FORAGES

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INTRODUCTION

NEED FOR FORAGES ON THE SMALL FARM

If the small farm is to be a permanent source of food for its owners, it must be managed in a sound fashion that provides a constant source of nutrients, fuel, construction materials, etc. without damage to the land or its productive capacity. Forage crops are important to the small farm as one element of the production system because they can utilize lands that are not easily used for other crops, they can grow rapidly and often can be produced continuously, they serve as principal sources of feed for a number of different kind of animals, and thus indirectly as sources of meat, milk, and eggs. They are inexpensive crops to grow and usually easy to produce. Furthermore, grasses are useful in preventing erosion, and legumes can increase the nitrogen available in the soil for other crops.

CLASSES OF FORAGE PLANTS

The term forage is defined as herbaceous plants or plant parts fed to domestic animals. Generally the term refers to such material as pasturage, hay, silage, and green chop, in contrast to less digestible material known as roughage. In practice, however, the concept is often extended to woody plants producing succulent growth and indeed in the tropics some shrubs and trees are of considerable importance in this respect. Forage crops may be used in pastures or may be cut and carried to the animals that are expected to eat them.

The most important forage plants are the grasses. About 75% of forage consumed in the tropics is grass. The family of grasses, Graminae, includes about 620 genera and 10,000 species. While the number of cultivated grasses reaches 350 or more, nevertheless, a relatively small number of grasses predominate and can be considered principal forage species.

A second major group of forages is the legumes. The family Leguminosae is one of the largest of flowering plants with an estimated 700 genera and 14,000 species. Legumes are not as prominent in tropical pastures as are grasses, chiefly because they are difficult to maintain in a mixed pasture. Nevertheless, they are extremely important in improvement of the fertility of the soil, and in furnishing protein to the diet of grazing animals. A relatively few species have now been established as suitable for semi-permanent stands similar to alfalfa in the Temperate Zone. A few leguminous trees are useful as forage, and these might be especially valuable for some small farms.

In addition to these principal classes of forage, may other kinds of plants are at times valuable. Although seldom cultivated, they may be parts of the unimproved pasture and be convenient to use under some circumstances. They can be called the miscellaneous group. This group includes annual herbs (forbs) and woody shrubs and trees (browse).

CONSIDERATIONS IN SELECTING THE LAND FOR FORAGE CROPS

On the small tropical farm space must be used as efficiently as possible. The most fertile and easily managed lands should be reserved for food crops and grains. Lands that are steep, difficult to manage, or with shallow soils can frequently be used for pasture. On some very steep lands, pasture can constitute the most easily managed crop. Once established animals themselves can harvest it, for they climb to the places where forage can not be harvested in any other way.

Forage lands should also be selected with respect to long-term uses of other lands of the farm. Forages need to be rotated or replanted. In some cases the lands used for several years as forages can then be planted to forests. With continued use pasturelands can become so compacted that future use for intensive agriculture can be impeded. Occasional deep plowing can eliminate this problem.

The management of animals is an important consideration in selection of lands for forage and pasture. Animals can walk long distances through fenced lanes to pastures, but on the small farm cut forages should be near where they will be used, for they are heavy.

Practical matters such as location of other crops, provision for watering animals, provision of shade for animals, protection of animals from dogs and thieves are also important considerations in selecting a site for pasture and forage.

CONSIDERATION IN SELECTING FORAGE SPECIES

The site itself will determine in part the forage to be grown. The decision will have to be made whether the area will be grazed or the forage will be cut and removed. Adaptability of the forage to the site is the most important consideration. This will be determined by elevation, soil type, rainfall amount and distribution, and temperatures. A good forage should grow well and survive with a minimum of care. Even though it is desirable to treat pastures and fields of forage crops as carefully as possible, nevertheless, a good forage crop should resist neglect and abuse. A good forage should also resist the dry season of the year, continuing to grow or maintaining foliage and nutritive value and, above all, living through the dry season so that growth is resumed again with rains. Or, in the case of forage cut as hay, it should be uniform, timely, manageable, have good keeping qualities, and be nutritious.

Naturally, a good forage should be palatable to the animals for which it is grown. This palatability should extend throughout the year. When the forage is used through cutting or pasturing, it should regenerate rapidly. The overall yield should be high, and this depends in part on previously mentioned factors. Finally, nutritional value should be high. Height of forage is an important characteristic. Tall forages are easy to cut but difficult to graze. Improved cultivars might be available of any particular forage species, and technology might be developed for maximum production. Thus, for every region a certain body of information is usually available. Seeking for this information before establishing pasture or forage will be time saving. Local information on suitable forages is

often available from agricultural extension agents. Observing the success of forages and animals on the land of local farmers is an easy way to learn.

MANAGEMENT OF FORAGES

GENERAL PRINCIPLES

Forages are produced either in pastures, controlled grasslands used as feed for grazing animals, or in protected fields from which forage is cut to carry to animals. Such cut forage can be used fresh, dry as hay, or fermented as silage. Forages may be annuals or perennials. Annual grasses such as sudan grass, sorghum, their hybrids, and corn need more careful attention than perennial forages, but usually repay such careful attention with very high yields.

Cut forage generally yields more per unit area than grazed forage and is the technique of choice for some, especially tall grasses. On the other hand, cutting forage is laborious. When animals graze they often select the forage richest in protein and their weight gains may be greater than those from the same forage presented to them in cut form.

Some features are common to each form of use and must be understood in order to manage forages well. As forage grows it rapidly occupies the space that is available to it. In a mature field for forage, for example, the ground will be covered with forage, plants and the soil will be filled with the roots. Each individual plant will occupy a space that is limited by competition with neighboring plants. Eventually a static state will be achieved in which growth slows or even halts. Before this mature state is reached forage should be cut or grazed in order to make room for new growth. This use is comparable to the harvest of any other crop. Timing is very important. When forage is mowed and carried away to feed animals, all plants are cut to similar heights and all have equal opportunities to regrow. However certain species will always grow more rapidly than others will and thus the relative amounts of different kinds of forage in the field can change and this may be beneficial, or a detriment. Thus, it is important that the forage species used are a suitable combination. If not, one species will come to dominate the others. On the other hand, a combination of forage species might be such that some species dominate in one season and others in another season.

Inadequate grazing also affects a pasture in a negative way. Animals will select the most palatable species to eat first and, in doing so, afford to the less palatable more space to grow. The composition of the pasture will change so drastically that within a short time undesirable or less desirable forages or unusable weeds will predominate. Therefore, either many animals should be introduced to a pasture at a time or a few animals should be introduced to a small area so that all plants are grazed more or less equally. Undergrazing should be avoided. Rotational grazing is an important practice for it permits regrowth after appropriate grazing. Overgrazing due to too many animals on the land for too much time, or to over frequent use of a pasture, must also be avoided.

There are some situations where rotational grazing is not preferred, especially in a pasture where production is low and where special techniques for management are not used. In such pastures, which often are found on poor tropical farms, animals receive a more uniform feed from non-rotated pastures. When pastures are used more or less continuously it is very important to eliminate periodically the species not used as feed or they will eventually predominate.

Other destructive changes can take place in a pasture or forage field. Undercut or undergrazed fields may develop large quantities of old, tough, lignified stems that are not palatable. It may be necessary to cut or burn such fields in order to obtain palatable new growth. Burning is a destructive technique that can eliminate some desirable plants, especially legumes, but it can be desirable at times.

Fields of forage can also exhaust the nutrients, particularly the nitrogen of the soil. While this can be replaced by applications of mineral fertilizers or manure, legumes in the forage provide nitrogen and extend the life of the pasture.

Although pasture may be long lived, rotation of pastures with other crops is often useful. Such rotation permits the soil to be broken by the plow, organic materials can be incorporated, necessary changes to improve drainage and controls for erosion can be made, and the resulting situation can be more suitable for replanting to forage crops. Rotation of pasture with trees permits nutrients that are deep in the soil to be removed and, when trees are destroyed, such minerals can become available for other classes of plants, including shallow-rooted grasses.

A good pasture should produce foliage throughout the year, including the dry season. To make this possible, forages of several classes must be grown either together in a complementary fashion, or in separate plots. Mixed forage, which consists chiefly of grasses and legumes, has some advantages over forages of pure stands. Nitrogen fixed by legumes is useful for the production of grasses, which probably fix little or none of their own nitrogen. Combinations of grasses and legumes in the tropics as well as the Temperate Zone yield more protein and minerals than other grass or legumes grown separately. A ration of 25 percent legumes to 75 percent grasses in pastures is recommended.

On the small farm very important decisions on management of forages will have to be made. These decisions will probably revolve around the critical question of how to feed farm animals during the dry season when forage is limiting. Thus the choice of forage, cutting technique, and use of forage will have to be decided. Because small farms are so diversified, no one technique or set of techniques will do for all.

SOIL PREPARATION AND PLANTING

As in the case of other crop plants, soil preparation is desirable before forage crops can be grown. Nevertheless on the small farm in the hot, humid tropics, soil preparation will often be minimal. As a general rule, preparation begins by removing old vegetation. Burning is sometimes the best way to remove old and undesirable grasses and, in fact, in some cases it is an important technique in removing old, lignified, inedible stems, returning minerals to the soil. On the other hand, burning followed by heavy rains leads to leaching of the soil and possibly erosion.

Therefore, where practical, a strip system is recommended. Vegetation can be cleared from strips following contours. This vegetation can be piled in continuous piles following the contour at the lower edge of the strip. The rotting of this vegetation over a period of time will restore its nutrients to the soil.

Newly planted forages need the stimulation of a loose and penetrable soil for maximum growth. However plowing will often be impossible or, when erosion is expected, impractical. Unless soils are naturally loose some provision for opening them will have to be made, particularly in the immediate area of the individual plant.

Herbicides are sometimes used before establishing new forage plantings. Those that kill broad-leaf weeds and trees might be very economical in eliminating brush and trees, even on the small farm. Herbicides are best applied in the early spring; and brush can be removed several weeks later. Grass killing herbicides are also frequently used especially when undesirable grasses predominate. It must be remembered that herbicides are dangerous chemical compounds that should be applied according to manufacturer's suggestions and local laws or regulations.

If plowing is done ridges or furrows can be prepared 60-100 cm. apart. If planting is done by hand these are appropriate distances between plants or planting holes. Lime should be applied to very acid soils when it is available and economical to use. When available, lime is justified in terms of the increased forage that can be expected from its application. For best results lime should be mixed into the soil, but on the small farm this may not be practical. It is here that barriers of cut vegetation along contours are useful. Such barriers impede the loss of lime and fertilizers and give them a longer time to soak into the ground. The small farmer may not have mineral

fertilizers to apply, but manures and rotted plant material should be mixed into the soil if possible. While on the small farm such operations are labor intensive, they are important if a good pasture is to be established.

Because of labor requirements, it is recommended that on the small farm a percentage of the existing forage be retired each year, perhaps for conversion to forest, and a new forage strip be established. This plan permits the farm to produce wood for fencing, fuel, and construction while simultaneously using land in adjacent strips for forages.

Propagation of the various forage species depends on the nature of the seed or cuttings used. Some practices are given in table 1. There are many variations of these practices. Forages are usually planted in rows for convenience, but seed can be broadcast if the soil is prepared to receive it. Note that tropical kudzu can be inoculated by mixing the seed with soil from a successful kudzu field. This technique is also useful for other legumes when inoculants cannot be purchased.

POST-PLANTING CARE

Newly planted pastures need protection from grazing until they are well established. This may require 4-8 months. Fences can be established, and five separated plots for rotational grazing have been recommended. For the small farm, living fence posts of local materials such a madre de cacao (*Gliricidia sepium*), bucar (*Erythrina berteroana*) or other trees which are planted as large cuttings which root readily can be recommended.

Fertilizers are often applied to pastures several months old at the rate of about 400 kg per hectare. Weeds must normally be controlled until pastures are well established. Mowing vigorous grasses, or cutting with machete will tend to eliminate weeds. Vigorous weeds and trees should be carefully removed. Herbicides are sometimes used in intensively managed pastures.

Pasturing or cutting removes mineral nutrients from the soil. Where use is intensive, materials are removed more rapidly. On the small farm where purchase inputs are to be minimized it is not desirable to use pastures so intensively that they suffer loss of plants or do not regrow sufficiently rapidly for regular reuse. Nevertheless, when used on a rotational basis, even unfertilized pastures have the capacity to regrow after pasturing. The sources of nitrogen to sustain such pastures are the minimal amounts: deposited with rains, that fixed by legumes and possibly some grasses, and manures left behind by animals. Other elements, potassium and phosphorous, are slowly released to the soil by weathering. The regrowth capacity of an unfertilized pasture varies. Rotation of pasture with forest permits accumulation in the upper soil of very deeply buried minerals.

Pasture should be grazed heavily for up to one week by the appropriate number of animals. Grazing animals should remove the major part of the available forage of all species of forage present. After animals are removed from a pasture, untouched, undesirable plant species should be killed, so that they do not multiply and spread. This single management practice can do much to increase the value of an unfertilized pasture on the small farm.

While five pastures are suggested, a particular farm may in fact have many more. The period of grazing may be less than a week, but to reduce it means that the pasture will not be used with sufficient intensity and preferred forages will be eaten first, giving the less palatable forages a competitive advantage.

Forage is not produced uniformly throughout the year. Where the monsoon type climate occurs, the dry season is often one of shortage of forage and of suffering of animals. This problem is resolved by cutting and storage for dry periods.

Storage of forage by making hay, dried forage, is often possible. In order to make hay, the forage must be mowed. This is done uniformly with machinery but can also be done by scythe or machete. The cut forage is usually allowed to lie for several days until dry and then is gathered by raking and/or baling and is carried to storage areas. Preparation of hay is difficult if rains fall after cutting. Forage when fresh or dried can be spoiled by excess

moisture. Large farms often dry hay artificially before storing it, a practice that is costly and not practical for the small farm. On coffee farms, forage can be dried on the flat surfaces used for drying coffee but the process is laborious and doesn't eliminate the threat of rain. Hay is less nutritive than fresh forage.

Storage can also be in the form of silage, a fermented form of forage of less nutritive value than fresh forage but of more value than hay. Forage can be packed in upright structures called silos or in trenches often dug into embankments. The latter are more suitable for the small farm. The success of ensilage depends on several factors including the species of forages and its water and sugar content. Molasses is sometimes added to the packed fresh grass to encourage fermentation. Silage must be packed tightly and sealed to reduce or prevent entry of air. The chief types of fermentation that take place are lactic acid and butyric acid fermentation. The organisms responsible for fermentation sometimes add to the nutritive value of the silage. Practical silage practices must be learned for each locality and depend on forages and other materials available, and their relative costs in money or labor.

It is highly desirable to plant pastures that will continue to grow through the dry season or that produce a feed that retains its value in the field, even when forage plants are not growing. Merker grass is better in this respect than the related, more productive Napier grass. Some legumes are more productive during the dry, than the wet, season.

Intense management includes the following classes of practices: control of insects and diseases, weed control, frequent liming and fertilizing, harvesting at the right time and height, and rotational grazing. Using intensive practices the yields of tropical pastures can be increased tremendously, whether for cutting or for pasturing, for meat or for milk production. These practices might be unsuitable for small farms where incomes are insufficient to pay for the necessary inputs. Furthermore, such inputs are not available everywhere and may not be consistent with the long-term objective of living on this earth in harmony and in a non-destructive fashion. A small farmer faces a difficult choice in this respect, whether to develop sound practices based on low productivity and minimum purchases, or to use intensive inputs for maximum forage yields. The appropriate choice may vary from place to place and time to time depending in part on the supply and distribution of inputs and the sales prices of outputs (forage or animal products).

RECOMMENDED FORAGES

GRASSES AS FORAGES

The grasses produced in tropical pastures are hundreds in number and constitute an enormous and economically important resource of the tropics. Classification of the 10,000 or more species of grass in the world is very difficult, and it is not possible to classify species into reliable groups larger than the tribe (an association of genera). Nevertheless, the many genera are quite distinct, not only in their morphological characters but also in their physiology, reproduction, suitability for distinct uses, and their values.

For the small farm it is not necessary to know or to cultivate a large number of grasses. It is desirable to recognize 5-10 of the most important species and to cultivate several different species for their abilities to produce in distinct parts of the farm, or their suitability for different animals or different purposes.

Tropical grasses are propagated in several ways (Table 1). Some can be planted from seeds, some of which are apomictic (not sexual in nature and genetically identical to the parent plant). Seed production can be poor, the germination can be erratic due to poor viability of the seed, or the seedling may die earlier before the plants are well established. This is usually associated with poor conditions for growth. In addition tropical grasses often propagate themselves from normal or modified underground or prostrate aerial stems (rhizomes or stolons). Sometimes the stolons are no more than upright branches (tillers) from the principal stem, which root at the base. Such a grass forms a clump (tuft) which can be broken into numerous plants for replanting. A grass may form either stolons or rhizomes or both. The ability of a grass to extend itself by rhizomes or stolons varies remarkably but is obviously related to the planting, establishment, and long term survivability of a grass. Tufted grasses are

usually long lived. Stoloniferous and rhizomatous grasses often fill a soil so thoroughly that new growth cannot occur. They are then said to be sod bound. Rhizomatous grass may form thick stands that are difficult to eradicate.

Table 1. **PROPAGATION MATERIALS AND PRACTICES FOR SOME PRINCIPAL GRASSES.**

Scientific Name	Common Name	Nature of Propagation	Amount per hectare	Other Notes
Panicum maximum	Guinea Grass	Seeds,3-5% viable	25 kg	Do not cover with soil
Melinis minutiflora	Molasses Grass	Seeds, 80% viable	2 kg	Do not cover with soil
Pennesetum purpureum	Napier Grass	Mature Stem Cuttings	4.5 tonnes	Lay in furrows Cover with 2-5 cm soil
Digitaria decumbens	Pangola Grass	Mature Stem Cuttings	2-3 tonnes	Lay in furrows Cover with 5-8 cm soil
Brachiaria mutica	Para Grass	Mature Stem Cuttings	2-3 tonnes	Lay in furrows Cover with 5-8 cm soil
Cynodon nlemfuensis	Star Grass	Mature Stem Cuttings	2-3 tonnes	

Tropical grasses vary in adaptability. They are more prevalent in semi-arid and wet monsoon type climates than in climates characterized by year round rain. The latter climate is more suitable to the development of rain forests. Grasses may be important crops in the process of succession that passes when forested areas are disturbed. Or, grasses may invade such areas and permanently exclude the forest.

Grasses are either adapted to medium temperature (15-20 degrees C) and medium light intensities with C-3 type of photosynthesis or, as in the case of most tropical grasses, their growth rate will increase with increased temperature and light intensity up to more than 30 degrees C. Such grasses have the C-4 type of photosynthesis. Most tropical grasses are day neutral; that is, they flower equally well throughout the year; or short day sensitive, flowering best during short days of the year. Grasses differ remarkably in adjustment to particular soils and rainfall patterns or drought resistance. Grasses differ in their need for nutrients and ability to survive on poor, unfertilized soils.

Grasses differ in their uses. Some grasses are best cut and carried to the animals that will use them. This is often the case when the grass is very tall and could easily be tramped to the ground by grazing animals, or when animals are likely to damage or destroy the grass plants by their grazing. On the other hand, some grasses are especially suitable for grazing in pastures.

Some of the more important grasses of the tropics are given in Table 2. However, it should be emphasized that many other grasses are available in the tropics and may often be more desirable than those treated in the table below.

PRINCIPAL TROPICAL GRASSES

Table 2. **PRINCIPAL GRASSES FOR THE SMALL FARM.**

Species	Common Names	Method of Propagation	Other characteristics	Weaknesses
Andropogon gayanus	Gamba	Principally seeds, also clump divisions	Perennial, tufted, dry areas, as pasture or cut forage, excellent regrowth	Poor seed production
Brachiaria mutica	Para	Cuttings of shoots	Perennial, prostrate except for flowering shoots, rooting at nodes, vigorous, as pasture or cut forage	Poor silage
Cenchrus ciliaris L.	Buffel	Seed	Perennial, tufted or rhizomatous, dry areas, principally as pasture, resists overgrazing	Yields inadequate in moist areas
Chloris gayana	Rhodes	Seed, rarely cuttings of stolons	Perennial, stoloniferous, widely adapted, as pasture or hay	Poor silage
Cynodon dactylon	Bermuda	Cuttings	Perennial, stoloniferious and rhizomatous, moderately dry areas of subtropics, principally as pasture	Weedy, not suitable to hot, humid tropics
Cynodon nlemfuensis	Star	Cuttings of stolons	Perennial, stoloniferous, widely adapted, mostly as pasture	Weedy, can produce hydrocyanic acid
Digitaria decumbens	Pangola	Cuttings of stolons	Perennial, tufted, with long stolons rooting at the nodes, persistent, well adapted to lowland tropics and monsoon climate, mostly as pasture, sometimes cut as hay	Aphid and virus susceptible
Euchlaena mexicana	Teosinte	Seeds	Annual, tufted, maize-like, dry areas, as cut forage, sometimes as hay or ensilage	
Melinis minutiflora	Molasses	Seeds	Perennial, tufted, viscous, mat forming, adapted to steep areas and poor soils, as pasture	Pubescence objectionable, shouldn't be used young
Panicum coloratum C.	Colored Guinea	Seeds	Perennial, tufted, very widely adapted, as pasture or cut foliage.	
Panicum maximum	Guinea	Seeds, clump divisions	Perennial, tufted, very widely adapted, as pasture or cut forage, used as hay	Weedy, poor seed viability
Paspalum dilatatum	Dallis	Seeds	Perennial, tufted, spreading, very leafy, coarse grass, adapted to hot, sunny areas with lots of rain	Slow establishment
Paspalum notatum	Bahia	Seeds, also rhizome pieces	Perennial, creeping, spreading, widely adapted, as pasture or cut foliage.	Herbage yields not high, nutritive value moderate
Pennisetum americanum	Pearl millet	Seeds	Annual, usually tufted, widely adapted, cut for hay or silage, also pasture. Can regrow; good seed production	Short lived
Pennisteum clandestinum	Kikuyu	Stolon pieces	Perennial with thickened rhizomes and stolons, adapted to middle altitudes of tropics, principally as pasture	
Pennisetum purpureum	Elephant, napier	Stem cuttings	Perennial with thickened rhizomes and stolons, adapted to middle altitudes of tropics, principally as pasture	

Table 2. **PRINCIPAL GRASSES FOR THE SMALL FARM,** continued.

Species	Common Names	Method of Propagation	Other characteristics	Weaknesses
Pennisetum purpureum	Merker	Stem cuttings	Variety of above, similar in behavior, widely adapted, for cut forage, although sometimes grazed	Less productive but more drought tolerant than above
Setaria anaps		Clump separation, or seeds	Perennial, tufted, adapted to medium rainfall and subtropical conditions, as pasture, cut forage, or silage	
Sorghum almum	Columbus	Seed	Perennial, tufted, dense, rhizome forming, adapted to rather dry subtropical areas, many soils, as pasture, hay or silage	Can produce hydrocyanic acid under stress
Sorghum bicolor	Sorghum	Seed	Annual, at times perennial, tufted, drought resistant, widely adapted, used as cut forage or ensilage	
Sorghum sudanense	Sudan	Seeds	Annual tufted, vigorous, erect widely adapted and drought resistant, high yielding, as cut forage or ensilage. Improved cultivars available	Not good for hot, humid tropics, can produce hydrocyanic acid
Zea mays L.	Corn, maize	Seeds	Annual, tufted or single stems, vigorous and productive, can be used before or after cob is produced, cut forage or ensilage.	

Brachiaria. This genus includes a large number of species with a good range of adaptability in the topics. One example is Para grass (*B. mutica*) which has tolerance to swampy conditions and grows well also in more dry conditions. This species is very aggressive and has the tendency to crowd out all other grasses under poor management conditions. Para grass is planted vegetatively. It is a perennial with coarse runners that root at the nodes. It produces erect shoots with broad hairy leaves.

Cenchrus. *Cenchrus cilaris* (Buffel) is the most important species of this genera. Buffellgrass is well known for its drought resistance. This grass is propagated by seed and makes an excellent contribution to the grassland farming in areas of low rainfall in the tropics.

Chloris. The only important grass in the genus is *C. gayana* (Rhodes). It is important in Australia and other areas.

Cynodon. This genus includes many species of economic importance throughout the world. There are two man species recognized in east Africa: *C. plectostachyus* and *C. dactylon*. In the literature, the term "Stargrass" has been used to identify the robust taxa (non-rhizomatous) while the Bermuda types are the types or forms with rhizomes. Of the non-rhizomatous types, Stargrass" the species *C. nlemfuensis* is the most promising. There are two well-known varieties, robustus and nlemfuensis. The robustus are tall plants with soft leaves. The glume exceeds 75% of the spikelet. The variety nlemfuensis is less robust, glaucous and looks like a big *C. dactylon*. Under stress, some varieties produce poisonous hydrocyanic acid.

Digitaria. This genus covers a wide number of species widely distributed. The most well know species is *D. decumbens* Stent represented by "Pangola" and "Transvala". Another species of economic importance is *D. pentzi*. The cultivar "slenderstem" occurs also in this species. Pangola is a perennial grass that produces long stolons. It flowers abundantly in the tropics. Pangola grows up to 50cm in height and spreads quickly, forming dense vegetation in a relatively short time.

It has been found that well fertilized Pangola grass in humid areas is easier to manage than other more productive grasses such as Guinea (*P. maximum*). Excellent yield of over 35,000 kg/ha/year has been obtained.

Melinis. Molassesgrass (*M. minutiflora*) is the only species grown. It is used extensively in Brazil. This grass is useful in areas where annual rainfall is 40" or more. Leaves are covered with short hairs that exude a sticky substance.

Panicums. The guineagrasses (*Panicum* spp.) are very important grasses in the tropics. They have long been recognized as excellent for grazing, green silage, hay and silage. The guineagrasses make substantial contributions to animal production in many areas. Seed germination in guineagrass is very poor, approximately in the 5-percent range. Since the propagation of this grass is mostly asexual, the utilization of it could be limited. It is essential, then, to utilize types which are able to produce enough viable seed if the establishment of an economical pasture is desired.

Pennisetums. Elephant or Napiergrass (*P. purpureum*) is the most well known species of this genus. It is grown in most tropical countries because of its high yields. Napiergrass is a tall forage that grows into clumps and produces abundant tillering. It is propagated by stem cuttings and few produce viable seed. Many ecotypes of this grass have been developed and tested with excellent results. The yield potentials of the *P. purpureum* are enormous. In addition to Elephant or Napiergrass, Kikuyu grass (*P. clandestinum*) is an excellent forage because of its high feeding value and tolerance to heavy grazing. This grass, at low elevations, is restricted to the sub-tropics.

Sorghum. Sorghum-sudan hybrids (*S. bicolor*) are excellent material for pasture and forage. Many hybrids and improved types are available from commercial sources and could be of benefit to farmers as feed supplements in slack growing seasons, and as reserve feed in drought periods. Some strains, however, contain hydrocyanic acid under stress conditions. If properly utilized, forage sorghums could be of tremendous value as a source of forage for the small farmer. Sorghum can be utilized for silage. Its grain is an excellent source of energy.

LEGUMES AS FORAGES

Of the more than 10 thousand species of plants in the family Leguminosae only a relatively few are useful as forage. Use of legumes is complicated by the fact that many are poisonous. Others are unattractive to animals due to pubescence, odor, or taste. Furthermore, many species are trees that could be grazed but are generally out of reach of animals. The family is of tropical origin, however, and thus well adapted to the special conditions of the tropics. Some legumes grow very well on highly acid soils typical of the tropics. The importance of legumes in the pasture or field of forage is double. First, legumes contain large amounts of protein and thus enrich a diet of grass when the two are combined. Second, probably all legumes have the ability to enrich the soil with nitrogen, although this probably does not occur until the plant or part of its roots dies. This acidity reduces the need for nitrogenous fertilizer.

The ability of a legume to fix nitrogen depends upon the presence of the appropriate bacterium, *Rhizobium*. This bacterium lives in special structures on legume roots, the root nodules. Some species are very versatile, that is, very flexible with respect to the strain of *Rhizobium* that is suitable; other species are highly specific in their requirements. Similarly, some strains of *Rhizobium* are highly specific for certain legumes; others are capable of living in nodules of many leguminous species. Furthermore, some strains of *Rhizobium* are adapted to acid soils while others survive only on alkaline soils. If legumes do not encounter an appropriate strain of *Rhizobium* an inoculum is frequently added to the seed, some times as a fine cap or pelleting. On the small farm addition of inoculant to the seed may not be practical. Therefore, use of legumes that are easy to satisfy with respect to their *Rhizobium* requirement is desirable. These are *Cajanus cajan*, *Macroptilium atropurpureum*, *M. lathyroides*, *Stylosanthes guianensis*, and all species of *Vigna* (Bogdan, 1977). Whenever possible, local information concerning species and their inoculum should be obtained before planting legumes.

A few legumes can be grown in pure stand, but most grow and serve better in mixed plantings with grass. Mixed plantings are easy to establish but difficult to maintain. Heavy grazing almost always eliminates the legume and leaves the grass.

Most legumes are planted from seeds. Seeds are sown in normal ways, often alternated with rows of grass. Problems are often encountered with hard seeds that do not imbibe water readily and thus germinate irregularly. Seeds are sometimes scarified in hot water or sulfuric acid, something that must be done very carefully in order to avoid damage to the seed. After scarifying and as soon as possible after applying inoculant, seeds can be planted and watered. In spite of their ability to fix nitrogen, legumes benefit from light application of nitrogen at planting and normal quantities of phosphorous and potassium.

Legumes are subject to some pests and diseases including nematodes. No recommendations can be given here for the use of pesticides on the legumes of the small farm, a dangerous practice.

The dry matter yields of legumes per hectare are less than those of grasses. Fifteen tons per hectare per year is a very high yield. Naturally yields are lower when legumes are grown with grasses. Legumes in pure stands are used chiefly as hay. Grass legume mixtures can be used either as hay, silage, or as pasture.

Some good tropical legumes are summarized in Table 3, and the best of these are further characterized below.

Table 3. **LEGUMES FOR THE SMALL FARM.**

Species	Common name	Characteristics	Disadvantages
Acacia albida	Apple-ring acacia	Tree, dry areas, cut forage or hay	Said to damage milk
Albizzia lebbek	Woman's tongue	Tree, dry areas, cut leaves and pods	
Arachis hypogaea	Peanut	Annual herb, sandy soil, use as forage combined with use for seeds	
Cajanus cajan	Pigeon pea	Short lived perennial, widely adapted, cut forage	
Calopogonium mucunoides	Calopo	Annual, cut forage	
Canavalia ensiformis	Jack bean	Annual vine, widely adapted, cut forage	May be poisonous at times
Centrosema pubescens Benth.	Centro	Perennial, climbing vine, widely adapted, pasture	Principal growth during short days
Clitoria ternatea	Butterfly pea	Perennial, climbing vine, widely adapted, cut forage	Principal growth during short days
Cyamopsis tetragonoloba	Cluster bean	Annual herb, widely adapted, cut forage	
Desmodium intortum	Greenleaf desmodium	Perennial upright herb, widely adapted, pasture or cut foliage	
Dolichos uniflorus	Twinflower	Weakly perennial low vines, pasture, forage, and green manure	
Dolichos lablab	Lablab bean	Weakly perennial vine, widely adapted, pasture or cut forage	
Erythrina species	Coral bean	Tree, widely adapted, cut forage	
Glycine wightii	Glycine	Perennial vine, widely adapted, cut forage	
Leucaena leucocephala	Tantan	Tree, widely adapted, pasture or cut forage	Some forms contain poisonous alkaloid
Lototonis bainesii	Lototonis	Perennial herb, pasture	

Table 3. **LEGUMES FOR THE SMALL FARM,** continued.

Species	Common name	Characteristics	Disadvantages
Medicago sativa	Alfalfa, lucerne	Perennial herb, pasture in mature with grass or cut forage	Not adapted to acid soils, nor to much of the hot, humid tropics
Phaseolus atropurpureus	Siratro	Perennial herb, pasture and cut forage	
Pueraria phaseoloides	Tropical kudzu	Perennial trailing or climbing vine, pasture	Pubescence irritates some animals.
Stizolobium deeringianum	Velvet bean	Annual bushy vine, cut forage	
Stylosanthes guyanensis	Fine stylo	Perennial herb, pasture	
Stylosanthes humilis	Townsville stylo	Pernennial bush, pasture	
Vigna radiata	Golden gram	Annual herb, cut forage	
Vigna unguiculata	Cowpea	Annual vine, widely adapted, pasture, cut forage	

The pigeon pea, *Cajanus cajan* (L) Mill sp., is a highly variable bushy species from Africa or India. It is widely used for its dry seeds used as a pulse, or the green seeds used as a vegetable. The leaves are also sometimes used as a food for humans. When grown as a forage, pigeon peas can be cut at 50 centimeters or more from the ground. The cut foliage is used fresh, dried as hay, or occasionally used as ensilage. Most varieties are photosensitive and thus grow vegetatively during most of the year and then flower as days shorten. Thus pigeon pea is a good forage for the dry season when forage is scarce. However it can be produced year round (some races are perennial). Use of the plants for forage can be combined with use as a vegetable or grain. Pigeon peas are tolerant of many soils and are easy to grow. They do not need to be inoculated. Plants are established about 1 meter apart. They will produce well in semi-arid regions but are also tolerant of tropical rains. Nutritional value is high and this forage will result in good animal weight gains.

Centro, *Centrosema pubescens* Benth., from South America is an excellent forage, vigorous and productive, and capable of good growth and survival when planted with grasses, also used as a cover crop in orchards. As a climbing or trailing vine it can crowd out less desirable foliage. While a crop of the hot, humid tropics, centro is sometimes seen to be drought resistant. Since flowering and pod development continue over a long season, harvest of seeds is difficult. This is a principal limitation in its use as a forage. Centro is established from seed. Seeds are frequently hard and should be scarified to improve yields. *Rhizobium* requirements are highly specific and good establishments cannot be expected unless seed inoculation is practiced. This makes centro more difficult to use on the small farm. When grazed or cut, centro regrows readily and is seldom destroyed in green pastures. It may not be very palatable to cattle during the wet season. Its nutritive value is high.

Greenleaf desmodium, *Desmodium intortum* (Mill.) Urb., herb from South and Central America, is a large and vigorous perennial with upright stems or much branching. It is now especially popular in Australia but can be grown well elsewhere. It can be grown either in pure stands or with grasses. Since the foliage is sometimes not highly palatable, desmodium is frequently grown with tall grasses. This desmodium prefers a warm, rather wet, climate but otherwise is widely adapted. Established from small seeds, greenleaf desmodium needs specific inoculation for satisfactory establishment. Established pastures should not be overgrazed or cut too low.

Other species of *Desmodium* are often used as forage. Spanish clover, *D. uncinatum*, (Jacq.) DC. is another from South and Central America that is widely used. It is quite similar to the above species. It is very valuable for its persistence and high yields and is easy to establish, but specific *Rhizobium* inoculation is required.

The perennial soybean, *Glycine wightii* Verde., from drier regions of tropical and subtropical Africa, is a highly variable species of value because it is fairly long lived, mixes well with grasses, and is fairly drought resistant. It has been widely distributed in the tropics but is especially suited for Australia. Glycine is a perennial trailing, procumbent, or climbing vine planted from seeds. Moderately selective with respect to *Rhizobium*, it is sometimes successful without inoculation. It may be difficult to establish in hot, dry weather. It has been grown with a number of grasses and can perform well if given sufficient time to grow before grass is seeded. Although used principally for grazing, hay and even silage have been prepared from it. Nutrient content is a little low compared to that of other legumes.

The hyacinth bean, *Dolichos lablab* L., possibly from India, is widespread as an edible legume or pulse used as food, as well as a forage crop. It is either annual or perennial, usually growing vegetatively as long, vigorous vines during long summer days. If planted during short days, after growing it is in bush form. Varieties vary in day length sensitivity but very few flower in summer and all flower in winter. The hyacinth bean can be cut frequently for it is very vigorous and yields are heavy. It is usually used in pasture; often with grasses, and less often used as hay or silage. In some areas the hyacinth bean has been reported to be the most drought resistant of the legumes. However it grows very well in humid areas also.

Tan-tan, *Leucaena leucocephala* DeWit, is a small to medium sized rapidly growing bean from Mexico, now widely spread and often weedy. Tan Tan is drought tolerant but capable of very rapid growth during rainy seasons. It withstands severe grazing or cutting and indeed is difficult to eliminate except by systemic herbicides.

Despite the fact that *Leucaena* needs a specific *Rhizobium*, it apparently easily encounters it, for it is found almost everywhere in the dry tropics. Seeds are long lived and germinate irregularly over several years. The trees must be grazed when young to keep them small. Very vigorous varieties have been developed. Tan tan foliage, foods, and seeds contain an alkaloid, mimosine, which can cause loss of hair in some animals and metabolic disorders in all that eat it in quantity. Some cultivars have a low mimosine content.

Lotononis, *Lotononis bainesii* Baker, is a low growing perennial herb from South Africa that spreads by horizontal stems, rooting at the nodes. It has been well distributed in the subtropics where it is important for its ability to grow and survive with vigorous pasture grasses and for its high quality herbage. It grows well on acid soils. Its lifetime is short, however, and it does not resist drought. A definitely moist climate is desirable. Although propagated by seed, it can also be established from pieces of stem that root readily. Its inoculation requirements are highly specific.

Siratro, *Phaseolus atropurpureus* DC, and the related phasey bean (*P. lathyroides*) are species of American origin now appreciated in Australia where the former has been breed as a highly successful forage variety by the name Siratro. The latter is a creeping plant rooting at the nodes, highly capable of fixing nitrogen, resistant to drought, and surviving very well with grasses. It is highly adaptable but prefers areas of moderate rainfall. In the hot, humid tropics it grows best during the summer season. Although seed inoculation is recommended, the common *Rhizobium* strains known as cowpea types are suitable.

Tropical kudzu, *Pueraria phaseoloides* Benth., from tropical Asia is now extended throughout the hot, humid tropics where it is grown as a very vigorous, rapidly growing trailing or climbing vine, often weedy and difficult to control. It is planted from seeds, crowns, or cuttings of rooting vines. Seeds are hard and need scarification. While needing inoculation for good growth it is not highly specific with respect to *Rhizobium* needs. Best growth is generally achieved as days shorten, just before flowering is induced. Tropical kudzu was once recommended especially with molasses grasses. It is capable of rapid growth after grazing and is long-lived in pastures. Pubescence of the leaf make it unattractive to rabbits. It seems best suited to very poor and steep areas where other legumes cannot be established.

Finestem stylo, *Stylosanthes guianensis* Sw., from South America is a much branched, rather erect, perennial herb. It is now widespread and has been seen to be highly adaptable. It is particularly recommended for ability to

produce in poor and in acid soils. It can survive long droughts but also grows well in hot, humid climates. It is considered a very promising legume for present and future uses. Stylo is planted from seeds. These are usually hard and require some scarification. Inoculation is frequently unnecessary. Except for seed production, stylo is normally grown with grasses. Its initial growth is slow, however, and it should not be pastured too early. It is grazed or cut as hay, but much of its nutritive value is lost during such usage.

The cowpea, *Vigna unguiculata* Walp, from tropical Africa is now widely grown for its vegetable forms as well as a cover crop, green manure and pasture legume. Both annual and weakly perennial forms are found. Only the vine forms are used as forage. Cowpea is known for its rapid growth and ability to smother other herbage. Cowpea is another of the legumes that can be used first as a source of dried grain (pulse) and then later used as forage for the small farm. Although adapted to moderate rainfall, the species is found in very humid parts of the tropics as well, where sometimes it does very well. Interestingly, the young foliage is eaten as a leafy vegetable and it has been suggested that more cowpea is grown in Africa for their leaves than for their pods. The protein content of the herbage is high. Although numerous cultivars have been bred, use is declining in the southern United States, chiefly because of seed cost. The best forage cultivars come from Australia.

The particular legume for the small farm can seldom be selected on a completely rational basis because not all of the choice legumes are available to the small farmer. A farmer can learn a great deal by observing his neighbors, especially those with healthy animals and productive pastures. However where agricultural experiment stations exist local advice, and even seeds, might be available.

MISCELLANEOUS FORAGES

The possible value of other classes of forages on the subsistence farm should be mentioned (Table 4). Plants not of the Graminae or Leguminosae are usually neglected in publications on pastures and forages. Nevertheless, on small farms many other species of plants are used by animals and at times may be important parts of their diets. Some of the species are weedy and thus commonly present in fields and along fence lines. Some are trees that can be used in fences or maintained as hedges for cutting or grazing. More difficult to control than grasses and legumes, miscellaneous forages can be thought of as important assets on the small farm. Probably many other species could be added, but these must be discovered by experience, as the literature is so poor in this respect.

Table 4. **MISCELLANEOUS PASTURE AND FORAGE PLANTS FOR THE SMALL FARM.**

Species	Family	Common name	Some characteristics
Brosimum alicastrum	Moraceae	Mayan breadnut	Tree, dry areas, cut foliage and fruit
Cecropia peltata	Moraceae	Trumpet tree	Rapidly growing tree, wet tropical areas, cut forage
Commelina spp.	Commelinaceae	Commelina	Annual or perennial succulent herbs, pasture and cut forage
Crescentia alata	Bignoniaceae	Calabash	Young fruits eaten
Euphorbia spp.	Euphorbiaceae	Euforbs	Wild plants, mostly herbs, grazed. Many species are harmful or poisonous
Ficus spp.	Moraceae	Wild figs	Tree, leaves as cut forage
Hibiscus spp.	Malvaceae	Hibiscus	Shrub, cut forage
Ipomoea spp.	Convolvulaceae	Morning glory	Perennial climbing and trailing vines, pasture and cut forage
Opuntia and *Cereus spp.*	Cactaceae	Prickly pear and cactus	Perennial succulent herbs with spines, often too spiny to be eaten
Urena spp.	Malvaceae	Caesarweed	Annual herbs with spiny seed pods, grazed

SEED & OTHER RESOURCES

RESOURCES FROM ECHO

ECHO has seed for some tropical forages and several cover crop species (seed catalog available upon request).

ECHO also distributes the following related publications (available upon request):

- Green Manure Crops (ECHO Technical Note)
- Introduced Tropical Pasture Legumes by CSIRO
- Introduced Tropical Pasture Grasses by CSIRO
- Verano... A New Stylo for the dry Tropics by CSIRO
- Agronomy of *Luecaena leucocephela* by CSIRO
- Rodale's 1991 & 1992 Legume Seed Source Directory

OTHER SEED SOURCES

Adam Nieto at Windy Acres Farm (Vega, TX 79092, phone: 806/267-2790): Seed of the very drought tolerant forage *Kochia scoparia*.

CSIRO, Seed Centre, Division of Tropical Crops and Pastures, Banks St, Yarralumia, Camberra, ACT, AUSTRALIA: Seed and information.

Fr. Gerold Rupper at St. Benedict's Abbey (P. O. Peramiho, Tanzania): Sunnhemp

Kimseed, contact Mr. Stephen Hill at the Australian Revegetation Corporation Ltd. (51 King Edward Road, Osborne Park 6017, Western Australia, Phone: (09) 446-4377): An extensive inventory of arid land trees & shrubs, forages & cover crops and equipment for planting, harvesting, seed processing etc

Samuel Ratnam, Inland & Foreign Trading Co., ((PTE)LTD., P.O. Box 2098, Maxwell Road Post Office, SINGAPORE 9030): A good selection of forages, cover crops and related literature.

SETROPA, P.O. Box 203, 1400 AE Bussum, HOLLAND: Extensive listing of legume seeds

Yates Agricultural Seeds (P.O. Box 117, Rockhampton, Queensland, 4700, AUSTRALIA): A good selection of forages, cover crops and related literature.

OTHER RESOURCES

ILCA has identified and selected promising sets of forage/cover crop accessions best adapted to different environments. Contact Jean Hanson at the International Livestock Center for Africa (P.O. Box 5689, Addis Ababa, ETHIOPIA) for more information.

CIAT (Centro Internacionale de Agricultura Tropical, Apartado Aereo 6713, Cali, Columbia) works with forages for the high rainfall, low-fertility acid soils of the lowland tropics.

ICARDA works with Mediterranean forages (lathyrus, medic, vicia, grasses). Contact A. B. Damania at the International Center for Agricultural Research in the Dry Areas (P.O. Box 5466, Aleppo, SYRIA, telex: 331206 SY) for more information.

CIDICCO otherwise known as the International Cover Crops Clearing House is a clearing house for information on cover crops. They publish the quarterly *Cover Crop News*. Contact Mr. Milton Flores (Centro Internacional de Informacion sobre Cultivos de Cobertura, Apartado Postal 3385, Tegucigalpa, M.D.C., Honduras, C.A., Tel. 504/32 6633, Fax 504/31 2222) for more information.

The Heifer Project International, P.O. Box 808, Little Rock, AR 72203, phone: 501/889-5124. These folks deal with appropriate animal technologies for the developing world.

International Small Livestock Research Center, Alabama A&M University, Dept. Food Science & Animal Industry, P.O. Box 264, Normal, AL 35762, phone: 205/851-5445

Christian Veterinary Mission, 19363 Fremont Ave. North, Seattle, WA 98133.

Arthur Yates & Co., *Better pastures for the Tropics,* Yates. 1975 (address above)

Food and Agriculture Organization, *Forage Conservation Handbook for Small Farms*, FAO. 1986 (FAO, Regional Office for Latin America and the Caribbean, Technical Cooperation Programme, Caribbean Network of Cooperation in Small Animal Development, Santiago, CHILE).