GOLDEN VALLEY AGRICULTURAL RESEARCH TRUST

MANUAL ON IMPROVED FEEDING OF DAIRY CATTLE BY SMALLHOLDER FARMERS

For Dairy Extension Workers and Dairy Farmers

G. S. Pandey, Dairy Development Specialist
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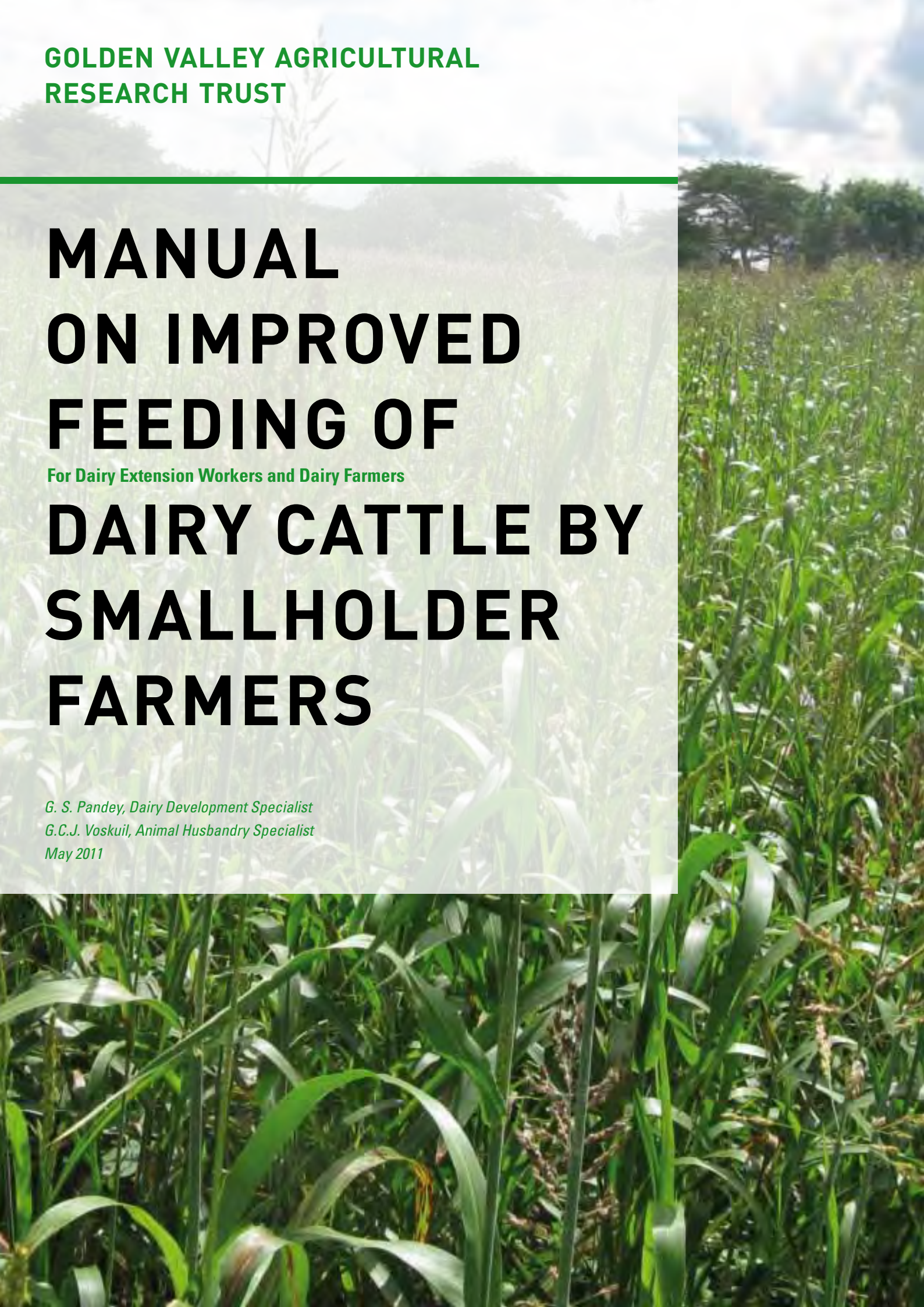
May 2011



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PREFACE

The annual consumption of milk in Zambia is about 25 litres per capita. This is well below the level of 200 litres recommended by the WHO and FAO. For this reason the Government of Zambia recently put dairy high on the national development agenda.
It is estimated that half of the domestic annual consumption of milk in Zambia is produced by smallholder farmers. According to Parmalat, the largest dairy processor in Zambia, the company's milk intake from smallholder farmers increased from below 10 % five years ago to ± 20 % at present.

GART's core science and technology competencies are in smallholder livestock systems, conservation farming and seed systems development. Under the smallholder livestock systems programme its Smallholder Dairy Development Progamme (SDDP) is the largest activity. Through Batoka Livestock Development Centre GART distributes ± 200 in-calf dairy crossbred heifers to smallholder farmers on a yearly basis. This has triggered the success of the programme greatly. GART started the SDDP in 1994 in Southern Province and expanded its activities in 2006 into Lesotho as well. Since 2006 GART is receiving support from the UN Common Fund for Commodities (CFC) to strengthen its smallholder dairy programme in Zambia and in Lesotho.
GART is increasingly being considered a centre of excellence and lead knowledge centre in smallholder dairy development in many parts in Zambia as well as in the whole SADC region. Typical services offered by GART to smallholder dairy producers are: training and extension in profitable small-scale dairy farming, attachment of dairy extension workers to producer groups, helping farmers to establish and manage milk collection centres and linking up with milk processing companies.
Co-operative producer groups are the backbone of the SDDP. The well functioning of these groups is of crucial importance for the successful operation of the emergent farmer, as they are often the only channel to reach the smallholder farmer. Through these cooperatives farmers continuously request for additional training and coaching in the various aspects of managing their dairy animals. There exists hunger for knowledge in the sector.

The major constraint experienced in small holder dairy farming in Africa is the quantity and quality of the feed supplied to the animals. This manual addresses this problem and in particular tries to come up with solutions to overcome the feed shortage experienced during the dry season. The manual is meant to provide extension officers with practical background material, what they can use to design and conduct training programmes on improved feeding for small holder farmers. I expect that this manual will serve that purpose.
I like to thank CFC who provided the funds to GART to publish and disseminate this manual. Finally, it is my wish that this manual goes a long way to support the smallholder dairy sector in the whole of Southern Africa.

Stephen W. Muliokela, PhD
Director GART

CONTENTS

1. INTRODUCTION

It has been observed that the milk production by smallholder dairy farmers during the dry season is significantly reduced. During that period, which might last up to six months per year, the quantity of milk, which the average farmer is able to sell and deliver is reduced by 35% - 60%. This means that the income of those farmers is also reduced considerably during that period. However, it is also observed that in many cases the milk production and the delivery of milk by commercial and by progressive smallholder dairy farmers is hardly affected. This fact is clearly illustrated in Table 1. The milk delivery from about 160 farmers at a Smallholder Dairy Farmers Association (SDFA) is reduced in the period April – October, while the delivery of milk by a commercial farmer is rather consistent during the year.

	Milk delivered in litres	
Month	**Magoye SDFA**	**A commercial farmer**
January	49,000	180,000
February	56,000	168,000
March	40,000	177,000
April	35,000	180,000
May	33,000	181,000
June	31,000	170,000
July	30,000	186,000
August	31,000	172,000
September	32,000	176,000
October	31,000	182,000
November	36,000	178,000
December	37,000	190,000

TABLE 1: An example of milk delivery by Magoye Smallholder Dairy Farmers Association and a commercial farmer from the same region in Zambia

The main reason for this difference is the availability of sufficient fodder during the dry season. A farmer should grow a quantity of fodder at his farm, that enables him to reserve part of it in the rainy season to make hay and/or silage. In addition animals can be supplemented with feed residues, byproducts and concentrates in the dry season. For an improved feeding it is also essential that sufficient water is made available for the animals to drink.

The evidence of such an approach is illustrated once more from the example in Table 2, which compares the difference in milk delivery between two smallholder dairy farmers in Zambia. The progressive farmer practices improved feeding and makes sufficient water available throughout the year. Although both farmers deliver equal quantities of milk during the wettest months December and January, on annual basis the progressive farmer is able to deliver much more milk and therefore to generate a much higher income from his animals.

	Monthly milk delivered in litres	
Month	**Ordinary farmer**	**Progressive farmer**
January	1,301	1,150
February	986	1,205
March	952	1,330
April	861	1,339
May	579	1,585
June	319	1,657
July	330	1,459
August	478	1,272
September	592	1,050
October	773	1,020
November	889	1,060
December	1,234	1,110
Total	9,294	15,237

TABLE 2: Milk delivery by two smallholder dairy farmers in Zambia

FIGURE 1: Graphical view of table 2

2. PURPOSE OF THE MANUAL

From the above data it is clear that availability of good pasture, feed and water is crucial for a sustainable milk production during the dry season. The aim of this manual is to assist, by imparting knowledge to extension workers and through them to smallholder dairy farmers, in achieving a more constant milk production throughout the year. Emphasis will be given to improved fodder and feed production, fodder conservation and the use of cheap dairy feed mixtures, based on the available different feed ingredients.

3. BENEFITS OF SMALL SCALE DAIRY FARMING

The benefits of small scale dairy farming include the following aspects:

- The produced milk is considered as a perfect human food. Through home consumption and sales, it contributes considerably to the health status of the people in rural areas.

- The sold milk provides the farmer with a regular income throughout the year.
- Income from milk is more reliable than from beef. Milk sales continue during outbreaks of diseases when livestock movements are banned.
- The animals provide income through the sale of surplus heifers, and at the same time form a source of meat.
- The animals provide organic (kraal) manure, which is essential to maintain a good soil fertility at the farm.
- The animals provide other by-products, like skins for leather, etc.
- Small scale farming is an agriculture based rural development enterprise, which creates employment in the rural areas.
- Small scale farming contributes to the formation of a commercial agro-industry and creates business opportunities.
- Dairy farming requires and therefore develops discipline among farmers and their workers.
- Milk enhances the immune system of people and in that way contributes considerably to the reduction of child mortality. Moreover, it remains available during periods when common food often is in shortage.

FIGURE 2: A smallholder dairy farm

3.1 Conditions that favour dairy farming

The following conditions are required to enable a good environment for dairy farming:

- A good climate with sufficient rainfall, preferably well distributed over the year.
- A good water supply from rivers, streams, dams, boreholes, etc. Water is essential for the animals to drink and to maintain a good hygienic standard at farms.
- A nearby market for the milk within reach. Either informally direct to consumers or formally through Cooperative Societies and milk processors.
- Availability of inputs, like stock feeds and veterinary drugs.

- Access to technical information and support of a dairy extension service and to breeding facilities, like Artificial Insemination (A.I.) or bull camps.
- Access to an infrastructure with all weather roads.
- Knowledge of good crop husbandry; like maize, foddercrops and legumes.
- A cultural background with a tradition of cattle keeping and milk consumption.

3.2 Essentials of successful dairy farming

To make dairy farming a successful enterprise at the farm the following factors are essential:
- Availability of good quality feeds, fodder, water and grazing throughout the year.
- Suitable breeding animals with potential for milk production.
- Good animal husbandry practices.
- Effective disease and parasite control.
- Title deed land settlement.
- Favourable good government policy biased towards smallholder dairy farmers.

4. SOURCES OF DIFFERENT NUTRIENTS AND THEIR FUNCTIONS

Animals require energy to enable them to live and produce. The only source of energy for them is the feed they eat. Animals rely in all cases directly or indirectly on plants as the origin of everything they eat. Plants contain 3 groups of organic compounds which contain energy (Fig. 3). These are:
- Proteins
- Carbohydrates
- Fats

Besides these, plants contain minerals, vitamins and water. In principle the animal body is composed of the same elements as plants. However, the composition of plants and animals is quite different. That is why animals require different types of feed which during the digestion are converted into nutrients essential for their body. These enable the animals to maintain their body and to receive sufficient energy for all their body functions. The different nutrients, their function in the animal body and their presence in some feeds are briefly discussed below.

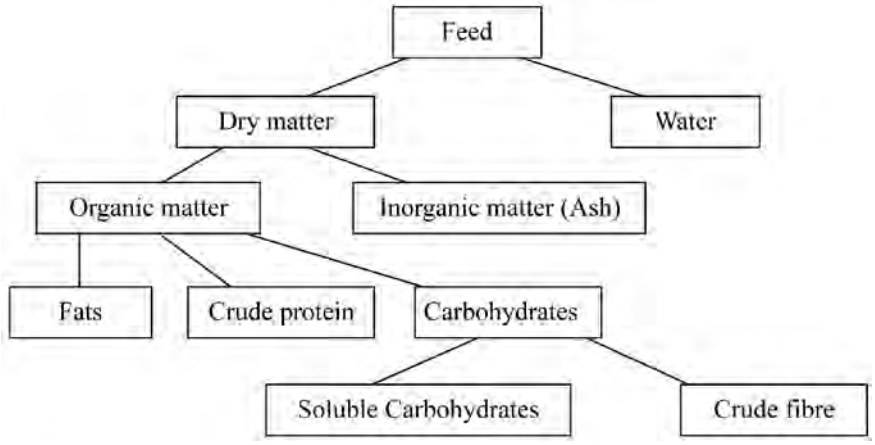

FIGURE 3: Chemical breakdown of a feed into its components

4.1 Protein

Proteins are composed of amino acids, which all contain Nitrogen (N). Nitrogen is not present in carbohydrates or fat. Proteins are one of the most important parts of a feed and form an essential nutrient. It is continuously needed by animals for the development and maintenance of their body and for the production of milk, etc. Moreover, a constant supply is necessary for the animals to remain healthy.

Functions of proteins in the animal body

- Make up new tissues and muscles in the body
- Repair the loss of body tissues / healing
- Necessary for growth and development of the body
- Necessary for the production and functioning of enzymes and hormones
- Necessary to produce milk of a good quality

- Necessary during pregnancy for the development of the unborn calf
- Hair, horn, hooves and feathers are composed of protein
- Assist in providing resistance against diseases
- Milk contains casein, what forms the basis of cheese making
- Excess protein gives energy to the body

Presence in feeds

Proteins are found in the soft and green parts of plants. In particular in the leaves. When a plant grows older, it develops a strong stem and becomes less leafy. That is why an older plant contains less proteins. Most plants obtain the Nitrogen (N), which they require to form proteins, through their roots from the soil. However, one group of plants, the legumes, are able to utilize N from the air. For that reason leguminous feeds always have a relatively high protein content.
The total protein content of a feed is expressed as crude protein.

Some examples of the differences in the percentage of crude protein in some feeds:

	Feed	Crude Protein %
Low	Straw	1 - 2
	Hay	6 - 7
Medium	Green fodder	3 - 12
	Legume - hay	13 - 15
High	Oilseed cakes	30 - 45

Not all the proteins present in a feed can be utilized by an animal. Part of it will appear undigested in the faeces. The part of the crude protein that is digested by the animal is called the Digestible Crude Protein (dcp), see chapter V.

4.2 Carbohydrates

In the group of carbohydrates we can distinguish 2 groups of chemical compounds:

Soluble Carbohydrates

The soluble carbohydrates consist of starch and sugars. These nutrients can be digested directly by the animals. The animals are able to utilize them well and their digestibility is high. These form the major source of energy for the animals. If more energy is provided than immediately needed, the surplus is stored as body fat.

Crude Fibre

This is the fibrous material in the plant. It is in particular found in the stem, where it provides structure to the plant and gives the plant its shape. Crude fibre (cf) is not easily digested by the animals. It consists of cellulose, hemi-cellulose and lignin. The bacteria in the rumen of the cow and other ruminants assist the animals in the digestion of these fibres. The digestibility of fibres is low. Ruminants always require a considerable amount of crude fibre in their ration for a proper functioning of the rumen. However, a very high content of crude fibre reduces the feed intake of the animal.

Functions of carbohydrates

- A ready source of energy (necessary to maintain the body and for activities, like walking, grazing, milk production, etc.)
- Maintain a constant body temperature
- Important to maintain the level of blood sugar
- Excess of carbohydrates are stored as reserve energy in form of body fat
- Milk sugar (lactose) gives sweetness to milk and is used by bacteria to turn milk sour
- Essential for the growth and multiplication of micro-organisms in the rumen
- Helps in the absorption of Ca (calcium) and P (phosphorus)

Presence in feeds

Soluble carbohydrates are found in particular in grains (wheat and maize), fruits (banana), tubers (cassava and potatoes) and sugarcane. Some examples are given below.

	Feed	Soluble Carbohydrates % (Starch & Sugars)
Low	Green grass and silage	5 – 20 %
Average	Oilcakes	20 – 40 %
	Grass	20 – 40 %
High	Cereals	60 – 70 %
	Molasses	62 %

As plants grow older, they become more fibrous and less digestible. The following figures can be given for the crude fibre content of some feeds.

	Feed	Crude Fibre %
Low	Animal products	0 %
	Fresh grass and green fodders	5 – 10 %
Average	Hay and dry fodders	20 – 35 %
	Cereal byproducts	15 – 25 %
High	Maize stover	30 – 40 %
	Straw	35 – 40 %

4.3 Fats and oils

Fats are high in energy. In fact fat provides 2.5 times more energy than the same quantity of carbohydrates. In fodder fats are only found in very minor concentrations. Byproducts like cakes from the vegetable oil industry (i.e. sunflower, cottonseed and soya bean) have a relative high fat content. Some fat should be present in the ration as they form a source of some vitamins. As the animals derive most of their energy from starch and sugars, fats do not play a major role in the feeding of livestock.

Functions of fat

- Body fat is a reserve source of energy
- Makes up 20% of the animal body
- Provides essential fatty acids
- Is a source of fat soluble vitamins
- Helps in absorption of carotene
- Cow milk contains about 3.5 - 5 % fat

4.4 Minerals / salts

Minerals are the inorganic matter in feeds. These remain after the material is burned and therefore are often referred to as Ash. Some minerals play a critical role in the structure of tissues of the body. Examples are Calcium and Phosphorus, which are the main components of the bones and therefore are essential in the formation of the skeleton.

Functions of salt / minerals

- Help in digestion and absorption of nutrients
- Help in clotting and formation of blood
- Help in producing enzymes and hormones
- Help in maintaining a good fertility and growth
- Make about 1% of the milk solids and improve the quality of milk
- Participate in bone, teeth and muscle formation
- Increase the palatability of the ration

Minerals are only found in small quantities in the different feeds. If high quantities are found in fodder samples, this usually means that the fodder was contaminated with sand or soil. Too much soil in the feed reduces the feed intake of the animals. It is advisable to provide cattle with a mineral lick block, so that they have a constant and free access to salts.

Presence in feeds

	Feed	Minerals %
Low	Green Fodders	1.2 - 2.5 %
	Cereals	1.5 - 4.5 %
Average	Oilseed cakes	5 - 6 %
	Dry Fodder	6 - 7 %
	Cereals byproducts	4 - 5 %
High	Bone meal	23 – 28 %
	Blood meal	15 - 18 %

4.5 Vitamins

Vitamins are necessary for animals in very small quantities. However, they are essential for different chemical reactions which take place in the body, which are in particular related to the digestion. Vitamins do not play a big role in the feeding of dairy animals. Most of them are synthesized by the bacteria in the rumen. When cows are fed green forage, usually no supplementation is required.

Functions of vitamins

- Necessary for the functioning of different body activities
- Important and essential for a good health status
- Help in growth and digestion
- Improve resistance (fighting power) against diseases
- Necessary for the growth and development of the unborn calf
- Prevent sterility in animals
- Improve milk production

Presence in feeds

Good sources of vitamins are: green fodders, hay, cereals, cakes and feed premixes

4.6 Water

All feeds contain a certain percentage of water. When all the water is removed from feeds the dry matter (dm) remains. So besides rivers, dams, boreholes, etc. also feeds are a source of ‘drinking’ water for the

animals. Without water life is impossible. Animals should always have access to plenty of water to survive. But milk contains ca. 87 % water too. So when the animal is not allowed to drink sufficient water, it will not be able to produce a good quantity of milk.
An average cow requires about 30 litres water per day to maintain its body. This amount depends highly on the season and the prevailing temperatures.
For milk production the cow needs in addition 3 litres of water for each litre of milk it produces.
In general a farmer should plan with a requirement of about 40 - 80 litres of water per day for one cow, depending on season, type of fodder and feed, body weight, age and milk production. When it is impossible to give cattle permanent access to water, the animals should be watered at least 3 times per day. In that case they should be allowed to drink as much as they like.

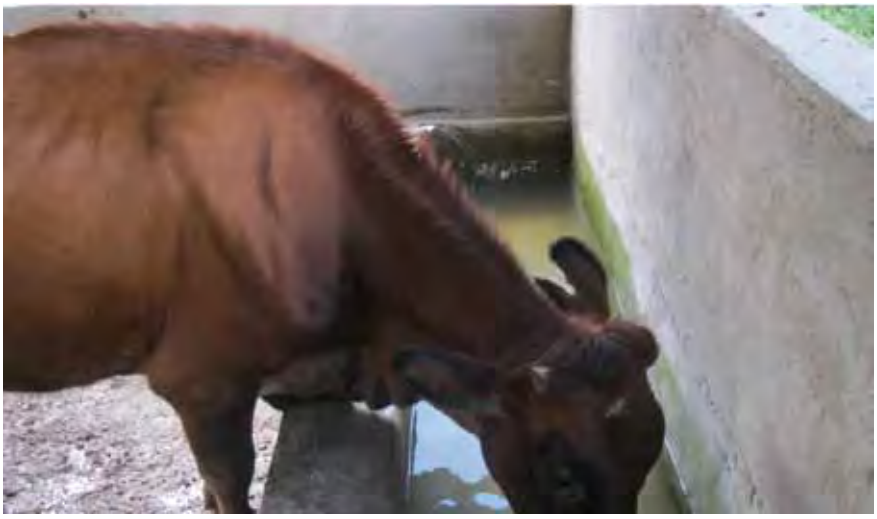

FIGURE 4: A cow should be watered at least 3 times per day

Functions of water

- Allows mastication and swallowing
- Helps in digestion
- As a solvent it allows absorption of nutrients and excretion of waste
- Essential for cell nutrition and transportation of nutrients to different parts of the body
- Regulates the body temperature
- Maintains the flow of blood
- Maintains the correct acidity in the body
- Dilutes or reduces toxicity
- Makes food palatable and dry feed soft
- Forms about 87 % of the milk
- A loss of 20-25 % water in the body may result in death

Presence in feeds

The moisture content in some fresh and dry fodders is as follows:

	Feed	Water %
High	Green grass	75 %
	Silage	70 %
	Lucerne	85 %
Low	Grain	9 – 10 %
	Straw	8 – 10 %
	Hay	15 –18 %

5. PRINCIPLES OF FEEDING DAIRY COWS

5.1 Digestibility of feeds and feed evaluation

Not all the feed an animal eats is digested. The part what is not utilized will leave the body as faeces. The digested part of a feed can be expressed as a percentage of the total feed intake. This percentage is called the digestibility coefficient. Depending on the kind of feed the digestibility may vary considerable. Some products like young grass and green fodders, which have a low crude fibre content, are very easily digested. Other products like overgrown fodders, straw and stover are very fibrous and have a very low digestibility coefficient.

The feeding value of a feed is mainly determined by its energy and protein content. Several feed evaluation systems take these 2 elements into consideration. In tropical countries most commonly the Total Digestible Nutrients (TDN) system is used for ruminants. The TDN considers the part of all the energy present in a feed, what can be digested by the animal. The protein content is expressed as Digestible Crude Protein (dcp). This is the part of the total protein content of the feed, which the animal is able to digest and to utilize.

Both the TDN and dcp values are usually expressed as grams per kg. When rations for the animals are being calculated, we want to know the feeding value of the feed as it is. So we express the TDN and dcp values as grams per kg feed.

In case we want to compare the feeding value of different feeds, we are interested in the quality of the dry matter. In that case we express TDN and dcp in grams per kg dry matter (dm).

5.2 Dry matter intake

To match the feeding value in a certain quantity of feed with the total requirement of an animal, we should have an indication how much the animal is able to eat. This quantity is expressed in dry matter (dm). The reason is that the quantity of water in a feed in fact can be considered as 'drinking' water for the animal. It does not contribute to the feeding value and to the intake of a particular feed.

The dry matter intake of an animal depends on a number of factors:

- the cow (age, weight, milk production, pregnancy, breed);
- the feed (quality, digestibility);
- the feed supply (grazing system, frequency of feeding, variation in the ration, water availability);
- the environment (temperature, rain).

When estimating the dm intake of an animal it is assumed that it receives an unlimited supply of roughage. This means that the animal has permanent access to the fodder. After eating as much as it likes, there should remain an edible left-over of about 10 % of the supplied forage. It has been established that under those conditions a ruminant will eat between 1.5 % and 2.5 % of its bodyweight in form of roughage. The actual percentage depends heavily on the quality of the fodder which is supplied. When an animal receives poor quality roughage its intake is reduced. And since the fodder it eats contains only little nutrients, the total intake of nutrients becomes extra low. Therefore good quality roughage is the basis for a high milk production. In general we can say that a cow with a bodyweight of 450 kg is able to eat approximately between 7 – 11 kg dm roughage per day. However, it should be realized that in order to achieve this amount, the intake of young, fresh grass might easily reach over 60 kg per day. In case the farmer cuts and carries the grass, he should supply about 70 kg fresh material per cow per day to enable the animal to get fully satisfied.
On average we can work in our calculations with a dm intake out of roughage of 2 % of the bodyweight.
The total dm intake, including concentrates, of a normal producing dairy cow can be considered in the range of 8 – 13 kg dm per day. However, a well developed, high producing cow, which is supplied with good quality fodder and concentrates might even take in up to 18 kg dm per day.

6. ROUGHAGE (FODDER) AND CONCENTRATES

The difference between roughages or fodder and concentrates is highly related to their feeding value. In general roughages have a rather low feeding value and a high crude fibre percentage. Concentrates have a high feeding value and are low in fibre. The main reason is that in case of fodder the complete plant is used as a feed, including the leaves and the stem. In concentrates only those parts of the plants are used which contain a higher concentration of nutrients, like starch and sugar. These are found particularly in seeds, tubers and sometimes in roots. Also byproducts of seeds are concentrated feeds. In conclusion we can say that:

Roughages are characterized by a higher fibre content, are bulky and generally contain the vegetative portion of a plant or tree. The digestible energy content is low and depends highly on the variety of the fodder and the maturity stage at harvesting. For that reason a high variation in feeding value can be observed.

FIGURE 5: Hay as a typical roughage

Concentrates are high quality, low fibre feeds. To this group belong cereal grains and their milling byproducts (bran), byproducts of oilseeds (cake), tubers, roots and animal products. Concentrates are high in digestible energy and protein.

FIGURE 6: A concentrate mixture

7. COMMON ANIMAL FEEDS AVAILABLE AND THEIR FEEDING VALUE

The following feeds usually can be found on or in the vicinity of smallholder farms and thus are available to include in the ration of the animals. For most of them an indication of their feeding value in TDN and dcp is given as well. Both TDN and dcp are expressed in grams per kg feed.

FEED	Dry Matter dm (%)	TDN	dcp
Grasses			
Natural grass (young)	20	116	11
Natural grass (old)	25	135	8
Rhodes grass	28	134	15
Starr grass	26	125	10
Buffel grass	25	120	3
Green Fodders			

FEED	Dry Matter dm (%)	TDN	dcp
Fodder-maize	20	120	10
Fodder-sorghum	23	115	13
Cow candy	23	145	11
Napier/Bana grass	18	110	10
Legumes			
Lucerne	20	116	30
Lab-lab	19	105	17
Cow pea	20	99	20
Sun-hemp	26	116	23
Velvet bean	24	140	25
Desmodium	22	130	22
Clover	11	70	20
Hay and silage			
Natural grass hay	93	455	4
Rhodes grass hay	87	425	15
Starr grass hay	89	445	36
Lucerne hay	90	470	98
Lab-lab hay	90	515	82
Cow pea hay	91	500	83
Velvet bean hay	90	480	77
Groundnut hay	92	470	51
Maize silage	25	135	11
Sorghum silage	26	145	10
Napier/Bana grass silage	24	95	16
Fodder tree leaves			
Leucaena			
Gliricidia	20	100	35
Calliandra	23	140	40
Sesbania			
Mulberry			
Crop residues			
Maize stover	90	450	1
Sorghum stover	90	500	0
Pearl millet straw	90	464	27
Cowpea straw	91	380	20
Soya bean straw	87	330	15
Banana leaves	15	96	16
Concentrates			
Dairy meal	90	648	108
Maize bran	90	695	40
Wheat bran	90	585	99
Cottonseed cake	93	690	279
Sunflower cake	94	660	282
Velvet bean	90	810	171
Cow pea	86	765	168
Molasses	75	540	7
Maize meal	90	702	57
Brewers grain	32	230	77
Meat and bone meal	96	625	453
Waste			
Chicken manure	90	-	103
Minerals and premixes			

FEED	Dry Matter dm (%)	TDN	dcp
Di-Calcium-Phosphate (DCP), lime, dairy premix, common salt, mineral licks, Molasses-Urea Blocks, probiotics			
Water			

TABLE 3: Some common animal feeds and their feeding value

FIGURE 7: Cow candy is a fodder sorghum rich in sugars

8. RATION FORMULATION FOR DAIRY COWS

8.1 Feed requirements

An adult cow, which is not producing still needs nutrients to survive. These nutrients are required for vital body functions, like respiration, blood circulation, maintaining the body temperature, etc. and also for movement. The nutrients needed for this purpose are called the maintenance requirement of the cow. If a cow receives less than its maintenance requirement, it reduces its reserves of body fat and it starts to loose weight.

Additional nutrients are required on top of the maintenance level to enable a cow to produce. This refers mainly to milk production, but it involves reproduction, fattening and growth as well. These extra nutrients make up the production requirement of the cow.

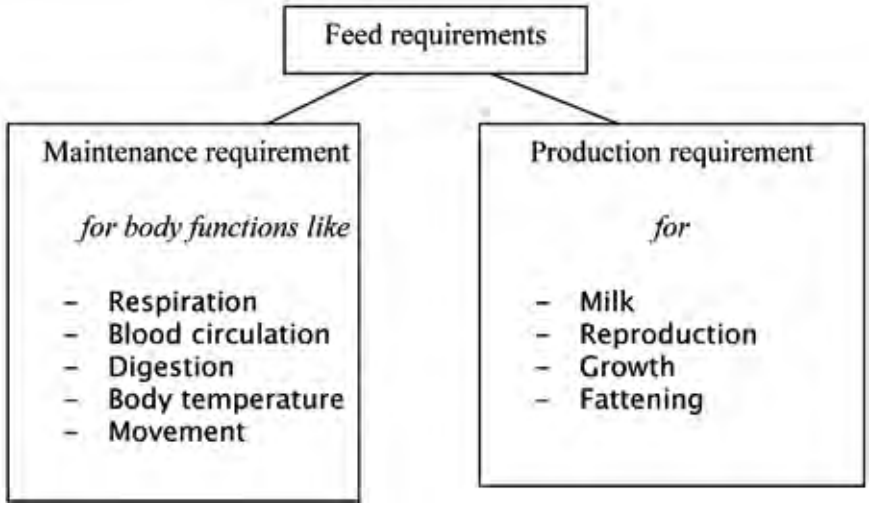

FIGURE 8: Overview of feed requirements

Obviously the maintenance requirement of an animal is related to its bodyweight. It has been established that a cow with a bodyweight of 450 kg, which walks during grazing about 5 km per day, has a **maintenance requirement of 3400 gram TDN and 275 gram dcp per day.**

In relation to milk the production requirement depends strongly on the fat-percentage in the milk. It has been concluded that a cow producing milk with 4 % fat has a
production requirement of 330 gm TDN and 51 gm dcp per kg milk.

In Table 3 is indicated that 1 kg dairy meal contains approx. 648 gm TDN and 108 gm dcp. That is more or less twice the production requirement for 1 kg milk.
As a rule of thumb we may thus conclude that a cow is able to produce:
2 kg milk out of 1 kg dairy meal or equivalent concentrate mixture.

8.2 Daily fodder rations

We can use the following presumptions as a first step towards the calculation of daily rations for cows. It is assumed that the animal has an unlimited access to the roughage and eats as much as it likes. In case of a cut-and-carry system, this means that about 10% of the supplied fodder remains in the feed-trough as a leftover. Calculations show the following indications of the quantity of milk a cow of approx. 450 kg bodyweight can produce from some common fodder rations, which are supplied unlimited.

	Maintenance	Kg milk per day
Natural grass		
Poor quality	-	-
Good quality	√	6
Improved pastures		
Poor quality	√	0
Average quality	√	3
Good quality	√	11
Green fodder		
Napier/Bana grass (overgrown)	√	0
Napier/Bana grass (good quality)	√	8
Mixture with legumes		
Improved grass / Lucern (75/25%)	√	9
Napier grass / Desmodium (75/25%)	√	0
Hay		
Natural grass	√	0
Rhodes grass	√	0
Lucerne	√	8
Silage		
Maize	√	4
Napier/Bana grass	√	3
Straw		
Maize stover	√	0
Cowpea straw	√	0

TABLE 4: Estimates of the maximum quantity of milk which a cow of 450 kg is able to produce on different fodder rations.

Table 4 shows that, except for poor quality natural grass, an animal is able to maintain its body on all fodder rations. Only in case an animal is supplied with overgrown, dry natural grass, it will start to loose weight in order to survive. For that reason it is advisable to add molasses to the grass or use a licking wheel with molasses to provide some extra energy to the animal.

FIGURE 9: Molasses can be added to dry natural grass to prevent loss of bodyweight

Table 4 makes clear as well that very fibrous fodders, without any supplementation, do not allow the production of milk at all. In most cases such fodders are the only roughage available during the dry season. This means that normally all the milk produced in the dry season has to be provided for by concentrates.

FIGURE 10: Concentrates provide mainly for milkproduction in the dry season

We have seen that, once her maintenance requirement is met, a cow is able to produce 2 kg milk out of 1 kg of good quality dairy meal. In other words in the dry season to maintain a production of 4 kg milk per day 2 kg dairy meal has to be supplied, 10 kg of milk requires 5 kg dairy meal, etc.

Finally, Table 4 shows that the highest quantity of milk a cow can produce out of roughage is around 10 kg milk per day under tropical conditions.

FIGURE 11: Good quality pasture can provide around 10 kg milk per cow per day

With these indications it is interesting to know how much concentrates have to be added to reach a certain milk production. A rough indication for different production levels from some common fodder rations is given in Chapter XVII.
Of course much more detailed ration calculations can be carried out for each cow based on the different feeding values and the feed requirements discussed before. But always remember that all figures and data used are estimates of the real situation. The results of all the calculations are just guidelines. However, if properly used these are indispensable to feed dairy animals properly and so to enable economic farming.

8.3 Qualities of an ideal dairy cow ration

- Provides adequate amount of different, mixed nutrients and is appetizing
- Is palatable and good digestible
- Has a good effect on health
- Contains a variety of feed ingredients
- Is bulky and includes sufficient fodder
- Includes preferably plenty of succulent green fodder
- Is properly balanced and contains adequate energy, protein, minerals and vitamins
- Is economical to feed
- Is nontoxic (not too old and stored in a damp place)
- Prevents undesirable flavor in milk
- Is free of undesirable weeds, dust, dung and urine

8.4 Some principles of rationing / feeding dairy animals

- Be kind and liberal in feeding the cows
- Maintain continuity in feeding. Avoid sudden changes in the ration. If necessary change as gradual as possible
- Feed twice daily at 12 hours interval
- Provide green fodder and/or silage throughout the year but definitely in the dry season
- A good palatability increases the intake and digestibility of the feed. The palatability can be improved by adding some molasses, maize bran or salt. Also by chaffing, soaking or grinding the feed

- Provide a laxative ration
- Provide a bulky ration (roughage)
- Feed individually for good results
- Silage should be fed after milking to avoid the milk to smell after it
- Excessive legume feeding should be avoided on an empty stomach to avoid bloat
- Feeding concentrate (dairy feed mixture) during milking causes a stimulation of the milk letdown
- Water should be present throughout or be provided at least three times a day

9. NUTRITIONAL DISEASES OF DAIRY ANIMALS

9.1 Acidosis

- When the animals eat too little fibrous feeds (fodder) and too much feeds rich in soluble carbohydrates (like grain, maize and maize-bran, brewers grain) the acidity in the rumen becomes too high and the pH drops
- After 8-12 hours the animals show the following signs:
    - loose appetite
    - show signs of indigestion and irritability
    - little rumen movement
    - produce loose and watery faeces (dung) with an offensive smell
    - reduced milk production
    - the body temperature remains normal.

9.2 Ketosis

- A metabolic disease of lactating cows that occurs within a few days after calving.
- It might be found when the animal has received a ration which was too rich in energy during the period she was dry.
- You may recognize the disease from a very specific smell in the urine.
- A decreased milk production is the result.

9.3 Milk fever

- Milk fever occurs mostly in high-yielding dairy cows soon after calving, usually within 72 hours.
- The cow shows signs of paralysis. She is unable to get up and rise to her feet and lies with her head turned back on the ground.
- Contrary to the name, the cow has no fever. She looses all appetite.
- The disease occurs when the feed has been deficient in Ca during pregnancy. In that case the cow uses her body reserves for the development of the foetus. When she starts to produce colostrum, which is also rich in Ca, a calcium deficiency occurs in her body.
- Treatment is simple with an injection of calcium borogluconate I/V in her blood. The cow will respond immediately and will stand.
- To prevent further problems DCP (Di-Calcium Phosphate) should be introduced in the ration.

9.4 Rickets/osteomalacia/night blindness

- Rickets is found mostly in young growing animals.
- The development of the skeleton is hampered and bones might be deformed.
- Rickets occurs due to Ca deficiency, what might have been caused by feeding a calf too little mothers milk.
- Osteomalacia is the corresponding disease in adult animals.
- Night blindness can be found due to Vitamin A deficiency in calves.

9.5 Bloat/tympanitis

- Bloat is an excessive accumulation of gas in the rumen of the cow. The reason is that the animal is unable to belch and to release the produced gas.
- It is usually caused by an excessive intake of a single type of green, fresh leguminous fodders, like lucerne, lablab, cowpea, velvet bean.
- It is recognized by a swollen rumen and a drum like sound when patting on it. The animal has difficulty in breathing, has pain and is generally uneasy.
- To treat bloat drench a vegetable oil immediately or make a trocard puncture in the rumen so that the gas can escape. Use probing and try to massage the rumen.
- Feeding of legumes should stop immediately.
- To prevent problems, allow the legumes to wilt some time after cutting and before feeding. Never let the animal graze on a pure legume stand and balance the ration with other roughages.

9.6 Constipation

- The animal produces solid dry faeces, which is brittle and covered with mucus
- The animal has pain and is straining during defecation
- No feed intake
- The reasons for constipation are:
- Eating of very dry feed together with insufficient drinking of water
- Eating moldy hay & insufficient exercise
- Intestine and liver diseases
- To treat constipation:
    1. Give an enema with soap water
    2. Provide green, succulent, laxative diet and plenty of water

9.7 Urea poisoning

- This poisoning is an acute and fatal disease caused by a too high or accidental consumption of urea
- The toxicity appears sudden and is due to a high ammonia production in the rumen
- Symptoms of the poisoning are: severe abdominal pain, nervous symptoms, twitching, weakness, breathing difficulty, excessive salivation and bloat
- Treatment can be done by administering vinegar

10. AGRONOMY OF PASTURE AND FODDER CROPS

The most important constraints to improve livestock production, in particular dairy production, are related to animal nutrition. When (cross-bred) dairy cows are kept on small-scale farms, planting improved pastures and fodder crops is essential. To obtain increased milk yields the animals should be provided with supplementary feeds next to the grazing of natural grasses. Improved pastures, especially when legumes are included, can produce large quantities of high quality feed for the dairy animals at a low cost.

Several possibilities are available to the farmer to improve the ration of his animals. These include:

1. planting of improved pastures for grazing;
2. planting of fodder crops for supplementary feeding during the dry season;
3. cutting natural grass in the veldt or improved pasture for making hay;
4. inter-cropping legumes in maize and/or grass to improve the nutritional quality and the utilization of the fodder.

Grasses should not be utilized in a too late stage of maturity. The leave-stem ratio determines the digestibility and thus the feeding value. Young grasses are green and leafy and very tasteful to the animals. Once grasses grow older, they develop a thicker stem and become more fibrous. In this way they loose much of their feeding value. In particular the protein content is reduced. Therefore grasses should be utilized before they start blooming and produce seeds. When one waits too long, it is true that one will harvest a bigger quantity of grass, but the quality will be reduced with about 20 %. Therefore it is advisable in case pastures are grazed, to make paddocks over which the animals can be rotated. Then you are able to provide your animals continuously with young, fresh grass.

Legumes are able to fix Nitrogen from the air and to convert this into proteins. For that reason legumes are richer in proteins than grasses and other foddercrops. The plants contain relatively more leaves and less stem than grasses. In the leaves we find about 80 % of the protein. Therefore legumes should be cut when about half the crop is in bloom. In that stage we still have sufficient leaves on the plant and a not too fibrous stem. When legumes grow too old they produce some poisonous substances. If fed in too big quantities these can cause skin problems and bloat. To prevent bloat in the animals pure stands of legumes should never be used for grazing. Especially not in early morning when the plants are wet due to dawn. After cutting, the legumes should always be left to wilt in the sun. Only when the plants are sundried, they can be fed to the animals.

The following are a few examples of grasses and legumes that are recommended as improved pasture and fodder crops.

10.1 Grasses

I Rhodes Grass

Rhodes grass is tolerant to a wide range of soils, from light sandy to clays. But it will not withstand water logging. It provides excellent first season grazing and hay. But yields in subsequent seasons decline if it is not fertilized and weeded. Replanting is necessary after about 3 to 5 years.

FIGURE 12: A nice field of Rhodes grass starting to flower

Establishment:

The grass is established from seed. It can be sown in rows of 0.5 to 1.0 m apart or be broadcasted at a rate of 3 to 7 kg seeds per hectare. Fresh seed is best stored for a period of 6 months before planting.
The seed should be sawn at most 1 cm deep. The seedbed should be lightly rolled if it is drilled and harrowed or swept over (using branches) lightly if it is broadcasted. In this way the seeds are not pushed too deep into the soil. Sowing should not take place until the rains are well established.

Fertilizer:

To increase the growth of the grass and to improve its quality, the crop has to be supported by either use of artificial fertilizers or cattle manure and/or compost. Since the cost of fertilizer in Zambia is prohibitive, smallholder dairy farmers are advised to apply as much cattle manure as possible into their field. This should be applied before planting and in the dry season, once the crop has established well. A topdressing of D compound at the rate of 100 kg per hectare is recommended.

Management:

New stands of Rhodes grass should be allowed to set seed before cutting, especially if the stand was poorly established. Manual weeding can be carried out in the month of December/January. Peak grass production is usually obtained in the first two seasons. Thereafter it is recommended to allow the stand to flower, set and shed seed before harvest. After 3 to 5 years it is best to plough and replant.

II Buffel Grass (Fox Tail Grass)

Buffel grass is tolerant to a wide range of soil conditions with the exception of water-logging. Buffel grass does best on light soils in medium and low rainfall areas. It is more drought and fire tolerant than Rhodes grass. Also it remains green for longer periods than Rhodes. It is therefore more suitable as a permanent pasture.

FIGURE 13: A field of Buffel grass, with lablab on the left and Napier grass on the right side

Establishment:
The same procedure is followed as described above for Rhodes grass. Only more seed is used at a rate of 6 - 8 kg per ha. The lower seed rate of 6 kg is used for planting the seed and a higher rate when broadcasting. Fresh seed usually will not germinate during 9 to 12 months after harvesting (due to dormancy) and so should not be used.

Fertilizer:
As for Rhodes grass.

Management:
Buffel grass persists well and hence may not need replanting for several years. It is tolerant to fire and so controlled burning can be used to clear the old growth and weeds at the end of the dry season.
Buffel grass has certain features that make it easier to establish, manage and maintain than Rhodes grass. Especially under Zambian soil and climatic conditions. However, the fact that Rhodes grass is more palatable and nutritious and that the seed is more readily available, makes this often the better choice for the smallholder dairy farmer.

III Napier / Bana grass

Since Bana grass is a variety of Napier grass, both names are used simultaneously. It is a highly recommended fodder to supplement the feeding of dairy animals. Napier grass is high yielding and as it is reasonably drought resistant, it remains green into the dry season. Therefore it can be used very well in the formation of a fodderbank, which can be used during the dry season. Napier grass should not be grazed by the animals, but is very suitable for cutting. If properly managed the feeding value is good and if fed at an early stage the palatability is very good. Napier grass prefers well drained soils, but can be grown on almost any soil.

FIGURE 14: Napier grass ready for cutting

Establishment:
It is advisable to plant Napier grass near to the night paddock of the animals. That makes it easy to carry the cut grass to the animals, but also to return the manure from the paddock to the Napier field. The grass should be planted in rows, with a spacing of 90 cm between the rows and 60 cm in the row. It is the easiest to plant cane cuttings, similar to sugar cane. These can be obtained from overgrown Napier grass. Use the middle part of the stem and cut this into pieces with 3 – 4 nodes each. These cuttings are pushed into the soil under an angle of 45 ° so that at least 2 nodes are covered by the soil. Also rootsplits can be used. As handling these splits is much more laborious, this procedure remains usually restricted to fill gaps in already established fields.

Fertilizer
When cutting the Napier grass large quantities of nutrients are removed from the soil. These have to be replaced. Therefore it is important to return as much as possible manure close to the plants. In addition artificial fertilizer should be applied at a rate of 10 bags NPK per ha per year. To stimulate the growth of Napier grass well into the dry season, half of this amount can be applied towards the end of the rainy season.

Management
If properly managed, Napier grass remains productive for 10 – 15 years. The quality of the grass is reflected by a dark green colour. Cutting is done best when the grass is 60 – 90 cm tall. Do not let it overgrow. It becomes more bulky then, but the quality is reduced seriously. If you have excess Napier during a certain period, it is better to cut the grass in the right stage and make silage out of it, than leaving it in the field to overgrow. After each cutting, the grass should be weeded and manure can be applied.

10.2 Legumes

Velvet bean

Velvet bean is a vine. Without support it will spread over the ground, producing large quantities of vegetative material. This is a desirable feature. It is mostly cut as a forage and occasionally for its seed. It

is also recommended as a good cover crop for farmers who practise conservation farming. If grown for hay or silage the crop should be cut when the first pods reach their full size but are still green.

FIGURE 15: Velvet bean

Establishment:
Velvet bean is more drought tolerant than cowpea and requires a long warm growing season. It tends to suffer from root rot in high rainfall areas and does not tolerate water logging. Planting should be done at a rate of:
40 - 50 kg seeds per ha in rows of 0.5 to 1 m apart, if the crop is grown for it's leafy material as a fodder. The depth of the seeds should not exceed 2 to 3 cm
15 - 20 kg seeds per ha if it is intercropped with maize or sorghum as a mixture to make silage.

Management:
Velvet bean requires regular weeding in the first weeks as it grows slowly initially. Later on it effectively smothers all weed competition. Velvet bean makes an excellent silage if intercropped with cereal crops, like maize, sorghum, pearl millet, etc. When feeding fresh to livestock it should be combined with hay or a cereal fodder in a ration of 1 part velvet bean to 3 parts hay, green maize or sorghum. The grinded seeds can be used up to 15 - 20 % in a dairy meal mixture as a source of protein. However, it should only be given to cows, oxen or bulls and not to young stock.

Cowpea

Cowpea is a spreading annual legume that can be used as a fodder for livestock to provide green fodder, hay, silage or grain as a concentrate. It is drought tolerant. Green pods and dry beans are also used for human consumption. It is a triple purpose crop since it serves as a fodder, as a human food and it increases the fertility of the soil.

FIGURE 16: Cowpea

Establishment:
Cowpea should be planted in soil that is well-drained and free of weeds at a seed rate of about 15 - 20 kg per ha. It is best to keep the crop free from weeds for the first four weeks after which it naturally smothers weeds.

Management:
Cowpea is susceptible to attack by fungi. Apart from spraying fungicides, the best way to prevent this is to practise crop rotation. Blister beetles might eat the flowers. If these beetles are found, destroy them by hand or use a suitable insecticide.
As a feed for livestock, the green leaves can be plucked regularly or the whole crop can be harvested when the pods are green. The complete plant can be incorporated in silage or be dried as hay. The seeds can be dried and ground and fed as a meal. In addition pods can be fed whole, either fresh or dried. Cow pea is an excellent fodder crop for smallholder dairy farmers.

Red Sun-hemp

Sun-hemp is a tall, upright, slender annual legume. It is predominantly used for green manure (due to its rapid growth), but also used for silage, hay or fibre. It will grow on practically any soil. It improves those which are highly infertile and it is generally free from most diseases and insect pests. In addition, it is not very sensitive to weeds. Exclusive feeding of sun-hemp to dairy animals is not recommended. It must be mixed with hay, silage, green maize or green sorghum. Animals may not like the taste in the beginning but after some time they become used to it.

FIGURE 17: Red Sun-hemp

Establishment:
Seed should be drilled in a smooth seedbed that has been ploughed and harrowed. Planting should be done at a rate of 10 - 15 kg per ha in rows of 0.5 to 1 m apart. Planting is carried out soon after the rains have started.
If being grown for hay or silage, it is best to cut when the crop starts to flower. If rainfall is good 2 cuttings can be taken in a year. Black sun-hemp can also be used, but is more fibrous and woody than red sun-hemp. The seed rate for black sun-hemp is about 25 - 30 kg per ha.

Dolichos Lablab

Dolichos lablab is an excellent leguminous cover crop. Lablab will grow on a wide range of soils but does not withstand waterlogging. It shows an excellent growth in the rainy season and is tolerant to drought. So it does well even in low rainfall areas. It can be grazed or used for hay or silage. The whole seed and green pods can be fed to stock as a protein supplement and these can be used as a relish in human consumption. It is a perennial plant and it sprouts during the dry season. Therefore it can also be used as a green fodder during the dry season.

FIGURE 18: Violet Dolichos

Establishment:
The seed should be sown in a smooth seedbed that has been ploughed and harrowed. The seed rates are similar to those of velvet beans.

Fertilizer:
The crop will benefit from application of manure, which has to be ploughed in before planting.

Management:
It can both be grazed (it is more tolerant than cowpea to grazing) and be cut and carried. It is best to use it fresh, as it dies slowly and tends to shed most leaves in the process.
Pod borers and blister beetles can attack flowers and young pods. These should be controlled by spraying.
The first cuttings are available 6 - 8 weeks after emergence and then again after 4 to 6 weeks. It is best not to cut lower than 15 cm from the ground. Like cow pea, it is also a triple purpose legume.

11. CONSERVATION OF FODDER AS SILAGE AND HAY FOR THE DRY SEASON

11.1. Silage

To overcome periods of scarcity of green forage, in particular the dry season, fodder can be preserved by turning it into silage. The process of silage making is based on fermentation. Bacteria, which are present in the air and on the crop, produce acid and the pH of the grass rapidly decreases to a value of approx. 4.2. This prevents decomposing and deterioration of the fresh grass and allows it to keep its quality. To enable this process sufficient soluble carbohydrates (sugars) should be available for the acid production. To provide these it is recommended to add i.e. molasses to the fodder. Molasses is rich in sugar. This enables the bacteria to produce acids immediately.
Leguminous fodders, which are rich in proteins and low in sugars, are therefore difficult to ensile. To allow the bacteria to grow air (oxygen) should be expelled. That is why the fodder is heaped and pressed. To facilitate pressing and thus the process of ensiling, it is advisable to chop the green fodder. To prevent air to enter in a later stage the silage heap is covered with plastic sheets and a layer of soil.
It takes about 60 days for the silage to mature. After that it is ready for feeding. If no leakage of air or water occurs, the silage can remain for several years, without loosing its quality.

Advantage
Proper ensiling ensures a succulent fodder during periods of scarcity of green fodder, with a reasonable loss of nutrients only. Silage is very palatable, laxative, digestible and more nutritious than hay. It requires less floor area for storage than hay. It is recommended that also small-scale dairy farmers practice silage making. This will enable them to maintain a good level of milk production in the dry season

Ensiling process
There are four methods to produce and store the silage: in a pit, a trench, a tower and for small quantities in sacks.
The silage trench preferably should be located at a place with a higher elevation to avoid rain water to enter into the trench. But at the same

time care should be taken that it is close to where the animals are kept to avoid much labour during feeding.

FIGURE 19: A trench for silage making

Crops such as maize, sorghum, pearl millet, cow candy, oat, and napier/ bana grass are very suitable for ensiling. These contain fermentable carbohydrates (sugar), what is necessary for bacteria to produce sufficient acid. This acid acts as a preservative.
The fodder which is used for silage should not be too wet. If it contains more than 70 % water, it is advisable to wilt it in the sun first. The dry matter of the material should preferably be in the range of 30 - 35 %. To get an indication whether the right dm content has been reached, a small bundle of the fodder can be taken and wringed with 2 hands. If no moisture comes out, it is ready to ensile.

During ensiling the fodder must be pressed to expel maximum air out of the material.
Crops for silage, like maize, should be harvested at bloom stage (milk stage) to achieve an optimal feeding quality.
To ensure a good ensiling process additives like molasses, common salt, formic acid or chopped sugarcane can be mixed with the fodder. When very small quantities are made sour milk or whey can be used. An additive provides the best conditions in the fodder to enable a good fermentation process.

Preparation of silage
The ideal time for making silage in Zambia is late March – April, depending on the availability of green fodder, its maturity and the rain pattern. For smallholders a trench silo is the most suitable. A trench of 0.5 – 1 meter deep and 2 meter wide has to be prepared. It is advisable to put up plastic sheets on the sides of the pit before starting to fill it. Add some dry grass at the bottom of the trench. Before filling the trench the fodder has to be chopped into pieces with a length of 2 – 5 cm. If available maize cobs can be mixed with the chopped fodder.

FIGURE 20: Filling a small silage trench using plastic sheets

During filling sprinkle the fodder after each layer with some molasses (in total approx. 5 % can be added) or add some common salt. Proceed in this way until the pit is full and the heap reaches a level of 1 meter above the ground. It should then be pressed by rolling a drum full of water over it or by trampling by i.e. playing children. After filling, cover the top of the heap with plastic as well. If you do not have plastic you can use dry grass to put around the pit to avoid water and air entering into the chopped fodder. Finally add a layer of soil on the plastic to provide weight for compressing the fodder and to protect the silage. The silage pit should be filled and closed in a period of maximum 2 days. Otherwise it becomes almost impossible to keep the air out.

Opening the silage pit

At opening the silage trench the flavour of the silage gives a good indication of the quality. The silage should have a fresh acidic smell. The quality can be determined more precisely by measuring the pH in the pit. The silage can be graded as follows:

Grade	Flavour	pH Range
Excellent	fresh acidic / sweetish	3.5 - 4.2
Good	acidic	4.2 - 4.5
Fair	less acidic	4.5 - 5.0
Poor	pungent	5.0 and above

FIGURE 21: Opening a silage pit with good quality silage

Never open the whole silage trench at one time. Only 1 end of the narrow side should be opened a bit. After that the silage should be removed part by part over the full width of the pit, like cutting slices from a loaf of bread. In that way air is prevented to enter and still spoil the silage. Each animal can be given about 6 - 15 kg of silage per day. It is advisable not to feed silage immediately before or during milking. Especially when the quality of the silage is poor. The milk can easily take the smell of the silage and be rejected by consumers. Ideally one should ensure that silage is available in the period August – middle of November.

FIGURE 22: A cow enjoying good quality silage in the dry season

11.2 Hay

Another method to preserve cut green fodder from rotting and decomposing is drying it by sun and wind. Once the moisture (water) content is reduced from 80 % in the fresh material to less than 20 %, we speak of hay. It is much better to cut the fodder fresh and preserve it, than to leave it to dry on the stem. In that case it becomes very old and fibrous and looses almost all its feeding value. Well prepared hay remains leafy, clean, soft, palatable and nutritious. Plant residues like stovers and straw are also dry like hay. However, these contain more fibre and indigestible material and therefore have a lower feeding value. Examples are the maize plants after removing the cobs and pea-plants after harvesting the green pods for vegetables. Lucern must be dried to a water content of only 10% to become hay. Ordinary common bush grass, when harvested before it naturally over-matures, is also a source of good hay. Care should be taken that the hay is stored in a dry place. If exposed to rain it will loose its quality.

Kinds of hay

I Legume hay

Hay of legumes has a high feeding value and is especially rich in digestible crude protein, vitamins and minerals. It has a high palatability and is liked by the animals. Examples are:, lucern, cow pea, soya bean, velvet bean, sun-hemp, etc.

FIGURE 23: Good quality hay of lucern

FIGURE 24: Properly stored sun-hemp hay

II Non-legume hay

Hay from other fodders is in general less palatable than legume hay. However, this depends highly on the stage in which the fodder is harvested. The same is true for the feeding value. Protein content, minerals and vitamins are usually lower than in legumes. Examples are: Rhodes grass, buffel grass, natural grass, maize stover, sorghum straw, etc.

III Mixed hay

The nutritive quality depends on the type of mixture and the ratio of legumes and non legumes. Examples are: cow pea and maize, velvet bean and sorghum, velvet bean and maize.

Curing and storing of hay

To achieve an optimum combination between the quality and quantity of grasses and legumes, the cutting should be done when the first ears appear and blooming starts. To prevent losses in feeding value as much as possible the period during which the crop is left to dry, should be as short as possible. Shattering and turning the crop will shorten the drying period. But this should be done only soon after cutting, when the plants are still green and moist. Once they become dry, they should be touched as little as possible. This is especially true in the case of legumes. The finer parts of the plants, being the leaves with the highest feeding value,

will dry first, become crisp and easily break off, if worked in. In case the crop is dried quickly no significance change in aroma and flavour will be observed and the hay remains highly palatable.
Depending on the area the crop can be cut by hand or machine. Then it is dried in the sun for approx. 2 days till the moisture is reduced to 15 - 20 %. This stage is reached when no sap (moisture) can be drawn from the stem of the grass anymore, when it is pressed with the fingernail. When removing the hay from the field it can bundled in small bundles or boxed and tied. Then it is stored under roof in a shed, so that no rain can enter and deteriorate it.

FIGURE 25: Making hay bales with a wooden frame

12. FODDER TREES FOR INCREASED MILK PRODUCTION DURING THE DRY SEASON

12.1 Why plant fodder trees?

Most small-scale dairy farmers with grade dairy cattle, graze their animals on unimproved, natural grass. Although some crop residues may be added, this does not form a balanced ration for a good milkproduction. Moreover, the quantity of feed supplied to the animals is often not enough. These inadequate amounts of good feeds lead to a low milk yield.
Foddertrees can be an ideal solution to supplement the animals with high quality feed, particularly during the dry season. Several foddertrees like Calliandra and Leucaena are legumes. Their dry seed pods can be included as well. Also leaves and twigs originating from pigeon pea and mulberry can be used as well. The opinion that cattle do not browse or eat tree twigs / leaves, is not correct.
An advantage of foddertrees is that they can easily be included and grown on small scale farms, because they do not take much space.

12.2 Where to plant fodder trees?

- Along farm boundaries to leave all the available land for crop fields
- Along roads, passages and terraces to make them stable and avoid soil erosion.
- Around the homestead to provide privacy
- In plots of Napier grass, so that they can be harvested together as a mixture.

12.3 How to plant fodder trees?

- Make a nursery for Calliandra and Leuceana seeds. Seeds are planted in lines at 5 cm distance between each other and 10 – 15 cm from seed to seed in the line
- To improve germination of the seeds these should be soaked in cold water for 72 hours
- Mulberry cuttings can be planted directly in the field during the rainy season. Pigeon pea should be sawn in November after the rains.
- Seedlings can be planted in the field as well. A nursery can be established in the shade of some mature trees to produce the seedlings on the farm.
- Plant the seedlings and cuttings at the start of the rains when they are 20 – 30 cm high.
- Plant the seedlings in rows at a spacing of 0.5 m (1.5 ft) to form a hedge.
- Apply manure from a 1 kg tin or 1 tablespoon full of D-compound per hole
- One cow needs about 500 trees to feed on for a year. This means a single hedge row of 250 meter or a double hedge of 125 meter.

12.4 How to manage fodder trees?

- Harvest trees at a uniform height of about 1 meter (3ft) using a sharp panga or sickle.
- Harvest trees every 10 - 12 weeks i.e. 4 - 5 cuttings in a year.
- Cut the plants back to about 15 cm (6 inches) after 6-7 years to promote new growth.
- Apply manure using a 1 kg tin per tree at the beginning of the long rains every year.

12.5 Other benefits of planting fodder trees

1. When eaten by livestock, these produce good manure.
2. Provide stakes for supporting vegetable crops, like tomato and beans
3. Provide forage for bees to make honey
4. Source of good firewood.
5. The fallen leaves and roots improve the soil
6. Mark boundaries and provide privacy

Prevent soil erosion

12.6 Fodder trees suitable for smallholder dairy farmers

Leuceana	Sesbania	Moringa
Gliricidia	Pigeon pea	
Calliandra	Mulberry tree	

FIGURE 26: Leuceana

13. DRY SEASON SUPPLEMENTATION WITH UREA MOLASSES BLOCKS (UMB)

Molasses Urea Mixtures are an ideal supplement to provide energy, protein and minerals to ruminants, when these nutrients are in short supply during the dry season. Only ruminants can utilize urea, which is converted into proteins by the bacteria in their rumen.
Urea is highly poisonous to other animals. But also to ruminants, if it is given in excessive amounts. For the same reason it should never be fed to young calves before these are weaned and start ruminating.
The mixture can be fed using a licking wheel, by pouring it over the fodder and then mix it so that it sticks to the fodder. It can also be provided as a Urea Molasses (lick) Block (UMB).
A molasses urea mineral block can be made easily. To enable the mixture to harden sufficiently so that firm blocks are made, some cement can be added. Make sure that you do not use too much urea (poisonous) or cement (the block will become too hard).

13.1 Preparation of Urea Molasses Blocks (UMB) and their recommended composition

- Prepare wooden frames with the dimensions: 10 cm x 20 cm x 5 cm.
- Obtain the necessary ingredients and weigh them carefully. In case you make a quantity of 100 kg (sufficient for 25 – 30 blocks of 3.5 - 4 kg each) use the following quantities:

Molasses	38 kg
Urea	12 kg
Mineral Mixture / DCP / bone meal	2 kg
Salt	3 kg
Cement	13 kg
Wheat Bran / Maize bran	32 kg
Total ingredients	100 kg

- Start with the molasses. Add 1 – 3 % water if it is too dry to mix easily.
- Add the urea and mix until it is completely dissolved.
- Add the bone-meal or mineral mixture and the salt.

- Add the cement and mix it till the liquid reaches uniformity.
- Finally add fine wheat bran, maize bran or rice polish and mix it well.
- Pour the mixture into a wooden frame to give it a rectangular shape.
- Allow the blocks to dry for 3-4 days in the shade before they can be used to feed the animals.

Recommended quantities of urea molasses mixture to feed per cow per day:

Large cows (over 400 Kg)	2 kg
Small cows (under 400Kg)	1 kg

If provided as a block a mature dairy animal will consume (lick) up to 0.5 kg per day.

Some feed companies do make the urea molasses mineral block. Also blocks containing only molasses and minerals and no urea are available in the market. Farmers should provide these salt licks throughout as these minerals are essential to maintain a good fertility status among their cows.

14. DRY SEASON FEEDING OF DAIRY COWS AT LIVESTOCK DEVELOPMENT CENTER DEMONSTRATION FARM – BATOKA, ZAMBIA

At Batoka Livestock Development Centre (LDC) in Southern Zambia GART established a Smallholder Demonstration Unit with a small group of dairy crossbred animals in 2004. This farm unit is managed as an independent unit, in that way resembling the situation of a smallholder dairy farmer.
The objective of the demonstration farm is to generate information pertaining to milk production, and general management of the F1 and Jersey heifers which are sold by Batoka LDC to smallholder dairy farmers. Special attention is paid to the situation in the dry season.

At the Smallholder Demonstration Unit feeding in the dry season is done in two phases, namely

A. Inside the milking parlour while milking
B. Outside the milking parlour in the paddocks

14.1 Feeding inside the milking parlour

In the milking parlour cows are fed according to the level of their milk production using a concentrate mixture, which is prepared at the unit with the locally available feed ingredients.

The following ingredients are commonly used in the concentrate mixture at the dairy:

Maize bran	62 %
Cottonseed cake	35 %
DCP *)	1.5 %
Salt	1.5 %
Total	100 %

*) DCP = Di Calcium Phosphate = Mineral mixture

One of the cows, No 122 / 8, with an average milk production of 16.2 litres per day, is being used as an example for the feeding. It is assumed that this cow is able to produce ca. 5 kg milk out of the fodder it is supplied with. Per kg of the above mixture the cow is able to produce ca. 2 litres of milk. Therefore cow No 122/8 receives 5.5 kg of dairy meal in the milking parlour. This is given in 2 portions; 3.5 kg during the morning milking and 2 kg in the afternoon.
The cows which have just calved down are given lead feeding. Lead feeding means feeding a cow up to 1 kg concentrates per day more than is required for the level of milk she produces. This will enable the cow to increase her milk production gradually until she reaches the peak of her producing capacity.

14.2 Feeding outside the milking parlour

The lactating cows are fed with 6 kg of silage per cow per day after the morning milking.

The ingredients added to the silage to make a quantity of 300 kg are as follows:

Silage (Bana grass / maize / velvet beans)	255 kg	85 %
Fuzzy cotton / sunflower cake	20 kg	6.6 %
Molasses	20 kg	6.6 %
DCP (Mineral mixture)	2 kg	0.7 %
Salt	3 kg	1.0 %
Total	300 kg	100 %

Hay is mixed with the above ration and given in an unmeasured quantity. Its purpose is just to maintain the structure value of the ration. After milking in the afternoon the cows are allowed to graze in the paddock. At night the cows feed on Rhodes grass hay sprinkled with molasses. The most important is water for the dairy cows which is present nearby in water troughs.

14.3 Silage making

Making of silage at GART-LDC Batoka was introduced in 2004 as an experiment. The silage was made from Bana grass and the quality of the silage was very good.

In the year 2004 the average milk production of the cows was higher than in the year 2005, although in 2005 more silage was fed than in 2004. This was due to the drought experienced in 2005.
In the 2005 / 2006 growing season the area for Bana grass was increased from 0.5 ha to 2 ha. In addition the fodder-maize and the Bana grass were intercropped with velvet beans. This was to increase the protein content and so the nutritive valve of the silage made out of it. Since then the quantity of silage being made has been on the increase and the milk production during the dry season has been maintained at a good level. Manure collected from the manure pit at the milking parlour was applied to the fodder as a basic fertilization.

FIGURE 27: Making silage at Batoka

The importance of feeding good and nutritious feed to dairy animals in the dry season is clearly demonstrated below.

Code	Month	Milk production (kg)	
		Before introducing silage	After introducing silage
1	Jan	5,490.0	5,440.5
2	Feb	6,661.5	4,970.5
3	Mar	6,824.0	7,120.0
4	Apr	5.124.5	6,206.5
5	May	4,312.5	4,560.0
6	Jun	3,821.5	4,078.0
7	Jul	3,037.0	4,418.5
8	Aug	2,775.5	5,531.0
9	Sep	2,085.5	3,118.0
10	Oct	2,481.0	4,105.0
11	Nov	3,378.5	4,836.5
12	Dec	8,283.0	6,272.5
Total		54,274.5	60,657.0

TABLE 5: The milk production before and after introducing silage at the smallholder demonstration unit at GART-LDC Batoka.

15. DIFFERENT CONCENTRATE MIXTURES FOR SMALLHOLDER DAIRY FARMERS

Some examples of different concentrate mixtures are given, which can be prepared on-farm to supplement dairy cows. The feeding value of these mixtures compares to commercial dairy meal.

Dairy Feed Formula No 1

Wheat bran / Maize bran	45 Parts	or	45 kg
Maize grinded / No3 Mealie meal	16 Parts	or	16 kg
Cakes (cottonseed / sunflower)	35 Parts	or	35 kg
Mineral mixture (DCP)	2 Parts	or	2 kg
Common salt	2 Parts	or	2 kg
Total	100 Parts	or	100 kg

Dairy Feed Formula No 2

Number 3 Mealie meal	58 Parts	or	58.0 kg
Sunflower Cake	38 Parts	or	38.0 kg
Mineral mixture (DCP)	0.5 Parts	or	0.5 kg
Lime stone	1.5 Parts	or	1.5 kg
Salt	1.5 Parts	or	0.5 kg
Dairy Premix	0.5 Parts	or	0.5 kg
Total	100 Parts	or	100 kg

Dairy Feed Formula 3

Wheat bran / Maize bran	45 Parts	or	45.0 kg
Maize grinded / No3 Mealie meal	15 Parts	or	15.0 kg
Cakes (cottonseed / sunflower)	37 Parts	or	37.0 kg
Mineral mixture (DCP)	1 Part	or	1.0 kg
Common salt	1.5 Part	or	1.5 kg
Dairy Premix	0.5 Part	or	0.5 kg
Total	100 Parts	or	100 kg

- Out of 1 kg of each of these concentrate mixtures a cow is able to produce 2.0 – 2.5 litres of milk per day
- Such concentrate mixtures should contain about 16 -17% crude protein. Grinded cow pea and pigeon pea can be used in stead of cakes, in case these are grown by the farmer.
- Velvet beans can be grinded and given up to 20 % to replace the cakes. If one wants to incorporate velvet beans in the above feed formula no 3, one can mix 20 parts velvet beans and 17 parts cottonseed cake.

16. CHEMICAL COMPOSITION OF SOME FEEDS

GART collected the following forage samples and analyzed the chemical composition to assist farmers to formulate proper rations for their dairy animals.

1. COMPOSITION OF WHEAT STRAW (%)

DM	93.00
Moisture	7.00
Protein	2.00
Fibre	38.00
Ash	5.00
Calcium	0.74
Phosphorus	0.06

2. COMPOSITION OF MAIZE + VELVET BEAN SILAGE (%)

± (80% Maize + 20% Velvet bean green)

DM	58.00
Moisture	42.00
Protein	4.00
Fibre	13.00
Ash	9.00
Calcium	0.34
Phosphorus	0.16

3. COMPOSITION OF RHODES GRASS HAY (%)

DM	92.00
Moisture	8.00
Protein	2.00
Fibre	34.00
Ash	6.00
Calcium	0.18
Phosphorus	0.11

4. COMPOSITION OF SUNHEMP HAY CHOPPED (%)

DM	92.00
Moisture	8.00
Protein	17.00
Fibre	27.00
Ash	5.00
Calcium	0.34
Phosphorus	0.22

5. COMPOSITION OF MAIZE STOVER (%)

DM	92.00
Moisture	8.00
Protein	2.50
Fibre	32.00
Ash	5.00
Calcium	0.18
Phosphorus	0.11

6. COMPOSITION OF COTTON SEED CAKE (%)

DM	94.00
Moisture	6.00
Protein	41.00
Fibre	12.00
Calcium	0.15
Phosphorus	1.20

7. COMPOSITION OF FUZZY COTTON SEED (%)

DM	93.00
Moisture	7.00
Protein	21.00
Fat	17.00
Fibre	25.00
Calcium	0.15
Phosphorus	0.75

Maximum feeding of cottonseed should not exceed more than 2.0 Kg / day/cow

17. REQUIRED CONCENTRATES (kg) AT DIFFERENT FODDER RATIONS

The following table gives an indication of the quantity of concentrates, which at different fodder rations, have to be supplied daily to enable milk production levels from 5 – 20 kg. The figures show that with poor fodder rations it is impossible to reach a high milk production of more than 15 kg per day. The limiting factor in those cases is the feed intake of the animal.

Daily Milk Production:	5 kg milk	10 kg milk	15 kg milk	20 kg milk
Natural grass (veld)				
Poor quality, old	2 ½ kg	5 kg	-	-
Good quality, young	0 kg	2 kg	4 ½ kg	-
Improved pasture				
Poor quality	3 kg	5 ½ kg	-	-
Average quality	1 kg	3 ½ kg	6 kg	-
Good quality	0 kg	0 kg	2 kg	4 ½ kg
Napier/Bana grass				
Poor quality (overgrown)	2 ½ kg	5 kg	-	-
Good quality (2-3 ft high)	0 kg	1 kg	3 ½ kg	6 kg
Mixtures with legumes				
Improved pasture/lucern (75/25%)	0 kg	½ kg	3 ½ kg	6 kg
Napier grass/desmodium	0 kg	0 kg	2 ½ kg	5 kg
Hay				
Natural grass	3 ½ kg	6 kg	-	-
Rhodes grass	2 ½ kg	5 kg	-	-
Lucern	0 kg	1 kg	3 ½ kg	6 kg
Silage				
Maize	½ kg	3 kg	5 ½ kg	-
Napier grass	1 kg	3 ½ kg	6 kg	-

TABLE 6: Required quantity of concentrates at different production levels

In these calculations we assume that a cow is able to produce 2 kg milk out of 1 kg dairy meal or comparable concentrate mixture. Concentrates requirements for daily milk productions which are not indicated above can easily be calculated using this rule.
As examples try to find the required dairy meal for a cow producing 8 kg milk per day on the following rations:
a. good quality natural grass b. average quality pasture and c. maize silage.
And for a cow producing 12 kg per day on the rations:
d. good quality natural grass, e. pasture/lucern mixture and f. Napier grass silage.

(answers: a = 1kg, b = 2½ kg, c = 2 kg, d = 3 kg, e = 2½ kg and f = 4½ kg)

18. STANDARDS FOR THE DAILY FEED REQUIREMENT FOR A DAIRY COW

Some standard daily requirements, which are useful when feeding dairy cows are given below:

Fodder:	20 - 25 kg dry hay or stover
	50 - 70 kg fresh, green material
Water:	40 - 80 litres
Salt:	30 gms
Mineral Mixture:	30 gms
Dairy meal:	1 kg enables a cow to produce 2 kg of milk
Dairy meal:	1.5 kg per day during the dry period when the cow is pregnant

FIGURE 28: An animal in poor condition with a rough hair coat

FIGURE 29: A cow in good condition with a shiny hair coat

19. CHECKLIST TO JUDGE THE FEEDING SITUATION AT A FARM

The feeding situation of a dairy cow is to a great extend reflected by her milk production. However, also other signs can be noticed from the animal. The following checklist can be used as a guideline to diagnose a feeding problem on a farm.

1. Milk production
Is the milk production according to what you would expect? This in relation to the type of animal, the lactation stage and the history of the cow.

2. Body condition
Are the animals in a poor, fair or good condition?

3. Hair coat
Is the hair coat smooth and shiny? A smooth hair coat reflects a good health and feeding. This relates in particular to de-worming and mineral feeding.

4. Health status
A healthy cow eats and ruminates regularly. And she is curious. The animal will stay in the group and does not isolate herself.

5. Water availability
Is there free access to water all the time? If that is not the case how frequent are the animals given the chance to drink and how much is given?

6. Type of roughage
Has the animal access to fresh fodder or grass or is there only stemmy material, like maize stover?

7. Amount of roughage
The animal should always be given the opportunity to eat. An empty feed trough indicates underfeeding. This is also true for the night kraal!

8. Minerals
Do all cows have continuous access to minerals, in form of a mineral lick? If that is not the case are minerals fed regularly and which type?

9. Concentrates
Are concentrates being fed and in which quantity? Are these home made mixtures or is it commercial dairy meal? Does the farmer feed according to production and to the lactation stage? Are records kept on the farm to check this? Concentrate supplementation will, especially during the early part of the lactation, increase milkproduction.

If all these points of the checklist are up to standard and the milkproduction is not satisfactory, the provided ration and the requirements of the animals have to be calculated in more detail.

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