Feeding dairy cattle
A manual for smallholder dairy farmers and extension workers in East Africa

Margaret Lukuyu, Dannie Romney, Robert Ouma and Keith Sones
Smallholder Dairy Project

The Smallholder Dairy Project (SDP) carried out research and development activities to support sustainable improvements to the livelihoods of poor Kenyans through their participation in the dairy sub-sector. SDP was jointly implemented by the Ministry of Livestock and Fisheries Development (MoLFD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI). The project was led by the Ministry with primary funding from the UK’s Department for International Development (DFID). The three organizations worked with many collaborators, including government and regulatory bodies.

By combining the research capacity of KARI and ILRI with the experience and networks of the Ministry, SDP provided high-quality and wide-ranging research information to support smallholder dairy farmers, market agents, stakeholders and policy-makers from 1997 until 2005.

Kenya Dairy Development Program

The Kenya Dairy Development Program (KDDP) is a USAID-funded programme implemented by Land O’Lakes in partnership with African Breeders Service Total Cattle Management, International Livestock Research Institute (ILRI) and World Wide Sires.

The programme focuses on promoting milk and dairy products through promotional campaigns to increase consumption of dairy products. KDDP also focuses on processors and entrepreneurs, where interventions lead to an improved cold chain, improved quality and new dairy products with increased handling capacity. For dairy producers, KDDP interventions improve animal production during dry seasons and develop smallholder business capacity.

For more information about KDDP contact:
Land O’ Lakes (LOL), Peponi Plaza, Westlands, P.O. Box 45006 Nairobi
Tel: 3748526/3748685
Feeding Dairy Cattle

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Smallholder dairy project / Kenya Dairy Development Program
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Margaret Lukuyu, Dannie Romney, Robert Ouma and Keith Sones
Nairobi, Kenya
January, 2007
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-fed basis</td>
<td>Feed in its normal fresh state rather than as <strong>dry matter</strong>.</td>
</tr>
<tr>
<td>Balanced diet</td>
<td>Combination of feeds that provide the animal with the correct amount of all the different nutrients it requires to remain healthy and productive.</td>
</tr>
<tr>
<td>Bloat</td>
<td>Build-up of gas or foam in the rumen that can lead to death, associated with eating too much of certain types of feed.</td>
</tr>
<tr>
<td>Bulk forages</td>
<td>Fibrous plant feeds, such as grass, that form the major part of cattle rations.</td>
</tr>
<tr>
<td>Colosrum</td>
<td>Milk produced by the cow immediately after calving and for the next 3 to 4 days, higher in protein, fat and vitamins than normal milk, and also contains antibodies that help to protect the calf from infections.</td>
</tr>
<tr>
<td>Concentrates</td>
<td>Nutrient-rich feeds that are low in fibre and high in protein and/or energy.</td>
</tr>
<tr>
<td>CP</td>
<td>Abbreviation for <strong>Crude Protein</strong>.</td>
</tr>
<tr>
<td>Crude protein</td>
<td>A way of measuring the protein content of feeds based on the amount of nitrogen in the feed.</td>
</tr>
<tr>
<td>DM</td>
<td>Abbreviation for <strong>Dry Matter</strong>.</td>
</tr>
<tr>
<td>Dry matter</td>
<td>The portion of feed remaining when all the water has been removed in a laboratory, usually expressed as a percentage.</td>
</tr>
<tr>
<td>Fodders</td>
<td><strong>Forages</strong> such as Napier grass, especially grown as crops to feed to cattle.</td>
</tr>
<tr>
<td>Forages</td>
<td>Fibrous plant feeds including bulk forages and supplementary forages.</td>
</tr>
<tr>
<td>Hay</td>
<td>Dried grass or herbaceous legumes prepared as a way of conserving grass for feeding to cattle.</td>
</tr>
<tr>
<td>Legume</td>
<td>A group of plants, including herbs, shrubs and trees, that can fix nitrogen from the air, have high protein contents and boost soil fertility.</td>
</tr>
<tr>
<td>Macro-minerals</td>
<td>Chemical elements, such as calcium and phosphorus, that cattle need in their rations in relatively large amounts in comparison to other elements – see micro-minerals.</td>
</tr>
<tr>
<td>Micro-minerals</td>
<td>Chemical elements, such as iron, copper and cobalt, that cattle need in their rations in very small amounts, also known as trace elements.</td>
</tr>
<tr>
<td>Nutrients</td>
<td>The component parts of feeds that supply nourishment to animals.</td>
</tr>
<tr>
<td>Ration</td>
<td>The combination of feeds fed to cattle.</td>
</tr>
<tr>
<td>Rumen</td>
<td>One of the four stomachs of ruminants containing large numbers of micro-organisms that can digest fibre.</td>
</tr>
<tr>
<td>Ruminants</td>
<td>Animals including cattle that have four stomachs including a rumen, chew the cud and which can digest fibrous feeds.</td>
</tr>
<tr>
<td>Silage</td>
<td>A way of preserving grass and other materials for feeding to cattle in which the grass is fermented.</td>
</tr>
<tr>
<td>Standing hay</td>
<td>Grass or other crops left standing in the ground to dry naturally and cut or grazed as needed.</td>
</tr>
<tr>
<td>Supplementary forages</td>
<td>Fibrous feeds, usually legumes, that are higher in protein than bulk forages.</td>
</tr>
<tr>
<td>forages</td>
<td>A strain (also called cultivar) of a plant crop that has been selected by plant breeders for its special characteristics which offer some advantage over the standard type such as disease resistance, high yielding; similar to breeds of livestock. Varieties sometimes have names and sometimes just have identification numbers.</td>
</tr>
</tbody>
</table>
There are more than two million small-holder dairy farmers in East Africa. Most keep one or two dairy cows, usually crosses between European dairy breeds and local zebu, in a system that combines growing a variety of crops and keeping dairy animals. Due to shortage of land, some practice zero or semi-zero grazing.

Keeping dairy cattle in this way can be very rewarding. It can provide a range of benefits, including nutritious milk for home consumption, extra milk for sale and manure to help maintain soil fertility. By also growing protein-rich fodder crops, especially those from the legume family which can fix nitrogen from the air, this not only helps boost production of milk and saves money on buying commercial dairy meal or other concentrates, but will also further boost soil fertility. And growing perennial fodder crops, such as legume shrubs and trees, especially along contours of sloping sites or along your boundary, can help prevent erosion of soil and supply useful products and services for the farm and household, such as fodder, fuel wood, mulch, living fences, shade and shelter, stakes and timber.

Cross-bred dairy cows can be highly productive and make a major contribution to household economies as well as providing milk packed with essential nutrients, such as protein and minerals, which are especially important in the diet of children and for expectant and nursing mothers. But dairy cows will only be productive if they receive sufficient quantities of the right sorts of foods. The challenge smallholder dairy farmers face is to provide their cattle with a balanced diet that supplies the right quantity, quality and mix of nutrients and avoids any dangerous feeds – and to achieve this at the least cost using feedstuffs that are readily available, year-round; not an easy thing to do!

This booklet is designed to guide extension workers and possibly smallholder dairy farmers through the basics of feeding dairy animals. It includes essential background information as well as practical advice and suggestions. By better understanding how a cow digests its food, the importance of providing a balanced diet, how nutritional needs vary at different stages of the animal’s life and how different types of feed can meet these needs, dairy farmers will be able to get the most benefit from their investment and keep their valuable animals healthy and productive.
2. WHY CAN COWS EAT GRASS?

By the end of this chapter you will:
• Know that cattle are ruminants
• Understand what a ruminant is
• Know how cattle can digest grass and other fibrous feeds
• Know the advantages and disadvantages of being ruminants

Thanks to a special large stomach full of millions of tiny micro-organisms, animals such as dairy cows, sheep and goats can remain healthy and productive on a diet based on fibrous foods, such as grass and hay – foodstuffs that people and most other animals cannot digest. This means that dairy cows can turn relatively inexpensive ingredients, such as roadside grass, weeds and straw, into valuable, nutritious milk. They can do this because they are ruminants.

What are ruminants?
Cattle, sheep, and goats as well many wild animals that graze grass or browse on leaves, such as antelopes, buffaloes and giraffes, are all ruminants. The digestive system of ruminants is different to most other animals, such as pigs, dogs and people.

All ruminants ‘chew the cud’. This means that food they ate earlier is returned to the mouth for a second thorough chewing, usually 30-60 times for each mouthful, before it is re-swallowed. Dairy cattle usually do this when they are quietly sitting down – at such times you can see the mouthfuls of food moving up and down the oesophagus (the tube that joins the mouth to the stomach) at regular intervals, every few minutes.
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The rumen

The structure of the ruminants’ digestive tract is different from people and most other animals. The main difference is that ruminants have four different stomachs whereas people and most other animals have just one. One of these stomachs is very similar to the human stomach, but ruminants also have three additional stomachs including a large bag-like one called the rumen.

Structure of ruminant digestive system showing four stomachs, rumen, reticulum, omasum and abomasum.

The rumen contains very large numbers of tiny living creatures (micro-organisms), mostly bacteria. Some bacteria cause diseases but the bacteria that live in the rumen do not harm the ruminant – in fact they are extremely helpful because they can digest grass, hay and other fibrous foods. These bacteria are very small, much too small to be seen by the naked eye: thousands could fit on the full-stop at the end of this sentence. But they are present in the rumen in very, very large numbers – many, many millions. Once the bacteria have broken down the fibrous food, ruminants such as dairy cows can absorb and use the nutrients contained in them. So, although ruminants themselves cannot directly digest fibrous foods, the micro-organisms that live in their stomachs do the job for them. In affect, as a dairy farmer you are feeding the micro-organisms in your animals’ rumen – which in turn feed your cows.

Advantages and disadvantages of being ruminants

As well as breaking down fibrous food and making the nutrients available to cattle and other ruminants, the micro-organisms in the rumen serve some other useful functions. They can make some vitamins, such as the B group vitamins. Vitamins are essential for health and most animals and people have to consume vitamins regularly in the diet. But ruminants can rely on the micro-organisms living in their rumens to make some, but not all, of the vitamins they need to remain healthy and productive. Fortunately, the vitamins they cannot make tend to be naturally present in the feeds cattle usually eat and so farmers do not usually have to worry about vitamins in rations for dairy animals.
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At the same time the micro-organisms in the rumen can make protein from simple, inexpensive, nitrogen-containing substances, such as the chemical urea and old chicken litter. These proteins are then digested and used by the ruminant – for example in dairy cows they can be used to make milk. Unlike ruminants, people and most other animals cannot make protein from these simple substances. People, especially growing children and pregnant or nursing mothers, need to eat expensive, high quality, protein-rich foods, such as meat, eggs and milk, regularly if they are to remain healthy and to ensure normal development. But before adding urea or chicken litter to your cow’s ration seek expert advice.

There are however, some disadvantages to the ruminant’s digestive system. For example, high quality protein feeds are broken down by the micro-organisms which means dairy cows cannot get the full benefit of these expensive feeds.
By the end of this chapter you will:
• Understand the importance of proper feeding
• Know what a balanced diet is
• Know what the major types of nutrients are
• Understand the difference between the way people and cattle eat
• Know what types of feed supply the main nutrients needed by cattle

Proper feeding is essential to ensure cattle:
• Stay alive
• Remain healthy
• Are in good body condition – not too thin, not too fat
• Have enough energy to move.

In addition, proper feeding enables:
• Young animals to grow
• Heifers and cows to become pregnant and give birth to healthy calves
• Cows to produce enough milk for their calf and extra which can be consumed at home or sold to earn money.

A balanced diet
Cattle must eat different types of feed to supply the various nutrients they need to survive, remain healthy and be productive – that is to grow, produce milk and reproduce efficiently. In fact all animals, including people and cattle, need balanced diets - that is diets that supply both the right variety and amount of the different type of nutrients the body needs.

Diets of cattle are usually called rations. The challenge for dairy farmers is to put together a ration for their cattle, using feeds that are readily available, that supplies all the animals’ nutritional requirements, does not cause any health problems, enables the cow to produce as much milk as it is capable of - and to do all this in the most economical and cost-effective way possible.
Types of nutrients

People and cattle eat different sorts of food and a balanced diet for people is made up of very different foods from a balanced ration for cattle. But for both people and cattle the basic types of nutrients needed are the same. These are:

**Energy:** Energy providing foods form the main part of the diet and supply the body’s fuel, allowing the animal to move, keep warm, stay alive and be productive.

**Protein:** Protein in feeds helps young animals to grow and develop strong muscles and enables cows to produce healthy calves and plenty of milk.

**Vitamins:** These are a group of substances that are required in the diet in very small amounts for normal functioning of the body. Insufficient supply of any of the vitamins results in a specific deficiency disease.

**Minerals:** These are also required by the body in small amounts and serve a wide variety of important functions, including forming strong bones and generally maintaining health and normal body function. They differ from vitamins in being simple chemical elements whereas vitamins are more complex chemical compounds.

**Water:** All animals need water for the body to function normally. Without water to drink animals die very quickly. Water is necessary for food to be digested, for the animal to cool its body when it is too hot, and to remove waste materials from the body. Also, milk contains up to 85 per cent water.

<table>
<thead>
<tr>
<th>Type of nutrients</th>
<th>People’s diets</th>
<th>Cattle rations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Cereals – maize, wheat, rice</td>
<td>Bulk forages – pasture grass, Napier grass, straw, stovers; Cereal by-products – bran, pollard; Commercial dairy meals; Root crops – cassava chips; Oil seed products – cotton seed meal, sunflower meal.</td>
</tr>
<tr>
<td></td>
<td>Cereal flour-based foods - ugali, bread, potatoes, sugar, fats.</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>Milk, meat, fish, eggs</td>
<td>Supplementary forages – desmodium, leucaena or calliandra leaves Commercial dairy meal; Concentrates – cotton seed meal, sunflower meal; Urea*; Poultry litter*.</td>
</tr>
<tr>
<td></td>
<td>Pulses – lentils, cowpeas, beans.</td>
<td></td>
</tr>
<tr>
<td>Vitamins</td>
<td>Fruit and vegetables; Milk; Margarine.</td>
<td>Green forages made in rumen by micro-organisms.</td>
</tr>
<tr>
<td>Minerals</td>
<td>Milk; Green vegetables; Liver; Salt.</td>
<td>Forages; Mineral licks; Salt.</td>
</tr>
</tbody>
</table>

*Non-protein nitrogen sources converted into protein by micro-organisms in rumen.

Example of a balanced diet

**People’s diets**

Maize meal (ugali), green vegetables (sukumawiki), beans, milk, pawpaw, plus a little vegetable oil, salt and water.

**Cattle rations**

Napier grass, desmodium, dairy meal, plus access to mineral licks and/or salt, and water.

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Basic feed types for cattle
Balanced rations for cattle are made up of five basic types of feed. When combined in the right amounts, these feeds can supply all the nutrients needed to keep cattle healthy and productive. The five types of feed are:

**Bulk forages for energy:** These are mostly grass-like plants that have long stems, long narrow leaves and flower spikes and contain a lot of fibre in their structure. They include fresh materials, such as green grass, as well as dry materials, such as hay. They provide most of the energy a cow needs and some minerals and will make up most of the ration – they are what fills the animal and stops it feeling hungry. Most bulk forages contain only low levels of protein. They often grow naturally, such as grass and other plants on roadside reserves or natural pastures, or are the part of the plant left over when crops grown for people are harvested, such as stovers or straws of maize, sorghum wheat or rice. Napier grass is often grown on the farm as bulk forage.

**Supplementary forages for energy and protein:** Supplementary forages provide both energy and protein and some minerals. These are fibrous plants, similar to bulk forages, but they are usually especially grown on the farm as feed for cattle and contain higher protein and/or energy levels than bulk forages. Most are legumes and include herbaceous plants, shrubs and trees. They are fed in addition to the bulk forages, usually in smaller amounts. They can be used either to compensate for poor quality bulk forages or they can be used as substitutes for concentrates. The feeding value of different supplementary forages varies; for calliandra, three kilograms of fresh forage is equivalent to one kilogram of a good quality commercial dairy meal.

**Concentrates for energy and protein:** These are feeds that supply more highly concentrated nutrients than forages. They contain high levels of protein or energy or both, and also some minerals. They are also low in fibre and easy to digest. They include specially made feeds, such as commercial dairy meals, as well as cereal by-products (for example pollard, wheat germ, maize germ) and other high energy and/or high protein feedstuffs (for example molasses, fish meal and brewers’ dried grains). Cereal grains such as maize, wheat and barley, if available and economical to feed, fall under this category. Concentrates are relatively expensive and are therefore fed in relatively small amounts in addition to forages; the amounts fed should depend on how much milk the cow is producing.

**Mineral supplements:** Although some minerals are naturally present in bulk and supplementary forages and concentrates, dairy cows also need to be regularly fed additional minerals. This is most easily done by regularly offering access to a commercially manufactured mineral supplement.

**Water, essential for life:** Ideally, dairy cows should have access to clean drinking water at all times. In addition to the amount required for normal bodily functioning, a milking cow requires about five litres of water to produce one litre of milk. A cow will also drink more water in hot weather.

Usually vitamins are not a problem with practical dairy cow rations: some vitamins are made by the micro-organisms in the rumen and others are naturally present in feeds, such as leafy green forages.
4. ENERGY, PROTEIN, MINERALS AND WATER

By the end of this chapter you will:
• Be aware of good sources of energy, protein and minerals
• Know the difference between macro- and micro-minerals and the particular importance of calcium and phosphorus
• Understand the danger of feeding too little or too much of these nutrients
• Be aware of the importance of water to cattle and know how much water a cow needs each day

Energy
Energy is the fuel that keeps all body functions going. Just as petrol powers the car, energy in feed powers the dairy cow. Milk production requires a lot of energy.

Too little energy in the diet
If not enough energy is provided by the cow’s ration it will lose body condition and become thin and weak. For milking cows, milk yield will drop. Pregnant cows may become ill after calving and the calf is likely to be small. In addition the breath of cows can smell unusual – a fruity chemical smell; this condition (ketosis) is most common soon after calving. And the cow can also develop a disease called fatty liver as a result of making energy available from its own body.

Too much energy in the diet
The most obvious sign is the animal becomes too fat. Cows that are too fat at calving are more likely to have difficult births, retained placenta (afterbirth), displaced abomasums (one of the cows’ stomachs) and more often develop the conditions milk fever and ketosis, both of which are dangerous and can cause death.

Sources of energy
People obtain most of their energy from staple foods – those that form the bulk of the diet - such as maize or rice. These foods are mostly carbohydrates, rich in starch. Fatty foods, such as yoghurt, cheese, butter, ghee, full-fat milk and fatty meats, are energy-rich and can also provide the energy people need – although doctors believe that too much fat in the diet is harmful to health.

Fibre: Unlike people and animals like pigs and dogs, cows can digest fibrous feeds, such as grass, hay and straw, which are called forages. Cattle obtain most of their energy from forages.

Carbohydrates: Like people, cattle can also obtain energy from carbohydrates (which include both starch and sugars). Some good sources of carbohydrates for dairy cows are:
• Chips made from dried cassava tubers
• Cereals, e.g. rice, wheat, maize, millet, sorghum
• Agricultural by-products, e.g. maize germ, pollard, molasses
• Commercial dairy meals

Fats: Fats are energy-rich feedstuffs. Soon after calving, when cows are not able to eat as much feed as their bodies require, fats can be added to their rations. This is only necessary in the highest producing dairy cows. Good sources of fat for dairy cows are oilseed meals. However, too much fat in the diet can prevent cattle from digesting fibre and so no more than five per cent of the dry matter of a ration should be provided by fat. Expert advice should be obtained before fat is included in the ration of cattle.
Protein

Proteins provide the essential chemical building blocks for all the body’s cells and tissues, including muscles, blood, skin, internal organs, and also to make milk.

People and animals such as pigs and dogs need to eat high quality protein in their diets, for example meat, fish, milk, eggs and pulses. But cattle and other ruminants can also make protein from cheap, nitrogen-containing materials such as the chemical urea and poultry litter as well as digesting the protein contained in their feed.

Milk production and protein

One litre of cross-bred cows’ milk usually contains about 35 g of protein (35 g of protein per litre of milk can also be expressed as 3.5% protein content). This means that a cow producing 25 litre of milk per day loses close to one kilogram (actually 25 litres x 35 g per litre = 875 g) of protein in the milk each day.

Cows cannot store much protein in their bodies and so it must be supplied in the daily ration in order to maintain high milk production.

Too little protein in the ration

For milking cows, there will be a rapid drop in milk production if the amount of protein in the ration is suddenly reduced. Rations providing too little protein will also cause excessive weight loss in milking cows, reduced growth rate in calves and heifers and result in small calves being born.

Too much protein in the ration

Protein-rich feeds are expensive. Feeding too much protein to dairy cows is wasteful because the surplus is broken down by micro-organisms in the rumen and then excreted from the body.

Sources of protein

For people, good sources of dietary protein include meat, milk, fish, eggs and pulses, such as lentils and beans.

Good sources of protein for dairy cows include:
- Cotton seed meal/cake, whole cotton seed, whole soy beans (cracked), groundnut meal, maize germ and sunflower meal/cake
- Animal products such as fish meal, blood meal, meat meal and by-products from milk processing, e.g. skim milk and whey
- Legume crops such as lucerne and desmodium and leaves from legume fodder trees and shrubs
- Cereal grains
- Commercial dairy meal.

Dairy cows can also make protein from materials that contain nitrogen - such as the chemical urea and litter from poultry houses - through the action of micro-organisms in the rumen. However, feeding urea to dairy cattle is potentially dangerous and expert advice should be obtained before introducing urea into a ration.
Minerals
Minerals are a small but important component of feeds. They are essential for cattle to remain healthy and for the body to function properly, for the development and maintenance of strong bones and for successful reproduction and production of milk.

The amount of minerals needed by cattle can vary, such as:
- Mineral requirements of young, growing animals are higher than for adults
- Pregnant and milking cows require more minerals
- High yielding cows require especially large quantities of calcium.
  Calcium deficiency is most likely to occur in early lactation.

Macro- and micro-minerals
Minerals are required in much smaller amounts than other nutrients, such as energy or protein. But dairy cattle need more of some types of minerals, called macro-minerals, than they do of others, known as micro-minerals which they require in only very small amounts. On average, about one thousand times more of the macro-minerals are required in the ration as compared to the micro-minerals.

The table below shows the macro- and micro-minerals that are required in dairy cattle rations:

<table>
<thead>
<tr>
<th>Macro-minerals</th>
<th>Micro-minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium; Phosphorus; Magnesium; Sodium; Potassium; Chlorine; Sulphur.</td>
<td>Iodine; Iron; Copper; Cobalt; Manganese; Molybdenum; Zinc; Selenium.</td>
</tr>
</tbody>
</table>

Too little macro-minerals
If animals do not consume enough macro-minerals this will cause reduced milk production, fertility problems, weakness of the bones and increased incidence of certain non-infectious diseases, such as milk fever (due to insufficient calcium).

Too little micro-minerals
Deficiencies in the micro-minerals (also called trace elements) can cause a variety of diseases and conditions depending on which mineral is not present in sufficient amounts. Deficiencies of micro-minerals are sometimes found in certain areas. In these cases the soils generally contain very low levels of the micro mineral.

The example of cobalt deficiency: In most areas, forages contain sufficient cobalt (a tiny amount of this micro-mineral is enough) to provide dietary needs and maintain cattle in good health. However, cobalt deficiencies are found in some areas, such as parts of Kenya near Nakuru, where soils naturally contain very low levels of this mineral. Forages and other crops grown in these areas also have very low levels of cobalt. Unless cobalt is added to the ration, cattle grazing in these areas develop a wasting disease (called Nakuritis in Kenya), become anaemic and eventually die. Addition of small amounts of cobalt to the ration, in the form of the chemical cobalt sulphate, effectively prevents the condition. Special mineral mixes are available for cattle kept in areas where cobalt deficiency is known to occur – ask your feed supplier or animal health adviser.
Too much micro-minerals

If the diet contains too much of any of the micro-minerals, either naturally in the feed or added accidentally, this can cause poisoning, although this is not common. Examples of conditions that may occur due to excess minerals are:

**Table 3: Micro-mineral toxicity**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Signs of excess amounts in the body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Muscular twitching; diarrhoea; blindness.</td>
</tr>
<tr>
<td>Iodine</td>
<td>Excessive tears, salivation and nasal discharge; congestion of the trachea (windpipe) leading to coughing.</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Copper deficiency characterized by diarrhoea.</td>
</tr>
<tr>
<td>Selenium (mild poisoning)</td>
<td>Dullness; lameness.</td>
</tr>
<tr>
<td>Selenium (serious poisoning)</td>
<td>Diarrhoea; difficult breathing and fast heart beat; death due to respiratory failure.</td>
</tr>
</tbody>
</table>

**Mineral supplements**

Although forages and concentrates contain some minerals, the types and amounts vary widely and not all minerals naturally present in feeds are available to cattle. Since feeds cannot be relied upon to supply all the required minerals, extra supplementation should be provided in the form of a mineral mixture, to which cattle should have regular access. A good quality mineral supplement will contain all the micro-minerals and most of the macro-minerals a dairy animal will require to remain healthy and productive.

It is recommended to construct a box to hold the mineral mix and place it in the housing unit or at a convenient place in the grazing area. Ideally, the box should be raised from the ground with a roof to protect it from rain so the minerals are not washed away.
There are many cheap salts and mineral mixtures for sale but their quality is often doubtful so:

- Purchase mineral supplements from well known manufacturers
- Make sure the package has a label clearly indicating the mineral content and the identity of the manufacturer
- Ask your feed or agro-vet supplier or animal health adviser about mineral mixtures specially made for your local conditions.

**Calcium and phosphorus**

Two macro-minerals are of particular importance. These are calcium and phosphorus and special attention needs to be given to them when formulating rations. Calcium and phosphorus are naturally found in grasses, legumes, cereals and concentrates and are added to commercially produced dairy meals, but:

- Most tropical soils are deficient in phosphorus and forages grown on them will also be low in phosphorus
- Pastures grown on acid, sandy or peaty soils in humid areas tend to be low in calcium
- During prolonged dry seasons, when there is a shortage of green leafy material, the amount of phosphorus in forages decrease
- Legumes tend to be have more calcium and phosphorus than grasses
- Grains are low in calcium
- Calcium deficiency is most likely to occur in early lactation (milk fever)
- Young, dark green forage tends to contain more minerals than old, dry, yellowing forage

Extra calcium and phosphorus usually need to be provided in the ration over and above that naturally present in the feed and mineral mix, especially for high yielding animals. Good sources of calcium and phosphorus include:

- Steamed bone meal
- Monocalcium phosphate
- Calcium chloride.

**Other macro-minerals**

Common salt (sodium chloride) should also be given to provide sodium and chlorine.

Magnesium is also required in relatively large quantities by high yielding dairy cows. Good sources of magnesium include magnesium oxide and magnesium sulphate.

Forages will usually supply enough potassium.
Water

All animals need water for their bodies to function normally. Without water animals die quickly, within a day or two – much more quickly than they would without food. Water is needed to make saliva to enable feed to be swallowed and for chewing the cud, for food to be digested, to cool the body when it is too hot and to remove waste materials from the body in the urine and faeces. In addition a milking cow needs water for milk production: it takes about five litres of water to produce each litre of milk.

Cross-bred dairy cattle are not well adapted to heat stress and it is therefore especially important to make sure that water is available to them at all times. The amount of water a dairy animal drinks per day depends on many factors, including how much milk is produced, how hot it is, the amount of feed eaten and the water content of that feed.

Ideally, water should be available to dairy cattle at all times. If this is not possible a rule of thumb is to supply one litre for every ten kilograms of bodyweight plus one and a half litres per litre of milk produced. So, a cow weighing 325 kilograms producing ten litres of milk per day should be given a minimum of: \((325/10) + (1.5 \times 10)\) litres = 32.5 + 15 = 45.5 litres daily.
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

5. FORAGES

By the end of this chapter you will:

• Know what factors affect the amount of feed an animal will eat
• Understand the role that bulk forages play in cattle rations
• Be able to judge the quality of forages
• Understand the difference between bulk forages and supplementary forages

Feeling full
People usually eat several meals a day, often breakfast, lunch and dinner, but given the opportunity cattle eat forage throughout the day and night. Dairy cattle, like people, can only eat so much before they feel full and stop eating for a while. It is therefore important that by the time they feel full they have eaten enough of all the nutrients they need to remain healthy and productive. And productive dairy cattle need to eat a lot of feed to supply all the nutrients they need each day.

Some feeds, like fresh green grass, provide relatively few nutrients in a large volume of feed – much of the grass is water. Other feeds provide more concentrated nutrients – for example dry grass (hay) has more nutrients than the same weight of fresh grass. But some dry feeds, such as straw, contain relatively small amounts of nutrients – see Quality of forages, below.

As the name suggests, feeds known as concentrates (such as commercial dairy meal and certain crop by-products) contain more concentrated nutrients than bulk forages.

The amount of feed that dairy cattle eat depends on various factors, some of which are:

• **The animal:** a large animal will eat more than a small one. Also an animal producing a lot of milk will eat more than one producing little milk. And immediately after calving, cows are able to eat less feed than usual.

• **The feed:** animals will eat more young, green, soft forage than old, yellow dry forage. This is because the young forage is more rapidly digested. And like people, cattle prefer some feeds to others.

• **The way the feed is presented:** animals will eat more if the feed is given in larger amounts so they are able to select the pieces they want.

Bulk forages
The cheapest ingredients, and the ones that form the largest part of the dairy cow’s ration, are the bulk forages. These are plant feeds with high fibre contents such as fresh grass, maize thinnings, weeds, hay, straw and stovers.

Forages that are specially grown for feeding to livestock, such as Napier grass or fodder legumes, are usually referred to as fodders.

Forages can be fed to animals either fresh (grazed directly or cut-and-carried), dried (for example as hay) or preserved as silage. Some forages, such as Napier grass, which have long stems, should be chopped into approximately 3 cm lengths before feeding to cattle. This makes it easier to mix with other feeds, such as concentrates, and also prevents wastage by making it more difficult for cattle to select only their favourite parts of the plant.
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

The major portion of the cow’s ration is made up of bulk forages, which have to be consumed in large quantities for the animal to remain healthy and productive. Cattle also need to feel full and bulk forages, with their high fibre content, supply the bulk needed in the ration to fill the gut and prevent cows from feeling hungry.

To remain healthy, stimulate rumination and produce good quality milk with a high fat content, the dairy cow’s ration has to contain enough forage; at least 70 to 80 per cent of the dry matter content of the ration should come from forage.

When designing a ration for dairy cattle, especially more productive cows, it is necessary to provide enough forage to supply the fibre and bulk required but at the same time to supply the energy and protein required to support the desired level of milk production. Dry cows can survive pretty well on forage alone and, provided they are given enough good quality forage, milking cows can produce 5 to 10 litres of milk per day from forage alone. But if the forage is of poor quality – such as rice straw or dry maize stover – then production levels from just forage will be much lower. And higher yielding cows simply cannot eat enough bulk forage to obtain all the nutrients they need – their guts fill up before they are able to absorb sufficient nutrients - and they have to be given other, more nutrient-rich feeds which are called supplements.

Supplements include better quality forages, called supplementary forages and non-fibrous, nutrient-rich feeds called concentrates.

Quality of forages
Good quality forages are those that contain relatively high levels of energy and protein. Young, dark green Napier grass is an example of a good quality bulk forage. Examples of low quality bulk forages are dry maize stalks and wheat straw which are low in both energy and protein – they are cheap but are high in fibre and low in digestibility: they make the animal feel full but provide few nutrients.

The table below classifies commonly fed bulk forages as either good, medium or poor quality – the higher the quality the more energy and protein the forage will supply.

Table 4: Relative quality of bulk and supplementary forages used in East Africa

<table>
<thead>
<tr>
<th>Highest quality</th>
<th>Good quality bulk forages</th>
<th>Medium quality bulk forages</th>
<th>Lowest quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplementary forages *</td>
<td>Young Napier grass (less than 1 metre tall; dark green stems and leaves)</td>
<td>Old Napier grass (1 to 2 metres tall)</td>
<td>Overgrown Napier grass (more than 2 metres tall)</td>
</tr>
<tr>
<td></td>
<td>Young Rhodes/Kikuyu/Setaria grass (fresh, green leaves and stems; up to flowering stage)</td>
<td>Old Rhodes/Kikuyu/Setaria grass (yellowing leaves and stems; seed set)</td>
<td>Dry maize or sorghum stover (after harvesting of the cob)</td>
</tr>
<tr>
<td></td>
<td>Young fodder sorghum (fresh, green leaves and stems; before flowering stage)</td>
<td>Old fodder sorghum (yellowing leaves and stems; seeds set and dropped)</td>
<td>Rice straw</td>
</tr>
<tr>
<td></td>
<td>Young fodder oats (fresh, green leaves and stems; before flowering stage)</td>
<td>Old pasture/grass (yellowing leaves and stems; seed set)</td>
<td>Wheat straw</td>
</tr>
<tr>
<td></td>
<td>Young weeds (fresh green foliage; before flowering stage)</td>
<td>Green maize stover (fresh, green leaves and stalks with cobs removed; food/feed maize)</td>
<td>Barley straw</td>
</tr>
<tr>
<td></td>
<td>Young roadside grass (fresh, green stems and leaves; before flowering stage)</td>
<td>Old weeds (yellowing leaves and stems; seeds set and dropped)</td>
<td>Old, dry pasture/grass (dry leaves and dry, hard stems; seed dropped)</td>
</tr>
<tr>
<td></td>
<td>Hay (made at early to mid-flowering stage of grasses)</td>
<td>Hay (made after seed set)</td>
<td>Bean haulms/husks (after harvesting the beans)</td>
</tr>
<tr>
<td></td>
<td>Maize thinnings</td>
<td>Old fodder oats (yellowing leaves and stems; seeds set and dropped)</td>
<td>Banana pseudostems and leaves (fresh green leaves and stems)</td>
</tr>
<tr>
<td></td>
<td>Horticultural waste (outer leaves of cabbages and fresh green beans and peas rejected by export companies)</td>
<td>Mature roadside grass (seed set, leaves and stems drying and turning yellow)</td>
<td>Sugar cane tops</td>
</tr>
</tbody>
</table>

* See also Table 5 for more information on fodder crops grown as supplementary forages.
Farmers can make some judgments about the quality of a forage from its appearance, smell and texture. For fresh forages, those with more leaf than stem, that are dark green and that feel soft are likely to be better quality than those that are mostly stem, have yellowish leaves and stems or that feel hard or woody. Avoid feeding musty smelling or mouldy forages.

The poorer the quality of the bulk forage, the more supplements will need to be fed to enable high yielding cows to produce as much milk as they are capable of.

None of the bulk forages provide high levels of energy and protein. However, some other forages do have relatively high concentration of these nutrients and are referred to as supplementary forages (see overleaf).

Supplements

Productive dairy cows simply cannot eat enough bulk forage to supply all their nutritional requirements. They need to be fed high quality nutrient-rich feeds in addition to the bulk forages that form the largest part of their rations. These nutrient-rich feeds are called supplements and there are two types:

• Supplementary forages
• Concentrates (see Chapter 6).
Supplementary forages

Supplementary forages are fibrous plants similar to bulk forages but they have higher level of protein and energy than ordinary bulk forages. Most supplementary forages are legumes crops, especially grown on the farm to feed dairy cattle. They include herbaceous legumes, such as lucerne and desmodium, and legume shrubs and trees grown for their leaves, such as calliandra. They are classified as medium to high quality feeds in terms of their protein and energy content.

Supplementary forages can be used in two ways: either to compensate for poor quality bulk forages (such as those listed in Table 4, column 4,) or to substitute for concentrates: for example three kilograms of fresh calliandra can replace one kilogram of commercial dairy meal.

Supplementary forages can be fed fresh, dried as hay, for leaves of shrub and tree legumes as dry leaf meal, or preserved as silage. But they should be fed with caution as feeding large amounts of some supplementary forages can cause bloat and other problems. Usually supplementary forages should not make up more than 25 to 30 per cent of the ration on an as-fed basis.

Lucerne: feed with care

Lucerne is a supplementary forage that cattle like to eat and it is a good source of protein. But if cattle eat too much there is risk of bloat. The risk can be reduced by wilting fresh lucerne for a few hours before feeding in cut-and-carry systems. In grazing systems, use of a commercial ‘stop bloat’ preparation in the drinking water can be helpful. Also, hungry cattle should not be turned out onto lush lucerne pastures.
### Table 5: Supplementary forages: fodder crops grown in East Africa

<table>
<thead>
<tr>
<th>Legume trees and shrubs (nitrogen fixing)</th>
<th>Annual rainfall (mm)</th>
<th>Altitude (masl)*</th>
<th>Soil</th>
<th>Planting material</th>
<th>On-farm role</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calliandra (Calliandra calothyrsus)</td>
<td>Over 1000</td>
<td>Up to 1900</td>
<td>Not acidic; Well drained, no waterlogging</td>
<td>Seed</td>
<td>Hedges</td>
<td>Needs to be fed fresh; Palatability reduced by wilting</td>
</tr>
<tr>
<td>Trichandra (Leucaena leucocephala)</td>
<td>1100 to 2000</td>
<td>200 to 2500</td>
<td>Neutral-alkaline; Well drained</td>
<td>Seed</td>
<td>Intensive plots; Hedges</td>
<td>Less susceptible to psyllid than L. leucocephala</td>
</tr>
<tr>
<td>Diversifolia (Leucaena diversifolia)</td>
<td>1500 to 3500</td>
<td>500 to 2500</td>
<td>Not acidic; Well drained</td>
<td>Seed</td>
<td>Intensive plots; Hedges</td>
<td>Less susceptible to psyllid than L. leucocephala</td>
</tr>
<tr>
<td>Pallida (Leucaena pallida)</td>
<td>500 to 1500</td>
<td>800 to 2500</td>
<td>Neutral-alkaline; Well drained</td>
<td>Seed</td>
<td>Intensive plots; Hedges</td>
<td>Frost tolerant; less susceptible to psyllid than L. leucocephala</td>
</tr>
<tr>
<td>Leucaena (Leucaena leucocephala)</td>
<td>More than 500</td>
<td>Up to 1000</td>
<td>Heavy, fertile, neutral to alkaline; not acidic; well drained</td>
<td>Seed</td>
<td>Intensive plots; Hedges</td>
<td>(Not now recommended due to susceptibility to psyllid insect pest; Toxic to pigs, poultry</td>
</tr>
<tr>
<td>Sesbania (Sesbania sesban)</td>
<td>500 to 2000</td>
<td>100 to 2300</td>
<td>Tolerates acid, alkaline and saline soils; well adapted to periodic flooding and waterlogging</td>
<td>Seed</td>
<td>Intensive pure stands; hedges and alley and intercropping</td>
<td>Indigenous to East Africa, growing near rivers and lakes; Short-lived; 3-5 years when intensively browsed or cut; Also dies back if cut too low (below 50 to 100 cm above ground level)</td>
</tr>
<tr>
<td>Gliricidia (Gliricidia sepium)</td>
<td>600 to 3500</td>
<td>Up to 1200</td>
<td>Tolerates moderately acid soils but needs moderate fertility; No waterlogging</td>
<td>Cuttings</td>
<td>Live fences; Hedges</td>
<td>High yielding and vigorous; Responds well to heavy cutting; regrows whentails in dry season but older shoots desirable; Unpalatable to livestock when fresh; Palatability increases when wilted</td>
</tr>
<tr>
<td>Tree lucerne (Chamaecystisus palmensis)</td>
<td>350 to 1600</td>
<td>Up to 1000</td>
<td>Slightly acidic to neutral; Free draining; does not tolerate waterlogging</td>
<td>Seed</td>
<td>Hedges or direct grazing</td>
<td>Drought tolerant; Recovers well from heavy grazing</td>
</tr>
<tr>
<td>Tree lucerne (Chamaecystisus palmensis)</td>
<td>350 to 1600</td>
<td>Up to 1000</td>
<td>Slightly acidic to neutral; Free draining; does not tolerate waterlogging</td>
<td>Seed</td>
<td>Hedges or direct grazing</td>
<td>Drought tolerant; Recovers well from heavy grazing</td>
</tr>
</tbody>
</table>

### Non-leguminous trees and shrubs

<table>
<thead>
<tr>
<th>Annual rainfall (mm)</th>
<th>Altitude (masl)*</th>
<th>Soil</th>
<th>Planting material</th>
<th>On-farm role</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulberry (Morus alba)</td>
<td>600 to 2500</td>
<td>Up to 2000</td>
<td>Slightly acidic to neutral; Fertile soils essential</td>
<td>Seed and cuttings</td>
<td>Pure stands and around home steads as shade trees</td>
</tr>
</tbody>
</table>

### Herbaceous legumes (nitrogen fixing)

<table>
<thead>
<tr>
<th>Annual rainfall (mm)</th>
<th>Altitude (masl)*</th>
<th>Soil</th>
<th>Planting material</th>
<th>On-farm role</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silverleaf desmodium (Desmodium uncinatum)</td>
<td>Over 850mm and less than 1500mm</td>
<td>800 to 2500</td>
<td>Wide range but not alkaline; Not tolerant of drought</td>
<td>Seed and cuttings</td>
<td>Pure stand, intercropped between Napier rows or as cover crop under fruit trees, bananas or coffee</td>
</tr>
<tr>
<td>Greenleaf desmodium (Desmodium intortum)</td>
<td>Over 850mm and less than 1500mm</td>
<td>800 to 2500</td>
<td>Wide range but not alkaline; Not tolerant of drought</td>
<td>Seed and cuttings</td>
<td>Pure stand, intercropped between Napier rows or as cover crop under fruit trees, bananas or coffee</td>
</tr>
<tr>
<td>Lab lab (Lablab purpureus also known as Dolichos lablab)</td>
<td>750 to 2500 to establish; 200 to 2500 once established</td>
<td>Up to 1000</td>
<td>Tolerates acid/low fertility soils; No waterlogging</td>
<td>Seed</td>
<td>Pure stand, cover crop or intercropped</td>
</tr>
<tr>
<td>Lucerne Medicago sativa</td>
<td>500 to 1000</td>
<td>Up to 2400</td>
<td>Deep, fertile loams, not acidic; No waterlogging</td>
<td>Seed</td>
<td>Pure stand or grazed</td>
</tr>
</tbody>
</table>

### Herbaceous non-legumes

<table>
<thead>
<tr>
<th>Annual rainfall (mm)</th>
<th>Altitude (masl)*</th>
<th>Soil</th>
<th>Planting material</th>
<th>On-farm role</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato (Ipomoea batatas)</td>
<td>750 to 1250</td>
<td>Up to 2000</td>
<td>Slightly acidic, deep fertile loams; Well drained</td>
<td>Vine cuttings from tubers</td>
<td>Tubers for human consumption; vines and foliage as green fodder</td>
</tr>
</tbody>
</table>
BASAL FORAGES

Napier grass

*Pennisetum purpureum* (Common name: elephant grass)

**What is it?**

A fast growing, deeply rooted, perennial grass growing up to 4 metres tall, that can spread by under ground stems to form thick ground cover.

Napier grass is a very important fodder crop in the cut-and-carry system of dairy production, for example in Kenya.

A number of varieties are available but the common ones are French Cameroon, Bana grass and Kakamega 1.

**Advantages**

High yielding; good palatability; good nutrient content when young (dark green, less than 1 metre tall); easy to establish and persistent; drought tolerant; very good for silage making; prevents soil erosion and can serve as a wind-break; can be intercropped with forage legumes such as desmodium.

**Disadvantage**

Not suitable for direct grazing; attacked by various fungal diseases in some areas, such as headsmut in Central Kenya – some varieties are more prone to disease than others; takes a lot of nutrients from the soil - requires a lot of manure/fertilizer to get high yields; not very frost tolerant

**Cultivation**

**Climate**

Napier grass can be grown at altitudes from sea level to 2,000 m – any higher, growth and regeneration after cutting is slow and it may die after frost. It does best in high rainfall areas, over 1500 mm per year, but survives well in droughts due to its deep root system.

**Soil**

Napier grass can grow in almost any soil but does best in deep, fertile, well drained soils.

**Site**

Napier does best as a pure stand. To save labour, under cut-and-carry systems, it is recommended that the plot be situated as close to the zero-grazing unit as possible. Napier may also be planted to prevent soil erosion such as in strips along contours, along river banks and on steep slopes which are unsuitable for growing food crops.

**Preparation**

Prepare site by ploughing or digging. Make sure the site is weed free at the time of planting. If farmyard manure is available, it can be worked into the soil at this time.

**Planting**

The best time to plant Napier is at the beginning of the main rainy season. Wait for two heavy down pours before planting.

Either canes or splits can be used for propagation. Canes require less labour and planting material. If using canes, select mature Napier and cut a length with three to four nodes with buds from the middle part of the cane. Plant canes at an angle of at least 45 degrees.

To use splits, cut the Napier plant to 10 to 15 cm above the soil. Uproot and divide into small parts. Each part should have some roots covered with soil.
Allow 0.5 m between plants and 0.5 m between rows in high rainfall areas and 0.5 m between plants and 1 m between rows in low rainfall areas.

An alternative method of planting napier grass is where several splits or canes are planted in big round or rectangular pits. This method is referred to as “tumbukiza.” For round pits, dig pits 60 cm in diameter, 60 cm deep and 60 cm apart. For rectangular pits, dig 60 cm deep by 60 to 90 cm wide. The length can vary depending on available land. The pits should be 90 cm apart. Separate top soil from sub-soil.

Mix about 20 kg of top-soil with about 40 kg of manure and put into each round pit or 90 cm of a rectangular pit. Plant 5 to 10 cane cuttings or splits in every round pit or for every 90 cm length of the rectangular pit. Cover and leave about 15 cm unfilled space at the top of each pit.

**Fertilizer**
Apply compound fertilizer (NPK: 20-20-0), 1 teaspoon per hole at planting time. After establishment, return as much as possible of the cows’ manure back to the Napier. If practicing zero grazing, collect slurry and apply after every cutting in a furrow between the Napier rows. If applying dry manure, work it into the soil. Apply NPK (20-10-10 or 20-20-0) fertilizer during heavy rains at the rate of 4 teaspoons per plant. Additional topdressing may be done using CAN at the rate of 1 teaspoon per plant after cutting.

**Weeding**
Keep the plot weed-free, especially after initial planting. Once established, Napier grass is able to suppress most weeds other than very stubborn ones like couch grass. Weed after every cutting and avoid heaping soil around the plants.

**Pests**
Napier is relatively free of pests and diseases but it is susceptible to Napier headsmut in some regions. Control by removing and avoiding infected material and planting resistant varieties, such as Kakamega 1.

**Harvesting**
Harvest from 3 to 4 months after planting, when the Napier is about one metre high. Cutting interval varies depending on rainfall but generally harvest when the Napier is about one metre high. Cut the plant to about 5 cm from the ground during the rainy season and 10 to 15 cm during the dry season.

With good climate, soil fertility and management yields can be over 25 tonnes (dry matter) per hectare per year. Yields of about half this amount can be achieved with little or no fertilizer.

**Feeding**
Fresh material is commonly fed in stalls under cut-and-carry system. Chop the material into pieces about 5 cm long to avoid wastage. Do not graze directly.

Excess Napier grass can be made into good quality silage. If it is not possible to make silage, leave a portion of the plot standing and continue to harvest the rest at the optimum height.

When necessary, use the tops of overgrown Napier to feed cattle. The old canes can also be used as mulch or they can be made into compost.
Rhodes grass
*Chloris gayna* (synonym Eustachys paspaloides)

**What is it?** A vigorous, perennial grass, originating in South Africa, with a strong root system giving good drought tolerance. It spreads quickly forming good ground cover and grows to 1.5 metres tall.

It grows under a wide range of conditions and is useful in cut-and-carry system and for open grazing and is very popular for hay making. There are a number of varieties but the common ones are Giant, Boma, Mbarara and Masaba Rhodes.

**Advantages**
- Does well in low rainfall areas and is drought tolerant;
- Stands heavy grazing;
- Very palatable;
- Good for hay making.

**Disadvantages**
- Can be hard to establish due to poor seed germination;
- Can be grazed out due to high palatability.

**Cultivation**

**Climate**
- Grow at altitudes from 600 to 2000 m above sea level. It does well in areas receiving rainfall of more than 250 mm annually and also persists well under drought conditions.

**Soil**
- It grows in a wide range of soil conditions but performs best in loamy, fertile soils. It does not do well in alkaline or very acid soils.

**Site**
- It is best grown in grazed plots or shut-up for hay making.

**Preparation**
- Plough and harrow at least once to make a fine seedbed. Harrow after the weeds have emerged to reduce competition during establishment. Sow immediately after harrowing.
- Sowing: it is usually established from seed but root splits can also be used. The best time to sow where there are two rainy seasons is during the short rains. Where there is one rainy season, plant from early to mid rains.
- Sow when the soil is loose (dry). Make furrows 25 cm apart using a peg. Drill the seeds in the furrows, at a seed rate of 12 kg per hectare. Cover the seeds lightly, for example by pulling light tree branches over the furrows.

**Fertilizer**
- For high productivity, apply nitrogen fertilizers preferably during heavy rains at the rate of 100 kg per hectare.

**Weeding**
- Make sure the plot is weed-free during the initial period of establishment. Remove weeds between the rows using a hand hoe.

**Pests**
- No diseases of importance but common pests such as army worms may attack the pastures.

**Harvesting**
- Start harvesting or grazing soon after flowering. If cutting, cut close to the ground to stimulate spreading. Leave to re-grow again until next flowering.
- When well managed, Rhodes grass can yield an average of 8 tonnes dry matter per hectare per year.
- Feeding Grazing is the most common method of feeding Rhodes grass although some farmers use it for cut-and-carry. Tends to decrease in abundance on over-grazed pasture due to its high palatability.
- Rhodes grass is very good for hay making.
- It can also be used for seed production; up to 350 kg seed per hectare can be harvested.
Setaria

*Setaria sphacelata* (common name: Nandi setaria)

**What is it?**
A tall, tufted, perennial grass that grows up to 1 metre high, producing succulent, very dark green, narrow leaves with flowers borne on a long stalk. The grass is nutritious and highly palatable in the young stages but becomes tough at the base as it matures. Mainly useful in open grazing system but can also be used for cut-and-carry systems. It can also be used for silage and hay making. The common varieties are Nandi, Kazungula and Narok.

**Advantages**
Withstands water-logging; nutritious and palatable

**Disadvantages**
Forage yield is generally low; grazing must be managed very carefully otherwise the stems become hard and leaf production becomes even lower; unproductive in dry periods.

**Cultivation**

**Climate**
It can grow in a wide range of areas but is more common in medium to high altitude areas with rainfall ranging from 700 to 2000 mm per year.

**Soil**
Will grow under a wide range of soil conditions but does best on sandy or loamy soils of good fertility. It withstands water logging.

**Site**
Setaria can be grown in cut-and-carry as well as grazed plots. It can also be grown in strips along contours for soil erosion control.

**Preparation**
Prepare a fine seedbed by ploughing and harrowing at least once. Harrow after the weeds have emerged to reduce competition during establishment. Sow immediately after harrowing.

**Sowing**
Plant early to middle of the rainy season. Where there are two rainy seasons, it is best to plant during the short rainy season. Setaria can be established from seed, splits or rooted cuttings but is best established from seed.

Sow seed when the soil is loose (dry). Make furrows 25 cm apart using a peg. Drill the seeds in the furrows no deeper than 2 cm, using a seed rate of about 12 kg per hectare. Cover the seeds lightly by pulling light tree branches over the furrows.

If using splits or cuttings, plant on ridges, using a spacing of 20 cm between plants and 50 cm between rows.

**Fertilizer**
If manure is available, a generous amount should be worked into the soil during seedbed preparation or put into the planting furrows/holes and thoroughly mixed with soil. In addition, apply 125 kg NPK fertilizer per hectare at planting time. After the first harvest apply 250 kg NPK fertilizer per hectare each year.

**Weeding**
Keep the plot weed-free especially during the initial period of establishment. After the grass is well established, it competes well with weeds.

**Pests**
General pests such as army worm and locusts may pose a threat to setaria but there are no important diseases.
Harvesting

Start harvesting or grazing soon after flowering. Initially it should be lightly grazed but once well established, graze heavily to prevent it becoming tough. When cutting, cut to 10 cm from the ground. If well fertilized, it can be cut or grazed every 8 weeks.

It can yield an average of 7.5 to 15 tonnes dry matter per hectare per year depending on location and management.

Feeding Setaria is best utilized for open grazing.

Although setaria can be used in silage making, excess grass is best conserved in the form of hay.
GROWING MAIZE FOR FOOD AND FODDER

What is it?  It is possible to obtain both fodder for dairy animals and grain for household use or sale from a single crop of maize. This involves planting maize more densely than is usual when growing maize just for grain.

Fodder from maize is a good alternative when Napier regenerates too slowly, as can happen after severe draught or frost. It is possible to produce as much as 40 tonnes of green forage per year per hectare by planting maize densely.

Advantages
• More and better quality fodder from the same land
• Fodder from maize when other feed is scarce; saves buying feed off-farm
• Napier is allowed to regrow while fodder fed from maize or the Napier can be harvested and conserved for use in time of scarcity
• Surplus fodder can be sold for cash

Disadvantages
• The major disadvantage to dense planting is the increased requirement for fertilizer and manure
• When using a higher seed rate, beans should not be planted in the same hole as maize but in between the maize rows. This may result in increased labour requirement.
• Bean yields are reduced where maize is intercropped with beans
• Dense planting produces many smaller cobs. This may present an obstacle to selling green maize for roasting. If the maize is harvested dry, it will require more labour for harvesting and shelling

Methods
Fodder can be obtained from a maize crop by:

**Thinning:** This is removal of weak, thin and sick plants whilst weeding the crop or as need for fodder arises. Maize thinnings are of high nutritive value and can be obtained even after flowering so that only one or two plants are left to mature for grain.

**Leaf stripping and topping:** This involves removing the bottom leaves and cutting off the plant top soon after the ‘dough’ stage.

**Harvesting the stover (the maize stem and leaves):** This is done after the maize cobs have been harvested. The stover can be either green or dry depending on how long it is left in the field.

**Salvage crop:** This is an option when the maize crop fails, for example when the rains fail.

**Denser planting:** More fodder from a maize crop can be obtained through denser planting. This involves either planting more seeds per hole or using a closer spacing than is usual for maize.

More seeds
Plant 4 or 5 instead of the usual 2 seeds per hole to increase the number of plants and hence the amount of available fodder:
• Apply double the usual amount of fertilizer or manure: 20 g (two teaspoons) fertilizer instead of the usual 10 g (one teaspoon) or four handfuls instead of the usual two handfuls of manure per hole at planting
• Dig holes double the normal size and spread the maize seeds evenly.

**Closer spacing**  Reduce the spacing of the planting holes to 30 cm between holes and 60 cm between rows to increase the number of plants. Apply fertilizer and manure at the usual rate: 10 g of fertilizer or two handfuls of manure per hole at planting.
TYPES OF SUPPLEMENTARY FORAGES

Desmodium

Desmodium intortum/ Desmodium uncinatum (common name: green leaf/silver leaf desmodium)

What is it? A trailing or climbing perennial legume with small leaves and deep roots which, in favourable conditions, forms very dense ground cover.

There are numerous varieties but the two most common are the green leaved and the silver leaved ones. Green leaf desmodium is leafier with reddish brown to purplish spots on the upper surface of the leaves and reddish brown stems.

Silver leaf desmodium has stems and leaves covered in dense hairs which make them stick to hands and clothing. It has green and white leaves which are light green underneath.

Desmodium is popular in cut-and-carry systems.

Advantages High quality, protein rich forage; can be grown between or under other crops - as it fixes nitrogen it increases yields and reduces the need for nitrogen fertilizer.

Disadvantages Seed is expensive and very small; needs rhizobium inoculant; in very high rainfall areas (more than 1500 mm per year) it suffers from pests and diseases; does not tolerate drought; may need irrigation in lower rainfall areas; does not tolerate alkaline soils.

Cultivation Climate It does well in warm, wet regions at altitudes of 800 m to 2500 m receiving at least 875 mm rainfall per year.

Soils Adapted to a wide range of soils from sands to clay loams and tolerates slight acidity but not salinity. Acidic soils can be improved by applying manure at the rate of 8 tonnes per hectare prior to sowing or planting.

Site Desmodium can be grown as a pure stand or as a mixture with Napier grass in cut-and-carry plots. It can also be grown under a maize crop or even as a cover crop under bananas or coffee.

Preparation Desmodium seed is relatively expensive, very small and the seedlings can be swamped by weeds, so it is best sown in a weed-free, well prepared nursery seedbed with fine textured soil. A seedbed 3 m by 3m, raised 15 cm high, will require about 100g of seed.

Desmodium needs to grow in close association with a group of very beneficial bacteria called rhizobia. These bacteria live in the roots of desmodium and other legumes and can fix nitrogen from the air, which is then available as a free fertilizer to the desmodium plants.

If available, packs of rhizobia inoculant should be obtained. Mix the contents with the desmodium seed and carefully following the instructions on the pack. If not available, mix the seed with a handful of soil from another good desmodium plot.

Sowing The best time to plant is at the start of rains. For areas with two rainy seasons, sow seeds during the short rains but plant cuttings during the long rains.
Sow the seed immediately after adding the inoculant. The seeds can be sown either by drilling or by broadcasting. For drilling, make shallow furrows about 5cm deep spaced 30cm apart. Cover the seed with 1 cm of soil and press softly. For broadcasting, spread the seed evenly over the seed bed.

The nursery bed should be watered carefully and often. Shade may be provided but it should be removed soon after germination.

Desmodium can also be established from cutting. Compared to seed, cuttings are bulky but can be obtained at little or no cost from a neighbour and they compete well with weeds during establishment.

Get cuttings from an established nursery or from desmodium in the field. Desmodium cuttings should be vines 60cm long with soil still attached to the new roots. Make furrows 30cm apart and 10cm deep and plant the vines 30cm apart.

Desmodium can be grown between rows of Napier grass. Plant the Napier grass at a spacing of 1m between plants and, wider than usual, with 2m between rows. Make holes between rows of the newly planted Napier. Plant desmodium cuttings 30 cm apart, as you would sweet potato vines. When grown together with Napier, desmodium adds nitrogen to the soil, benefiting the Napier and reducing the amount of nitrogen fertilizer required for topdressing. Once desmodium has fully established, it forms a complete ground cover which smothers the weeds, thus reducing the labour requirement and cost of weeding the Napier plot.

*Intercropping Desmodium with Napier grass: Napier grass planted at a spacing of 1m between plants and 2m between rows. Desmodium planted between rows of the Napier.*
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

**Fertilizer**
Apply 500g of phosphate fertilizer, TSP (45% P) or DAP (46% P, 18% N) to the 3m by 3m plot before sowing and mix thoroughly with soil.

Alternatively add 15 kg dry farmyard manure to the seedbed before planting.

When growing desmodium with Napier grass, add one handful of farmyard manure per hole at planting and mix thoroughly with the soil. Also apply 2 bags TSP or DAP fertilizer per hectare during heavy rains and after every cut apply manure in a furrow and cover with soil.

**Weeding**
Keep the plot weed-free especially during the early stages of establishment. When well established, desmodium is able to suppress weeds.

**Pests**
Common pests are aphids and the Amnemus weevil, both of which can be controlled by use of insecticides: be careful to strictly observe use and safety instructions on the pack. If aphids are not controlled, they may transmit a viral disease known as little-leaf.

A fungal disease, anthracnose, can affect desmodium especially in poorly drained soil.

**Harvesting**
*Desmodium pure stand:* Start harvesting after at least four months. The best harvesting regime is to cut at 12-week intervals at no less than 10cm above soil level.

*Desmodium – Napier mixture:* First harvest should be at least four months after establishment or when the Napier is about 1 m high and at an interval of 4 to 10 weeks thereafter. Cut the desmodium and Napier together. Leave stumps of 10 to 15 cm above the ground for both crops.

**Feeding**
Desmodium is a good quality supplementary forage with a high protein content. It should be given in small quantities mixed with basal fodders.

Harvest just what is needed and spread it in the sun for a few hours to wilt. Chop and mix thoroughly with other forages, such as maize stover or Napier grass, then feed to the animals.

Three to six kilograms of green desmodium is equivalent to one to two kilograms of the commercial concentrate.

Excess desmodium may be cut, dried and baled into hay and used as a protein supplement. It can also be mixed with grass when making hay.
Lucerne

Medicago sativa (Common name: alfalfa)

What is it? Lucerne is a deep rooted, perennial herbaceous legume that produces a lot of stems and leaves and, upon maturity, small purple flowers. It is established from seed.

It is used as a supplementary forage for dairy cattle as well as feed for horses, beef cattle, sheep and milking goats. It is high in nutrients and highly palatable.

Lucerne is used primarily as hay, but it can also be used in cut- and-carry systems and even as year round pasture. It is generally grown alone but can also be mixed with grasses or other legumes.

Advantages

Highly palatable; high nutrient content; high yielding under irrigation.

Disadvantages

Needs a lot of water and usually requires irrigation; does not tolerate water logged or acid soils; risk of bloat if overeaten.

Cultivation

Climate

Lucerne will grow in a wide range of climatic conditions but does best in warm climates with a lot of sunshine. It will not do well unless adequate water is available.

Soil

Lucerne is adapted to a wide range of soil conditions but prefers deep, well drained, highly fertile loamy soils. It does not tolerate water logged or acid soils and occasional liming of the soil is required.

Site

Lucerne is best grown as a pure stand.

Preparation

Prepare a very fine, levelled and firmed seedbed.

Sowing

Sow seeds at the start of rains, either in furrows or by broadcasting. Prepare shallow furrows 30 cm apart. If growing lucerne for the first time, the seed needs to be inoculated with rhizobia; follow instructions on the pack. Drill along the furrows or broadcast seed at a rate of 5 to 7.5 kg per hectare or, if growing under irrigation, double the amount of seed sown. Cover the seeds to a depth of approximately 0.6 cm.

Fertilizer

If possible, apply 100 kg of single super phosphate fertilizer per hectare before planting. To maintain a vigorous, productive stand, reapply phosphate fertilizer each year.

Weeding

Keep the plot weed-free until full ground cover is achieved.

Pests

Lucerne is susceptible to numerous pests and diseases which can cause damage at any stage of growth. Some important pests include lucerne weevil, caterpillars, cutworms/army worms, aphids and leafhoppers.

Some important diseases are bacterial leaf spot, common leaf spot, downy mildew, stem blight and many others. They can be controlled by natural predators, use of chemicals, maintaining a healthy stand, crop rotation and use of resistant varieties.

Harvesting

Harvest for the first time when the crop begins to flower. Cut at 5 cm above the ground every 5 to 7 weeks, or, if grown under irrigation, monthly.
Dry matter yields can be up to 20 tonnes per hectare depending on management. In general, annual yields of lucerne decline with the age of stand, the decline being faster if the crop is poorly managed, affected by extreme weather or attacked by pests and diseases.

**Feeding**

When feeding as cut-and-carry fodder, leave the cut forage to wilt before giving to the animals to prevent bloat or mix the lucerne with grass. If lucerne is to be grazed, use a rotational grazing system, allowing 30 to 35 days for re-growth. Allow animals to graze only when the soil is dry to avoid root damage from trampling.

To reduce the chance of bloat, use a commercial “stop bloat” preparation in the drinking water and do not turn hungry animals onto lush lucerne pastures.

Excess lucerne is best conserved as hay or silage. For the best quality hay, cut the crop in the early bud stage. It is also possible to make silage but the crop must be wilted and an additive such as molasses applied or it can be mixed with other feeds such as sorghum. Lucerne can also be dried and processed into cubes, pellets or meal.
LEUCAENA

Leucaena spp.

What is it? The various species of leucaena are perennial, deep-rooted, large shrub/small tree legumes growing up to 20 m tall. They have compound leaves with many thin leaflets, white flowers and produce a lot of seeds in pods.

The leaves are a very good source of protein and can be used in both cut-and-carry and open grazing production systems. Re-growth occurs very fast after cutting.

It can be used as shade in plantation crops, as living supports for climbing crops, such as passion fruit, and also for soil conservation and, being a legume, aids maintenance of soil fertility. The mature shrub can be cut for poles for fencing and wood fuel and as bee forage.

Advantages Drought tolerant, highly digestible and palatable forage supplement.

Disadvantages High mimosine content which can be poisonous in large amounts; can become a weed due to its prolific seed production

Cultivation

Climate Leucaena grows from sea level up to 1900 m but performs best up to 1000 m above sea level. It does well in areas with rainfall above 600 mm per year.

Soil It grows best on deep, well drained clay soils and does not do well in acid soils.

Site Leucaena may be planted as single plants, single hedgerows or multiple hedgerows, in cut-and-carry plots, grazed plots, along boundaries or even along contours for soil erosion control.

Preparation Thorough seedbed preparation is required. Plough and harrow to make a fine seedbed.

Sowing Leucaena is established from seeds which can be sown either directly into the field or in a nursery.

To break seed dormancy, soak in warm water for 48 hours, or in boiling water for 4 seconds, or nip the broad (round) end. Inoculate the seed with the correct rhizobia.

Make a sticking agent by mixing 2 parts sugar with 1 part of warm water. Mix the sticker thoroughly with required amount of inoculant, following the instructions on the pack. Pour the seeds into the mixture and mix until every seed has a fine sticky coating. Spread the seed to dry in cool shade for 15 to 30 minutes. Plant immediately.

For direct sowing in the final growing site, make furrows 3 to 10 m apart and sow the seed at a rate of 1 to 2 kg per hectare, planting the seeds 2 to 3 cm deep.

For nursery propagation, use plastic tubes filled with free-draining soil, sand and manure in the ratio of 3:2:1. Sow two seeds per tube. Water regularly as required and control weeds by hand pulling.

One week after the seedlings emerge, thin to one seedling per tube.

Transplant seedlings when they are eight weeks old. For a pure stand, prepare holes spaced 1 m by 1 m and at least 30 cm deep. For alley cropping or grazing, allow a spacing of 75 cm between plants and 3 to 10 metres between rows. Remove plastic tubes and place the seedling in the holes. Cover with moist soil and firm around the seedling.
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**Fertilizer**
At the time of transplanting, apply triple super phosphate fertilizer at the rate of 120 kg per hectare, or one tablespoon per hole, and mix with soil.

**Weeding**
Leucaena seedlings are very susceptible to weed competition, therefore make sure the plot is weed-free when the seedlings are small.

**Pests**
The psyllid insect (Heteropsylla cubenseis) is the most important pest and it can wipe out the entire crop, especially of the species L. leucocephala. To control it, plant species that are resistant to this pest such as L. diversifolia. Biological control using a beetle and a parasitic wasp is showing promise.

Damping-off is an important fungal disease affecting seedlings in the nursery. This is controlled by avoiding excess watering and using free-draining soil.

**Harvesting**
Start harvesting at the beginning of the second wet season by cutting back to 50 cm above ground level. Cut twice during the wet season when re-growth is 50-60 cm, or once at the end and conserve as dry leaf meal. First grazing may be done when the plants are 1.5 m in height but it should be light at first. Avoid heavy grazing until the plants are fully mature, from 1 to 3 years old. Grazing or harvesting intervals can be 6 to 8 weeks or 12 weeks in less favourable conditions.

When well managed, leucaena can yield up to 2 tonnes dry matter per hectare per year.

**Feeding**
Leucaena is a high quality, very palatable supplementary forage. It is best cut and fed fresh or as dry leaf meal.

Feeding excessive amounts can cause bloat and hair loss, therefore leucaena should not make up more than 30% of the total ration.

Leucaena leaves can be dried and fed as dry leaf meal or used in
CALLIANDRA

Calliandra calothyrsus

What is it?
A small leguminous tree growing up to 12 m tall with a dense canopy and pink flowers. Although evergreen in humid areas, it drops its leaves during prolonged dry periods and may die back in severe droughts but will recover with the rains.

It responds well to coppicing (harvesting the branches from near to the ground) and the leaves and young stems are used as protein supplement in cut-and-carry systems.

Other uses include for fuelwood, erosion control, smothering weeds and as green manure in rotation with arable crops. It is also used in alley-cropping systems and can be used as an effective understorey in coconut plantations.

Advantages
Grows well on acid soils on which leucaena does not thrive. Leucaena also suffers from psyllid insect (Heteropsylla cubana) attack, whereas adult psyllids are unable to feed or lay eggs on calliandra.

Disadvantages
Has a lower forage production and lower feeding value than leucaena; can only be fed fresh; digestibility is lower than that of other common tree fodders. Calliandra can be a poor seeder so seed production is often limited. When grown with food crops, it can suppress yields if not cut back in good time.

Cultivation

Climate
It grows well in warm climate at altitudes up to 1500 m above sea level with an average rainfall of 700 to 4000 mm per year.

Soil
It grows in a wide range of soils, including acid soils, but need moderate fertility. It does not tolerate water logging.

Site
Calliandra may be planted as a pure stand in cut-and-carry plots at planting densities of up to 40,000 trees per hectare, as hedgerows or live fences along boundaries and around the homestead, within Napier grass plots, along contours for soil conservation and as an alley crop.

Preparation
For direct sowing, plough the land and harrow to prepare a fine seedbed. If seeds are to be sowed in a nursery, prepare a seed bed about 1 m wide and 3 m long for 400 seedlings. Raise the seedbed by piling the soil to a height of about 10-15 cm and then level the top. Paths of 0.6 m should be left if additional nursery beds are to be prepared Support the sides with materials like banana stems, timber or stones.

Sowing
Plant just after the onset of heavy rains. For areas with two rainy seasons, prepare the nursery during the short rains so that the seedlings may be ready for transplanting during the long rains.

The seeds may be sown directly into the field or in the nursery. Seeds will germinate without pre-treatment, but germination can be improved by brief immersion in almost boiling water and then soaking for a further 24 hours. If inoculating, mix inoculant with water, add soaked seed then sow immediately but use of inoculant is not considered essential.
Direct sowing of seed: Make furrows 3 to 10 metres apart and drill the seed at a rate of 1 to 2 kg per hectare. Place the seeds 2 to 3 cm deep.

Nursery establishment: Make furrows in the seed bed about 2 cm deep and 10 cm apart. Place the seeds in the furrows at 5 cm intervals and cover to depth of 2 to 3 cm. A seedbed 1 m x 3 m requires about 40 g of seed. Water the seed bed thoroughly immediately after sowing. Cover with dry grass if termites are not a problem. Ideally, seedlings should be replanted into plastic tubes when they produce two leaves to improve their survival rate.

Nursery management: Make a shade structure 1 m in height, covered lightly with grass. Reduce the shading gradually as the seedlings grow. Water twice a day (morning and late evening) in the first two months then reduce to once a day, preferably late evening. Avoid over-watering. Keep the nursery completely free from weeds. Sprinkle ash around the seedlings to protect them from pests.

Transplanting into the field: Two weeks before transplanting, reduce the watering frequency to 2 to 3 times a week. Remove the shading completely to harden off the seedlings in order to help them withstand field conditions. Dig planting holes 0.5 m apart. Remove seedlings carefully from the seedbed or plastic tubes and plant in the prepared holes. Bare roots should be kept in water to prevent the seedling from drying up.

Fertilizer: When preparing the nursery, apply 15 kg of manure to a 1m by 3m seed bed and mix thoroughly with soil. After germination apply about 2 g (one soda bottle top) of phosphate fertilizer at the base of each seedling to speed-up growth. When transplanting seedlings, apply 2 kg manure per planting hole and mix well with the soil. To sustain production, supply the trees with adequate manure or apply fertilizer at the rate of 100 kg P per hectare.

Weeding: Keep seedlings weed free especially during the first few months after transplanting. A fully established crop is able to suppress most weeds, however weed out stubborn weeds after every harvest.
Feeding dairy cattle: *A manual for smallholder dairy farmers and extension workers in East Africa.*

### Pests

<table>
<thead>
<tr>
<th>Pest/Disease</th>
<th>Importance</th>
<th>How to control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales</td>
<td>White powdery insects that attack mature trees on the stems.</td>
<td>Sprinkle washing detergent (e.g. &quot;Omo&quot;) solution.</td>
</tr>
<tr>
<td>Black ants</td>
<td>Attack the bark of mature tree; tree can die.</td>
<td>Dig out and destroy the ant nests. Smear wet dung, old engine oil or sprinkle ash at the base of the stem.</td>
</tr>
<tr>
<td>Termites</td>
<td>Seriously damage the tree by feeding on the stem.</td>
<td>Control as in the case of black ants.</td>
</tr>
<tr>
<td>Crickets and hoppers</td>
<td>Attack mainly young seedlings in the nursery and immediately after transplanting.</td>
<td>Pest repellents used in horticulture may be used but chemicals are not appropriate where trees are for feeding livestock. Tobacco and garlic mixture may also be used.</td>
</tr>
<tr>
<td>Armillaria mellea</td>
<td>A fungus that attacks the roots causing the plant to die. Common in formally forested areas which have recently been cleared.</td>
<td>Do not plant calliandra in areas which have been recently cleared of trees. Uproot affected plants and burn them. Leave affected areas for some years before replanting.</td>
</tr>
</tbody>
</table>

*Source: Charles Wambugu, 2002. *Calliandra calothyrsus: Tree management and utilization. A pamphlet for farmers and field extension staff* by ICRAF.*

### Harvesting

Coppicing can start 9 to 12 months after planting, when the tree is about 2 m high. Initially, cut the tree to 30 cm above ground level to encourage it to spread from the base. Later, cutting heights should be higher, usually from 0.5 to 1 m above ground level but it may be cut lower – even to ground level - if grown between food crops.

A well established stand can be harvested 4 or 5 times a year with harvesting interval varying with the rainfall. Cut again when re-growth is 50 to 60 cm. Calliandra can also be grazed, but this tends to reduce the life of the trees.

Depending on rainfall and soil fertility, dry matter yields range from 5 to 10 tonnes per hectare per year.

### Feeding

Feed fresh calliandra to supplement basal forages such as Napier or other grasses, weeds, crop residues, hay or straw. Three kg of fresh calliandra fodder can replace one kg of commercial dairy meal.

Drying or wilting of calliandra greatly reduces the extent to which it can be digested so it should be fed fresh within one hour of cutting.

The best way of conserving excess calliandra is leaving it uncut on the tree and harvesting it when it is needed.
By the end of this chapter you will:
• Understand the role of concentrates.
• Know how much concentrate to feed and how to feed it.
• Know how to make a home-mixed concentrate.

Concentrates

Concentrates are nutrient-rich feeds – they provide far more nutrients (energy and/or protein) than an equivalent amount of bulk forage. They include compound feeds manufactured by milling companies, such as dairy meals, cubes and pellets, as well as single ingredients, such as brewers’ waste, maize germ meal or molasses.

Concentrates differ from supplementary forages in two main ways: they usually have little or no fibre and also usually have a higher dry matter content.

Advantages of concentrates:
• Supply concentrated nutrients.
• Contain very little fibre.
• Have a high dry matter content.
• Are palatable (cattle like to eat them) and easy to digest.

Disadvantages of concentrates:
• Are expensive.
• Quickly break down in the rumen forming acid which can prevent effective digestion of forages.
• Can cause health problem if too much is eaten, for example where concentrates form 60 to 70 per cent (dry matter) of a ration or more than 14 kilograms is fed per day.

Economics of feeding concentrates

Failure to feed enough supplements, especially early in the lactation, is the main reason why many cows give much less milk than they are capable of, which reduces the profit the farmer could have made. Also, soon after calving cows cannot eat enough bulk to provide all the nutrients they need and supplements, including concentrates, are especially needed at this time.

As much forage as possible should be fed before supplementing the ration with concentrates. Too little forage in the ration can also lead to a decrease in milk fat content. Concentrates are expensive – more expensive than forages - and they should therefore be used to support additional milk production. This means that the farmer will get a return on the money spent on concentrates. If the rules of concentrate feeding are followed (see below), money spent on concentrates will lead to higher milk yields and higher profits.

Different types of concentrates

There are many different types of concentrates. They can usefully be classified according to the major nutrient supplied – some are good sources of protein others of energy and some are good sources of both protein and energy.
Table 6 classifies concentrates as high, medium or low protein and high, medium or low energy.

<table>
<thead>
<tr>
<th>Protein level*</th>
<th>High &gt;17%CP</th>
<th>Medium 10 to 17% CP</th>
<th>Low &lt;10% CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High &gt;12 MJ/kg DM</td>
<td>cotton seed meal</td>
<td>groundnut meal</td>
<td>molasses</td>
</tr>
<tr>
<td>Medium 10 to 12MJ/kg DM</td>
<td>sunflower meal</td>
<td>dairy meal</td>
<td>rice bran</td>
</tr>
<tr>
<td>Low &lt;10MJ/kgDM</td>
<td>poultry litter</td>
<td>brewers' waste</td>
<td>maize bran</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maize germ meal</td>
<td>wheat pollard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wheat bran</td>
<td></td>
</tr>
</tbody>
</table>

* Protein levels are given as crude protein expressed as a percentage of the feed's dry matter (CP % DM).

Note: In addition some other concentrates have very high protein levels (50-95 per cent crude protein). These include blood meal, meat and bone meal and fish meal. Although not commonly used by smallholder dairy farmers, addition of small amounts of these concentrates may be appropriate in some situations and depending on their price. Expert advice should be sought before feeding these very high protein concentrates.

How to feed concentrates

The type and amount of concentrate to feed an individual cow will depend on the quality of forage the cow is given and the level of milk production. Forages vary in quality: generally legumes are of high quality, fresh grasses medium and crop residues, such as straw, low quality, containing high, medium and low levels of protein, respectively.

If the milking cow is fed on forage with a low protein content, such as tall, overgrown Napier grass or dry maize stalks, then concentrates with a high protein content need to be given to provide a balanced diet and support a high milk yield. If the cow is fed on high protein forages, such as good quality pasture, or also receives supplementary forages, such as lucerne, lower protein concentrates can be used – or no concentrates may be needed, depending on the cows’ milk yield.

How much to feed?

Concentrates are expensive and therefore should be fed carefully to get the best return on your investment. The amount of concentrates fed should depend on the level of milk production and the quality of forage. The most economical level of feeding concentrates is the point at which the last amount of additional concentrate added to the ration is just paid for by the extra milk produced by that unit of concentrate. But this point may be difficult to determine for individual cows – it requires careful measurement of the amount of concentrate given and milk produced. Also, it is influenced by changes in milk and feed prices – if the milk price drops, it may no longer be economical to feed as much concentrates.
Alternative approaches to feeding concentrates

**Challenge feeding:** This method of concentrate feeding is traditionally recommended for cows in early lactation. Begin with a low level of concentrates, such as four kilograms of dairy meal per day, and gradually increase the amount of concentrates fed each day until the point is reached when adding more concentrate does not result in an increase in the next day’s milk production. Continue with this level of feeding for the first 12 weeks of the lactation. After 12 weeks, the amount of concentrates fed should depend on the milk yield. If the cow is fed on good quality forage it should be able to produce five to ten litres of milk per day on forage alone. For every litre of milk produced over and above five litres, feed half to one kilogram of concentrate. So, for a cow producing eight litres of milk per day after 12 weeks, feed one to two kilograms of concentrate per day.

**Flat rate feeding:** Feeding a constant amount of concentrates, for example two kilograms per day, throughout the entire lactation is not recommended. During early lactation the concentrate fed is insufficient, while during late lactation it will be too much.

**Targeted concentrate feeding:** If financial constraints mean it is not possible to feed as much concentrates as would be ideal, then it is best to feed all the concentrates available during early lactation. Cows produce more milk during early lactation and they need plenty of nutrients to support this. Also, the amount of milk they produce during this period influences the amount of milk they will produce later in the lactation - the more milk they produce in early lactation, the more milk they will give in late lactation.

A comparison between flat rate and targeted feeding is shown in following box. Targeted feeding is probably the simplest and most effective way for most smallholder farmers to feed concentrates.

**Comparison of flat rate versus targeted feeding of concentrates**

Farmer A and Farmer B both have cows which came from the same herd and are capable of giving the same amount of milk. Both farmers feed as much good quality Napier grass as the animals will eat, but Farmer A practices flat-rate feeding while Farmer B practices targeted concentrate feeding.

Farmer A feeds his cow 2.4 kg of dairy meal every day throughout the ten month lactation. Meanwhile Farmer B feeds his cow 8 kg of dairy meal for the first three months only. The results are very different as shown in Table 7, overleaf:
### Table 7: Flat rate vs. targeted feeding

<table>
<thead>
<tr>
<th></th>
<th>Farmer A – flat rate feeding</th>
<th>Farmer B – targeted feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrate fed</td>
<td>2.4 kg per day for 10 months</td>
<td>8 kg per day for first 3 months only</td>
</tr>
<tr>
<td>During the first 3 months</td>
<td>cow gives 8 litres milk per day</td>
<td>cow gives 15 litres milk per day</td>
</tr>
<tr>
<td>During next 7 months</td>
<td>cow gives 6 litres milk per day</td>
<td>cow gives 5.5 litres milk per day</td>
</tr>
<tr>
<td>Total milk yield over 10 month lactation</td>
<td>1,980 litres</td>
<td>2,505 litres</td>
</tr>
<tr>
<td>Total amount concentrate fed</td>
<td>720 kg</td>
<td>720 kg</td>
</tr>
<tr>
<td>Cost of concentrate fed (@KSh1200/90kg*)</td>
<td>KSh 9,600</td>
<td>KSh 9,600</td>
</tr>
<tr>
<td>Value of milk produced over entire lactation (@KSh19 per litre*)</td>
<td>KSh 37,620</td>
<td>KSh 47,595</td>
</tr>
<tr>
<td>Profit: value of milk less cost of feed</td>
<td>KSh 28,020</td>
<td>KSh 37,995</td>
</tr>
<tr>
<td>Benefit from targeted feeding</td>
<td>-</td>
<td>+ KSh 9,975</td>
</tr>
</tbody>
</table>

*Note: the price of milk and feed varies. These figures are used as an example only.*

### How to make your own concentrate mix

In chapter 2 we learned about the importance of a balanced ration and the major nutrients that make up such a ration: energy + protein + minerals. Providing your cow with a balanced ration using the feeds and ingredients available to you is a challenge. Animal nutrition is a specialist subject and professional animal nutritionists have access to a great deal of information and can use laboratories and computers to help them. This section aims to provide simple, basic guidelines for making your own concentrate mix for your dairy cows.

Commercial dairy meal is produced by mixing different feeds so that the final feed is relatively high in protein (about 16% CP DM) and has a good (but not overly high) amount of energy. Dairy meal is often expensive, and may not be cost-effective, especially if the quality is sub-standard or the farmer has to pay high transport costs. It is possible to make a better quality and more cost-effective mixture using largely ingredients grown on the farm. However, seasonal fluctuations in availability mean that the ingredients needed are not always available and it may not always be possible to make your own ration.
Table 8 classifies different supplementary feeds – concentrates and supplementary forages – commonly fed in East Africa, according to the amount of protein and energy they contain.

Table 8. Protein and energy content of common supplements

<table>
<thead>
<tr>
<th>Protein</th>
<th>Energy</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Medium</td>
<td>cotton seed meal</td>
<td>sunflower meal (1)</td>
<td>turnips (chopped)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2)</td>
<td>mangolds (chopped) (3)</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
<td>groundnut meal</td>
<td>maize germ meal</td>
<td>maize bran</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sweet potato vines</td>
<td>brewers’ waste (wet)</td>
<td>rice bran (6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lucerne; desmodium</td>
<td>wheat bran</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>calliandra leaves</td>
<td>wheat pollard (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>sesbania leaves (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To make a mixture similar to dairy meal, select feeds from the different boxes (see Table 9 below).

Table 9. A concentrate mix for lactating cows

Option 1: Using feeds in box 1–6 in Table 8

60 buckets or scoops from box 5; 25 buckets or scoops from box 6 or 3
15 buckets or scoops from box 1 or 4; 2 buckets or scoops of minerals

Option 2: Using feeds in box 1–6 and fish meal

60 buckets or scoops from box 5; 35 buckets or scoops from box 6 or 3
5 buckets or scoops of fish meal; 2 buckets or scoops of minerals

If feeds are fresh (wet) rather than dried (e.g. box 3, forages in box 4 and brewers’ waste in box 5), add three times as many scoops. This is because the dry matter content of these feeds is much lower.

Carefully mix the ingredients together – you can do this by placing them on a large polythene sheet and mixing with a shovel. Store your home mixed ration in a dry place and use your concentrate mix as you would have fed commercial dairy meal.

How to mix rations at home: groundnut meal; brewers waste, maize bran turnips and cotton seed are some of the ingredients described in Table 8 (Box 1-6)
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

Maintaining stable conditions in the rumen

People generally eat one or more large meal a day. But cows need to be fed in a different way. Because their feed is first digested by micro-organisms in the rumen, it is important to keep conditions in the rumen as constant as possible so the micro-organisms can do their job efficiently. To achieve this, cows need to feed almost constantly - so you should always aim to have basal forage available for them. Also, it is best to mix supplements with the bulk forage to avoid big changes in the feeds entering the rumen and to prevent the cow from eating the supplements too quickly. This will avoid the risk of digestive problems, such as acidosis, which will put your cow off its feed and can even lead to lameness. If cereals are fed as part of the ration, these should not be over-processed, for example by grinding too finely, as this too can lead to acidosis: all that is required when feeding grains is to crush them lightly so the grains break in half.
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

7. FEEDING CALVES, HEIFERS AND COWS

By the end of this chapter you will:
• Understand that dairy cattle need different amounts of nutrients at different stages of their lives
• Know how to feed calves
• Know how to feed heifers
• Know how to feed milking cows
• Know how to feed dry cows

Dairy cattle need different amounts of nutrients (energy, protein and minerals) at different stages in their lives and, for cows, depending on how much milk they are producing. Nutrients are needed for:

Maintenance: Animals require nutrients, especially those that supply energy and minerals, to remain alive and keep their bodies working properly without losing weight.

Growth: Apart from maintaining the body, young growing animals require additional nutrients, especially protein, energy and minerals, in order to develop and grow normally.

Reproduction: A pregnant cow requires additional nutrients, especially protein and minerals, to support the development of the calf growing inside it.

Milk production: A lactating cow requires more nutrients in order to produce more milk – the more milk produced the more nutrients, especially protein, energy and minerals, it will need.

Feeding the calf
The aims of a good calf feeding programme are:
• Fast growth rate and rapid weight gain
• Strong disease resistance
• Development of a healthy, normal calf

This should be achieved economically, allowing milk to be also taken for home consumption or sale.

A properly fed cow which is in good condition during pregnancy should give birth to a healthy, well developed calf.

Unlike adult cattle, when a calf is born it is not able to digest fibrous feeds, such as grass. This is because the rumen – the bag-like stomach that in adult cattle contains enormous numbers of tiny micro-organisms that can digest fibre and make the nutrients available – is not yet developed. New-born calves’ digestive systems are more like that of people than cattle. But by introducing good quality fodder from the second week, the rumen gradually develops, so that the calf can start to digest fibrous feeds, such as grass, hay and Napier grass, whilst continuing to be able to digest milk.

From birth until eight to twelve weeks of age, the calf’s diet consists mainly of milk.

From the second week after birth it can gradually be introduced to concentrates (ideally calf pellets) and good quality forage, such as good hay.

Calves can either be fed naturally, by allowing them to suckle from their mothers, or can be fed from a bucket. Advantages of the two methods are shown in the table below. In most cases, natural suckling is to be recommended for small-scale dairy farmers as it is simpler, more hygienic and less likely to lead to health problems.
Table 10. Advantages of suckling and bucket feeding calves

**Advantages of suckling**
- Simpler system to manage
- Milk is at the correct temperature (body temperature)
- Milk is clean; there is no chance of contamination through poor handling or from unclean equipment
- Calf is unlikely to get scours
- No investment required for feeding equipment
- No labour is required for feeding the calf
- For zebu cows, the calf suckling stimulates milk let down; without a calf being present the cow cannot be milked
- Lower mortality rate

**Advantages of bucket feeding**
- Calf experiences less noise and disturbance
- Records can easily be kept of consumption
- Easier to control the amounts of milk and other feed given to the calf
- Possible to record and monitor the cow’s milk production

To teach the calf how to feed from the bucket:

- Put two fingers in the calf’s mouth so it starts to suck
- Gently lower its mouth into the colostrum in the bucket
- Slowly remove the fingers and the calf will start drinking from the bucket
**Feeding the calf: day 1 to 4**
Encourage the calf to suckle immediately after birth. The milk that cows produce for the first three to four days after calving is called colostrum. Colostrum is different from normal milk. It:
- Contains antibodies, which help protect the calf against certain diseases
- Is very rich in nutrients and easily digested
- Has a higher protein and energy content than normal milk, and also contains higher levels of vitamins and minerals
- Has a laxative effect that assists the calf to pass its first faeces.

The calf should be allowed to drink as much colostrum as possible during the first four days of life. Either allow it to suckle freely for the first day and then three times a day up to day four, or with bucket feeding feed four to five times a day.

**Feeding the calf: day 5 to weaning**
Where the calf is allowed to suckle from the cow (natural feeding), let it suckle only after milking – the calf will need to be kept away from its mother when not suckling.
Do not completely milk the cow out or there will be no milk left for the calf. A simple way to feed the calf is to leave one teat unmilked and allow the calf to suckle this after each milking. Leave the calf with the mother for around two hours and then remove it until after the next milking.

**Bucket feeding**
For calves that are bucket fed, give milk according to whether it is in an early (at eight weeks of age) or late (at 15 weeks of age) weaning system.

| Table 8. Protein and energy content of common supplements
| Age | Daily allowance: offered in 2 to 3 meals |
| --- | --- | --- | --- |
| | Milk (litres) | Early-weaner pellets (kg)* | Good quality hay or forage |
| Birth to 4 days | colostrum-free choice | nil | nil |
| Day 5 to week 6 | 6 | _ - 1 | free choice |
| Week 7 to 8 | 4 | up to 1.5 | free choice |

*Or dairy meal if not available.*

| Table 12: Example of a feeding schedule for late weaning |
| Age | Daily allowance: offered in 2 to 3 meals |
| --- | --- | --- | --- |
| | Milk (litres) | Early-weaner pellets (kg)* | Good quality hay or forage |
| Birth to 3 days | colostrum-free choice | nil | nil |
| Day 4 to 7 | 4 | handful | free choice |
| Week 2 – 3 | 5 | 0.5 | free choice |
| Week 4 – 8 | 5 | 0.75 | free choice |
| Week 9 | 5 | 1.0 | free choice |
| Week 10 – 11 | 4 | 1.0 | free choice |
| Week 12 – 13 | 3 | 1.0 | free choice |
| Week 14 - 15 | 2 | 1.0 | free choice |

*Or dairy meal if not available.*

Alternatively, a good rule of thumb is that calves should be fed 15 per cent of their birth weight in milk each day. So, a calf that weighs 30 kilograms at birth would be fed 4.5 kilograms of milk per day.
Feeding dairy cattle: A manual for smallholder dairy farmers and extension workers in East Africa.

When bucket feeding of calves care should be taken:

• Feeding excess milk to the calf can cause scouring. If scouring occurs, reduce the amount of milk by half and mix this with an equal amount of water
• Give the calf its milk immediately after milking when the milk is at body temperature
• Observe strict cleanliness and hygiene to prevent scouring and other disease problems
• From the second week, provide the calf with clean drinking water at all times
• From the second week start introducing small amounts of solid feeds, such as good quality hay, sweet potato vines and a little dairy meal (or ideally calf pellets or pencils)
• Hang a mineral lick where the calf can get the minerals it needs.

Feeding the heifer

Heifers are young weaned female cattle that have not yet had their first calves.

The way a heifer is fed is very important as it can greatly affect:

• Age at first service
• Ability to conceive (to become pregnant)
• Age at first calving
• Lifetime milk production
• Length of productive life.

A well-fed, healthy heifer that was also well-fed as a calf should be ready for its first service (mating) at 18 months of age. A poorly fed heifer will never reach its full potential. The heifer calf should be accustomed to solid feed, including forages and concentrates, well before weaning (see above).

Heifers that are less than one year old have high nutrient requirements as they are still growing - their rumens are still quite small and cannot hold a lot of forage. Unless the heifer is fed on good quality forage, forage alone will not provide the ideal amount of nutrients and will result in a slow growth rate.

Provide access to water and a mineral lick at all times.

From 3 to 6 months

Continue feeding good quality fodder, preferably as much as the calf will eat. In addition, feed young stock pencils or if unavailable a good quality dairy meal at the rate of one and a half kilograms per day, reducing to one kilogram per day by the time the calf is about six months old. During this period the calf will be weaned off milk – in some systems it will have been weaned earlier.

From 6 to 18 months

By six months of age, good quality fodder (such as chopped, dark green, one metre tall Napier grass) is sufficient to meet the heifers’ needs. If only poor quality fodder is available, however, continue feeding dairy meal.
Feeding the milking cow

A good feeding programme for a milking cow should:
- Achieve a high peak yield early in lactation and a high total lactation yield
- Prevent too much weight loss
- Enable the cow to go on heat, become pregnant and produce a healthy calf
- Make best use of the feeds available.

A lactating cow requires nutrients for:
- Maintenance
- Growth if she is young (less than 30 months)
- Growth of the unborn calf if she is pregnant
- Milk production.

The amounts of the different nutrients required will depend on which of the above applies to the cow.

Immediately after calving, the cow has a low appetite and will not eat as much feed as the body may require. In addition, the cow needs a lot of nutrients to recondition the body as well as to support milk production.

If the cow is not given adequate feed during early lactation, it will not produce as much milk as it could, even if the feed supply is improved later in the lactation.

In order to make milk production more economical, feed cows with as much forage as possible before offering concentrates – forage is cheaper than concentrates.

Ensure the milking cow has constant access to water and regular access to a good quality mineral mix.

Early lactation

**Forages:** Always provide the cow with as much good quality forages as possible, such as young, dark green Napier grass. With good quality forage, it is possible to produce five to ten litres of milk per day from forage alone. Large breed of cow, such as a Friesians, can eat more than 100 kilograms of fresh forage each day. Lighter breeds, such as Jerseys, can eat 65 to 85 kilograms of fresh forage a day.

When supplementary forages, such as lucerne, desmodium, calliandra or leucaena, are available, these should be mixed with the basal forage, such as grass or Napier grass, ideally at a ratio of one part fresh supplementary forage to three parts fresh basal forage.

**Concentrates:** Research has shown that it is much better to feed eight kilograms of concentrate per day for the first twelve weeks of lactation and then just good quality forages alone, 8 kilograms per day (see Alternative approaches to feeding concentrates, p x).

Mid to late lactation

During this time the milk yield drops gradually. Supplement the diet depending on the quality and quantity of forage. Feed the cow as much good quality forage as it will eat. At this stage the cow should produce up to five litres of milk on good quality forage alone and concentrate should be given according to the milk yield. For every one kilogram of concentrate fed, one to one and a half litres of milk should be produced over and above the five litres produced from the bulk forage. Alternatively, under the targeted feeding regime, no concentrates will be fed during this period.
Feeding the dry cow

Around two months before the expected date of calving, the cow should be ‘dried off’ – this simply means stopping milking. This is done to allow the cow time to prepare for the next lactation. The dry period should be between 45 and 60 days.

The aim of the feeding programme for the dry cow is to:

- Ensure that the cow is in good condition at the time of calving and gives birth to a healthy calf
- Enable the cow to produce as much milk as it is capable of during the next lactation
- Avoid health problems around calving (e.g. milk fever) or in early lactation (e.g. ketosis).

During the dry period the cow requires nutrients to:

- Maintain the body
- Support the unborn calf
- Repair milk-producing cells of the udder in preparation for the next lactation.

The dry cow should not gain excessive body weight; cows that become too fat are more likely to have problems at calving time and over-feeding dry cows is wasteful and does not make economic sense.

The amount of concentrate fed, if any (see below), should be decided according to the quality of forage available and the body condition of the animals. A good quality forage, such as one metre tall, dark green Napier grass, can be fed alone. However, a lower quality forage, such as dry maize stalks, requires supplementing with concentrates.

During the last two weeks of pregnancy, the cow’s appetite will be reduced.

**Dry period (60 to 14 days before calving)**

During this time the cow can eat a lot of forage. To allow the cow to dry off, do not feed concentrates during the first two weeks of the dry period. After this, and depending on the body condition and quality of forage available, start with half a kilogram of dairy meal (or equivalent) per day, gradually increasing the quantity as shown in Table 13.

Provide the cow with access to a good quality mineral mixture during this time.

**Preparation for the next lactation (14 days to calving)**

In addition to the basal forage, feed concentrates increasing the amount gradually so that by the time of calving the cow will be getting at least four kilograms per day – this is called ‘steaming-up’ and is done to ensure a healthy calf and prepare for the next lactation.

Stop offering mineral supplements for the first week of this period - that is between 14 and seven days before calving is due. This will stimulate the body’s mechanism for drawing on calcium stores in the bones which can help avoid health problems in early lactation (milk fever). Resume feeding minerals one week before calving is due.

**Table 13: An example of a steaming-up schedule**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Amount of dairy meal per day (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 weeks before calving</td>
<td>0.5</td>
</tr>
<tr>
<td>5 weeks before calving</td>
<td>1.0</td>
</tr>
<tr>
<td>4 weeks before calving</td>
<td>1.5</td>
</tr>
<tr>
<td>3 weeks before calving</td>
<td>2.0</td>
</tr>
<tr>
<td>2 weeks before calving</td>
<td>2.5</td>
</tr>
<tr>
<td>1 week before calving</td>
<td>3.0 – 4.0</td>
</tr>
</tbody>
</table>
8. CONSERVING FORAGES AND COPING WITH DROUGHT

By the end of this chapter you will:

• Know that there are different ways of storing forages
• Know how to make hay and dried leaf meal
• Know how to make silage
• Know how to cope with drought

Forages grow well during the rainy season and grow more slowly, or stop growing all together, during the dry season unless irrigation is possible. But dairy cattle need to be fed all year round and often milk prices are higher during dry periods. Dairy farmers therefore need to plan ahead and make sure that forages will be available during all seasons. In addition, periodic droughts present even bigger challenges to smallholder dairy farmers.

Storage of forages

There are three main ways that forages can be stored – they can either be dried, which is the most common approach, be preserved by turning them into silage or can be left unharvested in the field and used as needed. Different types of forage require different types of treatment and some treatments are more suited for use by small-scale farmers than others.

Hay making

Hay is made from grass or herbaceous legumes, such as lucerne and desmodium. The fresh material is cut and dried naturally by the sun and wind and in the process the water content is greatly reduced. Hay is a good source of forage for dairy cattle.

Grass is about 80 per cent water and hay is about 20 per cent water – this means that for every kilogram of grass, 800 g is water, while for every kilogram of hay, just 200 g is water.

The quality of hay depends on the material it is made from, the stage in the growing cycle of that material, the way the hay is made and how it is stored. Hay made from natural pasture and grass can make bulk forage while hay made from herbaceous legumes can make supplementary forage containing higher levels of protein.

To make good hay it is important that the material is cut at the right stage of the growing cycle. If cut too early there will be little material for hay making. If cut too late the protein level in the hay will be much lower – much of the plant’s proteins will have been put into making seeds which drop from the plant as it dries and the leaves will become brittle and easily break off leaving just hard, indigestible stems. Generally the best time to make hay is when the plant is at the early to late flowering stage. This can be difficult to achieve as it may occur during the rainy season – when it is obviously impossible to make hay. The longer the grass is left after this stage, however, the lower the nutritional quality will be.

To make hay, first the grass or herbaceous legume is cut close to the ground and left in the field to dry. It is turned over once a day for three days. This process needs to be carried out during hot, dry weather. Hay is ready when it breaks when the stems are bent in half and is a light brown colour.

The best way to store hay is in bales. On large farms, bales are made using a tractor drawn baler, which gives compact, regular shaped bales that can readily be stacked. But bales can also be made by hand using a simple wooden frame. The frame should measure 100 cm x 50 cm and be 40 cm deep and be open at the top and bottom. First, two lengths of sisal twine are laid across the frame and left to hang over the side. Hay is then placed in the frame, tightly compressed – for example by walking on the hay – and then when the box is full of well compacted hay, the bale is very tightly tied with the twine before pushing it out of the frame.
Hay should be stored away from rain and sun, ideally in a barn. If this is not possible the bales can be stacked on wooden slats to raise them off the ground and covered with plastic sheeting until needed. If it is not possible to make bales, hay can be simply stored on a wooden tripod – the hay is placed with the stems lying up and down (not across) the tripod so that the rain can more easily run off. Finally, if it is not possible to make hay using either of these methods, the grass or other materials can be left growing in the field where it naturally dries off and becomes standing hay. This method is not ideal, however, as the crop matures completely and is exposed to sun and rain, and as a result is of poor nutritional value.

**Leaf drying**

Leaves from legume trees and shrubs, such as calliandra, leucanena and Sesbania sesban can also be dried and make a convenient high protein supplementary forage. The leaves are cut, as they would be for feeding, during hot, dry weather and dried on a large sheet of polythene until they become dry and brittle, which takes around three days. The dried leaf meal can then be stored in sacks kept in a dry place until needed.

**Straw and maize and sorghum stalks**

Straw and dried maize and sorghum stalks can simply be stuffed into old sacks, which are then kept in a dry place until needed. They can also be stored in barns or stacked on wooden slats as suggested above for hay.

**Silage making**

Silage is a way of preserving grass and other materials for later use as cattle feed. Unlike hay making, in which the material is dried, in silage making the material is fermented (a similar process is used to make beer) in conditions where there is little air available. Natural micro-organisms turn the sugars in the plant material, and extra added as molasses, into weak acids (a bit like vinegar) which then act as a preservative. The result is a sweet smelling, dark coloured, moist feed which, once they get used to it, cattle love to eat.
Silage can be made in large, black plastic sacks. The plastic must have no holes in it to keep the air out - otherwise the silage will spoil. Silage can be made from grass, fodder sorghum, green oats, green maize or Napier grass. First the material is cut – the same considerations regarding when to cut, discussed above for hay, also apply to silage. The material then needs to be chopped into pieces no more than 2.5 cm long. It is then sprinkled with a molasses and water mixture: for one sack use 600 ml to one litre of molasses mixed with two- to three-times as much water. Place the chopped material, sprinkled with the molasses/water mixture, into the black plastic sack – this can be made from a length of specially made 1000 gauge plastic ‘tubing’ that is 1.5 metres wide (available from agro-vet and hardware shops). Cut a 2.5 metre length, tie off one end and then fill with the material, compressing it well and then tie off to seal. Stack filled sacks until needed. A well-prepared silage will be bright or light green-yellow in colour, smell similar to sour milk and have a firm texture. The moisture content should be 60-70 per cent and the pH below 4.2 (acid) for wet crops and below 4.8 for wilted silages. Bad silage tends to smell similar to rancid butter or ammonia (contained in household bleaches). Fermentation is usually complete after 21 days.

Sequence of drawings showing making silage – chopping, sprinkling with water & molasses and compressing.
9. FEEDING DAIRY CATTLE DURING DROUGHTS

Usually the aim of keeping and feeding dairy cattle is to maximise profit – that is to provide the appropriate combination of feeds that supplies all the nutrients the cow needs to enable it to produce the maximum amount of milk, and to do this in the most cost-effective manner possible.

However, when feeds are in very short supply, for example during droughts, the objective changes. In such situations the main aim is to keep the animal alive until conditions improve. If necessary, a healthy, previously well-fed cow can lose up to one fifth of its bodyweight and still remain healthy, and recover its normal weight when more feed becomes available.

During droughts there is a shortage of fresh, green forages and bought-in feeds are likely to become more expensive. But cattle still need to be fed. There are a number of tactics and strategies that can be used to help the dairy farmer cope with drought conditions. These include short-term emergency measures as well as longer-term strategies.

Short-term measures

As the usual forages become scarce or unobtainable introduce unconventional feeds that are available locally. These might include: sugarcane bagasse, sugarcane tops, straws, tree leaves, vegetable leaves, horticultural waste, cactus, paper waste, sawdust, Neem seed cake and others.

But care should be taken with unusual feeds: for example, sawdust has no feed value and is used simply to provide gut fill and keep the rumen working. The sawdust used must not come from timber that has been treated with any chemicals. Sawdust must not be fed to calves and when fed to adults must not make up more than 15 per cent of the ration on an as-fed basis.

Also, crops which fail to grow to maturity due to the drought can be used as forages.

In addition, consider reducing the number of animals in the herd by selling any unproductive cows or old animals.

If milk production needs to be maintained – droughts can also be opportunities as milk prices are likely to be high - then high quality nutritional supplements need to be fed, which will be costly. Options include:

- Urea treatment of straws (expert advise is needed before this option is adopted)
- Complete feed formulations or commercial feeds (although this can be expensive).
Long-term strategies to help dairy farmers be better prepared for droughts include:
- Creation of feed and fodder banks
- Preserving surplus forages grown in good seasons/years as silage, hay or leaf meal for use in the lean season/year

Using conserved forages during times of drought can help farmers cope with feed shortages.

- Avoid wasting of feed and fodder for example by adopting methods such as chopping forages to reduce loss during feeding
- Plant alternative fodder crops
- Adopt intercropping / mixed cropping strategies to increase fodder production
- Cultivate fodder in unused areas of the farm
- Plant fodder trees and shrubs, especially along boundaries as edible hedges
- Adopt deworming and vaccination strategies to improve overall health and increase ability of animals to cope with drought and, in the case of deworming, to decrease loss of nutrients to worms. See your animal health advisor for more details.

Keep your cow in comfort
If you feed your cow a ration made up of the correct amount of the right ingredients, fed in the right way, you will be well on the way to getting the most from your investment. But there is more to keeping a cow than feeding it. One area often neglected is comfort. A good rule of thumb is, do not expect your cow to sleep on a bed that you would not like to sleep on! Providing comfortable bedding for your cow is simple and inexpensive but can avoid a lot of problems with wounds on the legs and blisters on the feet. The bed can be soft sand, soil, straw or rubber mats – almost anything is better than bare concrete.
In case of problems with your cow’s feet, or any other health problems, contact your animal health advisor without delay.