A GUIDE
TO IMPROVED PASTURES
FOR THE DRIER AREAS
OF
THE EASTERN CARIBBEAN

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FOREWORD

This bulletin has been produced by the Forages Section of the CARDI Leeward Islands Unit based in Antigua, as a contribution to the livestock farmers of the drier, calcareous islands of the Eastern Caribbean. It is based upon experiences gained in Antigua and elsewhere in a forage programme which was initiated in 1974 under the auspices of the University of the West Indies. The programme and its staff passed to CARDI in 1979. Although research and selection of improved pasture species continued, the emphasis during most of the present decade has been on seed production and pasture development at the farm level.

While the responsibility for any errors or omissions must remain that of the authors, they gratefully acknowledge a debt of gratitude to the many people who have been associated with the programme since its inception. Foremost among this distinguished group are Dr. John Keoghan, who started the programme and continued to labour tirelessly for eight years before returning to his native New Zealand, and Messrs. Gerald Proverbs of CARDI and Robbie Quintyne of the Ministry of Agriculture in Barbados who, enthused by the results obtained in the experimental work, threw themselves wholeheartedly into the promotion of the new pastures for commercial use. Without these workers and their colleagues, this booklet could not have been written.

Thanks are also due to a series of foreign aid donors. IDRC, together with CIDA and CUSO provided financial and technical support for much of the early experimental work of Keoghan and his colleagues, while the European Development Fund (EDF) has, in recent years, funded the CARDI pasture activities in most of the Caribbean Region, an initiative which included the production of this booklet.

The Authors
Antigua, June 1986
1. INTRODUCTION

In the Eastern Caribbean, most ruminant production takes place from pasture. While in some territories, especially in Barbados and to a lesser extent in Antigua, there are examples of the commercial establishment of improved swards, most of the animals are kept on native or volunteer grazing. The native pastures in general share two major characteristics, both of which are the result of an extended period of poor pasture management, almost invariably associated with over-grazing.

(a) The legume component consists mainly of unpalatable species or those which are protected from heavy grazing by spines, etc. (e.g. Acacia spp)

(b) The grass component is made up of species such as Antigua Hay Grass (Dichanthium aristatum) and Seymour Grass (Bothriochloa pertusa) which flower early and dry off to make poor quality feed during the dry season.

As a result of this, most native pastures will provide a productive diet for only a few months of the year. Ruminants grazing these pastures suffer severe loss of condition every year during the dry season, and when a severe drought occurs, such as in Antigua during 1983-84, many animals die.

The purpose of this guide is to show how improved pasture species, both grasses and legumes, can be used to increase the productivity and the profitability of livestock farms situated on the neutral to calcareous soils in the drier areas of the Eastern Caribbean. It cannot be considered to be a recipe book, because each farm is different. Generalizations are only useful up to a certain point, but in attempting to produce a guide which can be used in several different territories of the region, it has been necessary to make some fairly sweeping statements.

Where recommendations are made with regard to establishment methods, they are those which have been shown by practical experience to be effective over a range of soil and climatic conditions. They should not be taken to imply that any alternative method is doomed to failure in a specific situation, but only that the recommendations are those which generally offer a good chance of success.
The recommendations with regard to pasture management should be taken as guide-lines rather than as hard-and-fast rules. In times of severe stress, for example during droughts, it is inevitable that pastures will be over-grazed. The harder a pasture is treated, however, the more permanent damage will be done to it. It’s productive life will be reduced by severe and prolonged over-grazing, which will reduce the financial return from the large investment made during the establishment period. The farmer should be aware of this fact, and should make his management decisions in such a way as to minimise his losses in a bad season in order to maximise his profits in the long run.

Finally, it is argued that the established livestock farmer should manage his herd in such a way as to obtain a continuous income from his animals. It is poor economic logic to fail to sell animals during a year of low prices, if this leads to over-stocking, with its expensive, damaging effects both on the pastures and on the growth rates of the young animals, since in turn this will lead to reduced income in future years. This guide rests on the philosophy that a heard or flock of animals should be considered as a production unit rather than as a bank account, and that the animal enterprise, even if it is a small, part-time activity for the owner, should be treated as a business, based on good business principles.
2. RECOMMENDED PASTURE SPECIES

Plants which are useful to the grazing animal in the tropics fall mainly into two groups, the grasses and the legumes. Those species which have been shown to be best adapted to the drier regions of the Eastern Caribbean are briefly described below. Most of these plants have previously featured in the CARDI Factsheet series. A list of the Animal Production and Forages Factsheets is presented as an Appendix.

2.1. Grasses

It has long been recognised that the native grasses of the region produce poor pasture, since in general they have a short growing season. During the driest part of the year the grasses are also dry, providing little more than fibre to the grazing animal. One notable exception is native Guinea grass (see below), but in many areas this has disappeared as a result of over-grazing.

The first attempts at pasture improvement in the Caribbean region usually involved the use of Pangola grass (*Digitaria decumbens*) and remnants of these sowings can be found in most of the islands. While this is a highly productive and persistant grass in the higher rainfall areas, particularly in fertile soils, or where heavy doses of fertilizers are applied, it is much less productive in the drier areas. It is well known throughout the region, however, and since it is better than the native grasses in terms of animal production, it is the standard against which other introduced grasses can be judged. It should be noted that Transvala grass, another variety of *Digitaria decumbens*, is more drought tolerant than Pangola, and also shows resistance to Pangola wilt virus, a disease that is seriously affecting pastures in Guyana. In Barbados, recent commercial sowings of Transvala appear very promising. As more experience is gained with this grass, it may be added to the list of recommended species for the drier calcareous soils.

(a) African Star and Bermuda (*Cynodon* spp).

The Bermuda grasses, such as Coast Cross 1 are less coarse and more digestible than African Star, but in general these grasses can be considered together because of their similarities. They have the appearance of a large, vigorous "devil's grass" (*Cynodon dactylon*) to which they are closely related, but they spread by forming roots at the nodes of above-ground stems (stolons) rather than by sending out underground runners (rhizomes). They are persistent and productive grasses which
respond well to fertilizer application, but will also grow well in relatively infertile soils. The lower limit of rainfall for these species is about 660 mm (26 ins), but they will do best at 900 mm (35 ins) or above. They are compatible with a range of legumes and when not allowed to become overmature, are palatable and highly digestible. They make good quality hay which is well accepted by all stock, and ideal for horses. They are planted from stem cuttings, as most varieties do not produce viable seed. Experience in Barbados has shown that when planted in rows, successful establishment can be obtained from 660 kg/ha (600 lb/ac) of Star Grass, or 770 kg/ha (700 lb/ac) of Bermuda Grass planting material.

(b) Guinea (*Panicum maximum*).
Although Guinea grass is native to Africa, it is naturalized in large areas of Central and South America and the West Indies, particularly where grazing pressure is light. Where over-grazing is practiced for extended periods it disappears since it is very palatable and is selectively grazed out.

There are two broad categories of Guinea grasses, the tall (or giant) varieties which frequently grow to 2 m (6.5 ft) or more, and the shorter dwarf types which usually do not exceed 1.5 m (5 ft). In general, the tall types are more productive during the rains, but yield less during the dry season. The dwarf types are preferred, as they have less tendency to become fibrous and are easier to manage under grazing. They also usually respond better to showers during the dry season by producing fresh, new growth.

All Guinea grasses are erect plants and are very compatible with legumes. They can be used successfully for either grazing or cutting and will grow well under light shade from trees or bushes, but are very susceptible to short-term flooding or water-logging. They are persistent only in well-drained soils which receive at least 800 mm (32 ins) of rainfall per year. The more leafy of the local types are almost as good in terms of productivity as the commercial varieties, although the more stemmy types should be avoided. After testing many varieties, the CARDI forage programme has selected the variety “Likoni” as being best for Caribbean conditions.

Most varieties are good seed producers, although fresh seed should be stored in a cool dry place for six to eight months before sowing to allow for the break of seed dormancy. Seeding rates will depend upon seed quality and seed-bed preparation, but in general are in the range of 2 to 7 kg/ha (2 to 6 lb/ac).
Vegetative propagation is simple and reliable, although it requires a lot of labour. The most important factor is to compact the soil around the split to ensure good contact between the plant and the soil.

(c) **Bambatsi** (*Panicum coloratum* cv Bambatsi). This highly drought resistant grass is a relative of Guinea grass, which will thrive on as little as 500 mm (20 ins) of rainfall. Bambatsi has a characteristic blue colour of both the leaves and flowers. It is well adapted to heavy clay soil and shows some tolerance of soil salinity. It will tolerate summer flooding followed by winter drought. It tends to spread by stolons, but forms a relatively open stand which is compatible with legumes. Establishment from seed is possible, but the seedlings grow relatively slowly in the early stages, so a good seed-bed is essential. Under poor seed-bed conditions, establishment from vegetative splits is usually more successful. The sowing rate for seed is from 2 to 4 kg/ha (2 to 4 lb/ac). It is a very palatable grass, providing good quality feed. It will also make excellent hay.

(d) **Buffel** (*Cenchrus ciliaris*). Buffel grass is well adapted to the lighter soils in very dry areas, where it will grow on as little as 300 mm (12 ins) of rain. It is not usually recommended in pure stands since few areas of the Caribbean are regularly as dry as this, but could be included in a mixture for areas where severe drought is a common occurrence. It establishes readily from seed, and 1 to 2 kg/ha (1 to 2 lb/ac) would be adequate in a mixture with Bambatsi or Chrysopogon. The seed carries hairs (awn) which tend to block up sowing equipment. Seed flow can be improved by mixing it with sawdust or damp sand.

(e) **Chrysopogon** (*Chrysopogon* sp). This is a new pasture grass that is proving to be well adapted to the drier areas of the Caribbean where it is highly productive. It appears to be susceptible to the drying effects of strong winds in Nevis, but if sown in relatively sheltered spots, or protected by wind-breaks, it retains good grazing quality well into the dry season. It is compatible with legumes but forms a good, protective cover over the soil. It is well accepted by livestock and produces abundant, light, fluffy seed. The hairs (awn) can be removed from the seed by a light hammer-milling to improve the flow through sowing equipment. In a well prepared seed bed, 1 to 2 kg/ha (1 to 2 lb/ac) is sufficient to give good establishment.
(f) Elephant (Pennisetum purpureum).

This grass is well known throughout the Caribbean. Although recently developed dwarf varieties are currently under test in many areas, the common Elephant grass will grow up to about 3 m (10 ft) under fertile conditions. It spreads by short, thick rhizomes to form clumps up to 0.9 m (3 ft) across. When grazed, it is persistent only under a rotational system; grazing for 3 to 5 days followed by 30 to 35 days rest. It is best adapted to a cut-and-carry system, where cutting when the grass reaches about 1.2 m (4 ft), or about every five to six weeks during the rains, will produce high yields of good quality forage. It will survive long periods of dry weather, but productivity is greatly reduced during drought conditions.

Highest yields of dry matter will be achieved by planting Elephant grass alone in rows about 1 m (40 ins.) apart and by applying fertilizer after each cut, but this intensive system is expensive. Good results have been obtained in terms of both yield and quality by planting the grass at double this width between rows and by sowing climbing legumes or leucaena between the rows.

(g) Sugar-cane.

When unburnt cane is harvested for sugar extraction, the tops can be used as fodder. The green leaves provide a diet of medium feeding quality. If the whole plant is to be fed to animals, excessive wastage can only be avoided by chopping the cane into small sections by passing it through a hammer-mill or similar machine. The resultant material is high in energy but deficient in protein. Whole sugar-cane fed alone should be considered as a survival ration for use during drought conditions. It can form a production ration if mixed with a protein source such as legume foliage, cotton seed meal or a non-protein nitrogen supplement such as urea.

(h) Maize and Sorghum.

These crops are seldom sown specifically for grazing, but are often used for fodder conservation. In general, maize will give a higher yield in a single cut, but will not regrow after cutting. Sorghum or hybrids of sorghum with Sudan grass will regrow, the total yield over two or three cuts being higher than that from maize. Sorghum will continue to grow under very dry conditions. It is therefore useful as a dry season forage reserve, particularly if sown with legumes. The first growth is often cut for silage, leaving the aftermath for dry season grazing. In hot dry conditions, hay can be made from sorghum, but in general both crops are better used for silage. It is usually necessary to chop the material in order to assure sufficient compaction in the silo.
Sorghum and Sudan - Sorghum hybrids can be used as nurse crops to provide protection for perennial pastures sown at the same time. In this case, the tall crop must be frequently cut to prevent it from providing too much competition once the slower growing species begin to get up and away.

2.2 Legumes

Many tropical legumes originated in Central and South America, and the native vegetation of the Caribbean has numerous examples of this very useful class of plants, amongst which perhaps the best known in the drier areas are wild tamarind (*Leucaena leucocephala*) and rabbit vine (*Teramnus labialis*). Where grazing pressure is light, many other examples may be found, including species of *Stylo*santhes, Desmodium, Desmanthus, Alysicarpus and Rhynchosia, but where animals abound, overgrazing, particularly with sheep and goats, has led to the disappearance of all except plants such as the cassie bushes (*Acacia* spp) which are protected by their sharp spines. In terms of productivity, quality and persistence, the most important legumes for animal production are described below. All are sown by seed, although the tree legume, leucaena, is often established in small areas by seedlings grown in a nursery.

(a) Siratro and Mexican Macro Y61

(*Mucroptiliun atropurpureum*)

Siratro is a commercial variety bred in Australia, while Y61 is a Mexican variety selected by CARDI for its high productivity in the Eastern Caribbean, but they are similar enough to be considered together. They are hardy, vigorous, drought resistant, twining legumes that are well accepted by livestock. They will grow in 750 mm (30 ins.) of rainfall, but do best in the range 900 to 1500 mm (36 to 60 ins.). As with most pasture legumes, they will not tolerate water-logged soils, but will grow in soils ranging from slightly acid to highly alkaline. The seeding rate when sown as the only legume should be 3 to 4 kg/ha (3 to 4 lb/ac) but when included in a mixture with other legumes, about 2 kg/ha (2 lb/ac) is plenty. They are the fastest of the common pasture legumes to establish, producing relatively large, vigorous seedlings. Legume mixtures will therefore often appear to be dominated by Siratro in the first year, the composition becoming more balanced in the second and subsequent years. These legumes flower at the start of the dry season, flowering being induced as much by moisture stress as by daylength. The flowers are large and deep purple in colour. Reducing the grazing pressure at this time of the year will ensure that some seed is set and dispersed, to assure a reserve of seed in the soil. New plants will then grow to replace the parent generation.
(b) Glycine (*Neonotonia wightii*).
As with Siratro, both Australian commercial varieties (Tinaroo, Cooper etc) and a CARDI selection (CPI 52614) have been used with success in the region. Glycine is a deep rooted, twining legume that is well suited to relatively fertile, well drained soils receiving from 800 mm (32 ins.) to about 1400 mm (55 ins.) of rainfall. The seed is smaller than Siratro, so the seedling is less vigorous. It is more susceptible to weed competition in the early stages, and so requires a well prepared seed bed. The seed should be shallowly sown at a rate of from 3 to 4 kg/ha (3 to 4 lb/ac) if it is the only legume, or at 1 kg/ha (1 lb/ac) in a mixture with other legumes. The small, white flowers usually appear in January in the Caribbean areas, the pods becoming ripe in March. Unlike many other legumes, the pods do not easily shatter when ripe, so seed harvesting is relatively easy. If not subjected to gross mis-management, Glycine is a highly productive and persistent legume which will form an important, long term component of the pasture. It is worth taking a little extra trouble over the establishment to ensure a good initial stand which will provide quality grazing over a period of many years.

(c) Rabbit Vine, Winer (*Teramnus labialis*).
Rabbit Vine is native to the Caribbean region in areas with rainfall of 900 mm (35 ins.) and above, being well suited to neutral or alkaline soils including cracking clays. It is less productive in the dry season than Glycine or Siratro, but is better able to withstand high stocking rates, since it has a deep crown with buds that remain protected below the level of grazing. It is not usually sown as the only legume, because of its relatively low dry season productivity, but it makes a useful contribution to the pasture when included in a mixture at rates of about 1 kg/ha (1 lb/ac). First year yields are generally low, but in later years, it becomes more productive. It is highly persistent, since it will tolerate both drought and heavy grazing. It also produces stolons which will develop roots, thus allowing it to spread throughout a pasture. Depending upon the variety, the flowers, which usually appear in January, range from white to deep pink in colour. The pods, which are relatively small, will shatter when ripe, but seed production is prolific.

(d) Mother Segel (*Stylosanthes hamata*).
Mother Segel, an annual or biennial legume, is native to the Caribbean region and to parts of South America where it grows well in areas that receive 900 mm (35 ins.) of rainfall or above.
It produces large amounts of seed, from which it will readily regrow, year after year, particularly under conditions of heavy grazing. On the shallow, droughty calcareous soils, it is the most productive of the many legumes that have been tested. It is a deep-rooted, erect plant which produces small trifoliate leaves and attractive yellow flowers. The small pods have a hook at one end and form a valuable source of protein during the dry season, when animals will lick them up from the soil surface. Under an infrequent grazing regime, this rather small legume can be swamped by taller companion grasses, but under hard grazing it will thrive on relatively infertile soils. The Australian variety “Verano” will do well on mildly acid soils, while the CARDI selection “Caribbean” is highly productive on soils ranging from slightly acid through to highly alkaline. It should be sown at a rate of 2 to 3 kg/ha (2 to 3 lb/ac).

(e) **Blue Pea (Clitoria ternatea).**
Blue Pea is a tall, slender, deep rooted climbing perennial which is extremely drought tolerant, surviving on only about 400 mm (16 ins.) of rain, although it requires 600 mm (24 ins.) or above to be productive. It is well adapted to alkaline soils where high levels of productivity have been recorded, although its usefulness is limited by its susceptibility to a range of diseases which attack the growing crown. It is not resistant to grazing, since it is usually highly palatable and preferentially selected by the livestock. It is also susceptible to damage by trampling. It may be best considered as a short term pasture break in a cropping rotation, where it should either be used in a cut and carry operation, or else cut for hay. The seeding rate should be 3 to 5 kg/ha (3 to 5 lb/ac), sown into a well prepared seed bed.

(f) **Leucaena, Wild (or River) Tamarind (Leucaena leucocephala).**
This is a perennial, deep rooted shrub or tree which is native to Central America. It is found in many Caribbean islands, growing on well drained neutral to alkaline soils, receiving at least 550 mm (22 ins.) of rainfall, but the native varieties are much poorer producers than the recognised commercial varieties. It produces foliage with very high levels of crude protein (often 25 per cent on a dry basis) and as such, is particularly useful for complementing poor quality, dry grasses during the dry season. It will regrow rapidly after cutting, and can be cut almost to ground level if necessary. When grazed, the animals will eat not only the leaves, but also the young stems, up to about the diameter of a pencil. There is a possible danger of toxicity due to a high mimosine content
if ruminants consume more than 30 per cent of their dry matter intake as Leucaena over long periods of time. The tolerance of non-ruminants (pigs, poultry) is considerably less, and it should not make up more than about 10 to 15% of the diet of these animals. If animals fed on this plant show signs of lethargy and hair loss, they should be given other pasture immediately as continued use of Leucaena will lead to severe weight loss. Mimosine toxicity has been reported from places such as Australia where the plant has been introduced, but has not, so far, been seen in the Caribbean. It could well be that local animals have tolerance to the levels of mimosine found in the plant.

Leucaena can be direct seeded at rates of 6 to 8 kg/ha (5 to 7 lb/ac) but the initial growth is quite slow until the plant has reached a height of about 30 cm (1 ft.). During this period, it must be protected from weed competition. If small areas are to be sown, a better alternative is to produce seedlings in pots or plastic bags, and to transplant these into the field once they are well grown. The versatility of the plant makes it ideal for use as the protein source in a forage bank, with Elephant or Guinea grass as the energy source. It can be used to stabilize steep slopes. Two main varieties are recommended for the Caribbean region, CARDI Cunningham for forage production, and Giant K8 for fence posts, fuel wood, charcoal etc. Further information about this interesting plant is contained in the publication "Leucaena: a versatile plant" by Gerald Proverbs (1985), available from CARDI offices throughout the region.

Seed Treatment of Legumes

Unless fresh seed is to be sown, the germination rate of all of the legumes will be improved by scarification. Submersion in water at 50°C for about 3 minutes is sufficient for most species, but in the case of Leucaena, the water should be at 80°C. Upon removal from the hot water, the seed should be rinsed in cold water and dried before sowing. It should be remembered that while scarification will lead to a rapid, uniform germination, there will be little viable seed left in the soil should a dry spell after germination kill the developing seedlings. Scarified seed should only be used when the chances of a 2 to 3 week dry spell in the first month after sowing are very low. At other times of the year, hard seed left in the soil after the initial germination is an advantage, since even if adverse weather conditions kill all of the seedlings produced from the first flush of germination, there will still be sufficient live seed in the ground to produce a stand when the weather improves.
None of the legumes mentioned above require inoculation to form nodules in Caribbean soils. It may be that further research will show a small initial response to inoculation with improved strains of bacteria but, at present, the expected benefits are too small to justify the expense of inoculation.
3. ALTERNATIVES FOR THE FEEDING OF LIVESTOCK

The Caribbean region, like most areas of the world, is faced with the problem of seasonal growth of pastures. During the rains they grow vigorously and there is plenty of feed available for the animals. At this time even the native grasses contain sufficient nutrients to allow animals to grow and produce. Once the dry season sets in, feed becomes scarce. The native grasses are the first to dry off and to stop growing, but soon, even the quality of the best of the cultivated grasses falls to levels which can no longer support animal production unless irrigation is available. As the crude protein content of the diet falls below about 7 per cent, the appetite of cattle is reduced. As they eat less, they are less able to obtain the amount of digestible nutrients necessary to maintain themselves and they begin to lose weight. This process can only be reversed by providing them with feed with greater than about 7 per cent crude protein equivalent. In some parts of the world, this can be supplied by protein supplements in the form of concentrate, either as bagged feed, as agricultural by-products such as copra and cottonseed meal, or as high-quality conserved fodder such as silage. In most parts of the Caribbean, the best way of supplying this protein is by the use of legumes. Legumes can be incorporated into the farm in several ways. They can be sown into general purpose pastures for year-round grazing. They can be saved for use only in the dry season either as pure stands (protein banks) or associated with highly productive grasses (protein-energy banks). Alternatively, they can be cut and stored as conserved fodder for feeding back in times of need.

3.1. General Purpose Pasture

Experience has shown, in Antigua and elsewhere, that in general during the rains, green, actively growing grass is more attractive to livestock than are tropical pasture legumes. The exceptions to this rule are Blue Pea (Clitoria ternatea) and Leucaena (Leucaena leucocephala) which are actively sought-after at all times. When a mixed grass-legume pasture is grazed, the animals tend to eat mostly grass during the rains. This gives an advantage to the legume. The well-managed mixed pasture will be dominated by legume at the start of the dry season, leaving this component to be consumed at the time of the year when it will do most good for the animal. If the stocking rate is too high during the rains, the animals will be forced to eat the legume as well as the grass and no feed will be left for the dry season. Conversely, persistent low stocking rates can lead to the disappearance of the shorter legumes. The subject of the pasture management will be covered in a later chapter, but it should be remembered that the stocking rate on the farm should be set at a level which will allow the animals to be fed throughout the year.
The pasture mixtures to be used for general, long term pastures, will depend upon the soil type and the rainfall regime, but the work of Keoghan in Antigua, supported by that of Proverbs and Quintyne in Barbados has shown that examples of combinations suitable for the drier areas of the Caribbean include the following:

(a) Shallow skeletal calcareous soils: Buffel and/or Chrysopogon with Siratro and Mother Segel

(b) Shallow skeletal non-calcareous soils: Buffel and/or Chrysopogon with Siratro, Glycine and Rabbit Vine

(c) Alkaline cracking clays: Bambatsi with Siratro, Glycine and Rabbit Vine

(d) Calcareous clays and deep volcanic loams: African Star, Bermuda or Guinea with Siratro, Glycine and Rabbit Vine, possibly also with Mother Segel.

Pastures such as these, if well managed, will remain balanced and productive for many years. They are versatile, and can be used for direct grazing, for cut-and-carry systems or for fodder conservation, mainly in the form of hay.

3.2. Legumes in Banks or Reserves

Legumes have the capacity to maintain high feeding quality throughout the year. They can therefore be left to grow without grazing during the wet season and be saved for use only in the dry season. Such an area of pasture is usually referred to as a bank, or reserve. If it is pure (or almost pure) legume, it is called a protein bank, while if it contains a grass such as Guinea or Elephant, it is known as a protein-energy bank. Reserves must be securely fenced to prevent unplanned grazing.

A protein bank is usually utilized only during the three or four worst months of the dry season, no grazing or cutting being permitted during the rest of the year. The animals are maintained on grass pastures, and either allowed limited access to the protein bank (perhaps two or three hours per day, or half a day on three or four occasions per week) to direct graze it, or preferably, a small part of the reserve is cut daily and fed fresh to the animals.
Three alternatives for dry season feeding: hay, silage and forage sorghum sewn for green chop.
With a protein-energy bank, the grass component is usually cut at regular intervals during the rains, until about three months before it is planned to start using the reserve. This will ensure that the growth is not too stemmy and mature to be palatable during the dry season. Again, utilization can either be by direct grazing or by cut-and-carry. In both types of reserve system, cutting allows for more efficient usage of the accumulated material, although it requires more labour and is therefore more expensive. The decision between cutting and grazing depends upon the number of animals and the availability of labour on the individual farm.

There are many possible species combinations that can be used as reserves. Protein banks can be formed from any of the normal herbaceous legumes described in Chapter 2, although the most common are probably Siratro and Glycine, either alone, or possibly in combination with Rabbit Vine. If a single species is sown, it could be harvested for seed as a cash crop once a commercial seed market develops in the region. Protein-energy banks can be formed from any herbaceous legumes sown with productive grasses but the most common combination is Leucaena sown with Elephant grass. If it is to be grazed directly, the Leucaena will need to be cut down fairly low at the end of the utilization period each year, to prevent it from growing beyond the reach of animals.

A further alternative is to sow annual, or short-lived perennial species to form the fodder reserve. Possibilities here include forage sorghum, or sorghum-sudan hybrids together with Blue Pea. This combination could be sown half way through the rains, some 3 months before it is to be used. Another possible legume for use either with sorghum or maize is the Dolichos or Hyacinth Bean (Lablab purpureus). Although there is little local experience with this legume, it is highly productive on neutral soils in Central and South America.

In the drier areas of the Eastern Caribbean, if banks are to provide for all of the animals on the farm, from 10 to 25% of the grazing area should be devoted to this purpose.

3.3. Legumes in Conserved Fodder

Experience shows that although grass can be conserved, either as hay or silage, it is not easy to produce a feed of high quality. With native grasses, good quality hay can only be obtained when the pastures are cut early, preferably from October
to November. This is the time of highest rainfall, when it is difficult to dry the cut material. Several cycles of wetting and drying will noticeably reduce the soluble (easily digestible) fraction of the hay, even if rotting and spoilage can be avoided. Cultivated grasses maintain their quality for a longer period, and offer the alternative of grazing up to October or November, before closing the area to allow cutting in January when weather conditions are more suitable for drying the hay. If a late cutting is planned, the quality and yield of the final harvest is threatened by the possibility of an early start to the dry season. Perhaps the best way to make hay is to use a mixed pasture of grass and legumes. In most years, cutting in late December will result in reasonably favourable conditions for hay-making, while allowing the pasture to make some aftermath growth if the rains persist. The legume content will ensure a high quality product, but since the twining legumes tend to shed their leaves when dry, it is important to handle the cut material as little as possible, and to have an appreciable quantity of grass mixed with the legume material in such a way as to minimise the loss of leaf material, even if it falls off the stems. Hay can be made on a large scale, using tractor drawn cutters and balers, or on a small scale, using a cutlass or a small mechanical mower, and storing the material either in loose hay stacks (see CARDI Factsheet AP-F/1, June 1980) or in hand-made bales (see photographs).

Silage making is a difficult process for the small-scale, non-mechanised farmer, since it relies on a fermentation process which must take place in the absence of air. With coarse, tropical grasses, it is often necessary to chop them into pieces 2.5 to 5 cm (1 to 2 ins.) long to achieve the required degree of compaction, unless a tractor can be driven over the material to compress it. As well as this, the material must be handled while it still contains a high level of moisture. This entails much hard work and is probably best avoided by most small-scale livestock farmers.

On a larger scale, the process of silage making must be mechanised. The use of tractors and forage harvesters is expensive and, particularly if the machinery must be hired, it involves large cash payments.

The cost of the final product can be reduced by obtaining maximum yields from small areas of land. The best way to do this is to use either maize or sorghum. If a legume is included in the mixture, the aftermath growth from cutting at a height of about 20 cm (8 ins.) will provide useful dry season grazing.
a. The baler being wheeled into position.

b. The components of the baler. Note: the strings are slipped into the V-shaped notches and draped over the inside of the frame. The half-moon shaped holes are to serve as toe-grips to hold the frame steady while the bale is removed.
c. Stacking the hay into the frame. The hay must be packed down well into the corners.

d. The pressure of the lever on the top of the grid compresses the bale.
e. The strings are tied around the bale.

f. The made bale is removed from the frame.
Maize will give a higher yield in a single cut than will sorghum, but will not regrow after cutting. Sorghum, or hybrids of sorghum with sudan grass will provide 2 or more cuts from a single area, and with their superior tolerance to dry conditions, they are to be preferred. Blue Pea would be a very suitable short-term legume, although Siratro together with Glycine and possibly Rabbit Vine would form a more persistent mixture. Silage making could be looked upon as a way of obtaining the maximum return from the year of establishment of a protein bank if this combination of legumes were to be sown with sorghum.

3.4. Protein Sources to Complement Poor Pastures

In the same way as daily access to a protein bank can complement relatively poor quality pastures, protein concentrate can be used to stimulate animal production in the dry season. In general, imported proprietary bagged concentrates are too expensive to consider, but more economical alternatives are available in some areas. It is impossible to give a complete list of all the possible materials that can be used for animal feed, but a few examples will illustrate the point.

(a) Agricultural by-products: These can include the tops of cassava, peanuts etc. after the harvest of the crop. They can be fed fresh, or dried for later use. The cleanings from deep-litter poultry houses can be sun-dried and fed to ruminants, although they must often be mixed with some grain or molasses to improve their palatability.

(b) Industrial by-products: Brewer's grain and the meal left over after the extraction of oil from coconuts, peanuts, sunflower seed, cotton seed etc. can all make useful, high protein supplements. In areas where cotton is an important crop but oil is not expressed from the seed, the whole seed can be fed to animals. Better utilization is obtained when the seed is lightly rolled or cracked before being fed. The milling process will reduce the danger of some seed passing through the animal to germinate in the pasture.

(c) Home-grown material: When Leucaena is cut and dried in the sun, the leaflets will readily fall from the branches. This material can be bagged for convenient storage before feeding.
(d) **Non-protein nitrogen sources:** Where available, a mixture of urea with molasses can be used to substitute a high proportion of the vegetable protein normally required by ruminants. The micro-organisms in the rumen use the urea to make protein, which is then used by the animals.

All of the above methods of feeding livestock are options which the manager should consider. The final choice of methods will depend upon many factors, including the farm size and soil types, the available labour and capital and the by-products that can be obtained by the farmer at a reasonable price. It should be emphasized that direct grazing is generally the cheapest way to feed livestock, even though trampling and fouling of the pastures will lead to large amounts of wastage. Most farmers will find it best to direct-graze improved pastures for most of the year, even if other methods may have to be employed to see the animals through the worst part of the year.
4. PASTURE ESTABLISHMENT AND MAINTENANCE

The establishment phase of a pasture is the period during which the land is prepared, the pasture is planted, either as seed or as vegetative material, and is subsequently managed in a way that will stimulate maximum growth of the sown species, so that they become dominant over the less desirable native plant population. In practice, this period may be as short as three to four months, but more commonly it will last for five, and even up to eight months with perennial species. Once this period is over, and the desired pastures are well established, a programme of maintenance should be initiated, which will ensure a long, productive life of the sown species.

Methods of establishment will vary with the species of pastures to be sown. The sowing pattern employed may range from sowing of the whole field, through planting only in strips, to isolated spot-plantings of desired species, but basically the principles of establishment are independent of the scale or pattern of planting. These principles, as they apply to commonly used perennial pastures in the Caribbean region, are described below:

4.1. Establishment from Seed

Pasture seed is generally very small in comparison with field crops such as cotton or maize. A small seed produces a small seedling which requires protection from competition if it is to grow and persist.

(a) Seedbed Preparation: Good seedbed preparation is of vital importance in reducing weed competition. This may be achieved by mechanical or chemical means or by a combination of both, but must be aimed at reducing the population of the resident species. In general, mechanical preparation starts with a relatively deep ploughing to aerate the seedbed and to kill the plants that are growing at the time. The existing sward should be turned under and completely buried, particularly if it contains rhizomatous grasses such as devil's grass. A subsequent light discing will break down large clods left by the ploughing operation. It is generally best to wait for a week or two to allow germination of the weed seeds brought close to the surface, before giving a second discing to kill the developing seedlings. Sowing should immediately follow this second pass of the light disc harrows.
a. *Leucaena* seedlings ready for transplanting into the field.

b. *A protein bank of Leucaena.*
It is difficult to make general recommendations for the use of herbicides to destroy the existing vegetation, since chemicals differ in their efficiency against different plant species, and when used on varying soil types. The use of desiccant contact herbicides such as paraquat (Gramoxone is an example) will kill many of the plants present at the time of spraying, but will not affect subsequent germination of seeds already present in the soil. Pre-emergence herbicides or a post-emergence application of 2:4-D can be used against broad-leaved weeds in a grass pasture, but most of these chemicals will also affect the legumes in mixed grass-legume pastures. Glyphosate (Round up) will kill many perennial weeds that are resistant to paraquat application.

(b) Sowing: Because of the small size of the seed of most pasture species, sowing should be shallow. The seed should be covered by only about 1 cm (0.5 ins.) of soil. It is much better to bury the seed in rows, rather than to broadcast it on the soil surface, because:-

- weeds between the rows can be easily controlled either mechanically or chemically if land preparation has not sufficiently reduced the resident population.
- seed lying on the soil surface is easily collected and removed from the field by ants and birds.
- the small roots emerging from seed on the surface are easily desiccated by dry conditions during the germination phase.

If seed has to be broadcast, the establishment of grasses will be more successful than that of legumes. Grass roots are of smaller diameter and therefore penetrate the soil surface more easily than legume roots. Where possible, rolling or dragging a tree branch over the field after broadcasting will cover the seed and improve establishment.

(c) Fertilizer: The seeds of most pasture species contain sufficient nutrient reserves for only about two weeks of growth. After that time the developing seedlings has to depend upon the uptake of nutrients from the soil. A fertile soil will usually be able to provide adequate nutrients for the growing plants, but this will not be the case in an infertile soil. The resident population will be
adapted to the native soil conditions, while the sown species may require additional nutrition which must be supplied by the application of fertilizers. These should be applied within a week or two of sowing so that the added nutrients are available by the time the seed reserves are exhausted.

Legume seedlings are usually effectively nodulated two to four weeks after germination, either by native Rhizobium strains or by those applied in the inoculation process. Small "starter" doses of nitrogen may be advantageous to legumes during the first month of life, but in general, applications of phosphorus, potassium and whatever trace elements are lacking, are more important than the use of nitrogen. Grass seedlings, on the other hand, are usually favoured more by the application of nitrogen and phosphorus than by other nutrients, except in situations with an extreme trace element deficiency when little or no growth will occur without application of the necessary nutrient. Such conditions are extremely rare in the Caribbean.

The placement of the fertilizer is of great importance in the establishment process. A general application may benefit the undesirable weed species to such an extent that they will choke out the sown pasture seedlings. It is therefore desirable to place the fertilizer where it will only be available to the sown species. This is usually done by putting it slightly below, and/or to one side of the seed row. Fertilizer should not be placed in direct contact with the pasture seed, as this will sometimes adversely affect germination.

(d) Pest Control: In general, a pasture which is highly susceptible to pests and diseases is not well adapted to the environment and therefore cannot be recommended for that situation. During the establishment phase, however, even ideally suited pasture species can be relatively susceptible. In the early stages, pests and diseases can ruin the establishment of a pasture that could withstand a similar attack if it occurred later in the growth cycle. Pest control is economically justifiable if it assures successful establishment of a pasture that will subsequently thrive without further pesticide application. Examples are as follows:-
Seed treatment with a fungicide will protect the seedlings from "damping off". This inexpensive treatment should be applied to seed to be sown into land which has history of seedling mortality. Care must be taken in selecting the product and the application rate for legume seed, since some fungicides will inhibit the formation of root nodules.

The use of biological control methods, or if suitable parasites are not available, the application of an insecticide to combat an outbreak of army worm should be considered as a justifiable additional expenditure to protect the large investment already made in land preparation, seed purchase and sowing.

(e) Grazing Management: Grazing management in the establishment phase should be lenient, since too much grazing pressure can destroy an otherwise successful stand. In general terms, the newly sown pasture should be protected from grazing for at least the first eight to ten weeks while the seedlings develop a strong root system. A rapid, light grazing using a large number of animals for a short period (mob-grazing, the so-called hoof and tooth treatment) will help the establishment of a stoloniferous grass, since it will encourage the plants to send out lateral runners, rather than to continue to grow vertically. This will help to fill in the spaces between the rows. This treatment should be followed by a minimum rest period of a further six to eight weeks before the newly sown area enters into the general farm grazing rotation. By this time the plants will have well-developed roots and will have accumulated a reserve of energy which will allow them to recover from further grazing.

When legumes are sown into an existing pasture, it is sometimes advantageous to graze the area during the first three to four weeks after sowing. At this stage, the legumes are too small to be actively grazed. Although they will suffer some damage from trampling, they will benefit from the removal of the competitive effect of the existing grass. Where grazing is allowed at this early stage, it should be carefully watched so that the animals can be removed before they do too much damage to the legume seedlings.
(f) Seed Set: Due to the high cost of seed, pasture establishment is usually carried out using low seed rates of about 4-6kg/ha (4-5lb/ac). Some seed set should be allowed during the first year in order to build up a reserve of seed in the soil and to thicken the stand. Many pasture species will produce in excess of 220 kg/ha (200 lb/ac) of seed annually. A full seed set is therefore not necessary, but grazing pressure should be adjusted so that about 10 per cent of the plants are allowed to flower and seed in the first year. By the second year, such lenient grazing is unnecessary but it is a wise precaution to allow some seed set every two or three years to assure the long-term survival of the sown species.

4.2. Establishment from Vegetative Material

Although many pasture legumes can be propagated vegetatively under experimental conditions, it is not a feasible practice in the field. Several of the recommended grass species must be spread in this way, however, since they do not produce seed (for example Star and Elephant grasses). Even the Guinea grasses, which do produce viable seed can be sown vegetatively if sufficient labour is available. There are three main methods which are described below:

(a) Root Division or Splits: Chrysopogon, Guinea and Bambatsi grasses can be propagated by this method. The recommended spacing is 60 cm (2 ft) both between and within rows, although this can be increased slightly if legumes are to be sown between the rows. The first step is to mow a good stand of the desired grass to a height of about 15 to 20 cm (6 to 8 ins.) to prevent excessive moisture loss. The clumps should be dug from the soil and separated into smaller sections. Those sections with some roots attached have the best chance of survival. These should be planted into moist soil, leaving from 5 to 10 cm (2 to 4 ins.) exposed. The soil should be well compacted around the planted section (the use of foot pressure is recommended) to ensure good contact between the soil and the split.

This process should only be attempted when good rains are expected. Fertilizer can be applied, if necessary, in a ring on the soil surface, close to, but not touching the plant itself. A well-grown stand should be ready for the
first, light grazing about 5 to 8 weeks after planting, but if conditions are very wet, it is best to delay the grazing to prevent the splits from being pulled out of the soil. After a further rest of 4 to 5 weeks, the pasture can enter into the farm rotation. If legumes are included in the pasture, both the first and later grazing should be delayed until they are well established.

(b) Stolons or Runners: This is the method employed for Bermuda, Star and Pangola grasses. The parent stand should be allowed to grow until the runners are at least 60 cm (2 ft.) long, and have several nodes. The material should then be cut fairly close to the ground. The runners are placed by hand into furrows 10 cm (4 ins.) deep and 0.9 m (3 ft.) apart. If material is plentiful, they can be spread directly onto the surface of the prepared soil. The furrows are then covered using a harrow, or the spread material can be incorporated into the soil by use of a disc harrow or rotavator. A final pass with a Cambridge (fluted) roller will ensure good contact between the soil and the vegetative material.

This method of establishment should be employed only where the soil is moist and where good following rains are expected. When furrows are employed weed control is easier and fertilizer application can be directed close to the rows, but it is more expensive since it requires more labour. In general, the first grazing should take place at least 8 to 10 weeks after planting. A further rest period of 5 to 6 weeks should see the grass well established and able to tolerate regular grazing.

(c) Stem Cuttings: Elephant grass is sown by this method. There are two main varieties, but in each case, the mother canes should be allowed to grow and mature before cutting. Short sets with three to five nodes (eyes) can be planted, basal end down and inclined at an angle with two or three nodes below, and one or two nodes above the surface. Although close spacings (60 cm or 2 ft within and between rows) are often used in pure stands, the width between rows should be increased, even up to 2 m (6.5 ft) if legumes are to be sown between the rows.
Alternatively, long setts (complete canes) can be laid horizontally in furrows and completely covered by 5 to 8 cm (2 to 3 ins) of soil. With this method, best establishment is obtained by laying a staggered double row of canes in the furrow so that the gap between two canes in one row is near to the centre of the cane in the adjacent row. A distance of about 0.9 (3 ft) between rows is adequate.

With both establishment methods, fertilizers can be applied close to the setts, or furrows. Grazing or cutting of the Elephant grass should take place once the grass reaches a height of about 1.2 m (4 feet).

With all methods of vegetative propagation, the sown plant contains large food reserves compared with the seed. The delicate seedling stage is avoided and the growing plant is better able to cope with competition. The establishment is faster and more efficient, provided that there is adequate moisture in the soil. While it is always worthwhile to prepare a good seed bed to minimise the weed problems in the establishment year, vegetative material can be successfully used under rough, clumpy conditions that would present serious difficulties for establishment from seed. It is however, more laborious and time consuming, and therefore generally more expensive. For those grasses which can be established by either method, the choice between seed and vegetable material will depend upon the availability of the planting material and the resources to which the farmer has ready access. It should be remembered, however, that grass and legume seed can be mixed together and sown in the same operation.

Where the grass is sown by vegetative means it is generally advisable to wait until it begins to grow actively, control the developing broad-leaved weeds (2:4-D usually provides the most economical control) and then sow the legume seeds between the rows of grass.
4.3. Maintenance

The process of pasture establishment is relatively expensive. It can only be justified if the pastures have a productive life of several years. The aim of pasture maintenance must therefore be to allow an optimum level of animal production over the maximum number of years. Under tropical conditions poor management can totally destroy a sown pasture within two or three years. The same pastures are capable of remaining productive for at least 12 years, and in many cases, up to 20 years under careful management. The most important aspects are as follows:

(a) Weed Control: The most dangerous weeds from the point of view of pasture maintenance are those which are not eaten by the grazing animal, either because of an unacceptable flavour (for example Digitaria insularis) or because of the presence of unattractive physical characteristics such as hairs (Rottboellia exaltata) or spines (Acacia spp, Mimoso spp). Since these plants are not continually defoliated by livestock, they will eventually dominate the pasture unless steps are taken to control them.

On a small scale, hand-chopping with a cutlass or hoe may be successful but larger areas require the periodic use of a brush-cutter. This is best achieved in a rotational grazing system by cutting after grazing. The spread of most weed species will be controlled if they are continually cut before they are able to set seed. The destruction of individual plants, or pockets of troublesome weeds, may be achieved by spot-spraying with a herbicide, but it should be remembered, particularly where the weeds have seeded, that unless pasture is sown into the empty space, the dead weeds may be replaced by other undesirable plants. Fire is sometime used in an attempt to control the invasion of shrubs and trees. To be successful, a large amount of grass must be present to produce a hot burn. The burning should take place at the end of the dry season when the undesirable species are starting to grow again and have their lowest reserves of energy.

At this time the fire will do the maximum amount of damage to the shrubs. Fire is a dangerous weapon, since it is difficult to control. It will seriously weaken the pasture if burning takes place in the early part of the dry season. It is particularly severe on legumes and should never be used in mixed grass legume pastures.
a. Hand-cutting used to control Cassie bushes

b. Maintenance fertilizer application to a mixed grass-legume pasture.
(b) **Soil Fertility**: Like any crop, pastures will benefit from periodic applications of fertilizer. With legumes, or in mixed grass-legume pastures the most important nutrients are phosphorus and potassium, while with pure grass pastures, nitrogen and phosphorus are most commonly applied. The rates and proportions to be used will vary according to soil type and relative prices of fertilizers and animal products. Trace elements should be used where necessary, at intervals which vary from one nutrient to another.

Areas that are frequently cut for forage conservation or under a cut-and-carry system are particularly prone to nutrient deficiencies since large amounts of plant nutrients are removed from the field in the cut material. These fields should be regularly fertilized in order to maintain pasture productivity. The slurry from the cow-shed, or the holding yards, should be returned to the field wherever possible, in a regular rotation, since much of the mineral content of the pasture passes straight through the animal, to be eliminated as urine or dung.

It is cheaper to return these nutrients to the field than to buy inorganic fertilizers on the open-market. Similarly where available, poultry manure is a useful nutrient source that is often cheaper than commercial fertilizers.

After several years under grazing, many soils will become compacted by the constant pressure of the animal hooves. This is particularly true of pastures which are grazed while the soil is excessively wet. Plant nutrients will be locked up in the soil organic matter, which will decompose only slowly in compacted soil. Under these conditions, the use of heavy disc harrows will aerate the soil. The entry of oxygen will result in the decomposition of the organic matter. The resultant release of plant nutrients, particularly nitrogen, will produce the same effect as an application of fertilizer. This renovation process can be repeated at intervals of from three to five years, depending upon the pasture species and the soil type.
(c) **Pasture Renovation**: A pasture is a dynamic system where weather conditions, grazing management, soil fertility etc. will all cause changes in the proportions of the various component species. In the event that a pasture becomes weedy as a result of these factors, or becomes too heavily dominated either by the grasses or by the legumes, it may be desirable to renovate it before it reaches the stage where it has to be ploughed up and resown. This can be achieved by the process known as over-sowing or reinforcement.

Several different reinforcement techniques have been used successfully in various parts of the world:

(i) A proportion of a field (say from 10 to 25 percent) can be prepared by ploughing or rotavating strips into the existing pasture. These strips can then be sown to the desired species, either by seed or by vegetative material using the methods described above. The species chosen should be those that are capable of invading the undisturbed areas between the sown strips. In this way, with careful management, the productivity of the field can be improved at only a fraction of the cost of resowing the whole area.

(ii) Alternatively, specialized machinery, the so-called "sod-seeder", is available which at a single pass can apply a contact herbicide to burn off the existing vegetation and open a furrow into which seed and fertilizer can be dropped. A following press wheel may, or may not, be used to close the furrow over the seed.

These two methods represent the more sophisticated approach to pasture renovation. While they are expensive, they offer the best chance of success.

(iii) At the other end of the scale, after a burn or a period of extremely heavy grazing, preferably by sheep and goats which will graze much closer to the ground than cattle, broadcasting seed onto the undisturbed soil surface can sometimes result in an increase in the proportion of desired pasture species. This rather crude method is inexpensive, but it is
also unreliable since the broadcast seed is at the mercy of the prevailing weather conditions and is also in danger of being collected by ants and birds. Although it can sometimes be successful, it is too uncertain to be recommended for general use.

The preferred method of pasture renovation under local conditions is the first one described, the preparation and sowing of strips into the existing pasture.
5. **GRAZING MANAGEMENT**

Successful grazing management is that combination of art and science that will result in maximum financial benefit from the available grazing resources in the long term. It is pointless to make a large profit in any one year if it results in the destruction of all the pastures on the farm, since it will take all of those profits, and more, to resow the pastures in the following year. A livestock enterprise that involves animal breeding is, by definition, long term, since a calf is unlikely to produce any income until it is at least two years old. Therefore, heavy emphasis must be placed upon obtaining a sustainably high level of production. There is no short cut to success. The observant farmer will continually learn more about his own fields. He will learn by his mistakes, and in the process, become a better and more successful manager. There are, however, certain basic principles of grazing management that should be adopted. This chapter deals with some of them.

5.1. **The Grazing System**

While at the optimum stocking rate, a continuous grazing pattern (one herd in one field, with no rotation) will give good results in terms of animal production, a rotational system, where there are more fields on the farm than there are herds of animals, will give certain advantages.

- smaller fields give more uniform utilization
- a pasture that has been over-grazed may be rested to allow it to recover
- if different soil types are fenced individually, the sown pasture species can be matched to the soil type without the danger of preferential grazing of more palatable species
- an area can be shut up for making hay or silage
- the herd can be divided up into groups of similar animals. This will allow better control of breeding as heifers can be kept away from the bull until they are large enough to breed. It will also allow for herd improvement by selective breeding of superior stock.
One powerful argument against the use of too many subdivisions is the high cost of fencing. Although the use of giant Leucaena (K8, K67 varieties) as living posts will reduce the cost of fence maintenance, subdividing a farm into small areas still represents a large capital outlay. Common sense dictates that the number of permanent fields should be kept to the minimum necessary to allow good animal and pasture management. If the soil type is relatively uniform, it may be sufficient to divide the farm into four parts, one for the breeding cows, one for the young heifers, one for the males and the final one in a resting phase. As the enterprise becomes more complex and sophisticated, however, a greater number of fields will be required, particularly when forage banks and fodder conservation become part of the normal farm practice.

Once cattle are trained to respect them, electric fences can make useful and economical temporary barriers, particularly if used in conjunction with solar generating equipment. They are of limited value with sheep and goats.

The best feed available on the farm should be given to the animals which are producing most. In a dairy enterprise, the lactating cows should be given highest priority, followed by the replacement heifers. After that, the breeding cows should have priority over the dry cows. On a beef farm, the young, growing animals are of primary importance, followed by the lactating and pregnant cows. Dry, empty cows are of lowest priority, unless they are being fattened for slaughter. These considerations have led to a special form of rotational grazing where after a period of rest, a pasture is grazed first by the animals with the highest priority, to allow them to select the best feed. They are then followed in turn by the other groups of stock on the farm. The opportunity to have first choice in a pasture will ensure that the most productive stock receive the most favourable diet.

Obviously, the use of any grazing system demands the use of good fences. It is better to have a few stock proof enclosures that permit strict control of the animals than to have many fields separated by poor fencing that the animals can pass through at will. Most important of all, however, is the boundary fence, since the entry of stock from outside can destroy the most careful pasture management (and animal breeding) plans. The early entry of sheep and goats, for example, into a newly sown pasture, can ruin an otherwise successful establishment.
The neighbour's stock can destroy an area which has been set aside as a dry season reserve (either as standing feed or for cutting as hay or silage) with disastrous results for the home herd in the dry season. It is therefore of vital importance to ensure that fencing is not only well constructed, but also that it is conscientiously maintained.

5.2. Stocking Rate

Under Caribbean conditions, the most frequently neglected aspect of animal production is the stocking rate. Many farmers appear to think that four poorly fed and slowly growing animals grazing on one hectare of land will give them more profit than two well fed animals on the same area. This is simply not true.

Overgrazing is very common in most areas of the Caribbean. When a pasture is over-grazed, the more palatable, desirable species are continuously defoliated. They use up their reserves in trying to send up new shoots only for these to be removed by the grazing animals before they can make any contribution to the dwindling reserves of the plant. It will become progressively weaker until finally, it will die. Unpalatable weeds are hardly touched during the process, so they continue to grow and flourish, replacing the more desirable species. As a result of this process, the pasture becomes less productive. If the animals are not removed, the pressure on the surviving edible plants becomes greater and the pasture enters into a downward spiral. In general, the legumes are the first to disappear, followed by the sown pasture grasses.

While this is happening to the pasture, the animals are also suffering. As feed first becomes scarce in an overgrazed field, the animals will compensate by spending more time searching for food and less time resting. Their growth rates slow down, since more energy is spent in grazing and less is available for growth. As intake becomes limited by lack of pasture, the growth rates will become slower and slower until finally the animals start to lose weight. Once this occurs, it is unlikely that empty cows will conceive until conditions improve once again. The farmer is losing money because he have over-stocked the pastures.
a. Heavily over-grazed pasture typical of many in the region.

b. A well-managed Bermuda Grass pasture in Barbados. The Jamaica Red cattle show high fertility and growth rates on grass legume pastures without concentrates.
At the other end of the scale, an old, over-mature pasture will become rank and stemmy. The protein content will fall, while the proportion of undigestible fibre increases. The growth rate of the pasture is low, even though there may be a lot of edible material in the field. Unless there is a high legume content in the pasture, the lack of quality will limit animal growth rates. This extreme is also undesirable, because it is wasting pasture.

Maximum animal productivity is achieved at intermediate stocking rates where the pasture is making rapid growth throughout most of the year and is producing forage of an acceptable quality. Local experience in Antigua has shown that with the pasture species recommended for the region, the height of the pasture should be maintained during the whole of the year within the limits noted in the following table:

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Grass alone Minimum</th>
<th>Grass alone Maximum</th>
<th>Grass with legumes Minimum</th>
<th>Grass with legumes Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short grasses</td>
<td>6</td>
<td>30</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>(Pangola, Bermuda)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium grasses</td>
<td>12</td>
<td>60</td>
<td>20</td>
<td>75</td>
</tr>
<tr>
<td>(Guinea, Bambatsi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tall grasses</td>
<td>15</td>
<td>100</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>(Elephant)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

The minimum limits should only be reached during the worst of the dry season, while the upper limits should be most closely approached during periods of maximum growth. Below the minimum levels, pasture productivity will be seriously reduced and recovery after grazing will be slow. Above the maximum levels, the pasture will be over-mature, and grazing quality will be lost.

In the drier regions of the Caribbean, improved pastures will carry about 2 to 2.5 adult cows per hectare (0.8 to 1 cow per acre) on a year-round basis, although in areas with high fertility, or where supplementary feeding or fodder conservation is practiced, the carrying capacity could be somewhat higher. Of course, during the rains, the stocking rate could be increased but then there would be insufficient feed to carry the animals through the dry season.
There will be times on any farm when the pastures will be subjected to a certain amount of abuse for the good of the animals, but the skillful manager will ensure that this happens as infrequently as possible. When it does occur, for example in times of droughts, it may be best to sacrifice one or two fields by grazing them very hard, in order to avoid over-grazing the whole farm. Under extreme conditions, it will then be necessary to reseed these fields when conditions improve. Even if reseeding can be avoided, it is important to allow the most heavily grazed areas a lengthy period of rest. This will permit the plants to regain their vigour and productivity. If such a rest period is not allowed, continued grazing will inevitably lead to the death of a proportion of the desirable plants, with a consequent decrease in the productivity of the whole field as has been described above. It is important to remember that while it is expensive to establish improved pastures, the cost is even greater if their productive lives are reduced by poor management. A little care and attention to detail can double the life of a pasture and save thousands of dollars.

5.3. Water and Shade

While not strictly part of grazing management, these comments are included here for the sake of convenience. The Caribbean region enjoys a tropical climate. In hot conditions, cattle, like people, have a higher requirement for water than they do in cold weather. It has been estimated that an adult cow requires from 36 to 45 litres (8 - 10 gals) of water per day in a tropical environment, although this figure will be higher for lactating cows. If this quantity of water is not supplied, performance will suffer. Animal management is made much easier if water is piped to each field on the farm, although a single large trough can supply several paddocks if it is situated in the corner where they meet. Troughs need not be sophisticated, expensive structures. An old bath tub, or oil-drum cut in half will serve the purpose if they are fixed in such a way that the cattle cannot tip them over.

Excessive heat can cause animals to lose appetite and to consume more water. The provision of shade will result in better animal performance and lower costs. Shade can be provided in many ways, but the use of giant Leucaena, sown at intervals of 3 to 4 m (10 to 14 ft) along all the fence lines is a multi-purpose alternative. By the time they are two years old, the trees are large enough to be used as living fence posts. They will provide some nitrogen to the grass growing near the fence lines and they
can be lopped in times of shortage of feed to supply high protein forage. By the time they reach three years of age, they will provide shade, even from the mid-day sun. Few trees are as versatile as Leucaena, since they can also provide fuel-wood and cut fence-posts if required. No livestock farm in the Eastern Caribbean should be without an area sown to this species, either along fence lines or as a separate area, since it can be utilized in so many ways.

5.4. Expected Production Levels from Pastures

Given good pasture maintenance and grazing management practices, improved pastures in the Caribbean region should have a productive life of at least 12 to 15 years and, in some instances, very much more than that, particularly if some renovation is done, for example, after a period of severe drought. With the animals that are on the farms at present, good management should produce weight gains in young, growing males of about 0.5 kg per day (1.1 lb per day) during the greater part of the year, particularly where the pastures contain an appreciable quantity of legumes. This should result in a gain of at least 150 kg per year (330 lb per year) from young males, with slightly lower figures for females. Milking cows should be able to produce about 7 kg per day (15 lb per day) from pasture alone, although yields above this level could be achieved by the limited use of concentrates or supplements as discussed above in section 3.4.
6. STRATEGIES FOR GREATER FARM PROFIT

While it must be remembered that each of the Caribbean countries is a separate entity with its own marketing structure and set of economic conditions, all of which will affect the profitability of the farming enterprise, there are some general considerations which can be applied to all of the islands in the Eastern Caribbean.

Although some of these points have been raised in previous chapters, they will be summarized here, for the sake of completeness.

6.1 Farming as a Business

If animal production is to be economically viable, it must be considered as a business. Many livestock owners appear to look upon their animals as an inflation-proofed bank account, but just as a storekeeper does not make any profit while the goods stay on his shelves, the livestock farmer only receives a return on the invested capital and on his labour input when he sells animals or animal products. The faster he gets his animals to market, the faster is his turn-over and the greater is his profit. The aim should be to sell well finished steers or bulls for slaughter at three years or less and to breed beef heifers at 24 to 26 months of age, so that they calve down at three years. It has already been noted above that young animals on improved pastures, but without purchased concentrates, can grow at 0.5 kg per day (1.1 lb per day).

At this rate of gain, an animal that continued to grow throughout its life without a set-back would reach 410 kg (900 lb) at about 26 months of age. This can be seen as the potential, but few animals will achieve it in practice since disease, parasites, shortage of feed etc. will usually cause the growth rates to fall below the target figure at one time or another. Looking at the problem another way, to reach slaughter weight by three years, the animal must make a net gain of, on average, about 125 kg (275 lb) per year. It must therefore gain weight for about 8.5 months of the year and maintain itself without loss for the other 3.5 months in order to reach the target. If weight losses are experienced during 6 to 8 weeks of the year, the target will only be reached if the animal grows rapidly during the whole of the rest of the year. Several conditions need to be fulfilled to achieve the desired level of performance.
(a) There must be adequate feed of a high enough quality to permit year round animal growth. While grasses can provide sufficient energy and protein during the rains, not even the best of them can do so without fodder conservation or irrigation during the dry season. Legumes, on the other hand, can provide the desired level of quality. The use of legumes, either in the general pasture, or as a protein bank, constitutes the key to successful and profitable animal production.

(b) The herd and the pastures must be well managed. A grazing strategy should be evolved, where the best available feed is provided to the young, growing stock, to ensure high growth rates. Dry cows in the early months of pregnancy do not require such a high quality pasture as growing animals or very productive, lactating cows.

(c) A marketing policy should be developed which attempts to sell some animals at the end of the rains, or at the start of the dry season, in order to reduce the grazing pressure on the farm during the hardest part of the year. Cows which conceive at the start of the rains will drop their calves towards the end of the following dry season. If those calves can be finished in less than three years (say 32 months) they will be ready for sale before the start of the dry season and their absence from the farm will allow the remaining animals to obtain more pasture during the period of feed shortage.

(d) Older stock, both males and cull cows, must be sold to make room for the younger animals that are coming on. It is usually more profitable in the long run to sell older animals, even at low prices, than to risk over-stocking with its consequent effects on both the growth rates of the younger animals and also on the productive life of the pastures. The young stock represent the future of the farm and must therefore be given the best treatment.

(e) Animals health standards must be carefully maintained. In general, the Caribbean islands are fortunate in that animal diseases present relatively few problems, particularly with cattle. Nevertheless, immunization programmes must be established in accordance with local recommendations and both internal and external parasites must be controlled.
6.2. Re-investment of Profits

(a) Into Pastures

Pasture improvement should not be seen as something that takes place only once in the lifetime of the farm, but rather as a continuing process. On the typical, unimproved farm in the Eastern Caribbean, there is a problem of over-stocking. The first step in any farm improvement plan must be the culling of the poorest animals to reach the correct stocking rate. The sale of these animals will realise capital, some of which can be used to sow an area of improved pasture, either a mixed grass-legume pasture, or a protein bank. If this is used to fatten young stock, there will be an increase in farm profit as animals reach slaughter weight faster, giving a more rapid turn-over. The well-finished, young carcass will be of high quality and, in many cases, profits will be further increased as the meat will attract a higher price on the open market. Some of this extra profit can be used to sow another area of improved pasture. In this way, the farm will enter into an upward spiral of increased profits, leading to improved pastures, which will further increase profits.

Even when the whole farm is sown to good pastures, the process does not stop. On occasions, the sacrifice of a pasture by over-grazing will be necessary, for example, to satisfy a contract to supply steers on a particular date, or during periods of drought. The pastures so affected will then require renovation or resowing. Each dry season the successful farmer will examine his fields to identify the worst pasture on the farm. He will then plan to improve that field during the following wet season.

(b) Into Animals

There will come a point when the ambitious farmer will realize that even with good management his profits are being limited by the productive ability of his existing animals. At this stage, further increases in profitability can only be achieved by improving the genetic quality of the herd. This step should only be attempted when the programme of pasture improvement is well advanced, since improved breeding will not improve productivity unless there is plenty of high quality feed available. The better animals will only be able to realise their true genetic potential if they are well fed.
An improved breeding programme, either by the use of live males or artificial insemination, is only possible if the females are isolated from all other breeding males. This can only be achieved if:

- boundary fences are well constructed and maintained to prevent the entry of males from neighbouring properties.

- unimproved males within the property are castrated before they reach breeding age. This will also help to produce a carcass with a desirable fat content.

The breeding bull should be placed in a separate herd with selected cows and heifers. A young bull should not be placed with more than 20 females, although under Caribbean conditions, a mature male can breed from 25 to 30 cows in a season. If the bull loses too much condition, he should be separated from the females and given special attention, including good forage and perhaps a daily ration of grain, wheat millings or cracked cotton-seed, to allow him to make a rapid recovery.

If artificial insemination is to be used, the key to success lies in the powers of observation of the manager. Artificial insemination offers a relatively cheap way to improve the breeding of the herd, since the farmer can purchase semen from a first-class bull, even though, in most instances, he could not afford to buy a bull of similar quality. Nevertheless, few cows will conceive unless heat detection is carried out by a keen and competent observer. Poor heat detection will result, not in increased productivity and profits but rather in a large financial loss to the farm.

In an environment such as the Caribbean, with large seasonal variation in pasture growth, it would be technically advantageous to mate all cows at the start of the rains. The calves would then all be born towards the end of the dry season, and if they were well fed and managed so that the males were sold at about 32 months of age, the herd requirement for pasture would be at its lowest during the dry season when pasture production is limited by lack of rain. Given the restricted sizes of the local markets, it is not feasible to recommend adherence to a strictly controlled breeding season, but the fact remains that animal numbers should be reduced before the dry season reaches its worst. Older cows should be culled in the second half of the rains when they are at their best, while all finished steers should be sold before the dry season sets in.
6.3. Dual Purpose Crops

The livestock farmer should try, where possible, to take advantage of the opportunity to finance his pasture improvement programme by the use of dual-purpose sowings. For example, where a pasture is to be established with climbing legumes such as Glycine and Siratro, at least a part of the area could be sown with widely spaced maize. This could be harvested for sale as green cobs, after which, the animals would graze the rest of the maize plants. In this way, the maize crop would help to pay for the establishment of the pasture.

There is a growing awareness of the importance of improved pastures in the region, but at present, the local supply of seed is limited. Imported seed, which comes mainly from Australia, is expensive. As the demand for seed increases, there will be opportunities for farmers to produce commercial crops of pasture seed. If the area is managed for seed production in the first year or two, the profit from the harvest will pay the establishment costs. It can then be turned over to grazing for the rest of its life.
7. **THE PROSPECTS FOR PASTURE FED CATTLE**

Many of the territories in the Eastern Caribbean are at present heavily dependent upon imports to satisfy their requirements for meat and milk. There appears to be little prospect of locally produced milk being able to compete successfully with cheap imports from Europe, except where the Government is prepared to utilize policies of restriction or taxation of imports, or to subsidise local production.

The situation with regard to beef is somewhat different. In those areas which rely upon tourism to support their economies, there is a certain amount of resistance on the part of the hotels to offer pasture fed beef to tourists. Clearly, the tourists demand a high quality product, but it is unlikely that more than a small proportion will actually insist on grain fed beef. At present, the level of grain production in the region is insufficient to meet human demands. Even if local production were to increase to the level of self-sufficiency, pigs and poultry are more efficient utilizers of grain than cattle and should therefore be given priority. In the foreseeable future, the feeding of grain to ruminants cannot be justified. The limited demand for this class of beef should continue to be met by importation.

Tasty, tender, high quality beef can be produced from pastures, using the methods outlined above. The hotel trade requires a reliable supply of a consistent product and, until this is locally available, importation will continue to dominate the market. As more farmers use improved pastures to produce quality carcasses from young, well grown animals, hotel resistance to local beef should decrease. The resident sector shows a marked preference for fresh, rather than frozen meat. These observations point to the existence of a large and growing demand for good, pasture-fed beef throughout the region. This demand could and should be satisfied by the local production of young, well finished cattle.
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