical guide to what you can and cannot expect from the centers, how you decide where and to whom to write, etc., all based both on their literature and your experience. The small farmer, the international research centers and your work will benefit if we increase the use that you make of this incredible resource. Please write!

Most of these centers also maintain genebanks (seeds or other material) which you may contact as a

source for information and perhaps seed of their respective staple crops. (For example, ECHO often refers seed requests for major crops to one of these centers.) The addresses and areas of expertise of each center are as follows:

AVRDC (Asian Vegetable Research and Development Center), Box 42, Shanhua, Tainan 741, Taiwan, ROC; fax (8866) 583-0009; http://www.avrdc.org.tw. Tomato, pepper, onions, eggplant, beans, and other vegetables.

CATIE (Centro Agronmico Tropical de Investigacin y Enseanza), Turrialba 7170, COSTA RICA; http://www.catie.ac.cr/. Research and education on sustainable tropical agricultural systems for the small farmer. Areas include livestock genetics and nutrition, coffee, cacao, agroforestry, and fruit crops.

CIAT (Centro Internacional de Agricultura Tropical), Apartado Postal 6713, Cali, COLOMBIA; fax (57)2-4450-273; http://www.ciat.cgiar.org. Germplasm development in beans, cassava, rice, tropical forages.

CIFOR (Centre for International Forestry Research), PO Box 6596, JKPWB, Jakarta 10065, INDONESIA; fax (62)251-32-6433; http://www.cgiar.org;80/cifor. Conserving and improving productivity of tropical forest ecosystems.

CIMMYT (Centro Internacional de Mejoramiento de Maz y Trigo), Lisboa 27, Apartado Postal 6-641, 06600 MEXICO D.F.; fax (52)726-7559; http://www.cimmyt.mx. Increasing productivity of resources committed to maize, wheat, and triticale.

Note: Web sites for the centers below have the format http://www.cgiar.org;80/acronym [as CIFOR above]. CIP (Centro Internacional de la Papa), Apartado 1558, Lima 100, PERU; fax (51)14-351570. Potato and sweet potato improvement, Andean roots and tubers. Natural resources conservation in the Andean region.

ICARDA (International Center for Agricultural Research in Dry Areas), P.O. Box 5466, Aleppo, SYRIAN ARAB REPUBLIC; fax (963)21-225105 or 213490. Increasing productivity of farming system involving wheat, barley, legumes, and forages in North Africa and West Asia.

ICLARM (International Centre for Living Aquatic Resources Management), MC PO Box 2631 Makati Central Post Office, 0718 Makati, Metro Manila, PHILIPPINES; fax (63)2-816-3183. Improving production and management of aquatic resources in developing countries.

ICRAF (International Centre for Research in Agroforestry), United Nations Avenue, PO Box 30677, Nairobi, KENYA; fax (254)2-521001. Mitigating tropical deforestation, land depletion, rural poverty through improved agroforestry systems.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru 502 324, Andhra Pradesh, INDIA; fax (91)40-241239. Contributing to more sustainable agricultural production systems through improved productivity and resources management of sorghum, pearl millet, chickpea, pigeonpea and groundnut.

IIMI (International Irrigation Management Institute), PO Box 2075, Colombo, SRI LANKA; fax (94)1-866854. Strengthening the development, dissemination and adoption of lasting improvements in irrigated agriculture in developing countries. IITA (International Institute of Tropical Agriculture), P.O. Box 5320, Ibadan, NIGERIA; fax 874-1772276 (no country code required). Sustainable and increasing food production in the humid/subhumid tropics in partnership with African national research systems particularly on maize, plantain, soybean, cowpea, yam, rice, and cassava.

ILRI (International Livestock Research Institute), P.O. Box 30709, Nairobi, KENYA; fax (254-2)631499; e-mail ILRI-Kenya@cgnet.com, and P.O. Box 5689, Addis Ababa, ETHIOPIA; fax (251-1)611892; e-mail ILRI-Ethiopia@cgnet.com. Animal health, genetics, feed, and natural resource management.

IPGRI (International Plant Genetic Resources Institute), Via delle Sette Chiese 142, Rome 00145,

ITALY; fax (39)6-575-0309. Conserving genepools of current and potential crops and forages. Supports and coordinates genetic resource conservation through regional groups.

IRRI (International Rice Research Institute), P.O. Box 933, Manila, PHILIPPINES; fax (63)2-891-1292. Generating and disseminating rice-related knowledge and technology of short- and long-term environmental, social, and economic benefit.

ISNAR (International Service for National Agricultural Research), P.O. Box 93375, AJ-2509 The Hague, NETHERLANDS; fax (31)70-3819677. Institutional development and strengthening of national agricultural research systems.

WARDA (West Africa Rice Development Association), 01 BP 2551, Bouake 01, IVORY COAST; fax (225)634714. Improving rice varieties and production methods among smallholder farm families in the upland/inland swamp continuum, the Sahel, mangrove swamps, inland swamps, upland conditions, and irrigated conditions.

HOW DO I BEGIN AN EXPERIMENTAL/ DEMONSTRATION WORK? Chris Alexander in Zambia asked about how to develop a testing site at the church. I very much encourage this "experimental" approach. God has filled this creation with far more resources than most of us ever imagine. We only need to learn about them and then find which ones can be a blessing to our communities. You can never be sure that any new plant or technique will work until it has been tested in the community where it is being considered. Just remember not to be embarrassed by "failures." If in your personal garden you do not have some things that are not working out, you are probably "playing it too safe," doing things you know will succeed rather than trying many new things, some of which will fail and some be outstanding. Above all, never think that special university training in research is needed to do your own "adaptive" research. (Adaptive research is trying things that have worked elsewhere to see if and how they can be adapted to your community). Several of you have reported how the small farmers themselves enjoy being involved in the research process. Roland Bunch told me that he believes teaching farmers to be experimenters may be more important in the

long run than the particular technologies he introduces.

Much of ECHO Development Notes is written for this very purpose, to suggest new things that you might want to try. So in a real sense, we are continually answering this question. The seeds you request through ECHO are likewise a good place to start. This collection of ideas from EDN should be a starting point. You should soon have enough ideas to keep busy for a few years.

THE SMALL FARM RESOURCE DEVELOPMENT PROJECT: A MODEL FOR BEGINNING OR STRENGTHENING YOUR AGRICULTURAL WORK.

INTRODUCTION. During the course of each year a number of individuals working in community development spend some days studying and planning at ECHO. In reality their felt need is not so much for a bit more knowledge (study), but for a project plan for how they are going to help local farmers. A number of such visitors have told me that the single most helpful thing I shared with them during their visit was the concept of the Small Farm Resource Development Project.

The central idea is that development organizations wishing to do agricultural projects have little choice but to do some of their own experimentation. Although many might wish it were so, no expert can come into a community and plainly tell what new idea to begin introducing. Such an expert can suggest many things to try, but little or nothing that one can safely talk farmers into adopting tomorrow.

Many rural development organizations who work in medicine, public health, education, water, sanitation, etc. hesitate to add agricultural components, perhaps because it is less clear what they should do to have a major impact in agriculture than in their other areas of emphasis. The bottom line of everything ECHO does comes down to this very point. How can we help you devise a project plan that will make a significant difference in the lives of peasant farmers?

WHAT IS NEEDED? See page 10 for some characteristics of a satisfactory agricultural project. I have often heard development workers say something like, "I have no need for additional technical

information. What I need is more insight as to how to get farmers to act on what I already have to offer." Perhaps. But more likely the problem is that the ideas are not nearly good enough. Although there may be few if any ideas which you can be certain will meet all criteria, there is hope. It is just that there is a step between getting the idea and beginning the extension work. Many things have the potential to be as successful in the community as they have been elsewhere in the world. They just need to be screened and fine-tuned under local conditions and on local farms.

(Ready-to-go agriculture projects do exist, especially in the veterinarian field, where much universally applicable knowledge is available. If chickens are dying of Newcastle's disease, for example, a vaccination program could be immediately useful. Exceptions would also be found if the organization were to come across an innovation that has already been proven in the community but the extension work has not yet been done. But be careful. I saw one such project where a local group had proven that pineapples would thrive. Several private and government pineapple projects soon sprang up. Pineapples were so cheap two years later they were hardly worth harvesting. The average development project gives far too little emphasis to marketing study and projections.)

THE SMALL FARM RESOURCE DEVELOPMENT PROJECT. Both your supporters at home and the farmers you serve have high expectations of you. They are going to look for great (and quick) success in whatever you try, and you will lose credibility quickly if you start things that fail-unless everyone knows up front that you are first going to be doing trials.

Much of the pressure is eliminated if you say something like the following: "Everyone knows that a lot of new ideas outsiders bring in are worthless. But there are a lot of things that have brought an improved life to farmers similar to you in other parts of the world. I'm going to be trying several of those things. Most of them probably will not be worth very much. But probably one or a few will be something that will be very useful to you."

"I invite you to watch the progress of things that we will be trying here at the Small Farm Resource Development Center (SFRDC). When we sort out which ones seem to be really interesting, you can

help us by doing a small trial on your own farm."

The purpose of the SFRDC is to evaluate in the community ideas that have been proven elsewhere. The most promising ideas are adapted to become the backbone of the agricultural outreach. This adaptive research, as it is called, is done directly by the private or voluntary organization (PVO) and local farmers. The same approach is adaptable to almost any size project, whether you establish a formal SFRDC or not. The "Center" can be as simple as an individual development worker's garden or as complex as an organization's headquarters' farm.

We use two names, one for the project itself and one for the piece of land where initial trials are done. The Small Farm Resource Development Project (SFRDP) coordinates trials on a central site called the "Small Farm Resource Development Center" (SFRDC) as well as on fields of individual farmers. Any new ideas, techniques, crops or new varieties of a local crop are first evaluated at the SFRDC. The most promising will be further tested through on-farm trials in the community, thereby also teaching local farmers to do their own testing of new ideas. Marketing studies may also be done.

THE OUTCOME: The goals of the SFRDP include (1) finding new sources of income, food and employment, (2) improving the profitability and reliability of present farming operations, (3) backing these up with marketing studies and market development activities, (4) improving both economic security and nutritional balance by including a greater diversity of crops, (5) reducing vulnerability to global economic swings by minimizing the need for imported items in operation of the farm, and (6) reversal of the ecological problems caused by erosion and deforestation.

The SFRDP can have two distinct functions. One, the experimental component, is to test and adapt new ideas which have potential to aid the community in development. This is not the kind of research done at universities, but rather adaptive experiments to make sure what has worked elsewhere can be reliably expected to work in this particular community. The other, the demonstration and training component, is to use the center and on-farm trials as a teaching tool. It

can be a base from which promising results are taught to your future extension staff and to other interested development groups or farmers in the country. Depending on whether training and teaching is a high priority of your program, this second aspect can be a major or minor component of the center. Charlie Forst, who helped develop a SFRDC for a school in Haiti (the Haitian American Friendship Foundation), described his goal as "developing the farm as a textbook."

WHERE SHOULD TRIALS BE DONE? Trials should be carried out both at a central SFRDC site and by local farmers on their own land. Each has its strengths and limitations.

It will be important to have a central focal point for visibility, both locally and with the diverse private and governmental groups in the country who might wish to learn from the SFRDC. It is also necessary to have a central location where a preliminary screening of new ideas can take place. Experiments that may have less likelihood of success should only be done at the central site initially until such time as they are shown to have definite promise.

Before Tom Post (see below) had an opportunity to establish a SFRDC, some on-farm trials were underway. It seemed like a great idea. The government research station had identified onions as a profitable cash crop that was being imported into the country. They also had selected varieties and developed cultural practices. But unknown to anyone, there was a disease in that particular part of Belize that ruined the onions. If the SFRDC had been in existence, the first trials would have been done there and farmers would not have had such a visible initial discouragement.

The on-farm trials are economically more efficient, are more representative of the diverse micro-climates, soil types, etc., increase visibility in the community, help farmers learn the experimental approach, give them a sense of ownership in the project, and greatly reduce the likelihood of poor choices for subsequent introductions. Once a success is proven in on-farm trials, much of the work of extension is already done. On-farm experiments will always be on a small scale so that the risk to any farmer is minor.

Project Global Village (PGV) in Honduras wondered if subtropical apples might be the basis for a

development project at a remote site very high in the mountains. We helped them arrange to bring in 1,000 subtropical apple trees, which were evaluated entirely with on-farm trials. I believe they were distributed to a couple hundred farmers. This fall I was told that they now have over 200,000 trees in the ground (no one knows for sure how many because farmers now graft their own trees).

A REAL-LIFE EXAMPLE. In the mid 1980's ECHO suggested to Tom Post, country director for the Christian Reformed World Relief Committee (CRWRC) in Belize, that they establish a SFRDP in Corozal Town. Tom shared the following observations on the value of the project.

"1. It provides a place to try crops on our own land that will not hurt the farmers if the crops should fail. We had begun our work directly with farmers before we had the SFRDP. Due to initial failures we dropped from 30 interested farmers to 3 the first year. Now negative results are just part of the expected outcomes of any large number of trials at the Center. For example, we failed to make money on an egg project that had originally looked good, but found that farmers could make money on broilers. A combined solar and wood burning grain dryer that we built turned out to have a design flaw and burned down-but it only involved the SFRDC.

"2. Even though we have degrees in tropical agriculture and years of experience, we need self-confidence and confidence in what we are about to promote. The same applies to the local extension staff. The SFRDC allows us to convince ourselves that what we are recommending really works.

"3. Consistently ideas had to be adapted to the regional climate and local management methods.

"4. It serves as a point of contact between our organization and Belizian institutions (other voluntary organizations, governmental ministries and agricultural research agencies). It gives our small group much more visibility and a "location" where we have a large sign by the highway "Small Farm Resource Development Center." Visitors can see and recognize quality work. We also are now seeing other groups picking up on some of our results. One has ordered 4,000 pounds each of velvet bean and jack bean seed.

"5. The SFRDP concept provides a bridge between the two worlds of research and the small farmer. Most agricultural research is still done on experiment stations with inputs that are not available to many small farmers and goals usually oriented toward more mechanized approaches.

"6. It is a valuable investment in the future. Development organizations tend to go for near-term results, using only ideas which are known to have a high probability of success. A result is that we do not consider other options. At the SFRDC we can try things that, for lack of experience, leave us less certain of success but hold a great deal of promise. Use of the moringa tree was in that category; now it is looking more and more like a sure success for our projects.

"7. It provides a valuable hands-on opportunity for North American supporters to be involved in ways that go beyond just giving donations. Donors feel an increasing need to know for themselves the benefit of their help. If work teams do projects in the village, they may be doing things that the local people can do for themselves [and resentment can result]. But projects done at the SFRDC will not disrupt village life and will be a genuine help to our work. North Americans can try out their skills without doing harm by their trial-and-error learning.

"8. The first-hand experience with a range of ideas (alley cropping, leguminous trees, pasture improvement, in- row cultivation, moringa, neem, small-scale irrigation) has been extremely valuable for me personally in my additional responsibility of project consulting in Central America."

From my reading before actually working in development, I had the impression that farmers were so resistant to change that they would certainly not be interested in doing experiments. I have been pleasantly surprised from reports in our network at how eager farmers are to do experiments, if they have confidence that some of them are worthwhile. Tom Post took me to visit some participating farmers in Belize. Each farmer had a particular experiment he was doing. One eagerly showed us some others he had come up with on his own.

SOME SPECIAL BENEFITS. Expensive infrastructures are avoided. No commitment need be made to multi-year funding. The SFRDP can be continued as long as its results are a clear benefit (or until so

many good, proven ideas are available that the extension staff has all it can use) and can be discontinued at any time with minimal waste of money.

Although we had been discussing with Project Global Village the possibility of starting a SFRDP, the apple project ended up having so much potential that all efforts went into its development. Always keep in mind that the SFRDP is there to benefit farmers, not to do research. If you invest little in infrastructure, efforts can be rechanneled at any time without waste.

OTHER POSSIBILITIES.

(1) Once a set of workable technologies have been proven, the sponsoring organization might wish to set up a demonstration area at the SFRDC to use in training. I do not automatically call the SFRDC a "demonstration farm" because that concept has not worked in some situations and cultures. The SFRDC is a place where trials are done, and assumes the added role of a demonstration farm only if that approach seems suited to the local situation.

(2) If an agricultural college or training center is nearby, opportunities for collaboration may exist. The students would benefit by gaining hands-on experience in a very applied kind of research. The SFRDC would benefit by being able to do many more experiments by using the free student labor.

(3) Increasingly donors want to see and experience the work first-hand. Although a missions study tour has advantages over a "work team," in my opinion, many feel obligated to work with their hands to justify the expense of the trip. So "work teams" have become increasingly popular. Having them work on projects in the village which villagers could have easily done themselves can foster resentment. Projects can usually be found on the SFRDC that provide a rewarding experience for the volunteers, which benefit the project, and which avoid misunderstandings within the community. At the same time they can work with and get to know the local people and culture and worship with them.

(4) Many American colleges send their students overseas for a few months of exposure to third

world conditions and cultures, but it is difficult to find assignments for which they are qualified. Poor command of language and lack of fully developed cultural sensitivity normally limit the effectiveness of such short-term people. They often return disillusioned because they did not do much of significance. However, the student working primarily with the experimental phase of the program could begin making a useful contribution the day after his/her arrival! Students would come to work under supervision of the SFRDP staff, not to introduce change into the society.

(5) Periodically a professor looking for a sabbatical opportunity calls to explore whether he/she might do something in the area of world hunger. You might put out a call for help from such a person.

WHAT KIND OF TRIALS SHOULD BE DONE? The primary focus of the small farmer is raising crops and livestock and related activities. Depending upon need, the SFRDP may concentrate on: finding new crops or improved varieties of presently cultivated crops; conserving topsoil; storing grain; increasing yield and decreasing labor; seeking better techniques for cultivation of crops that will not require cash (and foreign exchange) for purchase of inputs; animal husbandry; growing feed for animals; aquaculture; post-harvest storage and handling. The farm is free to use a mix of organic and chemical methods depending on your philosophy and the local situation.

Growing for export markets is very risky for the typical, relatively small, organization in ECHO's network. Don't even think of exporting unless a large, proven organization is already doing it and your farmers are just plugging into their program. Even then, one fruit fly scare or United Nations embargo can bring disaster.

Appropriate technologies may be chosen for the demonstration part of the farm, but they usually are included in the experimental component only at a minor level. Chances are there are so many good designs already that what is needed is someone with perspective to pick the one or two best suited and go with them, rather than making new designs. As a general rule, I believe that westerners are more enthused about appropriate technology than are most peasant farmers. (There are surprises

though. Three organizations which built self-composting toilets for their staff in Central America told me that the toilets generated intense interest in the community.)

WHERE DO WE GET IDEAS FOR THE TRIALS? The place to start is to carefully observe what farmers already do, ask where they feel that they need help (though remember they will not know to ask for things they have never heard about) and consider how to make their work easier or farms more productive with their current crops. Networking within your country will turn up promising ideas that have already been proven not too far away. Each issue of EDN contains many suggestions and seed offers that could become the basis for trials. Careful study of the back issues of EDN should give you more ideas than you will have time to try.

TAKING THE LONG VIEW. Development projects seem to proceed in units of a few years, but communities develop over long periods. Trials should be directed at both short- and long-term needs of the community. Some ideas should be selected with the anticipation that in the very near term (less than a year) they will be ready to go. (An unfortunate side effect of the short term nature of most projects, especially funding for them, is that only ideas with near-term payoff get serious attention.) Some trials that will not be completed for years should be started right away, e.g. in evaluating fruit tree varieties, trees should be planted so they can begin growing. If you start a SFRDP please keep us closely informed of your experience and what you learn.