ILRI MANUAL

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Smallholder Dairy Farmer Training Manual

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Foreword

Improving milk production in East Africa faces multiple constraints, however lack of farmer understanding of the productive cows' nutritional needs – and how to satisfy them – are frequently a "first-limiting" consideration. In recognition of this an intensive, four week training has been developed to improve farmer understanding and ability in this critical area. This manual forms the underlying learning material for this course and is also designed as a reference resource for all course participants.

The original material has been sourced from many places. Dr John Moran of Profitable Dairy Systems, was the major contributor to the sections on Husbandry and Nutrition. Work of various NGOs and CG centres, engaged with African farmers have contributed strongly to this manual and these are acknowledged below:

Feeding dairy cattle in East Africa (Lukuyu, B (Ed.) Dairy Development programme) – International Livestock Research Institute (ILRI).

Feeding dairy cattle (Lukuyu, M (Ed.) Kenya Dairy Development Programme) United States Agency for International Development USAID) – International Livestock Research Institute (ILRI).

A Primer on Planting and Managing'Push-Pull' Fields for Stemborer and Striga Weed Control in Maize (Khan, Z.R. and others) – International Centre of Insect Physiology and Ecology (ICIPE).

Improve the quality of your milk and please your customers: training guide for trainers of small-scale milk traders in Kenya (Smallholder Dairy Project) – International Livestock Research Institute (ILRI).

Doubled-up legume technology: Boosting land productivity by intercropping two grain legumes with different growth habits – Africa Rising.

Grassland Database – Food and Agriculture Organization of the United Nations (FAO).

Making High Quality Sweet potato Silage An Improved Tube Silage Making Method – The International Potato Center (CIP).

Additional editorial support on fertility and fertiliser from David Pelster, Sonata Learning.

Acronyms, terms and measurements convertion factors

CIP	The International Potato Center
FAO	Food and Agriculture Organization of the United Nations
ICIPE	International Centre of Insect Physiology and Ecology
ICIPE-TOC	International Centre of Insect Physiology and Ecology-Thomas Risley Odhiambo Campus
ILRI	International Livestock Research Institute
KARLO	Kenya Agricultural and Livestock Research Organization
USAID	United States Agency for International Development

AI	artificial insemination
BSC	body condition score
CIP	cleaning in place
CMR	calf milk replacer
CP	crude protein
DM	dry matter
DMI	dry matter intake
LW	live weight
MY	milk yield
NSD	Napier stunt disease
TDN	total digestible nutrients
TMR	total mixed ration
UMMB	urea mineral molasses blocks

The conversion factors for pounds and kilograms are below:

To convert lb to kg:
1 lb = 0.454 kg
10 lb * 0.454 = 4.54 kg

To convert kg to lb:
1 kg = 2.2 lbs
10 kg * 2.2 = 22 lbs

The conversion factors for inches and centimetres are below:

To convert in to cm:
1 in = 2.54 cm
10 in = 25.4 cm

To convert cm to in:
1 cm = 0.39370079 in
10 cm = 3.9370079 in

1. Dairy cattle nutrition

Topic objectives

The overall objective of this topic is to increase farmers' knowledge of the principles of feeding dairy cattle, so they can apply the learnings to feeding different categories of livestock.

Topic aim: By the end of the topic, the learner should

- Know the essential nutrients for feeding cattle.
- Understand the concept of dry matter in feeding.
- Understand the different components of animal fodder.

1.1. Essential nutrients for dairy cattle

Feeds can be divided into two groups: roughages and concentrates.

- Roughages are bulky fodder like Napier grass, maize stover, Leucaena, banana stem, sweet potato vines, hay, silage etc. This fodder is usually grown on the farm and is cheapest to feed to cows.
- Concentrates are products like dairy meal. Dairy meal, or cubes, are balanced concentrates for milk production.

Dairy cow requirements include: water, energy, protein, fibre, vitamins and minerals. Nutrients are obtained from food and used in the body to promote growth, maintenance, reproduction and production. Feedstuffs contain the nutrients animals require to perform normal body functions and to produce milk. The feedstuff must be digestible in order to be useful to the animal.

Feedstuff such as woody plants have little nutritional value as these are indigestible for dairy cows. These pass out through faeces. Also, some plants contain compounds that are toxic to the animal.

Examples for fodder with high protein content are: silver leaf and greenleaf desmodium, lucerne, calliandra, leucaena, sesbania and sweet potato vines (before and after the potatoes are harvested)

1.1.1. Common good quality forage

- Young Napier/Brachiaria grass (0.8 - 1m tall; dark green stems and leaves)
- Young Rhodes/Kikuyu grass (fresh, green leaves and stems; up to flowering stage)
- Young fodder sorghum (fresh, green leaves and stems; before flowering stage)
- Young fodder oats (fresh, green leaves and stems; before flowering stage)
- Young roadside grass (fresh, green stems and leaves; before flowering stage)
- Hay (made at early to mid-flowering stage of grasses)
- Horticultural waste (outer leaves of cabbages and fresh green beans and peas rejected by export companies)

1.1.2. Poor quality bulk forage

- Overgrown Napier/Brachiaria grass (more than 2m tall)
- Dry maize or sorghum stover (after cob harvesting)
- Rice straw
- Wheat straw
- Barley straw
- Old, dry pasture/grass (dry leaves and dry, hard stems; seed dropped)
- Bean haulms/husks (after harvesting beans)
- Banana pseudostems and leaves (fresh green leaves and stems)
- Sugar cane tops

Dry matter is what remains of a feed when all water has been removed and nutrients remain. This dry matter portion can be divided into organic matter comprising energy, protein and vitamins, and inorganic matter comprising minerals.

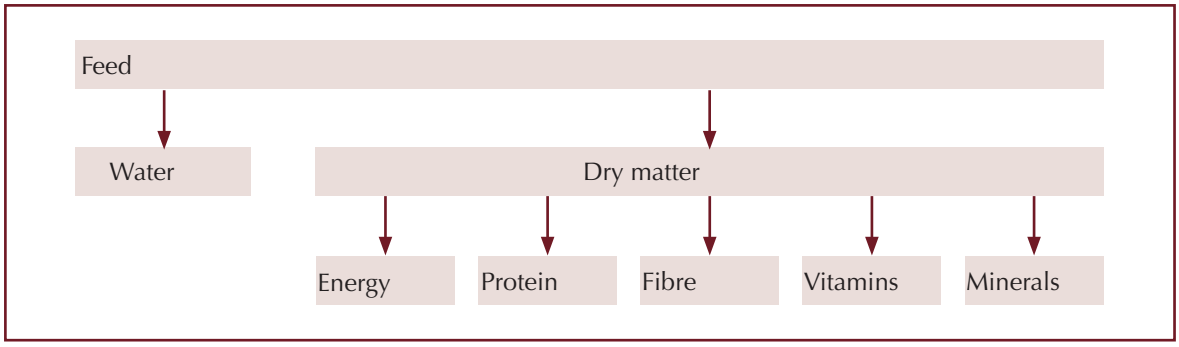


Figure 1.1: Components of feed (Source: Lukuyu et al., 2012)

1.2. Concept of dry matter in feeding cattle

Feed contains both water and dry matter. Animals must consume enough dry matter to obtain the required nutrients to keep them healthy and to let them grow, reproduce and produce milk.

Dry matter is expressed as a percentage of fresh feed. In a feed comprising 40% dry matter, for every 100kg of the feed, only 40kg are dry matter. It is from the 40kg that the animal will obtain its nutrient requirements. If the same feed contains 10% crude protein, the amount supplied by the feed will be 10% of 40kg, which is 4kg. Banana stem containing 10% dry matter means that if you feed 100kg of fresh stems, the cow will have only 10kg dry matter and 90kg water.

Dry Matter Intake (DMI) is the level of intake that a cow must consume of a ration that contains the energy concentration recommended for her. It is important to note that a cow has a maximum limit of dry matter it can consume. If this limit does not meet the cow's needs, concentrates must be added.

1.2.1. Estimating dry matter intake

- Measure how much of each feed a cow is eating.
- Weigh daily allocations of grain, protein meals, conserved fodder and hay. Intake of pasture and forage crops is more difficult to estimate. However, visual estimation, cutting quadrants and/or using rising plates are other ways of determining pasture/forage intake levels.

To help you track animal live weight and assist with a simple feed ration formulation, download the eWeigh app (Android only).

Scan here

1.2.2. Indicators of adequate daily dry matter intake

- Milk yield and composition on target.
- Lush pasture allocation not fully eaten.
- Silage, grain or mixed feed left in troughs.
- Cows not standing around 'waiting to be fed'.
- Body condition score on target.

1.2.3. Indicators of inadequate daily dry matter intake

- Low milk yield and problems with quality.
- Cows appearing hungry, bellowing, waiting for feed.
- Cows rushing to fresh forage, to feed troughs, and into dairy for grain.
- Cows eating all feed allocated in paddocks and troughs.
- Low body condition score.

Useful rules of thumb

- The heavier the animal, the higher its maintenance requirements, and the higher the intake required for production.
- An efficient milking cow needs a daily dry matter (DM) intake equivalent of at least 3% of its body weight. e.g. A 600kg cow needs at least 600kg × 3% = 18kg DM/day.
- Higher producing cows will eat more than 4% of their body weight as dry matter, e.g. a high producing (> 30 l/day) 600kg cow could eat 600kg x 4% = 24kg DM/day.
- Aim for maximum daily intake of good quality forage, supplemented and balanced with other feed sources.
- Minimise daily variation in forage fed. Rumen microbes can take up to 4-6 weeks to adapt, so change diets gradually.

Table 1.2 below highlights the dry matter content in various types of fodder.

Table 1.2: Dry matter content in various fodder

Fodder	Dry matter content (% of the fresh matter weight)
Hay	90
Maize stover (brown, dry)	85
Cut grass	30
Silage	25
Napier grass > 1.8m	25
Sweet potato vines	25
Weeds	25
Napier grass (1.8m)	20
Banana leaves	12
Maize stover (green at harvest)	10
Napier grass (0.6m)	10
Banana pseudo stem	5

(Source: Goopy and Gakige, 2016)

1.3. Nutrients in feed, their functions and sources

1.3.1. Energy

The energy portion of the feed fuels all body functions, enabling the animal to undertake various activities including milk synthesis. This is the major nutrient (in terms of quantity) that dairy cows require.

1.3.1.1. Functions

- *Maintenance:* Simply to maintain itself, an animal requires energy. Body weight does not increase or decrease, the animal does not produce; this energy is only for survival and the amount is affected by body size and environmental conditions.
- *Growth and weight gain:* Gain is especially important for young animals, who need to attain the recommended weight for a particular age.
- *Reproduction:* A cow requires more energy during pregnancy for the foetus to grow and develop normally.
- *Milk production*: The energy requirement of a lactating cow increases as milk production rises alongside the butter fat content of the milk.

1.3.1.2. Energy sources

Energy can be obtained from several types of feedstuffs that contain either carbohydrates or lipids (fats and oils).

- *Carbohydrates* are the major source of energy in the diet of dairy cows. Carbohydrates constitute between 50% and 80% of the dry matter in fodder and grains.

Feeds contain three major types of carbohydrates:

- *Sugars:* Sugars are soluble in water, making them readily available to the animal. Sources are molasses, sugar beets and sugar cane.
- *Starch:* Starch is the main form of carbohydrate stored in plants. It is the main component of cereal grains and some roots (potato tubers).
- *Fibre:* Forming the structural part of plants, fibre is present in large quantities in roughages. The fibre is broken down by microorganisms in the rumen (microbial enzymes) into products that the animal can use. It is also important in maintaining high levels of milk fat. Sources include grasses, fodder crops and crop residues.
- *Lipids (fats)* contain about 2.25 times more energy than carbohydrates per unit weight. Generally, plants are good sources of oils while animal products contain fats. Most plant seeds contain a small amount of lipids. The exceptions are oilseed plants (cotton, sunflower and soybean seeds), which may contain as much as 20% lipids and are better sources of lipids than animal fats.

1.3.1.3. Consequences of energy deficiency

The most obvious sign of energy deficiency is poor body condition due to excessive weight loss. Lactating cows are unable to reach peak milk production in early lactation, resulting in overall lactation yields.

1.3.1.4. Consequences of excessive amounts of energy

Cows that consume too much energy become too fat, resulting in low conception rates.

They are prone to difficult calving, retained placenta, and higher incidence of milk fever and ketosis.

In early lactation, feeding too much energy, especially in the form of grain, may lead to too much acid in the rumen (acidosis), increased risk of displaced abomasum, depressed feed intake and low milk fat percentage.

1.3.1.5. Special considerations

Usually fodder is high in fibre and low in energy, and concentrates are low in fibre and high in energy. Therefore there is a need to balance the two, as too much forage limits the intake of energy while too much concentrate results in milk fat depression, rumen acidosis and other health problems.

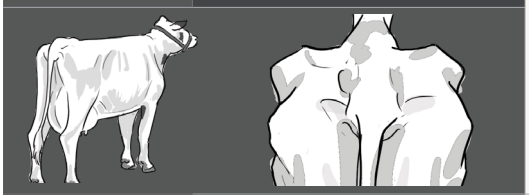
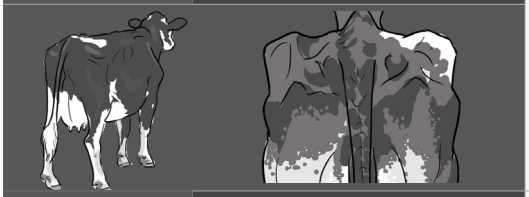
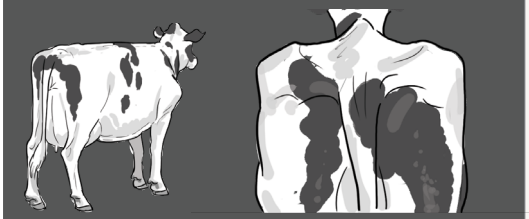
1.3.1.6. Use of body condition score to evaluate energy intake

Body condition scoring is the visual evaluation of the amount of muscle and fat covering the bones of an animal. The body condition can be assessed independently of live weight, gut fill and pregnancy status and involves observing specific points on the animal.

Body condition affects milk production and reproductive performance and enables farmers to compare the condition of their cows with recommended targets.

Knowledge of body condition scoring enables farmers to manage their feeding programs better. Increases when energy intake exceeds energy output and decreases when energy output exceeds energy intake. Body condition scores can be based on a 1 to 5 system, as in Table 1.3.

Table 1.3 Descriptors for condition scoring of dairy cows for the 5-point body condition scoring system

Five-point scoring system	Condition	Descriptors*
Score 1 Very poor condition (very thin) 	Very poor	Very thin. Spine like teeth on a saw. Transverse processes prominent, with more than half the length visible. Pin bones are very prominent, with a deep V shape cavity below the tailhead and no fatty tissue under the skin.
Score 2 Skeleton clearly visible 	Moderate	Skeleton clearly visible Individual vertebrae can be identified on the spine. Transverse processes are $^{1}/_{2}$ to $^{1}/_{3}$ visible with the ins rounded and can be identified individually. Pin bones are prominent with a U cavity below the tailhead and some fat under the skin.
Score 3 Skeleton and covering well balanced 	Good	Skeleton and covering are well balanced. Spine forms a sharp ridge. Transverse processes are $^{1}/_{4}$ visible. Individual vertebrae can still be identified, but only by pressing on them. Pin bones are rounded and smooth, with a shallow cavity below the tailhead and fat cover over the whole area. Skin smooth, pelvis can be felt.
Score 4 Covering has the upperhand 	Fat	There is excess fat covering. Individual vertebrae cannot be identified. Transverse processes have a smooth and rounded edge. Pin bones are covered in fact with a shallow cavity below the tail head and patches of fact evident.
Score 5 Obese 	Grossly fat/obese	Spine is covered with fat. The ridge of transverse processes is barely visible. Pin bones are completely covered in fat, with the cavity filled with fat rolls. Pelvis impalpable, even with firm pressure.

*The spine is assessed according to the lumbar vertebrae. The transverse processes are the horizontal part of the lumbar vertebrae. The pin bones are the bones on either side of the tail head.

1.3.2. Protein

Protein is quantitatively the second most important nutrient in feeding the dairy cow. Proteins are made up of building blocks referred to as amino acids.

1.3.2.1. Functions

Proteins provide the building material for all body cells and tissues (e.g. blood, skin, organs and muscles). Proteins are also major components of products such as milk and meat. Lack of protein therefore adversely affects milk production.

1.3.2.2. Protein sources

Good sources of protein for dairy cows include:

- *Oilseeds and oilseed cakes:* Residues after the oil is removed from oilseeds, e.g. cottonseed meal or cake, whole cottonseed, whole soybeans (cracked) or meal and sunflower meal or cake.
- *Products of animal origin:* Such as fish meal, blood meal, meat and bone meal, feather meal and by-products from milk processing (e.g. skim milk and whey).
- *Herbaceous legumes:* Such as lucerne, desmodium and fodder trees (e.g. calliandra and sesbania).
- *Non-protein nitrogen:* Cows can obtain protein from sources that do not contain true proteins, such as urea and poultry waste (which has uric acid). These sources are referred to as non-protein nitrogen sources. Microorganisms in the rumen use the nitrogen in urea to synthesise protein for their own growth.

1.3.2.3. Consequences of protein deficiency

For lactating cows, there is a sudden drop in milk production if the amount of protein in the diet is suddenly reduced. Severe deficiency may cause excessive weight loss in lactating cows, reduced growth rate in calves and heifers, and result in underweight calves being born.

1.3.2.4. Consequences of feeding excess protein

Protein is an expensive nutrient. Feeding to excess is a waste of money, as protein is not stored in the body. Rather, it is broken down by microorganisms in the rumen and excreted in the form of urea.

1.3.2.5. Protein and rumen microbes

Most of the protein in feed is broken down by microorganisms in the rumen (rumen degradable protein) and re-synthesised into bacterial protein. *Bypass proteins* are proteins resistant to microbial breakdown in the rumen (undegradable protein), and pass intact to the small intestines where they are digested and absorbed directly into the body.

1.3.2.6. Protein and milk production

Milk contains approximately 3.2–3.5% protein. Thus a cow producing 25kg milk per day secretes 800–900 g protein daily. Cows have little ability to store protein in the body and so it must be supplied in the daily diet to maintain the milk yield. Protein should be 15–18% of the total ration of a dairy cow depending on milk yield.

Like energy, the protein requirement is dependent on milk yield, maintenance (replaces the amounts lost in urine, faeces and skin), growth and pregnancy. Protein is not stored in the body and any excess is removed. Protein is an expensive component and overfeeding should be avoided to minimise the cost. In addition, extra energy, which would otherwise be used for milk production, is used to remove the extra protein (nitrogen) from the body in the form of urea in the urine.

As a rule of thumb, lkg increase in concentrate fed should result in an increase in production of milk of 1.5 to 2 l. Feeding concentrates is economical only as long as the price of I.5 litres of milk is higher than the price of 1kg concentrate.

1.3.3. Minerals

Minerals are nutrients that are required in small amounts in feed. They are required for the body to function properly, i.e. remain healthy, reproduce and produce milk. Some minerals are required in large quantities in the ration dry matter (macro-minerals) while others are required in small quantities (micro-minerals). Some minerals are stored in the body (e.g. iron in the liver and calcium in bones) while others are not (e.g. sodium, potassium) and have to be supplied in the diet all the time. Table 1.3.2 below gives and overview of macro- and micro-minerals.

Table 1.3.2: Macro-minerals and micro-minerals

Macro-minerals	Micro-minerals
Calcium	Cobalt
Chlorine	Copper
Magnesium	Iodine
Phosphorus	Iron
Potassium	Manganese
Sodium	Molybdenum
Sulphur	Selenium
	Zinc

1.3.3.1. Functions

Specific minerals may have different functions in the body. In general, minerals are required for

- bone formation
- formation of components of enzymes, vitamins and red blood cells
- production of hormones that control body functions
- control of water balance in the body
- milk synthesis

1.3.3.2. Factors that affect mineral requirements in animals

- *Age:* Mineral requirements for young growing animals are higher.
- *Physiological status:* Pregnant animals require more.
- *Level of production:* High-producing cows require large quantities of calcium; deficiency is more likely to occur in early lactation rather than late.

1.3.3.3. Sources

Although roughages and concentrates contain minerals, the types and amounts vary widely and hence may not meet the requirements. During ration formulation, macro-minerals calcium, phosphorus and magnesium are taken into account. Roughages will supply adequate amounts of potassium and common salt can adequately provide sodium.

Some ingredients (supplements) are added to supply a specific mineral (e.g. limestone, salt, magnesium oxide).

Buy salt lick from reputable agrovets and companies. Only buy what is well packed and labelled.

1.3.3.4. Consequences of mineral deficiency

Signs of mineral deficiency may not be obvious but they include

- poor fertility: lack of heat signs and low conception rate
- low milk production
- poorly developed bones in young animals (rickets)
- health disorders, for example, milk fever
- poor body condition, which may be accompanied by a change in coat colour

1.3.4. Vitamins

Vitamins are nutrients in the feed required by the body in tiny amounts for normal functioning, through their involvement in many body processes. Some are synthesised by rumen microbes and/or stored in the body of the animal while others must be supplied in the diet. The vitamins that must be supplied in the diet include A, D and E; those that are produced in the body include B complex, C and K. An improved appetite will increase feed intake and, as a result, uptake of vitamins like vitamin B.

1.3.4.1. Functions

Important functions of vitamins include

- maintenance of healthy protective tissues such as skin, stomach, intestinal and cell linings (vitamin A)
- production of red blood cells (e.g. vitamins B6 and B12), which prevents anaemia
- enhanced calcium and phosphorus utilisation (vitamin D), which supports bone formation and growth
- enhancing immunity (vitamin E)
- help in blood to clot (vitamin K)

1.3.4.2. Consequences of vitamin deficiency

Vitamin requirements of dairy cows are normally met through diet, rumen microbial synthesis or tissue synthesis. Deficiencies are rare under normal conditions but they can occur. Table 1.3.3: below illustrates the consequences of vitamin deficiency.

Table 1.3.3: Consequences of vitamin deficiency

Situation	Affected vitamins			
	A	B	D	E
Feeding poor quality roughage (overgrown), frost-damaged maize silage or long-term stored forage, heat-damaged fodder, periods of prolonged drought	x			
Very high grain-to-forage ratio	x		x	x
Cattle kept indoors throughout			x	
Feeding of milk or milk replacer rations alone	x		x	x
Crop residues as a major component of diet	x		x	
Prolonged stress period or disease	x	x	x	x
Very young calves (rumen not functional)		x		
Deficiency of cobalt		x		

(Adapted from Wattiaux MA. 1999. Dairy essentials. Babcock Institute for International Dairy Research and Development, Madison, Wisconsin, USA.)

1.3.4.3. Consequences of feeding excess vitamins

There is no important health consequence of excess vitamins as the body can get rid of the excess. However, vitamin supplements are expensive, so over-feeding is an economic loss to the farmer.

1.3.5. Water

Water, though not classified as a nutrient, is essential for all animal life. Water accounts for 74% of a calf's weight at birth. That figure drops to 59% for a mature cow. Every 100kg of milk contains up to 87kg of water.

The amount of water cows consume at will is influenced by several factors

- moisture content of feed. When the diet has a large proportion of dry fodder, e.g. hay and grains, the cow drinks more water than when the diet has a larger proportion of young or succulent fodder, e.g. young grass and legumes
- amount of dry matter consumed
- milk yield
- environmental temperature
- salt intake

An increase in any of the factors above increases the water requirement for lactating cows. The amount of water consumed will also depend on the quality and quantity of water provided. Table 1.3.4 below depicts a cow's milk production and water requirements.

Water stress, even for a short period of time, causes an immediate drop in milk production.

Table 1.3.4: Milk production and water requirements

Dairy cattle type	Level of milk production (kg milk/day)	Water requirement, average range (litres/day)
Dairy calves (1-4 months)		5-15
Dairy heifers (5-24 months)		15-40
Milking cows	14	65-85
Milking cows	23	85-105
Milking cows	36	115-140
Milking cows	45	130-155
Dry cows		35-50

(Adapted from McKague K. 2007. Factsheet on water requirements of livestock. Ontario Ministry of Agriculture, Food and Rural Affairs, Toronto, Canada.)

1.4. Summary

- Dairy cattle require a diverse mix of nutrients, to support optimal health.
- The quality of bulk fodder is as important as the volume. The feedstuff must be digestible, and the nutrients absorbed, if feed is to be useful to the animal.
- Dry matter is what remains of a feed when water has been totally removed and nutrients remain. An efficient milking cow needs a daily dry matter intake equivalent of at least 3% of its body weight.
- Energy, protein, minerals, vitamins and water all play an important role in producing healthy dairy cattle. Too much, or too little of any of these, will negatively impact the animal.
- Usually fodder is high in fibre and low in energy, and concentrates are low in fibre and high in energy. The two must be balanced to prevent limited energy intake, milk fat depression, rumen acidosis or other health problems.

1.5. Review questions

1. Livestock fodder is mainly divided into roughages and concentrates. Give 3 examples of roughages and concentrates commonly used by dairy farmers in Kenya.
2. Describe the difference between good quality and poor quality for these roughages: Napier grass, Rhodes grass, hay, maize.
3. Why is determining dry matter intake important in dairy cattle production?
4. List the major nutrients in fodder and their function in calves and milking animals.
5. What is the importance of feeding clean water to dairy animals?
6. Some woody plants have no nutritive value because they are indigestible and cannot be absorbed. Is this statement true or false?
7. List three ways you can tell that your cattle are taking in enough dry matter each day.
8. For cows, what are some of the health consequences of an energy imbalance?

2. Ration formulation

Topic objectives

The overall objective of this topic is to impart the skills necessary to formulate simple rations for dairy cows based on the available fodder.

Topic aim: By the end of the topic, the learner should

- Know the basic considerations when formulating rations to meet the specific requirements of the animals.
- Be able to formulate a simple ration based on the pearson square method.
- Be able to list the practicalities of sourcing and formulating rations.

2.1. Introduction to ration formulation

Ration formulation skills form the basis of any profitable dairy enterprise, whether they are used in a series of complex calculations or have been intuitively developed through years of experience. This skill involves selecting and sourcing a range of fodder to provide sufficient feed nutrients to optimise young stock growth and long-term cow performance.

Formulating a ration for milking cows requires a series of calculations to determine the energy, protein and fibre requirements, based on a series of descriptors of the cows' current live weight, stage of pregnancy, changes in live weight, milk composition and target milk yield. The next step is to select the most appropriate available fodder to supply nutrients at the lowest cost.

Good dairy farmers know how much they want to produce and how to feed their cows to achieve their targets. They follow a simple process, namely:

- Plan target milk yields (e.g. 10, 15 or 20kg/cow/d).
- Calculate how much nutrients (energy and protein) are required per day to achieve the target milk yield.
- Determine what fodder they require to supply these nutrients.
- Calculate how much of these feed they need, per day, per month, per year.
- Think laterally about future feed supplies.

2.2. Principles of ration formulation

The principles of ration formulation are as follows:

1. Calculate nutrient requirements (energy and protein).
2. Set production targets.
3. Assess what home grown fodder is available.
4. Decide what fodder needs to be purchased.
5. Ensure ration can be consumed to achieve production targets.
6. Ensure ration is most profitable at present and will last for duration of entire lactation.

It's important to plan feed requirements for the whole herd well in advance to accommodate every potential scenario. When a cow becomes pregnant, it requires a greater amount, or better quality, of feed, as it will soon be lactating. For this reason, advance planning in feed availability is needed, to allow the farmer to take advantage of the profitability of cows' enhanced milk production. The fodder must be sourced, either home grown or purchased. The major fodder should be sourced when it is cheapest and then stored on farm, even conserved as silage if necessary. Bulk purchases, such as using the cooperative approach, can minimise costs. The storage facilities should be carefully evaluated, to isolate different fodder in bird and vermin-proof rooms if required.

Quality fodder is relatively easy to find during the wet season. This may not be the case for quality fodder sourced in the dry season.

Quality dry season fodder is the key to profitable dairying in the tropics.

2.2.1. Determining cow nutrient requirements

The energy requirements for milk production depend on five key factors

- Cow live weight and climatic stress. This is called the maintenance energy requirements. Severe heat stress, such as is evident with cows panting, can increase maintenance requirements by up to 10%.
- Activity (such as whether grazing or pen fed) and the impact of climatic stress.
- Stage of pregnancy. This is only important after 6 months of pregnancy.
- Milk yield and milk composition. This varies with kg/day milk yield together with milk fat and protein contents.
- Change in body condition score or live weight. Live weight loss will decrease while live weight gain will increase total energy requirements.

The energy requirement of milking cows is the sum of the energy requirements for individual activities

- Maintenance
- Pregnancy
- Milk production
- Live weight change

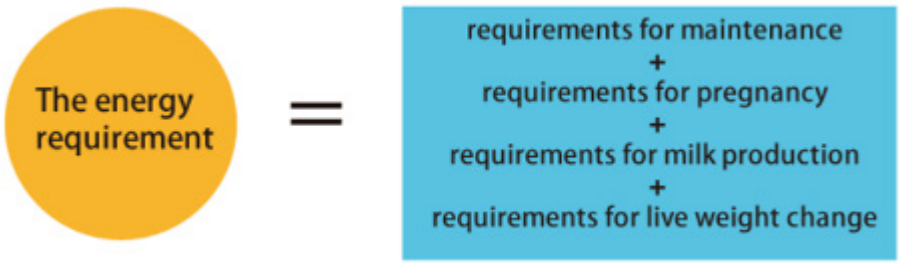


Figure 2.2: Activity-based energy requirements

2.2.1.1 Calculate energy requirements for target milk yield taking into account

- Cow live weight
- Activity (pen fed vs grazing)
- Months since calving/stage of pregnancy
- Target milk yield and milk composition
- Change in live weight/body condition score
- Energy requirements expressed in MJ of ME/cow/day

2.2.1.2 Calculate protein and fibre requirements of ration

2.2.2. Deciding on sources of feed and matching animal requirements

The ration will require

- Sources of forage to ensure dietary fibre is supplied.
  - Home grown fodder is generally cheaper.
  - If insufficient, additional fodder will have to be purchased.
- Energy rich fodder.
- Protein rich fodder.
- Additional vitamin and mineral supplies.

2.2.3. Matching cow requirements to available feed supplies

For each feed, it is important to accurately estimate the following

- Dry matter content.
- Energy content.
- Protein content.
- Fibre content.
- Calcium and Phosphorus content.

2.3. Methods of Ration Formulation

2.3.1. Qualities of an ideal ration

- Provides adequate amount of different, mixed nutrients and is appetising.
- Is palatable and thus has better digestibility.
- Has a good effect on health.
- Contains a variety of feed ingredients.
- Is bulky and includes sufficient fodder.
- Preferably includes plenty of succulent green fodder.
- Is properly balanced and contains adequate energy, protein, minerals and vitamins.
- Is economical to feed.
- Is non-toxic (not too old and has not been stored in a damp place)
- Prevents undesirable flavor in milk.
- Is free of undesirable weeds, dust, dung and urine.

2.3.2. Methods of concentrate formulation

This involves knowledge about nutrients to feed animals and optimize production. Basic information needed for ration formulation includes

- Animals' nutrient requirements. These can be obtained from feeding standards or via estimations.
- List of available ingredients and their chemical composition. Ingredients can either be locally grown, available from local markets or by-products.
- Nutritive value of available feedstuffs.
- Cost of feedstuffs to be used so as to come up with the most cost-efficient ration.
- Limitations of various ingredients available e.g. gossypol in cotton seed cake, fish meal not to be used above 10% in dairy meal.
- Identifying type of ration to be formulated i.e. either complete or supplemental ration.
- Animal's expected feed consumption.
- When formulating rations, have a variety of feedstuffs, because they make the ration more palatable. A mixture of different sources counters mineral deficiencies, especially for trace elements and vitamins.

Diet formulation is largely a set of mathematical procedures. The following are common methods of concentrate feed formulation.

2.3.2.1. Trial and error method

This is basically simple substitution of ingredients at different levels. It plays around with the amount of fodder, to arrive at the required level of nutrients. The method is tedious and time consuming, and it may not produce a least cost ration. It is used when dealing with a few ingredients.

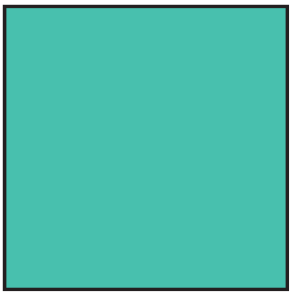
2.3.2.2. Use of computers (linear programming)

This method is used for least cost formulation. Complex equations are set up to satisfy the requirements for energy, proteins and minerals. An equation with the unit cost of each ingredient is included. It factors in unit cost, upper limits in percentage of ingredients etc. various software programmes are available, but most are expensive and only economically worth it for large enterprises.

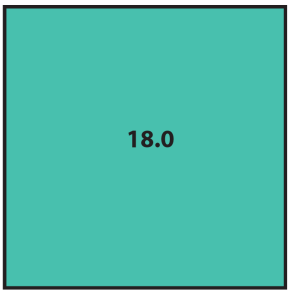
2.3.2.3. Pearson square method

The Pearson square provides one of the simplest methods to formulate rations at the farm level. The approach mainly involve mixing of two ingredients with known nutrient values. The steps followed while formulating a ration using the pearson square is as follows

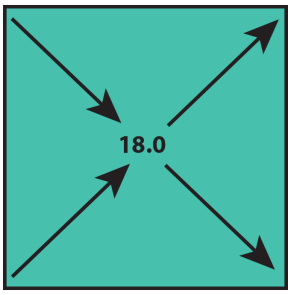
Step 1. Draw a square.



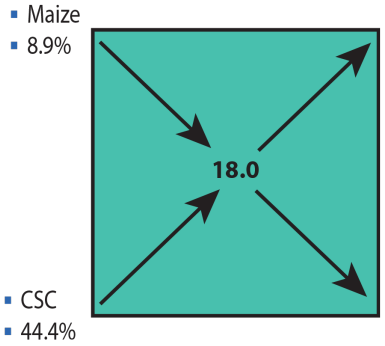
Step 2. Write the percentage of the crude protein needed by the animal in the centre of the circle.



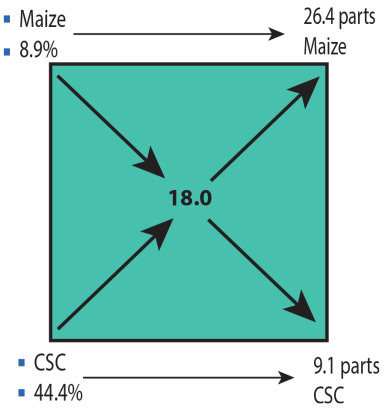
Step 3. Add diagonal lines from corner to corner.



Step 4. Write the volume of feeds to be used at alongside the corners. Indicate the percentage of crude protein in the feeds after the feed name.

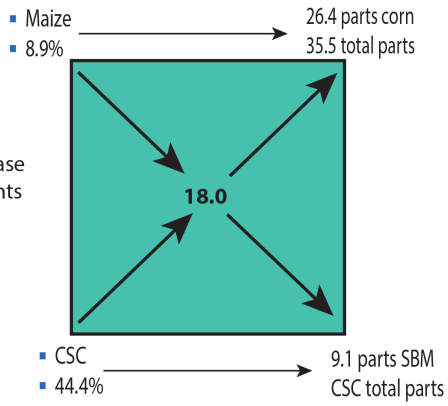


Step 5. Subtract the smaller numbers from of the the larger numbers. This involves crude protein needed by the animal and the feed. Write the difference in the opposite corners.



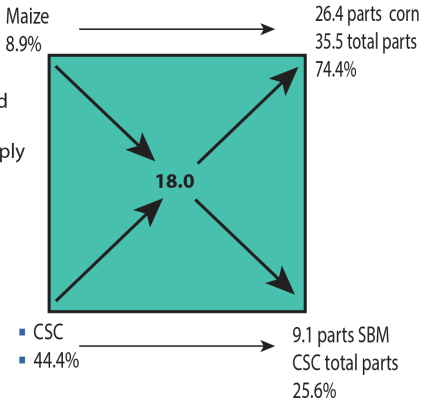
Step 6. The resultant number on the right side gives of the square gives the parts or proportions of each feedstuff required to make the intended ration.

Step 7. Add the parts to obtain the base that will be used to calculate the amounts of each feedstuff to be used in the feed.



Step 8. The percentage of each feed needed in the ration can be found by dividing the number of parts by the total parts, then multiply by 100.

- 26.4/ 35.5 = .744 x 100 = 74.4% Maize
- 9.1/ 35.5 = .256 x 100 = 25.6% CSC



Step 9. The amount of each feed ingredient for a large batch of feed is determine multiplying the percentage of each by the total amount of feed desired.

Scan here to get the eWeigh app to perform the calculations.

2.4. Summary

- Being able to formulate simple rations for dairy cows, based on available fodder, is crucial to a farmer's profitability.
- Farmers need to be able to plan rations to meet target milk yields and coincide with periods when the cows are experiencing peaks productivity e.g. during lactation.
- Farmers must also be able to gauge the dairy cows' energy requirements to meet milk yield targets.
- An ideal dairy cow ration is nutritious, palatable and has a good effect on the cow's health.
- Because the cost of a linear programming solution to formulate concentrate is prohibitive for most farmers, they use either the Pearson method, or the trial and error method.

2.5. Review questions

1. What factors should be considered when formulating the ration for milking cows?
2. How is the nutrient requirement of an animal determined to ensure that the ration formulated takes care of all the needs of the dairy animal?
3. List any 5 qualities of an ideal ration for dairy cattle.
4. What are the challenges you may experience when formulating rations for smallholder dairy farmers?
5. To match cow requirements to available feed supplies, name any 3 of the 5 factors you must accurately estimate for each feed.
6. Profitable dairy farmers select the most appropriate fodder to supply nutrients at the lowest cost. What key principles of ration formulation do farmers use to achieve their targets?
7. Among the most common methods of concentrate feed formulation are the Pearson square method, linear programming by computer and trial and error. Which method is right for you? Why?

Chapter Three

3. Fodder/forage production

Topic objectives

The overall objective of this topic is to increase the knowledge and skills of farmers around fodder establishment and management at the farm level.

Topic aim: By the end of the topic, the learner should be able to

- To choose the best fodder to grow on his/her farm
- To know the factors affecting fodder yield
- To know the common types of fodder and how to feed dairy cattle using different types of fodder

3.1. Definition of fodder

- Fodder crops are plants cultivated on arable land and grazed or fed to livestock either green or in a conserved form, like hay or silage.
- They are characterised by their high productivity per hectare (dry matter yield) compared to permanent pastures. Further, fodder crops are grown as supplementary feed during the dry months of the year.
- Fodder crops have been identified as the most important feed on smallholder farms in East Africa due to their high yield per unit area.

3.2. Factors to consider when selecting fodder to grow

There are a number of rules that guide selection of fodder. These rules help define which fodder crops are suitable for each farm or locality. In this sense, they help the farmer make good decisions. Good grass and legume species should be:

- Adapted to the climatic conditions and soil condition where they are grown.
- Fast-growing and well adapted to frequent cutting and defoliation.
- Able to provide good soil cover and prevent weeds from growing.
- Palatable (pleasant tasting) to livestock.
- High in nutritive value containing high energy and protein and should not contain any poisonous substance.
- Easy to conserve as hay or silage or able to stay green on the farm during the dry season.
- Able to produce high quality forage materials – high DM and low crude fibre.
- Easy to establish from seed or vegetative material.
- Able to withstand infestation of pest and diseases.
- Able to produce good quality seed and/or vegetative planting material in adequate amounts.
- Able to grow well with other crops where intercropping is practiced.

3.3. Factors influencing fodder yield

3.3.1. Land preparation

Land preparation is the first step to ensure that the field is ready for growing a crop. A well-prepared field does the following

- Controls weeds.
- Recycles plant nutrients.
- Provides a soft soil mass for transplanting and better root/shoot penetration.
- Improves entrance of water and air into the soil.

Initial land preparation begins after harvesting of the previous crop and continues until sowing or planting of the next crop, which is important for effective weed control and soil enrichment with organic compounds.

The goal of tillage is to bring the soil into the state of quality structure and to create a seedbed in the surface layer to a depth of sowing. The goal is to create ideal conditions for the germination of small and sensitive plants.

Pre-sowing soil preparation creates a seedbed for optimal conditions for germination of seeds and easy sprouting of young plants. There are fodder seeds e.g. lucerne which are small and require a seed bed to be prepared to enhance germination.

3.3.2. Soil management

Soil management is the application of operations, practices, and treatments to protect the soil and enhance its performance. It includes soil conservation, soil amendment, and optimal soil health.

The goal of good soil management is to meet essential plant needs. Healthy plants need water, nutrients, oxygen, and a physical medium that allows seeds to germinate, shoots to emerge and grow up toward the sunlight, and roots to anchor the plant by growing strong and deep.

To be able to effectively manage the soil the following need to be done

3.3.2.1. Soil analysis

The first step in managing soil fertility is testing the soil. A soil test provides very important information about nutrient levels in the soil, including phosphorus, potassium, calcium and magnesium and acidity.

Nitrogen, a very important nutrient and one that is frequently deficient, is not included directly in most soil tests. This is because nitrogen forms and amounts change in response to temperature, soil moisture, and biological activity, so a one-time test does not provide very useful information.

Soil pH is a very important aspect of soil fertility. pH is not a plant nutrient, but rather is a measure of the acidity of the soil. Most crops grow best when the soil pH falls between 6.2 and 6.8n (below being very acidic and above 7.5 becoming alkaline) , because this is the range in which plant roots can best absorb nutrients (like nitrogen, calcium, potassium and others) from the soil.

3.3.2.2. Soil fertilisation

Fertilisation of the soil should be based on the results of a soil analysis.

Plant nutrients are added to the soil in order to improve crop plant growth. Nutrients are typically added as fertilisers, but compost, manure, and cover crops are also sources of plant nutrients. There is a wide variety of commercial fertiliser products for farmers to choose from. These vary in formulation (granular or liquid), combination of nutrients, and amount of each nutrient.

Fertilisers may be applied at different times and by different methods, depending on the needs of the crop. Fertilisers are sometimes applied by broadcasting them uniformly over a field, and other times they are applied in bands close to crop plant roots. Typically, phosphorus and potash fertilisers can be applied at their full recommended rate at the beginning of the growing season, while nitrogen is best applied in several split applications, as the crop grows.

Just as with fertilisers, there are different types of lime available. Your soil test report will include recommendations on which type is best for the respective field.

3.3.2.3. Other methods of soil improvement

Adding composts and manures

Adding compost and manure to soil can increase soil organic matter content as well as add plant nutrients. Manure is a highly variable nutrient source.

The amounts of nutrients in manure vary by the animal it came from, what the animal ate, how the manure has been stored, and how long it has been stored. For example, poultry manure generally has more nitrogen than dairy manure and fresh manure has more nitrogen than stored manure. In general, composts are good sources of phosphorus and potassium, but they contain relatively little nitrogen.

Crop rotation

Rotating crops is one of the most important practices for keeping soils healthy and alive. If the same crop is grown over and over, pests and diseases can build up in the soil, and soil organic matter content can decline.

Soil conservation

Soil conservation practices involve managing soil erosion and its counterpart process of sedimentation, reducing its negative impacts and exploiting the new opportunities it creates. Fodder crops like Desmodium and Delichos lablab are good cover crops that further have the ability to fix nitrogen from the atmosphere and thus improve soil health.

3.3.3. Quality seeds/certified seeds

Certified seeds should be purchased from certified agro dealers. In cases where certified seeds are missing the farmers must source seeds from reliable farmers or traders. Quality Seeds are vital input in fodder production because:

- Crop status largely depends on the seed materials used for sowing
- Response of other inputs in crop production depends on seed material used

Characteristics of good quality seeds are:

- Free from other crop seeds
- Free from objectionable weed seeds
- Free from diseases
- High germination and vigour and germination percentage
- Optimum moisture content

3.3.4. Plant population (calibration/fertilisation)

Plant population refers to the number of plants per unit area of land. Yield potential of fodder will greatly depend on the population density of the field. When the population is too low, the yield reduces significantly as a result of weeds growing in between fodder crops.

3.3.5. Weather

Weather is one of the major factors that influence the yield of crops. In most smallholder farming systems, fodder is produced under rain fed condition as a consequence, the yield is dependent on the prevailing weather patterns. There are a number of ways to reduce the impact of weather on crops. For example, early planting and planting resilient fodder varieties like Napier grass that will increase the chances of getting a good harvest.

3.3.6. Crop management

These are agricultural practices used to improve the growth, development, and yield of crops. The combination, timing, and sequence of the practices used depend on the biological characteristics of the crops, the harvested form, the sowing methods, the age of the plants, and the soil, climatic, and weather conditions. Special crop-management practices include crop irrigation and mechanical, biological, and chemical methods of combating weeds, pests, and diseases. Control of weeds, pests and diseases should be prioritised to ensure increased quantity and quality of yield.

3.4. Most important species/varieties of fodder plants

3.4.1. Napier grass

Commonly grown Napier grass varieties

- Bana grass: leafy and with few silica hairs, which cause irritation during handling. However, it is susceptible to Napier grass head smut disease (Ustilago kamerunensis).
- Clone 13: resistant to white mould disease. It is a high yielder but its thin stems make it difficult to establish. It is also susceptible to Napier grass head smut disease.
- French Cameroon: a high yielder, established easily from canes. Susceptible to Napier grass head smut disease.
- Kakamega 1 and 2: both are tolerant to Napier grass head smut disease. High yielders. Kakamega 1 has a higher growth rate than Kakamega 2 or Bana.
- Pakistan hybrid: does well in drier areas.

Planting

Napier grass can be established from root splits or canes. It can also be planted alone or intercropped with forage legumes. Two methods of planting Napier grass are the conventional method and the tumbukiza method.

a) Conventional method

- The conventional method, Figure 3.4.1, involves planting one cane (with 3–4 nodes) or root split in holes 15–30cm deep.
- The spacing is 0.5m x 0.5m in areas with over 1400 mm of rainfall.
- In areas with 950–1400 mm rainfall the spacing is 1m x 0.5m. When cane cuttings are used, bury the nodes, leaving one node above the soil surface.

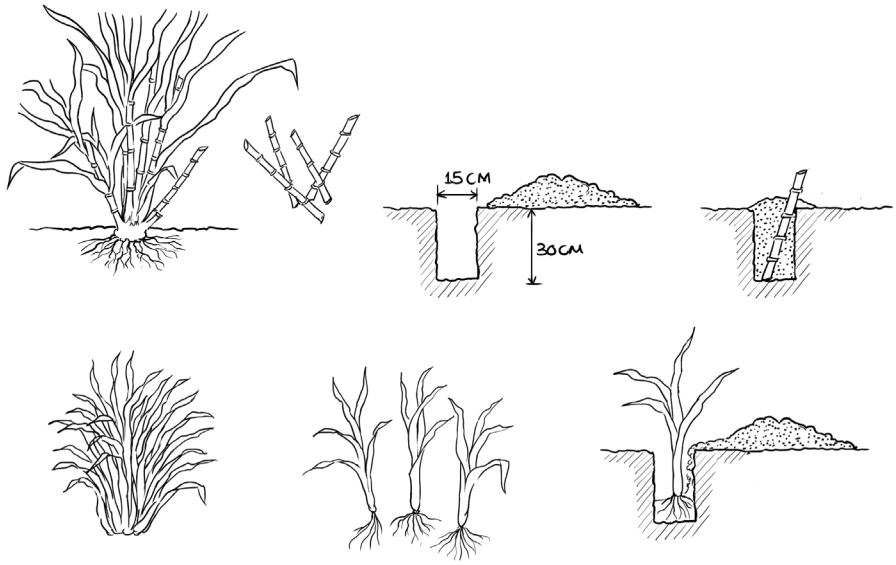


Figure 3.4.1: Planting Napier grass using the conventional method (Source: Lukuyu et al., 2012)

Forage legumes like silverleaf (Desmodium uncinatum), greenleaf (Desmodium intortum) and stylo (Stylosanthes guianensis) can be intercropped with Napier grass to improve the quality of the feed and reduce the cost of nitrogen fertiliser. Legume seeds at the rate of 3–5kg/ha can be drilled along the Napier grass rows or between the rows when the Napier grass is planted.

b) Tumbukiza method

'Tumbukiza', a Kiswahili word meaning 'placing in a hole', is a new planting method started by farmers to increase productivity per unit of land. The method, shown in Figure 3.4.1.2, involves planting cuttings or root splits in well-manured holes, produces more herbage yields than the conventional method. Hence less land is required for one dairy cow.

1. Dig round or rectangular pits, 60cm (2ft) deep and 60–90cm (2–3ft) wide. Alternatively, make trenches 60cm (2ft) deep and 60–90cm (2–3ft) wide and of various lengths depending on the farmer's preference.
2. Separate topsoil from subsoil as you dig the pit or trench.
3. Mix every 20l container ('debe') of topsoil with 1–2 debes of farmyard manure and put it into the pit. For the trench, place topsoil and farmyard manure mixture every meter along the pit.
4. Leave about 15cm (6in) unfilled space at the top of each pit.
5. Plant 5–10 cane cuttings or single root splits in the round and rectangular pits. In trenches plant 5–10 cane cuttings or single root splits every meter.
6. Plant sweet potatoes or forage legumes between the pits to increase the quality of forage and to control weeds. The initial labour cost for digging pits and trenches is higher than for the conventional method.

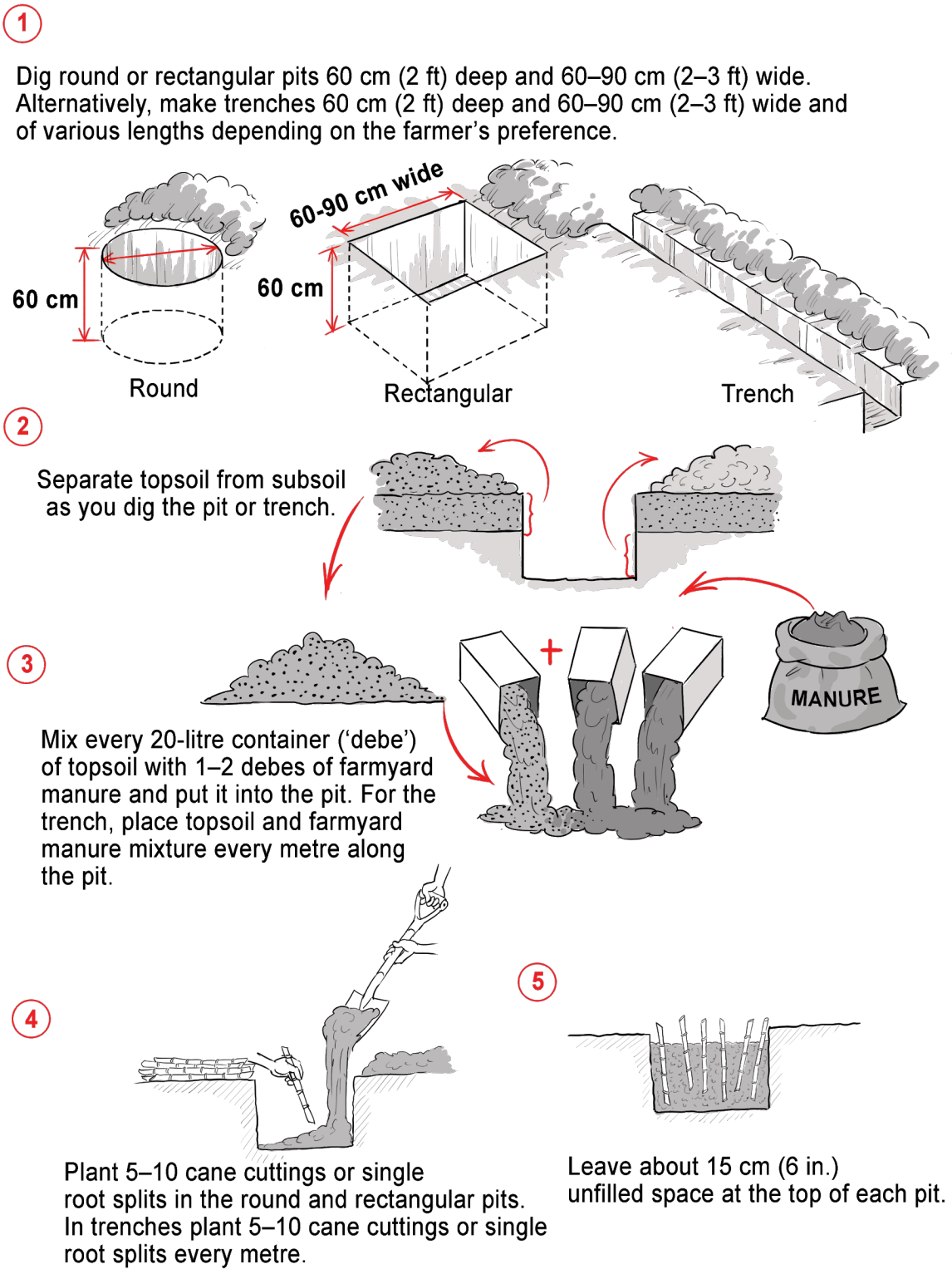


Figure 3.4.1.2: Planting Napier grass using the Tumbukiza method (Source: Lukuyu et al., 2012)

Benefits of Tumbukiza method

- Less land required.
- Regrowth is faster in the dry season.
- Feed available, even during the dry season.

Fertiliser and manure management practices

Four fertiliser and manure management practices are recommended for Napier grass. The choice depends on the financial resources of the farmer.

- Use 1–2 bags of TSP (Triple Super Phosphate) or DAP fertiliser per hectare at planting followed by 5–7 bags of fertiliser in three split applications per year, applied after harvesting and weeding in subsequent years.
- 10t/ha of farmyard manure at planting. In the following years apply the same amount, preferably after every harvest. If possible analyze the manure quality.
- Use ½–1 bag of TSP (Triple Super Phosphate) or DAP plus 5t/ha farmyard manure at planting and apply 5t/ha farmyard manure. Additionally, apply 2–3 bags in three split applications per year in subsequent years.
- Apply 60kg of slurry in furrows at planting followed by split application of the same quantity twice a year or more frequently if possible after harvesting.

Management and harvesting

- Weed after each harvest to maintain high productivity.
- Harvest when 08-1m high or every 6–8 weeks to obtain optimal quality and quantity.
- Maintain a stubble height of 5–10cm from the ground level at each harvest to avoid weakening the root system, which leads to low production in subsequent harvests.

3.4.2. Sweet potato vines

Sweet potato vines have a higher nutrient content than does Napier grass and are normally fed to cattle as a supplement. They are particularly recommended for calves as they increase the growth rate and promote rumen development. They are also good for recently calved and sick animals. They increase milk yield when fed to lactating cows. Their main setback is a relatively high moisture content.

Planting

- Plant sweet potato vine cuttings (30cm long) at a spacing of 90cm between rows and 30cm within rows.
- Vines may be planted in ridges, mount or flat. For fodder production ridging or mounting has no advantage.
- Apply 2 bags Triple Super Phosphate (TSP) fertiliser per hectare at planting.

Management and harvesting

The first harvest is done when the vines cover the ground about 4–5 months after planting. There are three methods of harvesting.

1. Harvest forage at intervals of 6 to 8 weeks leaving a stubble length of 25cm for dual-purpose varieties and 5cm for fodder varieties.
2. Selectively pluck vines at the length of ½–1m from the tip at an interval of 3–4 weeks.
3. For vines planted on ridges, cut those extending beyond the ridges.

Feeding

Cut and carry to the cow and feed up to 15kg fresh material per day, as a supplementary feed to Napier grass or other basal fodder.

3.4.3. Fodder sorghum

Sorghum is drought resistant and grows well in dry areas. Sudan grass and Columbus grass varieties are recommended for the drier parts of the East African region. Seeds are available from Seed Companies (ie. SeedCo) and are sold at various outlets.

Planting

- Sorghum requires a well-prepared seedbed to ensure even germination.
- Planting should be at the start of the rains.
- At planting drill 25–35kg of sorghum seed per hectare at a spacing of 30–40cm from row to row alternatively broadcast the seeds.
- Use 1 bag of TSP (Triple Super Phosphate) fertiliser per hectare during planting and top dress with 2–3 bags of Calcium Ammonium Nitrate (CAN) fertiliser per hectare after cutting or grazing to stimulate new regrowth.

Management and harvesting

- Sorghums should be cut every 6–8 weeks, when they are at dough stage.
- After 5–6 cuttings it becomes uneconomical to maintain the crop and it should be ploughed.
- Do not graze sorghum earlier than 6 weeks to avoid prussic acid poisoning.

Feeding

The daily quantities required to feed a dairy cow are the same as for Napier grass.

3.4.4. Fodder maize

Fodder maize is one of the best crops for making silage. There are a number of maize varieties that can be used. However in Kenya DK (Monsanto) and Duma (SeedCo) are recommended. In case other varieties are chosen, they should be early maturing varieties with a lot of biomass yield.

Planting

- Maize requires a well-prepared seedbed to ensure even germination.
- Planting should be at the start of the rains.
- Spacing should be 25–75cm from row to row.

Fertiliser and manure management

- Use 1 bag (50kg) of Nitrogen, Phosphorus and Potassium (NPK) fertiliser per acre during planting and top dress with 2 bags (100kg) of CAN fertiliser per acre.

Management and harvesting

- Maize does not withstand direct grazing and so should be utilised as a green chop. It can also be conserved in the form of silage.
- Harvesting should be done at between milk and dough stage. Under good agronomic management a biomass yield of up to 16t of fresh yield can be achieved per acre.

3.4.5. Rhodes grass (*Chloris gayana*)

A vigorous, perennial grass, originating in South Africa, with a strong root system that supports good drought tolerance. It spreads quickly forming good ground cover and grows up to1.5 meters 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. It does well in low rainfall areas; withstands heavy grazing; is very palatable; and good for hay making. It is best grown in grazed plots or when excluded from grazing for hay making. However, it can be hard to establish due to poor seed germination.

Climate: Rhodes grass grows at altitudes from 600 to 2000m above sea level. It does well in areas receiving rainfall of more than 250mm annually and also persists well under dry conditions.

Soil: Rhodes grass grows in a wide range of soil conditions, but it performs best in loamy, fertile soils. It does not do well in alkaline or very acidic soils.

Agronomic practices: Plough and harrow the land at least once to make a fine seedbed. Harrow after the weeds have emerged to reduce competition during establishment and attain a fine tilth (to enhance soil seed contact). Sow immediately after harrowing. Sowing 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 to prevent seeds being washed away. Where there is one rainy season, plant from early to mid-rains. Sowing is done when the soil is loose (dry). Make furrows 25cm apart using a peg. Drill the seeds in the furrows, at a seed rate of 12kg per hectare (5kg per acre). Cover the seeds lightly, for example by pulling light tree branches over the furrows. For high productivity, apply nitrogen fertilisers preferably during rains at the rate of 100kg per hectare.

Make sure the plot is weed-free during the initial period of establishment. Remove weeds between the rows using a hand hoe. No major diseases, but common pests such as army worms may attack the pastures. 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 8t dry matter per hectare per year.

Feeding:

- Grazing Rhodes grass 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 350kg seed per hectare can be harvested.

3.4.6. Desmodium

Desmodium can be grown as a sole crop or as an intercrop with grasses.

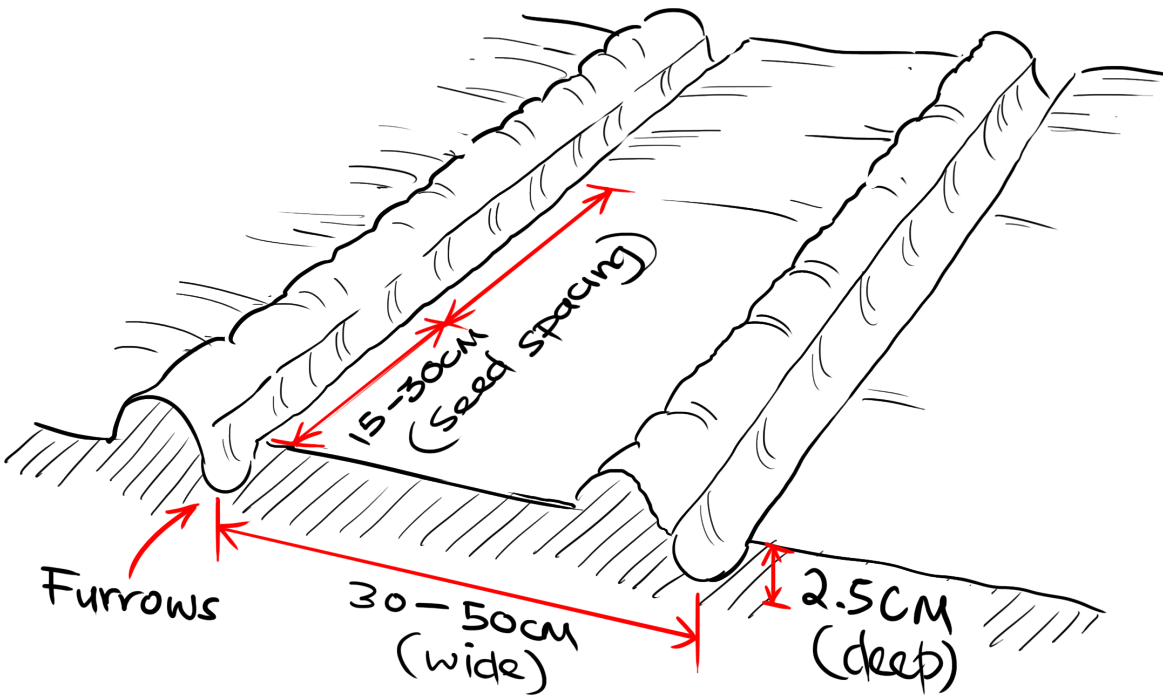


Figure 3.4.6: Growing Desmodium

Establishment

Two methods of establishing Desmodium, both shown in Figure 3.4.6 above, are common: from seeds and from cuttings.

Establishment from seeds

- Desmodium requires a fine, firm and weed-free seedbed.
- Seedbed preparation should be done well before the onset of rains.
- Use 3–5kg/ha (2kg/acre) Desmodium seeds.
- During planting, mix seeds with 2 bags of TSP (Triple Super Phosphate) or 4 bags of Single SuperPhosphate (SSP) fertiliser. Farmers can also use 5–10t/ha of well-decomposed farmyard manure.
- Drill the seed into shallow furrows 2.5cm deep spaced at 30cm or 50cm; cover with little soil, as shown in Figure 3.4.6.
- For intercropping with Napier grass, make furrows between or along the Napier rows and drill Desmodium seeds and fertiliser mixture in the furrows.

Establishment from cuttings

- Use mature parts of Desmodium vines.
- Use freshly cut vines.
- Bury 2 nodes leaving 1 or 2 nodes above the ground.
- Space at 30cm or 50cm from row to row and 15–30cm from vine to vine.
- Use the same rates of fertiliser as for seed but place it in holes.
- To maximise germination, ascertain that the amount of rain before planting has been adequate.

Management

- Keep the stand free of weeds, especially during the early stages before the crop covers the ground, by using hoe or herbicide 2,4-D amine 72% at the rate of 2.5 litres per hectare.
- Topdress with 2–4 bags of TSP (Triple Super Phosphate) or SSP (Single Superphosphate) fertiliser every year to maintain high yields of desmodium herbage and seed.
- For herbage production, make first cut 3–4 months from planting. Subsequent cuttings should be at intervals of 6–8 weeks.
- Spray against harmful pests, especially when producing Desmodium seed.
- Harvest seed when the pods have turned brown by hand stripping the ripe pods and store in a dry place after threshing to avoid rotting.

Use

- Cut and feed in green form.
- Cut and conserve as hay, whole or chopped.

Yields

Yields of 9–10t/ha dry matter per year of up to 20% crude protein have been reported under very good management. An acre can produce 30–60kg of seed.

Other benefits

- When intercropped with maize it will:
- Provide nitrogen to the crop.
- Inhibit the growth of striga weeds.
- Reduce damage by the maize stem borer.
- Control soil erosion.

3.4.7. Lucerne

Dairy farmers in the high-rainfall areas of East Africa prefer Lucerne over any other forage legume, primarily because of its palatability and high nutritive value that can sustain high milk production levels when fed to dairy cattle.

Seedbed preparation

Lucerne requires a fine, firm seedbed, prepared well before the onset of the rains. The subsoil should be well broken with a forked hoe. Apply 10t of well-composted farmyard manure or compost manure and dig it down to the subsoil

Lucerne is deep rooted and requires deep soils.

Planting

- Make furrows 30–40cm apart and 2.5cm deep.
- Mix 10–15kg seeds with 4–6 bags of SSP (Single Superphosphate) fertiliser or 2–4 bags of TSP (Triple Super Phosphate) fertiliser and drill into the furrows; cover with a little soil.
- Use 10–15kg/ha lucerne seed.
- In areas where Lucerne has never been grown use lucerne inoculants (available from the Faculty of Agriculture, University of Nairobi).
- If inoculant is not available, collect soil from areas where lucerne has been previously grown and mix with the seeds before planting.
- In acidic soils (pH less than 4.9) liming with agricultural lime is recommended at the rate of 10 t/ha.
- Phosphate, inoculant and liming promote root development, nodulation and nitrogen fixation, respectively.

Management

- Weed control: hand weed at least 4–6 weeks after planting and thereafter whenever weeds appear.
- Spray against aphids and other pests with insecticides such as dimethoate at intervals of 2–3 weeks if necessary.
- Continue applying farmyard manure to Lucerne field to improve soil fertility, structure, texture and herbage yields.
- Apply 1 bag of TSP (Triple Super Phosphate) fertiliser per hectare annually.
- Harvest Lucerne when it starts flowering (about 30cm high) to a stubble height of 4–5cm from ground level. One can obtain 6–8 cuts in a year.
- The crop can last up to 4 years under good management.

Use

- Cut and feed Lucerne in green form after wilting it, to avoid bloating in the animals.
- Conserve excess Lucerne as hay, whole or chopped.
- Conserve as silage when combined with other types of fodder, such as maize.

Yields

Yields of 5–6t/ha dry matter per year of 20–25% crude protein have been reported under good management.

3.4.8. Lablab (*Dolichos lablab*)

A short-lived perennial or annual legume, *Dolichos lablab* is cultivated as human food, green manure, cover crop and animal fodder. Dolichos has several advantages:

- It provides better late-season grazing because it is tolerant to seasonal drought.
- It is more compatible than cowpea with forage sorghum or maize when intercropped.
- It gives higher yields of materials for conservation than does fodder such as cowpea when drought sets in.
- It has better resistance to diseases such as phytophthora rust and stem rot, which wipe out many cowpea crops.
- It has better resistance than other fodder, such as cowpea, to attacks by insects like the bean fly.

Seedbed preparation

- Dolichos has a large seed, thus does not require a fine seedbed as does lucerne.
- Highest yields are obtained on land that has not been previously cultivated (fallow land).
- It grows well on acidic soils.

Planting

- Space at 45cm between rows and 30cm from plant to plant, placing 2 seeds per hole.
- Use 60kg/ha seed.
- Use 1–2 bags TSP (Triple Super Phosphate) per hectare or 5–10t/ha of well-decomposed farmyard manure.

Management

- Harvest for fodder at an interval of 6 weeks (1.5 months) leaving a stubble height of 15cm from ground level.
- Weed as required.
- To get optimal yields in quantity and quality, harvest at early flowering stage.

Use

- Dolichos can be conserved as hay or silage.
- It can be fed green to dairy cattle as a legume supplement.
- Dolichos analysed as a whole plant can contain up to 16.8% crude protein with a dry matter yield of about 6 t/ha. The seed yield ranges from 1.1 to 3.4t/ha with 20.25% crude protein content.

3.4.9. Fodder trees

Fodder trees are used by small-scale dairy farmers as a cheap source of protein for dairy cows.

Common types of fodder trees

- *Calliandra*—does well in upland areas with medium to high rainfall (700–2000 mm). It regrows well after cutting and harvesting.
- *Leucaena*—also does well in upland areas with medium to high rainfall. It is slightly more drought resistant but is more subject to attack by insect pests. Regrows well after cutting and harvesting.
- *Sesbania*—grows better in high-rainfall areas and does better than other fodder trees in higher, cooler areas. In its early stages, it grows faster than Calliandra or Leucaena but it does not regrow as well after harvesting.

Use of fodder trees

- Leaves, pods and soft young twigs provide good feed for cows.
- They are a good supplement to straw, stover and poor grass diets.
- They provide high-quality forage in the dry season.

Establishment

- To achieve good germination, place the seeds in boiling water for 4 seconds then soak them in cold water for at least 12 hours before planting them.
- Sow the seeds either directly into hedge rows at a spacing of 30–60cm from plant to plant, or in a nursery for later planting when they have reached a height of 60cm.
- Plant on the hedgerows around the homestead, on contour lines in the field, or as part of soil conservation structures.
- Apply 5 g (1 full teaspoon) of TSP (Triple Super Phosphate) fertiliser per hole during planting.

Management

- Protect young trees from livestock.
- Cut trees when they are about 2m tall, leaving a row of hedges 1m high.
- Harvest every 3–4 months.
- Leave a few trees to grow tall for firewood and seed.
- For seed, collect pods when they start to turn brown, before they split open.
- Dry pods on a sheet or gunny bag.
- Store collected seed in a tin or plastic container with a strong lid.

Feeding

- Can be either fed fresh cut or dried for later feeding.
- To encourage intake, mix with mineral salts or other fodder.

Other benefits

- Improves soil fertility by providing green mulch or by fixing nitrogen.
- Supplies fuelwood.
- Supplies wood for building.
- Provides live fencing.
- Provides food for bees.

Yields

- *Leucaena.* Start harvesting at the beginning of the second wet season by cutting back to 50cm above ground level. Cut twice during the wet season when the regrowth is 50–60cm, or at the end of the wet season, and conserve as dry leaf meal. 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 2t/ha dry matter per year.
- *Calliandra:* A well-established stand can be harvested 4 to 5 times a year with the harvesting interval varying with rainfall. Cut again when the regrowth is 50–60cm. Depending on rainfall and soil fertility, dry matter yields range from 5 to 10t/ha per year. The edible fraction of calliandra has a crude protein level of 20–25% of the dry matter.

3.5. Summary

- Fodder crops are plants cultivated on arable land. They are grazed or fed to livestock either green or in a conserved form, like hay or silage.
- The factors that influence fodder yield are land preparation, soil management, quality seeds/certified seeds, plant population (calibration/fertilisation), weather and crop management.
- The nine most important varieties of fodder plants are sweet potato, fodder maize, Rhodes Grass (*Chloris gayana*), Desmodium, Lucerne, Lablab (*Dolichos lablab*) and fodder trees.
- Climate, rate of growth and ability to provide good soil cover are among numerous factors to consider when selecting which fodder to grow.

3.6. Review questions

1. Apart from climate, rate of growth and ability to provide good soil cover, what other factors should smallholder dairy farmers consider when selecting fodder to plant?
2. What factors need to be taken care of to ensure maximum fodder yield?
3. What are the most important fodder crops in Kenya?
4. Give a brief description of the management of the following fodder crops; Napier grass, Rhodes grass, fodder sorghum and Desmodium.
5. List any 4 characteristics of good quality fodder seeds or planting material.
6. The two methods of planting Napier grass are the conventional method and the Tumbukiza method. Which method is right for your farm? Why?
7. Think about adding composts and manures, crop rotation and rotating crops. These are three ways of achieving what objective? Which of these methods would be right for your farm? Why?
8. As well as early planting, what other options are available to smallholder farmers who want to reduce the impact of weather on their crops?

4. Fodder conservation

Topic objectives

The overall objective of this topic is to enable farmers to understand the importance of fodder conservation and be able to conserve fodder in the form of hay and silage.

Topic aim: By the end of the topic, the learner should be able to

- Understand the importance of fodder conservation.
- Understand the principles that govern hay making, and make hay.
- Understand the principles that govern silage making, and be able to make silage.

4.1. Introduction to fodder conservation

Why and how to conserve fodder?

Due to distribution of rainfall, pasture and fodder production is not continuous. This results in times of plenty and scarcity. The excess can be conserved for use in times of scarcity.

Fodder can be conserved by reducing moisture content (store dry), fermenting and storing while wet.

4.2. Hay making

Hay is fodder conserved by drying to reduce water content so that it can be stored without rotting or becoming mouldy (reducing moisture content slows down the rate of growth of microorganisms that can cause spoilage). Moisture content should be reduced to about 15%.

Not all grasses and fodder are suitable for making hay.

4.2.1. Harvesting and curing

- Harvest the fodder for haymaking when the crop has attained 50% flowering. At this stage protein and digestibility are at maximum, after which they decline with age.
- Fodder should be harvested after 2 to 3 days of dry weather so that drying will be possible.
- Where possible, drying should be done under shade so that the dried fodder retains its green colour, which is an indicator of quality.
- Turn the fodder using a farm fork, to ensure even drying.
- Check the dryness by trying to break the stem. If it bends too much without breaking, there is still too much water.
- Legumes and grasses can be mixed to make better quality hay, e.g. Rhodes grass combined with Lucerne.

4.2.2. Baling hay

Baling the hay allows more material to be stored in a given space. A good estimate of the amount stored makes feed budgeting easier. Baling can be manual or mechanised. Manual baling is more economical for small-scale dairy farmers.

Manual hay baling (shown in Figure 4.2.2 below) is done using a baling box with dimensions 85cm long x 55cm wide x 45cm deep, open on both ends. If the hay is well pressed, the box will produce an average bale of 20kg.

Hay can also be stored without baling by heaping it into a dome-shaped stack and covering it with a polythene sheet, or a tarpaulin and storing it 10-20cm off the ground.

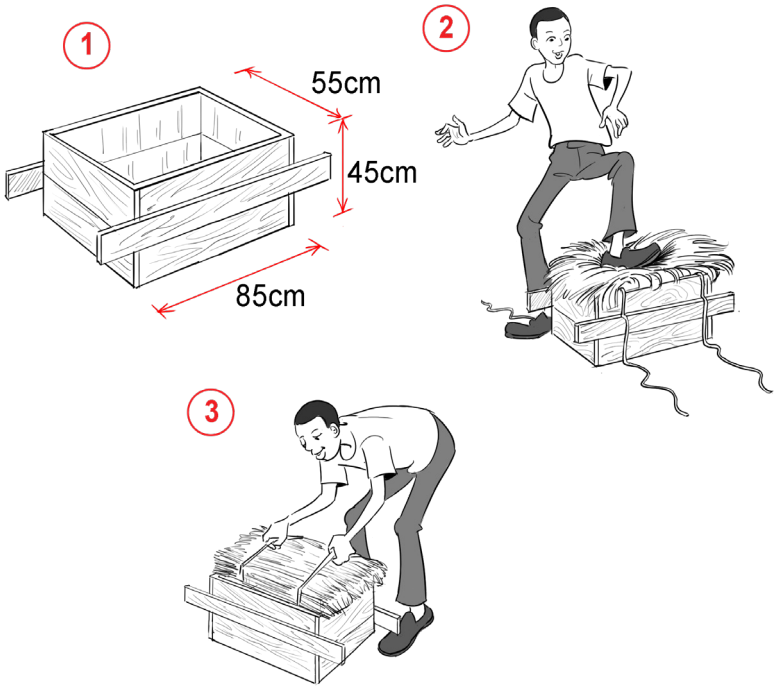


Figure 4.2.2: Manual baling (Source: Lukuyu et al., 2012)

4.2.3. Storage

Hay should always be stored in a sheltered enclosure away from direct sunlight and rainfall, e.g. in hay barns. Rats and other rodents should be controlled as they can damage the hay.

Characteristics of good quality hay

The quality of the hay should be evident on physical examination. Good-quality hay should:

- be leafy and greenish in colour.
- have no foreign material mixed with it.
- have no smell.

4.2.4. Feeding

A dairy cow weighing 400kg will consume the equivalent of about 3% of its body weight in dry matter (in the case of the 400kg cow these are 12kg dry matter) per day. Since hay contains 85% dry matter, if the cow consumes nothing else, it will require 14kg of hay per day.

4.3. Silage making

Fodder is packed in airtight conditions to preserve its nutritional value, improve its quality and taste, and to make it easily digestible. This is called silage or pickle of the fodder.

In this process, green fodder is fermented through special bacteria which can survive without oxygen. The resulting fodder is tasty and easily digestible for animals.

The preparation of good quality silage depends on timely harvesting of fodder, the quantity of air in it at the time of packing and the preservation method. In this process useful bacteria converts soluble starches into lactic acid. It decreases its acidic quality (pH) to 3.0-4.0, which stops the growth of harmful germs and thus makes the fodder safe for animal consumption.

4.3.1. Appropriate fodder for silage

An ideal crop for silage making should:

- contain an adequate level of fermentable sugars in the form of water-soluble carbohydrates.
- have a dry matter content in the fresh crop of above 20%.
- possess a physical structure that will allow it to compact readily in the silo after harvesting.

Maize, oats, sorghum and other materials are considered best for silage making. Normally fodder crops with broad leaves and thick stems are suitable for silage. Since leguminous fodder has less carbohydrates and protein content, it is usually mixed with non-leguminous fodder plants (like maize and sorghum) to make the best and nutritious silage. Furthermore, if moisture content is high in fodder, wheat straw or crushed cobs of maize can be added for silage making.

Crops not fulfilling these requirements may need pre-treatment such as:

- field wilting, to reduce moisture.
- fine chopping to a length of 2–2.5cm to allow compaction.
- use of additives, to increase soluble carbohydrates.

Dry matter yield of common fodders used for silage making is 4–12t/acre for Napier grass, 6.8–8.8t/acre for sorghum E6518 and 9.6t/acre for maize.

4.3.2. The right time to harvest fodder for silage

The nutritional value of fodder decreases when it is harvested before or after it is mature. Due to this the fodder does not remain easily digestible.

- Napier grass: Napier grass should be harvested when it is about 0.8-1m high and its crude protein content is about 10%. However, when ensiling Napier grass, it is necessary to add molasses to increase its sugar content.
- Maize and sorghum should be harvested at dough stage, that is, when the grain is milky. At this stage, maize and sorghum grains have enough water-soluble sugars so it is not necessary to add molasses when ensiling. The best time to harvest maize is when its grains are 50 percent milky.
- The best time to harvest leguminous fodder is when 50 percent of its flowers are in bloom. The best time to harvest green fodder for silage is when its moisture content is 65-70 percent.

To improve silage quality, poultry waste and legumes like Lucerne and Desmodium may be mixed with the material being ensiled to increase the level of crude protein. However, since protein has a buffering effect that increases the amount of acid required to lower pH, poultry waste and legumes should be incorporated within limits. Poultry litter should not exceed 5% and legumes should not exceed 25% of the total material ensiled.

4.3.3. Types of silos for storing silage

A silo is an airtight place or receptacle for preserving green feed for future feeding on the farm. Silos can be either underground or aboveground, the qualification being that the silo must allow compaction and be airtight. Five types are described here: tube, pit, aboveground, trench and tower.

- **Tube:** Silage can be made in large plastic sacks or tubes. The plastic must have no holes to ensure no air enters. This is popularly referred to as tube silage.
- **Pit:** Silage can also be made in pits that are dug vertically into the ground and then filled and compacted with the silage material.
- **Aboveground:** Aboveground silos are made on slightly sloping ground. The material is compacted and covered with a polythene sheet and a layer of soil is added at the top. When finished, it should be dome shaped so that it does not allow water to settle at the top but rather collect at the sides and drain away down the slope.
- **Trench:** The trench silo is an adaptation of the pit silo, which has long been in use. It is much cheaper to construct than a pit silo. Construction is done on sloping land. A trench is dug and then filled with silage material. This method is ideal for large-scale farms where tractors are used. Drainage from rain is also controlled to avoid spoiling the silage.
- **Tower:** Tower silos are cylindrical and made above ground. They are 10m or more in height and 3m or more in diameter. Tower silos containing silage are usually unloaded from the top of the pile. An advantage of tower silos is that the silage tends to pack well due to its own weight, except for the top few meters.

4.3.4. Steps for silage making

- Harvesting
- Chopping
- Ensiling

Harvesting

It's important to determine the right time to harvest fodder to get the best nutritional value from silage. The time to harvest can be determined from the following indications:

- When the plant is fully mature.
- Half of the grain in maize is milky.
- The fruitful fodder has 50 percent flowers.
- Moisture content is 65-70 percent.

Chopping

Fodder can be chopped with a common fodder chopper, but an electric chopper or the tractor's shaft can hasten the chopping process, which results in improvement in the quality of silage. Nevertheless, chopping can be done with the common machineries too. Modern harvesters are also available for the chopping process.

Size of chopped fodder

2 – 3cms size of the chopped fodder is considered quite suitable for silage, but a one inch size of 15-20 percent pieces of chopped fodder keeps its fiber ratio to a suitable level. Care should be taken to keep fodder loss to a minimum during chopping.

The chopped fodder should be pressed and stored as soon as possible to maintain its nutritional value.

Ensiling

The chopped fodder can be stored in a pit on comparatively higher ground, or on the surface with material, or in a tube. The following should be kept in mind when choosing a storage place:

- This storage place should be near the animals shed.
- It should be on a higher ground to protect it from water.
- There should be no salinity there.

The following should be observed when ensiling:

- Fill the chopped fodder into the silo.
- Press the chopped fodder into layer of 30-45cm.
- Filling and pressing should be completed as fast as possible.
- Use additives, if required.
- Ensure the silo is properly sealed.
- Open the silo after 45 days.

Note: The whole process of silage making – harvesting, chopping, pressing and packing – should be completed in 16 to 20 hours. Therefore, efficient and timely arrangements should be made for hiring of labour and required machinery relevant to the quantity of silage.

Delay in the preparation of the silage triggers harmful fermentation which reduces nutritional value. The filling and pressing process should be finished in a single day to initiate the process of useful fermentation. Spread the chopped fodder in in 6 to 9 inches thick layers. Steady packing is needed between each layer, which can be done with the help of a tractor to pack it tightly. This packing or pressure keeps the temperature at a suitable level. The weight squeezes out air and fermentation begins.

25kg to 30kg silage can be stored in one cubic foot. Fodder should be protected from air and rainwater. This can be done by covering it with a strong waterproof plastic and placing it on discarded vehicle tires, or by placing sandbags on it. Silage is ready for consumption as fodder for the animals in 4-6 weeks.

Tube silage

- Chop the wilted material to be ensiled into pieces not more than 2.5cm long.
- Sprinkle the chopped material with a molasses and water mixture. or every sack use 1 litre of molasses mixed with 2–3 times as much water. This is especially for material like Napier grass that has low sugar content. Maize bran or cassava flour can be added to improve the carbohydrate (energy) content.
- Place the chopped material, sprinkled with the molasses and water mixture, into the plastic tubing (1000 polyethylene gauge) with a width of 1.5m. Cut a 2.5m length, tie off one end and fill with the material, compressing it well, then tie the other end to seal.
- Stack the filled sacks until needed. Fermentation is usually complete after 21 days.

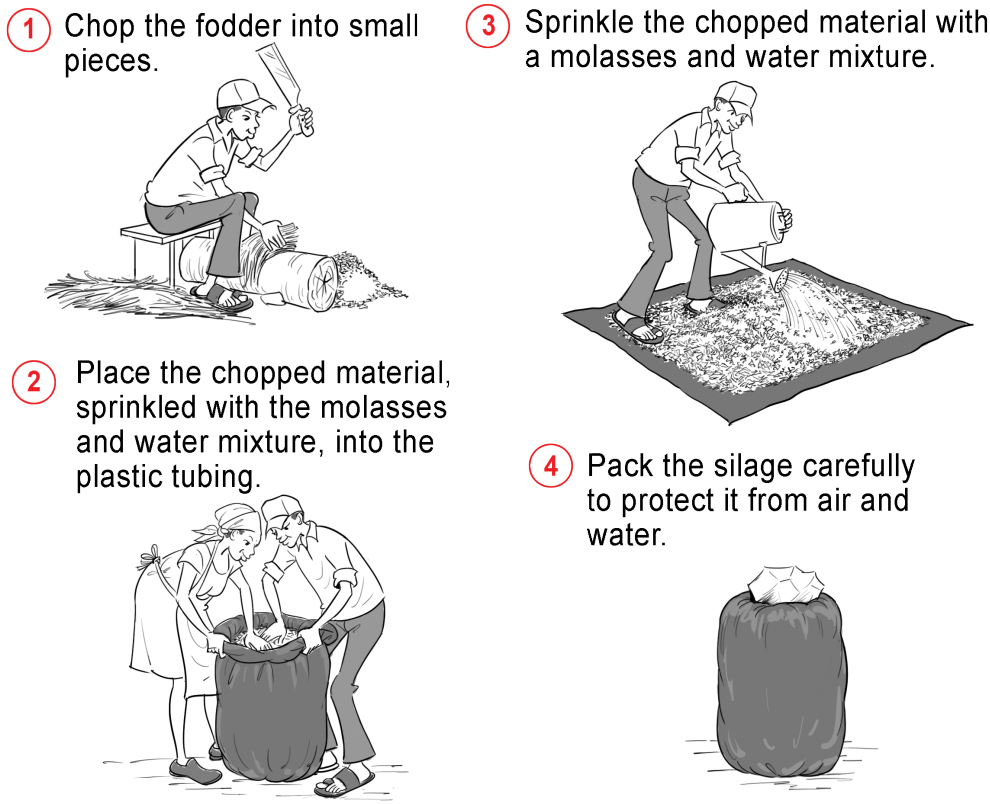


Figure 4.3.4: Tube silage (Source: Lukuyu et al., 2012)

4.3.5. Precautions for storing silage

- Chop the fodder into small pieces.
- Protect it from dust and do not let dirt stick to the tractor tyres during the pressing process - avoiding contamination with dust and dirt is relevant for all types of silage making..
- Fill the bunker or the pit quickly.
- Pack the silage carefully to protect it from air and water.
- Press the fodder with a tractor, or using any other method, to ensure there are no air spaces.

4.3.6. Factors affecting silage quality

- Maturity stage of crop cut.
- Type of crop.
- Moisture content of the material.
- Degree of compaction.
- Size of pieces ensiled.
- Amount of foreign material in silage.
- Volume of leaves in ensiled materials.

4.3.7. Storage and feeding silage

Tube silage should be stored under shade, for example in a store. Rats and other rodents that could tear the tube need to be controlled. When feeding, open the tube and scoop a layer and remember to re-tie it without trapping air inside.

When feeding from the pit, scoop in layers and cover after removing the day's ration, making sure the pit is airtight. Drainage from the top should be guided to avoid rainwater draining into the pit.

When feeding from the aboveground method, open from the lower side of the slope, remove the amount you need for the day and re-cover it, without trapping air inside.

To avoid off-flavours in milk, feed silage to milking cows after milking, not before, or feed them at least 2 hours before milking.

4.3.8. Losses

Nutrient losses may occur during silage making:

- In the field during cutting.
- losses due to respiration during wilting will be about 2% per day.
- If it rains, leaching may cause some loss.
- Overheating due to poor sealing gives a brown product, which may smell like tobacco and result in severe damage to nutrients, e.g. proteins.
- Effluent losses of 2–10% that occur from moisture seepage contain soluble and highly digestible nutrients; seepage should be avoided by wilting the herbage.

4.4. Summary

- Due to distribution of rainfall patterns, pasture and fodder can only be made intermittently.
- Good quality hay is leafy and odorless.
- The principles of harvesting and curing hay, as well as of baling, storing it and feeding it to cows, should be closely observed.
- Carefully evaluate whether you have the right type of fodder, before you begin the ensiling process.
- To limit fodder losses during the silage process, choose the right type of silo, take precautionary measures, and carefully follow the steps outlined in this chapter.

4.5. Review questions

1. What is the importance of fodder conservation in smallholder dairy farming systems?
2. Briefly describe the process of hay making using a box.
3. At what stage should a crop to be used for making hay be harvested?
4. What are the characteristics of good quality hay?
5. What are the characteristics of appropriate fodder for silage making?
6. Describe the process of tube silage making.
7. What are the main precautions when storing silage?
8. List as many factors that affect the quality of silage as you can recall.

5. Manure management

Topic objectives

The overall objective of this topic is to enable farmers to better utilise and manage manure from their farms for production of other crops and fodder.

Topic aim: By the end of the topic, the learner should be able to

- Understand the importance of manure, compost and bioslurry available on farms.
- Understand the application and use of manure, compost and/or bioslurry.

5.1. Manure handling systems

Animal manure consists of excrement from animals and can be mixed with leftover feed, litter, bedding material, cleaning water, etc. The amount and quality of manure obtained depends on the housing system, the manure collection and storage system, the amount of feed, the method of feeding (pen rearing, kraaling the animals at night, or free range), the quality of the feed and the efficiency of manure and urine collection.

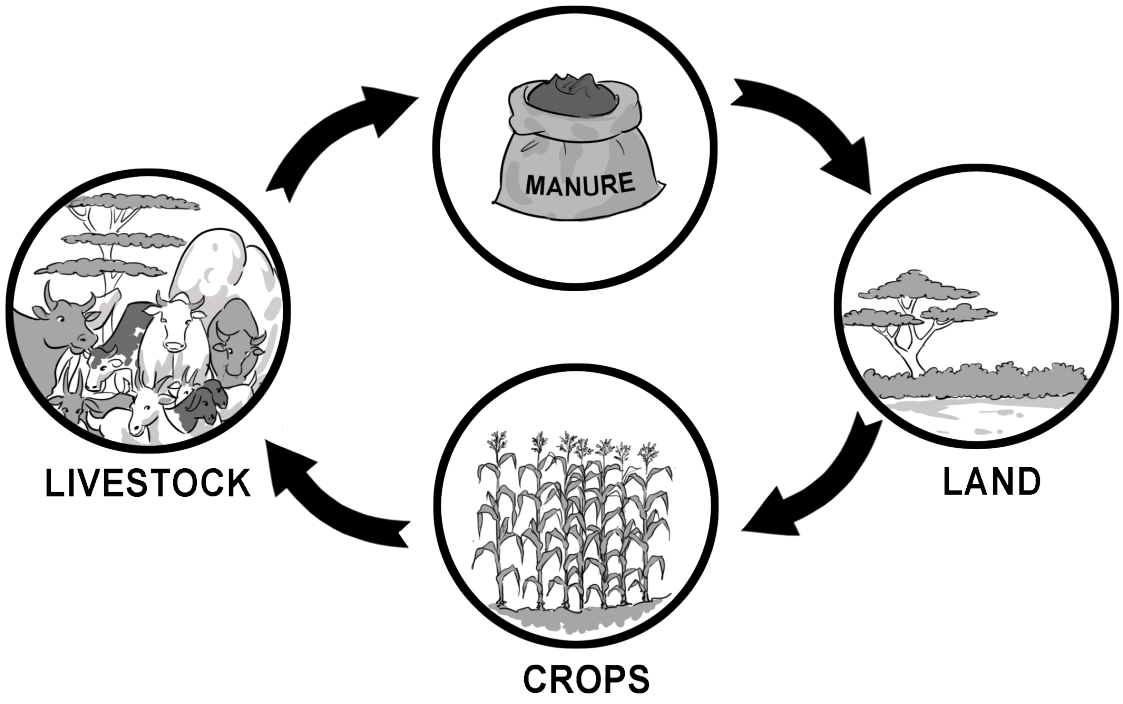


Figure 5.1. The manure process. Simplified scheme of nutrient cycling in crop livestock systems (Source: Goopy and Gakige, 2016)

- Manure is a valuable resource of energy, organic fertiliser and soil improver that should not be wasted.
- Biodigestion of manure produces clean and cheap energy.
- Applying manure to soils reduces the need to buy synthetic fertiliser, increases crop yield and saves water.

Handling of manure

A manure handling system comprises of the following:

- **Collection:** Initial gathering of manure from animal confinement area.
- **Transport:** Movement of manure after collection.
- **Storage:** Containment until treatment or utilisation.
- **Utilisation:** Land application.
- The type of cow house on the farm frequently determines how manure is handled on a dairy farm.
- Dairy-cow manure containing a fair amount of bedding, usually around 20% dry matter or higher, is spread as a solid.
- Solid manure is manure that is devoid of urine or washout water. It can be stored as a solid and stackable product.

5.1.1. Manure collection

- The housing system determines the major manure characteristics and collection systems.
- Animal housing should allow for the collection of all dung and urine and prevent losses.
- Solid manure should be stored on a waterproof floor and with a cover against rain.
- Urine should be collected, because it is a valuable source of nitrogen and potassium fertiliser.
- Manure should always be collected for use as a fertiliser or for energy production.
- Manure from the housing facility should be removed regularly and covered during storage to facilitate maturity and reduce nutrient losses.
- Develop a system to collect both solid and liquid manure for use.

5.1.2. Manure transportation

- An appropriate method for transporting manure should be put in place
- The transport ensures that manure can be removed from the housing and put at a location where it can easily be used.
- The transport method used should ensure that cleanliness of the compound is maintained
- In smallholder farms, manure can be transported using a wheelbarrow, wagon or hand cart.

5.1.3. Manure storage

- Manure storage is necessary to bridge the gap between the moment of excretion and the optimal moment of application on cropland.
- This is also the period in which nutrients are at most risk of being lost to the environment.
- Manure needs about 2–3 months to mature before it can be used as fertiliser. The maturation time allows organic matter to be broken down so the nutrients are in a form that is usable by plants.
- The volume of nutrients in the manure tends to decrease over time, because NH3, N2 or N2O are emitted as gases, or because soluble N (primarily Nitrate NO3) P and K are leached by rainwater.
- To prevent losses, manure should be covered during storage.

To see the right and wrong way to store manure, see Figure 5.1.3 on the next page.

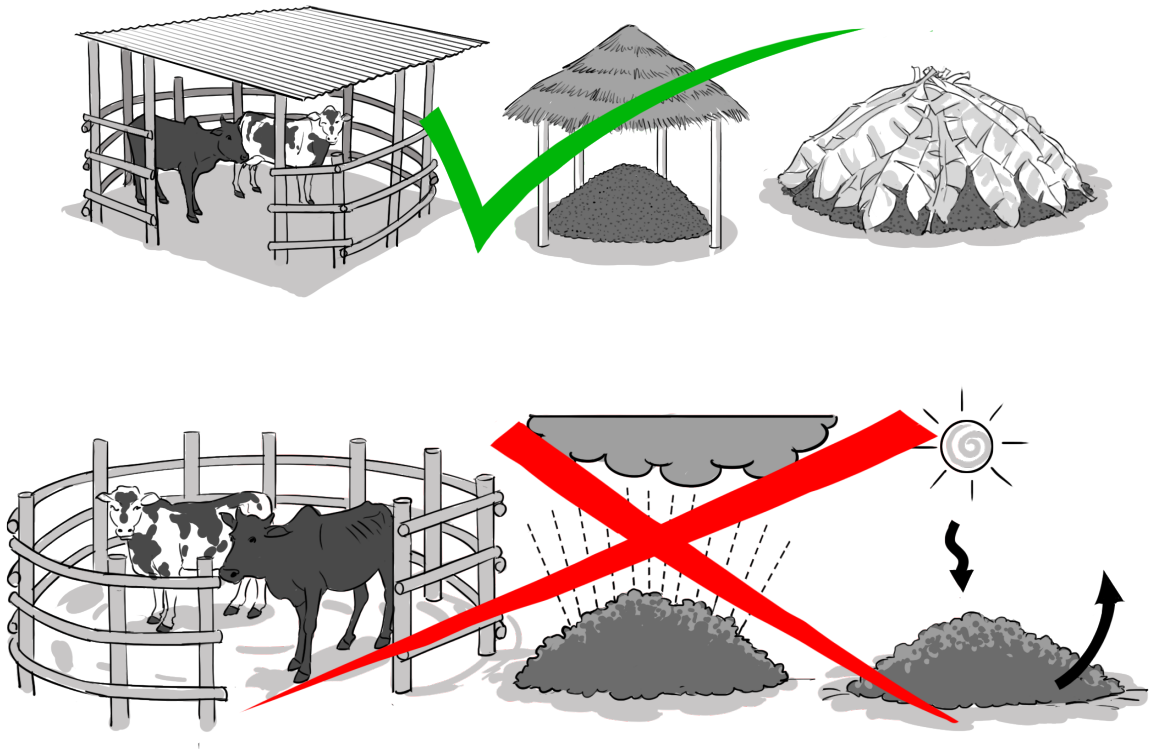


Figure 5.1.3 The right and wrong ways to store manure

- Proper storage preserves crop nutrients until the time of application.
- Storage roofing prevents runoff of nutrients to the soil and water.
- Storage flooring prevents leaching of nutrients into the soil and water.
- Air-tight storage covering prevents nutrients from volatilisation to the air.

5.1.4. Manure treatment

- Manure can be treated to reduce volume, to improve applicability, to prevent losses during storage, and to increase the value.
- Air drying is an easy method to reduce the volume of liquid manure like slurry and bioslurry. A major disadvantage of air drying is that practically all mineral N is lost through NH3 volatilisation.
- Composting is an attractive proposition for turning on-farm organic waste materials into a farm resource and is suitable in all farm situations, large or small, and with solid and liquid manure type.

5.1.5. Manure application

- Preferably use composted or well decomposed manure, which smells “earthy” and where the original bedding material cannot be recognised.
- When applied to fields, manure should be quickly incorporated into the soil (e.g. by ploughing), since exposure to sunshine for long periods causes loss of nutrients. Heavy rains can also wash some of the nutrients away through erosion.
- The best time to apply manure is 2–8 weeks before planting so that nutrients will be available when the plants germinate.
- Manure can also be surface banded (applied to the field in a “band” beside actively growing plants). However the plants should be a minimum size (e.g. for maize, the plants should be at least 30cm high).
- Manure applied while plants are actively growing should be combined with a synthetic fertiliser.
- The manure application rate varies based on soil fertility. 5t/acre is appropriate for most fodder crops.

5.2. Building and maintaining a small-scale compost heap or pile

1. Make a base 30 – 45cm deep, 2m wide and any length. Loosen the ground and lay down coarse plant materials, such as twigs. This will ensure good air circulation and drainage.
2. Put a layer of 30cm of dry vegetative matter, chopped into small pieces. Small pieces decay faster.
3. Add a 10cm layer of old compost, animal manure or slurry. This will add extra bacteria and fungi to speed up decomposition.
4. Add a 10cm layer of green materials. Try to maintain a ratio of 1 part greens to 3 parts of dry matter. Kitchen waste, such as fruit and vegetable peelings, decomposes quickly.
5. Add a sprinkling of top soil from the top 10cm of cropped land.
6. Ash can then be sprinkled onto these layers.
7. Water the whole pile well.
8. Repeat all these layers except the first layer of twigs until the heap reaches a height of 1 - 1.5m.
9. The heap should be covered, to protect it against heavy rain, otherwise nutrients can be washed away. A 10cm layer of topsoil can be applied, to reduce nitrogen loss from the compost.
10. A long sharp-pointed 'thermometer' stick (as in Figure 28) is then driven into the heap at an angle and used to check on heap condition from time to time and to allow air to enter the heap through the hole in the stick.
11. Water the heap twice a week. If the heap is too dry, the microbes become dormant and the composting process will slow down. If the heap gets too wet there will not be enough air and the microorganisms die.
12. The pointed stick should be used to measure temperature. The stick should feel slightly too hot when removed after a few days. If it does not, this may be because decomposition has not started and more air or water may be needed. If the heap is very hot, decomposition is taking place but excessive heat may kill the organisms and the heap should be compacted to reduce airflow, or water should be added to cool it down. If the stick is white, it indicates the presence of the 'fire fang' fungus. This is a sign of a poor decomposition process and water should be added.
13. The compost heap should be turned every 1 – 2 weeks so that materials on the outer layers of the heap are put in the middle of the heap. Turning will help to aerate the heap and will ensure that materials on the outer layers decompose as well.

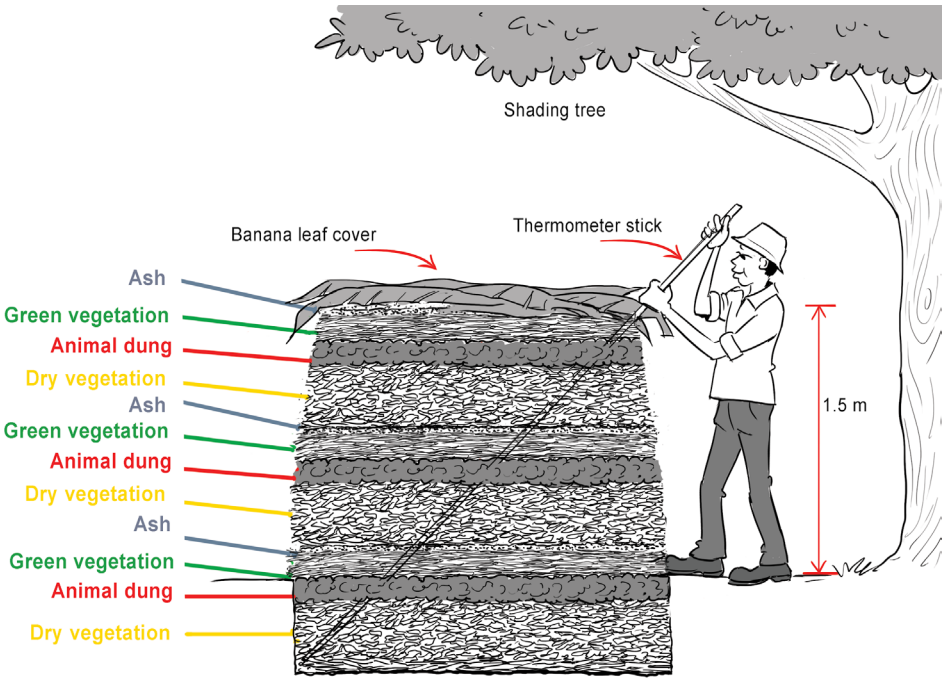


Figure 5.2: Layers of compost heaps

- The heap should always be covered (for example with banana leaves) after turning to protect the wash-away of nutrients by rain. Duration of compost making varies depending on the quality of materials used, but on average 6-8 weeks is sufficient to prepare, provided the material is not too fibrous.

Characteristics of mature compost

- Coarse materials become finer over time until a fine, loamy material is produced.
- The different materials are no longer recognisable.
- The material has a slight earthy, inoffensive smell.
- Temperature drops and the compost is cool.
- Compost is dry.

5.3. Benefits of using manure

- Easy to make and very effective at improving soil.
- Less expensive compared to other soil amendments.
- Improves the structure of the soil. This allows better aeration of the soil, improves drainage and reduces erosion.
- Improves soil fertility by adding nutrients and by making it easier for plants to take up nutrients already in the soil. This produces better yields.
- Improves soil's ability to hold water. This stops the soil from drying out in times of drought.
- Can reduce pests, diseases and weeds on the farm. Because, unlike raw manure, the high temperatures that occur during composting usually kill disease-causing organisms and weed seeds.
- Large amounts of vegetation, crop residues, garden weeds, kitchen and household waste, hedge cuttings, garbage, etc.ll can be put to use.
- When properly made compost nutrients become slowly available as "plant food".
- Good crops can be obtained with reduced need for extra chemical inputs.
- All farmers, regardless of financial resources, can make and use compost.

5.3.1. Disadvantages of using compost

- If not properly composted, the material may spread weed seeds.
- Requires more labor for collection, handling and application.
- The nutrient composition of the compost varies, depending on the materials used and the preparation methods.
- There may not be enough vegetation and water to make compost in drier areas.

5.4. Bioslurry management and use

Bioslurry is the liquid discharged from the biodigester outlet, after gas has been tapped for energy. It is a superior organic fertiliser; a co-product of the biodigester. It is 93% water and 7% dry matter. It contains nitrogen, phosphorous, potassium, zinc, iron, manganese and copper among other minerals. Wet slurry is alkaline (8.12PH), odourless and pathogen-free.

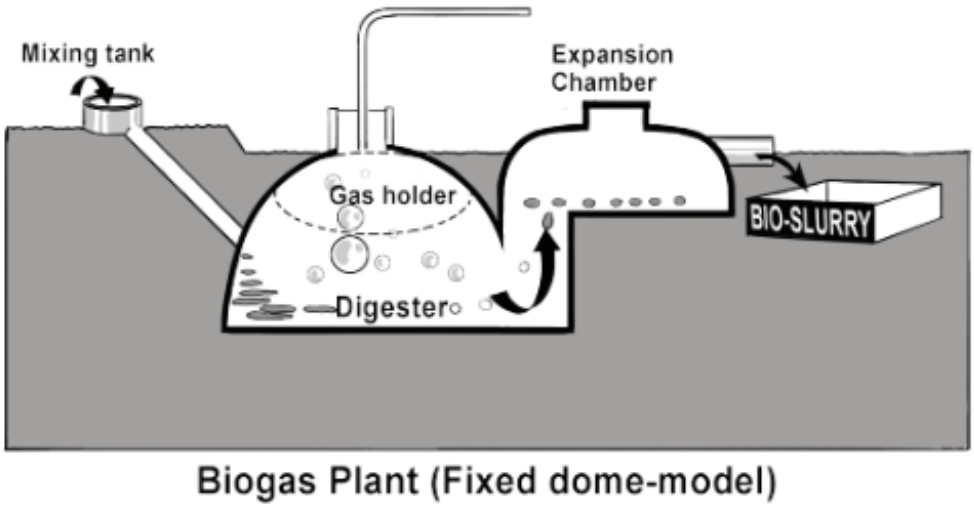


Figure 5.4: Managing bioslurry (Source: HIVOS)

5.4.1. Benefits of Bioslurry

- Excellent soil conditioner, adds humus.
- Enhances soil's capacity to retain water.
- Safe to handle.
- Highly nutritious.
- Contains trace elements.
- Is pathogen-free. Dung fermentation in reactor kills plant-disease causing organisms, including weeds.
- It repels termites and pests that are attracted to raw dung.
- Effective for over 3 years in soil, while chemical fertilisers serve only one cropping season.
- Supports cash savings on chemical fertiliser and pesticides

5.4.2. Bioslurry quality depends on

- Species and age of animal from which dung is drawn.
- Quality of water used in mixing dung.
- Types of animal feed and feeding rate.
- Use of urine along with dung.
- Storage, treatment and application of the slurry.

5.4.3. Modes of Application/Utilisation

Liquid

- Direct Feeding: The bioslurry is put in rows, around the crops. After application the slurry should be covered with soil.
- Foliar (Liquid Manure): Can be applied as a foliar fertiliser on the leaves of the crop. Bioslurry should not be applied to the leaves of crops that are to be eaten raw.
- Irrigated: the slurry can be diluted and irrigated through pipes to the crops.
- Solid: The slurry can be used to make compost by applying it in layers of a compost heap, as shown in Figure 5.4.
- Pellets and seed coating: The slurry can be dried and put as pellet during planting and can be used as a coating for seeds.

5.5. Summary

- To optimise performance, specific guidelines for handling, collecting, transporting, storing, treating and applying manure should be followed.
- Building a multi layer compost heap takes weeks of effort and the farmer›s regular intervention, to optimise the interplay between ash, vegetation and dung.
- Among the biggest benefits of manure are its ease of preparation, affordability and effectiveness in improving soil.
- Among the biggest disadvantages of compost are its labor-intensiveness, irregular nutrient composition and incompatibility with dry areas.
- Bioslurry, the liquid discharged from the biodigester outlet, after gas has been tapped for energy, is a superior organic fertiliser.

5.6. Review questions

1. What factors determine the type of manure handling system to use on a farm?
2. What are the best ways to store manure on the farm?
3. Explain the process of making compost.
4. What are the characteristics of good quality compost?
5. What are some of the factors that affect the quality of bioslurry?
6. What is the major drawback a smallholder should guard against when storing manure?
7. What is the benefit of applying manure 2–8 weeks before planting?
8. List five major benefits of using bioslurry.

Chapter Six

6. Disease Prevention

Topic objectives

The overall objective of this topic is to enable the farmers to know how to control and manage common diseases at the farm level.

Topic aim: At the end of the training, the learner should be able to

- Identify cattle diseases and know how to treat them.
- Identify and apply disease prevention measures at the farm level through better management.
- Identify and know how to address the main causes of diseases at the farm level.

6.1. Managing dairy herd health

Good care for an animal means preventing it from becoming ill. Even though treatment may cure the animal, the disease might have affected its body and these effects may last longer than curing the disease itself. Consequently, production losses may continue after the animal has seemingly recovered. Retarded or stunted growth in calves and a permanent reduced milk production are examples.

The operation of a dairy farm for maximum profit includes good feeding, breeding, care and management, as well as good record keeping and a dairy health program. The objectives of a health program are to prevent the introduction and occurrence of diseases (or disorders) and control the spread of infectious diseases and parasites.

Disease = response to external or internal pathogens (e.g. Mastitis, Foot and Mouth Disease (FMD), Anthrax etc.)

Disorder = disruption of normal bodily functions (Hoof problems, Hypocalcaemia)

It is for the farmer to understand the reasons for good management practices and the links between animal nutrition, housing and health. A written herd health plan should be developed that contains management actions to prevent and control diseases and/or disorders that are specific for the farm. While this training manual focuses on dairy animals, the herd health plan should be established for ALL animal species kept on the farm.

The plan should contain actions for preventative measures such as vaccination plans, ecto- and endo-parasite control (e.g. tick control, deworming), calf management, biosecurity measures (e.g. buying of new animals, quarantine) and reactive measures like foot care, mastitis control, and treatment plans. As part of this herd health plan, records should be kept of each animal.

6.1.1. The importance of good record keeping

An important aid for farm management is the keeping of records of each individual animal and events relating to animals throughout their lives. Records should include:

- Date of birth.
- Dam.
- Sire.
- Date of insemination.
- Calving date, sex of the calf and name/number.
- Date of vaccinations (including the name of the vaccine and batch number).
- Health problems.
- Date of treatment, name of the drug used, amount of drug used.

In addition, records on daily

- milk yield and
- feeding

These can help farmers identify potential problems (e.g. drop in milk production) and react quickly to address the problem.

The records also provide beneficial and relevant information for veterinarians to make correct diagnoses. Therefore, it is best to have well organized records kept for each animal, with the forms designed in a way that allow for easy interpretation. Keeping good records will help to manage productive and healthy animals!

6.1.2. Nursing and support

Once an animal is sick, it is important to call the veterinarian to provide treatment and nurse sick animals back to health. Supportive care that can be provided includes:

- Isolating the sick animal from the other animals, to avoid extra stress to the sick animal and potential spread of the disease to the healthy animals.
- Providing good nutrition to the sick animal, with freely available water and quality palatable forages and concentrates.
- Providing shade and clean bedding.
- Continuing treatments such as pain-relief, or dressing of wounds.
- Taking special care of stock unable to stand, providing support such as small hay bales to stop them rolling onto their side, moving them to dry, warm shelter with good footing, in case they try to stand.
- Checking on the animal at least 3 times a day to observe changes.

6.1.3. Responsible drug handling

Responsible drug handling and administration are the key to a successful animal health program. Drugs should be sourced from veterinarians or registered agricultural merchants only because medicines obtained from other sources may not be safe or effective. Drugs should be stored correctly in accordance with the instructions on the label. Storage temperature is critical for some medicines, especially vaccines (most vaccines need to be kept in a fridge or freezer). Direct sunlight can cause damage on drugs.

Drugs should be stored securely and locked where practicable and kept out of reach of children, animals and anybody not supposed to handle them.

Keep records of

- How much was purchased and when.
- The batch number and expiry date.
- When it was used and on what type of stock.
- The withholding period (start and end dates) for sale of milk or for slaughter.

Use drugs only on animals recommended on the label. Dispose of unused medicines safely when treatment is finished.

Safe and clean administration of medicines is very important:

- If using disposable needles and syringes, dispose of them in a safe container, after use.
- For other reusable equipment, clean and sterilize before and after use.
- If using a syringe that requires filling from a bottle between doses, use one sterile needle left in the bottle during use to fill the syringe and a separate needle to inject the animal.
- Use a separate needle, or at least sterilize it, between animals.
- Make sure the injection site is through an area of clean and dry skin.

High standards of sanitation are required at all times to prevent rapid spread of infectious diseases in both young stock and milking cows. The most effective way of destroying disease-carrying micro-organisms is cleaning and disinfecting (sterilizing or sanitizing).

6.1.4. Biosecurity when purchasing new stock

Most dairy farmers purchase new animals, so it is important to plan their introduction to the existing animals to minimize the risk that they will introduce infectious diseases.

Three factors are important in reducing this risk:

- Protecting the herd with proper vaccination:
- Ensure you vaccinate your animals regularly and according to the herd health plan.
- The source of purchased animals, including where they come from and how they are transported to the farm:

When purchasing new animals:

- ensure their health status is known by checking their records and veterinary health certificate (if available);
- do not buy sick animals;
- confirm with the government veterinarian if there are any known disease outbreaks in the area where the new animals come from;
- where possible, get the details of their vaccination program if known;
- avoid purchasing animals from unknown sources or animals that have mixed with other animals before sale (high risk of infection among those animals)
- purchase young animals (e.g. heifers;
- transport purchased animals preferably in the farmer's vehicle, in a clean truck or trailer and put adequate bedding to avoid injuries during transport.

The method used to introduce the new animals to the rest of the herd:

- New animals should be separated from the existing animals for a period of time. This way you can observe the animals and check for potential diseases and avoid spread to your existing animals.
  - calves purchased should be kept separate for at 2-3 weeks.
  - adult animals (e.g. heifers) should be kept separate for at least three weeks.
- Vaccinate newly purchased animals, to make sure they are integrated into the farm vaccination program:
  - De-worm newly purchased animals.
  - Treat newly purchased for ectoparasites (ticks etc.).
  - Talk them through a medicated foot bath before introducing them to the existing animals.

Other biosecurity measures that should be considered include controlling the movement of people, animals and equipment onto the farm. Some diseases like FMD spread on clothing and boots. If equipment is borrowed from other farms, it should be cleaned prior to use. Keeping transport or service personnel away from the main herd area, especially the calf shed, or at least providing them with footwear, will also reduce the likelihood of introducing diseases.

6.1.5. Animal and human health

Government veterinary services must maintain surveillance of infectious or notifiable diseases, such as, foot and mouth disease (FMD) and lumpy skin disease (LSD), through vaccination and quarantine measures.

However, as farms become more intensively managed, non-infectious diseases play a more important role in limiting cow performance. Factors such as undernutrition, poor hygiene and other bad management factors will affect herd productivity and increase the risk for disease outbreaks.

There are many diseases that can be transferred from intensively managed animals to humans (so-called Zoonosis). These include Salmonella (and other calf scour-causing micro-organisms), ringworm, mange (and other skin diseases) and Leptospirosis. Children are particularly susceptible to get infected by these diseases through direct contact with the animals.

Other potential hazard for young children are veterinary drugs and chemicals used for cleaning or sanitation. These should be stored in a secure place.

Milk can also transmit diseases organisms (like Salmonella or Brucella) to humans and should therefore be pasteurized before drinking.

Pasteurizing = heating the milk to 72°C and keep this temperature for a minimum of 15 seconds.

6.2. Healthy or sick cow? How to tell!

Vigilance, observation, and understanding are the most important skills needed for maintaining a herd of healthy cows, because recognizing that something is wrong is the first, necessary step of any action or treatment. The physical appearance and behavior of a cow is a good guide to its health status. So, observe your animals and check as follows:

1. Walking and standing: The way an animal moves can indicate pain in the body, the result of a traumatic injury or an infected hoof. A method of scoring the cow's ability to walk (locomotion score) which provides a good guide to lameness, is described later in the module.
2. Skin, coat, eyes, mucous membranes: The skin should be flexible and quickly return to normal when pinched - a lengthy delay indicates dehydration, as does a dry nose. The coat should be smooth and shiny. The mucus membranes (eyes, nose and vagina) should be pink and moist. In sick cows, these membranes may become either too red or too pale. Eyes should have a bright and lively expression with no discharge. Sunken eyes also indicate dehydration.

3. Appetite, rumination and faeces: Healthy cows have a good appetite and decreased intake or disinterest in food is often one of the first signs of illness. Similarly, changes in the consistency of faeces (too dry or too watery) or frequency of voiding, if not accompanied by a change in diet, are often early indicators of illness. Cows ruminate (chew the cud) frequently (at least 6 to 8 hours each day) when healthy, and not ruminating may be a sign of serious digestive disturbance or disease.
4. Urogenital: Urine should be thin, yellow and clear; thick, mucus or red urine is an indication of ill health. The vagina should be closed, with no swelling, no discharge and be slightly light pink; a swollen vagina with whitish discharge or decomposing membranes is indicative of reproductive problems.
5. Respiration: In healthy cows, respiration is quiet and regular, whereas in cases of unrest, fever, fatigue or heat stress, respiration rates increase. Coughing, nasal discharge, open mouth breathing, especially with the tongue out, can all be symptoms of ill health.
6. Body temperature: Normal temperature is 38.5 to 39.5oC. Just as in humans, a higher temperature indicates a sick animal – this may be due to an infection or to heat stress. Lower temperature can also be seen in sick animals.
7. Nutritional status: Cows can be fat, normal or thin. Thin cows are not necessarily sick, because they could have recently calved or simply be high-producing animals. However, sick cows tend to lose weight due to decreased appetite, poor feed digestion or loss of body reserves. Cow condition should then be judged in relation to all circumstances (see Table 1.3 for descriptors of body condition scoring).
8. Milk production: When a cow is sick, milk production drops.

The physical state of a cow is a good guide to its health status. Healthy animals are alert and active, and have bright eyes, with no discharge, smooth and shiny skin, they breathe and urinate regularly, and their tail moves to drive flies away. Signs of stress include loss of appetite, reduced daily milk yield, increased temperature, high respiratory rate, no rumination, dullness and isolation from other animals.

6.3. Causes of health problems

They are separated into two main categories: parasites and microbial agents, followed by nutritional (and metabolic) diseases and then miscellaneous agents.

Parasites

Parasites that infect cows include:

- Ectoparasites (live outside body): ticks, flies, lice, mites (mange).
- Endoparasites (live inside body): intestinal worms, lung worm, liver fluke;
- Tick and insect-borne diseases: theileriosis (East coast fever), babesiosis, anaplasmosis, bovine ephemeral fever (three-day sickness), trypanosomiasis, rift valley fever, pink eye.

Microbial agents

Microbial agents that infect cows include:

- Bacteria: Brucellosis, vibriosis, tuberculosis, paratuberculosis (Johne's disease), trichomoniasis, campylobacteriosis (or vibriosis), leptospirosis, anthrax, and tetanus, black leg and other clostridial diseases, haemorrhagic septicaemia (HS), salmonellosis, brucellosis. Bacteria can also cause mastitis, pneumonia, infectious foot rot, pink eye and joint ill
- Viruses: Foot and mouth disease, Rift Valley Fever, Lumpy Skin Disease, Contagious bovine pleuropneumonia, enzootic bovine leukosis, bovine viral diarrhoea, bluetongue, infectious bovine rhinotracheitis, rabies. Viruses can also cause pneumonia and diarrhoea (especially in calves)
- Others: Bovine spongiform encephalopathy (or mad cow disease), facial eczema (fungal), ergot poisoning (fungal), ringworm (fungal), blue green algae poisoning, eye cancer
- Agents mainly responsible for calf diarrhoea (calf scour): E. coli, cryptosporidia, rotavirus, coronavirus, Salmonella, coccidia.

Nutritional and metabolic disorders

Nutritional and metabolic diseases that affect cows include: acidosis, milk fever (low blood calcium), grass tetany (low blood magnesium), acetonaemia (or ketosis), bloat, displaced abomasum, photosensitisation, urea toxicity, nitrite toxicity, lead poisoning, foreign bodies (hardware disease) and miscellaneous plant poisonings (e.g. bracken fern, lantana, oleander).

Acidosis

Incorrect diets or feeding can lead to overly rapid fermentation in the rumen, which reduces the pH below the level at which microbes are most active, making it too acidic. This slows down forage digestion and reduces both feed intake and cud chewing which makes the problem worse by limiting the buffering effect of salivation.

Symptoms:

- Decreased or no cud chewing;
- eating dirt and drooling;
- loose faeces or diarrhea manure;
- weight loss;
- drop in milk yield
- increased temperature;
- kicking of the belly;
- panting.

Acidosis can cause death in cattle if not treated.

Treatment: Change the diet and feed the cow dry hay. Giving baking soda (either free-choice or force-fed) also helps.

Prevention: Correct diet with sufficient amount of hay (roughage).

Hypocalcaemia (milk fever)

The huge demand for calcium during the onset of milk production can cause blood calcium levels to drop sharply, causing milk fever either before or at calving. Even though cows can mobilise skeletal calcium, the process is slow and made worse by the demands of high yielding stock.

Symptoms:

- Lying down in a fixed position.
- Decrease in body temperature.
- Dry muzzle.
- Cold legs and ears.
- Staring eyes.

Milk fever can cause death in cows if not treated.

Treatment: call the veterinarian immediately so that he can administer some solution of calcium (40% calcium borogluconate). Cows lying on the side, should be put in a sitting position, supported by bales of hay.

Prevention: Feed adequate amount of hay and keep cows close to calving in a calving box, for better monitoring and observation. Calcium supplements after calving might help.

Hypomagnesaemia (grass tetany)

Cows only have a limited body reserve of magnesium and can only absorb a small proportion of the mineral in their diet, therefore grass staggers is easily caused by a fall in dietary magnesium. The risk is highest early in the grazing season (just after the rains) given the lushness and low mineral content of grass at that time. Similarly, later season grass toward the end of the dry spell, lowers mineral content.

Symptoms:

- Stiff walking, staggering.
- Frequent urination.
- In severe cases collapsing, paddling with feet and convulsions.

Grass tetany can cause death in cows if not treated.

Treatment: Call the veterinarian immediately so that he can administer a magnesium solution (often in combination with calcium).

Prevention: Feed hay and adequate mineral mix.

Ketosis (acetonaemia)

Ketosis commonly occurs as a result of a severe early lactation energy gap. The mobilization of large amounts of body fat in the liver, in an attempt to bridge the shortfall, can lead to toxic levels of ketones accumulating in the blood, milk and urine. This results in a loss of appetite and a marked fall in milk yield.

Symptoms:

- Specific smell of the cow's breath.
- Loss of appetite.
- Reduced in milk yield.
- Fever.
- Dull coat.

Treatment: Call the veterinarian immediately so that he can administer glucose (dextrose) solution.

Prevention: Provide a well balanced diet for the cow and try not to overfeed before calving.

Accidents and predators

There are a number of health problems which can be caused by accidents e.g. wounds resulting from poorly done structure, poor bedding or cattle falling. Other problems may be caused by injuries from predators.

6.4. Disease prevention and management strategies

"Prevention is better than cure" the target of every farmer should be to prevent diseases from occurring. However, in case of a disease occurrence it is strongly recommended to call for veterinary assistance when health problems are suspected (veterinarian or animal health assistant registered with KVB). Most diseases can be prevented by the same management measures that enhance production.

6.4.1. General preventive measures are:

- Hygiene, cleaning and disinfecting. Remember disinfection is not effective without proper cleaning beforehand!
- Free access to clean and fresh drinking water. Providing good and sufficient feed and water at regular times.
- Protection against predators, parasites and adverse weather conditions like rain, wind, cold, and intensive sunshine.
- A comfortable environment without unrest and stress.
- Avoiding contact with sick animals and wildlife because many diseases are contagious.

6.4.2. Isolation

Isolating sick animals and newcomers from the rest of the herd. This helps to avoid the spread of contagious diseases to other animals. Take special care of dung, urine, milk, blood and aborted material as these may transmit the disease to other animals. Some diseases, like tuberculosis and brucellosis are also dangerous to humans (Zoonoses: diseases transmitted from animals to humans). Assure proper cleaning and disinfecting. Dry and clean floors with bedding are important. Sick animals need special care. Provide them with shade, protection against wind, clean water and adequate feed.

6.4.3. Vaccination

Vaccination against a specific disease helps the animal's body withstand an attack by this disease. Sometimes it will protect the animal during its entire life, but many vaccinations have to be repeated. Unfortunately, vaccines are not available against all diseases.

Vaccinations against the following diseases may be relevant for dairy cattle:

Vaccinate against	Age	Application	Remarks
Brucellosis (S19)	3-8 months for heifers	Subcutaneous – Once in a lifetime	During threats of outbreak the whole breeding herd may be vaccinated. Unfortunately, it is difficult to get the vaccine. Note: Use vaccine with care. S19 live vaccine, if accidentally injected into humans can cause brucellosis in humans.
Anthrax and Blackquater	From 3 months and above	Subcutaneous - Annually or upon warning of an outbreak	Vaccine is cheap, SO USE IT. Anthrax is deadly for humans and animals.
CBPP Contagious Bovine Pleuropneumonia	After 2 weeks	Annually in endemic areas. In other areas only upon warning of impending outbreak. Vaccinated into the tip of the tail.	Consult your veterinary authorities. To be administered by trained veterinarians only. Animals can sometimes lose the tips of their tails from this vaccination.
ECF East Coast Fever	From 1 month and above	Subcutaneous under the ear. (followed by treatment with Oxytetracycline) Once in a lifetime.	Only to be used by licensed Veterinarians who are trained of application of the ECF Infection and Treatment Methods. Vaccine is commercialized in Tanzania and in Kenya
Foot and Mouth disease (FMD)	From 1 months	Subcutaneous – Calves who receive first vaccination should be boosted 1 month later; Vaccination of FMD quadrivalent vaccine is recommended every 4 months for all animals.	Different strains exist. Consult your veterinarian on the choice of vaccine. To be administered by trained government veterinarians.
Rabies	After 3 months	Subcutaneous – Cattle can be vaccinated annually and must be vaccinated when there is an outbreak	Vaccine is normally provided by the government vet. This is the only method that can protect herds affected by rabies (rabies is mostly introduced by bites from rabid dogs) if rabies vaccination is done within maximum one week after the rabid animal came into the herd. Report suspected cases immediately to the District Veterinary officer.
Rift Valley Fever	After 6 months	Subcutaneous – Preventive after heavy rains or when there is a risk of outbreak. In endemic areas annual revaccination is recommended.	A live vaccine is used. Vaccination is only carried out under order by the DVS. Pregnant animals may abort from the vaccination. Live vaccines may also be dangerous for humans, so HANDLE WITH CARE. RVF in humans can be deadly so control is very important. New RVF vaccines which do not cause abortions in livestock are being developed but are not yet registered in Kenya.
Lumpy skin	After 1 month	Subcutaneous – Annually. Preventive when there is a risk of outbreak.	When using this live vaccine, separate cattle from sheep and goats, as the vaccine is derived from modified sheep pox virus. If sheep and goat come into close contact with freshly vaccinated cattle the vaccine can cause acute pox disease in sheep and goats.

6.5. Prevention of some common diseases

6.5.1. Calf management and most common diseases (diarrhoea and pneumonia)

Remember signs of a healthy calf: Healthy, alert, clean eyes, shining coat and pricked ears. The nose and eyes should be clear and damp with no discharge. Moves and jumps around and drinks often. Calves should stretch when they stand up following a rest period.

Specific signs to look for in calves: Health problems are likely in calves with droopy ears, head down, not drinking, lying in a corner, dribbling, limping, swollen joints, swollen navel, scour or blood in their faeces. Discharge from nose or eyes. An odor of ammonia can indicate poor ventilation and potential pneumonia problems.

Good Practice in calf management and to prevent diseases in calves

1. Build immunity

- Do not separate the dam until 24 hours after calving, this way the calf can suckle after birth and drink the important colostrum, which provides the calf with protection from diseases through the dam; Ensure the early colostrum intake; assist if needed, and monitor the intake as closely as possible and record it ("maximum supervision, minimum interference").
- Provide adequate and clean bedding to allow the calf to stand without difficulty.
- Avoid stress and exposure to new disease agents during "poor immune capacity" between 2-9 weeks of age.

2. Minimize exposure

- Provide adequate numbers of calving pens and clean and disinfect them between batches.
- House calves of different ages in different rooms or with adequate separation.
- Isolate bought-in animals for 2-3 weeks before introduction to the rest of the herd.
- Provide good ventilation in the calf housing but avoid exposure to wind/draught.
- There should not be excessive humidity in the calf house.

3. Reduce stress

- Avoid overcrowding in calf pens;
- Provide good ventilation (but no exposure to direct wind or draught);
- Make sure that calves are well bedded during cold weather (the minimum critical temperature for newborn calves in a straw bedded pen is 6ºC);
- Provide shelter during prolonged cold and wet conditions on pasture;
- Avoid transport and introduction to new environment between 2 and 4 weeks of age;
- Time castration and disbudding away from weaning;
- Introduce diet changes gradually, particularly when housing calves.

Prevention and control of diarrhoea and pneumonia in calves

a) Diarrhoea

Diarrhoea, or scouring, is the main cause of death of young calves in the first 2 - 3 weeks of their lives. It is easy to detect: the faeces are liquid, different in colour (e.g. white, watery, bloody) and have a very bad smell.

Signs of a calf with diarrhoea: The calf looks ill, might have an arched back, sunken eyes, drooping ears and does not drink well.

Treatment: Diarrhoea in calves often needs to be treated with antibiotics. Consult your veterinary professional on the proper treatment.

Most calves die of diarrhoea, as they lose a lot of body fluids with the faeces. Rehydration is key for your calf to survive. A simple rehydration solution can be mixed and given to the calf orally at least 3 times a day.

- Recipe: Mix 5 tablespoons of sugar (or honey) and 1 tablespoon of kitchen salt in 2 liters of water. Shake the mixture well and give a quarter of the mixture (500ml)
- in the morning,
- at midday
- in the afternoon
- in the evening

Administer the liquid slowly with a bottle, and ensure that the calf swallows the liquid and it does not get into the wind-pipe.

Prevention: To prevent scouring the following should to be done;

- Colostrum: It is most important to provide the calf with colostrum (=first milk of the cow after calving down) within the first two hours of its life;
- Hygiene is essential. Clean buckets for feeding and clean housing are necessary. A clean and dry floor with bedding is a must.
- Ensure the calf is in a comfortable environment free of cold and strong winds.
- Consider the orientation of the calf shed in regard to normal wind and sunshine patterns.

b) Pneumonia

Pneumonia causes poor growth and death in the first four months of a calf's life.

Symptoms of Pneumonia: coughing, high fever, watery eyes and a runny nose. Calves are mainly affected after two months of age.

Treatment: treatment with a broad-spectrum antibiotic by a qualified veterinarian/ AHA for at least five days will generally be successful.

Preventing pneumonia

- Colostrum: It is most important to provide the calf with colostrum (colostrum = first milk of the cow after calving down) within the first two hours of its life.
- Clean open housing, with good ventilation but no wind/draught and a dry floor are important.
- Calves should be protected against large variations in environmental temperature.

6.5.2. Prevention and control of worm infection

Worm infections are the most common occurrences in livestock.

Symptoms: An animal suffering from a worm infection will lose weight, becomes ill and will also have a distended stomach ("pot-belly"). Young animals are particularly susceptible to gastrointestinal worm infestation from grazing. Remember that worms develop well under humid and hot conditions.

Prevention and control of worm infection

- Regular cleaning and keeping the stable floor dry.
- Stall-feeding instead of grazing will help reduce the risk of infection. Avoid grazing in humid areas or use mobile pens in clean pasture plots instead.
- De-worming with a broad spectrum anthelmintic is common practice for young animals, starting from the age of two months and repeating treatment every 3-4 months until about 2 years of age. As most infections occur during the rainy season, de-worming before and after this season is useful in many areas.

6.5.3. Tick control

Ticks can be a problem, especially under grazing conditions. They attach themselves to the animal, suck blood and infect the animal with tick-borne diseases (ECF, anaplasmosis, babesiosis, trypanosomiasis). They make wounds that allow bacteria to enter the skin resulting in loss of value of hides. Ticks can also attack the udder causing the loss of a teat, thus making the cow less productive.

Control: There are different methods of tick control. The one that will work best will depend on many factors such as the number of cattle, the facilities available, the tick and tick-borne disease situation in your area, how you want to control ticks (for example, whether you want to use strategic or intensive control) and the amount of money available for dipping compounds.

- The plunge dip is one of the common methods of tick control. The animal is completely immersed in the dipping compound (acaricide). To be repeated every 5-7 days.
- Spray races can be used where available. The animal walks through a race where it is sprayed with the dipping compound.
- Hand spraying can be done. The dipping compound is applied to each animal with a hand-operated spray pump. This can be time consuming when you have several animals. You need a back-pack sprayer/ knapsack sprayer.
- Hand dressing or spot treatment involves treating the sites where ticks commonly occur. Tick grease, oil or dipping compound can be used.
- Pour-on are dipping compounds which are applied on the back. They are easy to use but can be expensive compared to other options.
- Other methods, such as removing ticks by hand, the use of chickens to remove ticks and pasture management, can also be considered.

Movement of animals can spread ticks to other areas. It is recommended to treat cattle before moving them, and newly-introduced cattle before they are placed with the rest of your herd. Whichever method you use, always follow the directions and mix the dipping compound appropriately if necessary.

The frequency of treatment depends on the type of ticks, the breed of animal and the season. It varies from twice a week for exotic cattle like Friesians in regions with East Coast Fever to once every three weeks to control Boophilus (blue) ticks that transmit babesiosis and anaplasmosis. It also depends on the feeding system and the contacts of the animals with other cattle in the village. If an animal suffers from a tick-borne disease, seek veterinary assistance.

When to spray or dip

Spray early in the morning before animals get thirsty to minimize ingestion of the dipping compound, as this is often poisonous. A useful rule to remember is – do not spray in the heat of the day, spray before 9.00 am when the sun is not hot.

How to spray (using a backpack sprayer/knapsack)

Hold the nozzle of the spray pump at a distance of 30cm (1 ft) from the animal and then spray the body parts in the order shown in the diagram.

Ensure that the whole body is covered by the wash. Give special attention to the following areas:

- Around the base of the horns
- Around the anus
- Udder and teats
- Around and between the hoofs
- Around the eyes
- Inside the ears
- For male animals, around the scrotum

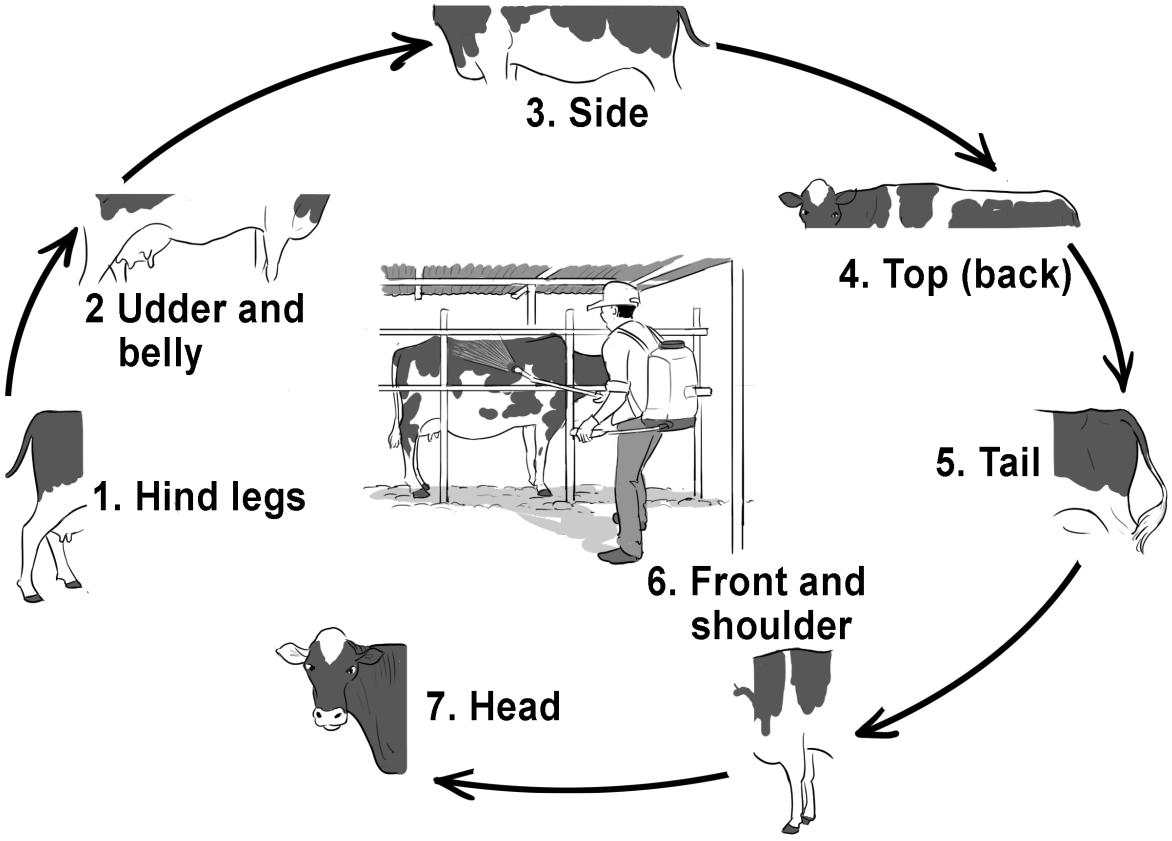


Figure 6.5.3: Tick control

6.5.4. Hoof problems

Besides lameness, cows with hoof problems may present a serious drop in milk production. Hoof problems can be caused by injury, infections or by hooves growing out of shape.

Prevention consists of the following measures:

- Hygienic housing: Clean and dry, well-levelled floors are required. Floors should not be slippery, so the surface should not be too smooth.
- Nutrition: Well-balanced feeding with sufficient roughage and no drastic changes is recommended. Provide sufficient mineral licks to the animals.
- Hoof trimming: Hoofs grown out of shape need trimming. This job requires special skills and should be done by an experienced person.
- Footbath: When problems occur frequently, a footbath with a disinfectant could be considered.

6.5.5. Mastitis

Mastitis management can be divided into three areas of activity:

1. Prevention strategies
2. Treatment strategies
3. Eradication strategies

6.5.5.1. Prevention strategies

- Clean udders/teats before milking. Cleaning the teats before milking is a very important step in preventing bacteria from getting into the teat canal during the milking process.
- Use proven effective pre and post milking teat dips. Teat dips reduce the number of bacteria on teats and thereby help lower the number of new udder infections. They should be routinely used by all dairy producers.
- Use paper towels or reusable cloth towels to clean and dry teats. One paper or cloth towel should be used for each cow to wipe the teats clean and dry before milking. Towels should be washed in hot water with a strong detergent or bleach.
- Fore-strip milk from each quarter. This practice should be done before milking to check for clinical infection, remove milk from the teat cistern that will most likely be higher in somatic cell count (SCC) and bacteria numbers than milk in the udder, help stimulate milk let-down, and increase milk flow rate.
- Provide comfortable, properly designed and bedded stalls. This is important for promoting the use of the stalls by cows and heifers. Cows that rest in clean, comfortable stalls are going to have cleaner udders/teats, will have less teat end exposure to bacteria and fewer infections than cows which lay in dirty alleys.
- Keep facilities clean and dry. Free stalls, alleys, feeding areas, parlor holding area, exercise lots, etc. should be kept as clean and dry as possible so the cows will be kept as clean as possible. Scraping/flushing manure from the alleys should be done at least two times a day. Clean facilities means cleaner cows, which means less mastitis.
- Check udders of cows and heifers while pregnant. Udder examinations should be done during the first 2-3 weeks of the dry period for cows, and any infections that are detected should be treated. Udders should also be examined for any infections during the last 2-3 weeks of gestation of both cows and heifers and treated as needed.

6.5.5.2. Treatment strategies

- Consult with your veterinarian for mastitis treatment regimes. Producers should utilize their veterinarian's expertise when deciding how to treat both clinical and subclinical mastitis cases.
- Consider drying off early. There may be situations when a cow is very sick or a quarter is so infected that the producer should consider drying-off the cow early or treating the quarter to cease milk production. This should be done only if the cow is a valuable animal that the producer wants to keep in the herd rather than culling.

6.5.5.3. Eradication strategies

- Cull chronically infected or incurable cows. Cows that have a chronic mastitis infection that is incurable should be culled from the herd to prevent the transfer of the infectious organism to other cows. This is a last resort tactic, but one that should be followed when required.

6.5.6. Wounds

Accidents occur. Besides treating the wound itself, it is very important to identify the cause and eliminate it. The building, equipment, fences, other animals, predators and parasites, may be the cause of wounds.

Cleanliness and protection against flies are the most important factors in wound treatment. Equipment, clothing, hands and housing should be clean. Hairs around the wound should be clipped and dirt removed.

Wash out with a weak disinfectant and try to stop bleeding. Apply iodine tincture, methylene blue or wound spray. If the problem is serious, call in a vet.

6.6 Summary

- When it comes to managing dairy herd health, it is important to keep good records, handle drugs responsibly, and make sure that you do not put existing stock, or humans, at risk.
- A cow's body and behaviour reveal much about the condition of its health. Among other signs, a cow's gait, skin, coat, eyes, appetite, temperature and respiration can all reveal symptoms of disease.
- Parasites, microbial agents, accidents, nutrition and predators can all cause health problems in cows.
- Alongside isolation and vaccination, hygienic conditions and being kept away from sick animals will help prevent, or manage, disease in your cows.
- Specific guidelines must be followed to prevent issues like diarrhoea, pneumonia, worms, ticks, hoof problems, mastitis and wounds occurring in cows.

6.7 Review questions

- What are some signs that show an animal is sick?
- What are the main causes of health problems in a dairy herd?
- List any 3 nutritional diseases/metabolic diseases common in smallholder dairy systems.
- What measures would you put in place to reduce pneumonia and diarrhea in calves?
- What are the preventive measure you would put in place to reduce hoof problem in dairy animals?
- What are the strategies you would employ to prevent the occurrence of mastitis on the dairy farm?

7. Milk quality and udder health

Topic objectives

The overall objective of this topic is to increase farmers' knowledge on the importance of quality milk, identify sources of contaminants and the importance of udder health in production of hygienic milk.

Topic aim: By the end of the topic, the learner should be able to

- Understand the characteristics and composition of quality milk.
- Identify the sources of contamination and how to prevent milk contamination.
- Know the basic test to measure milk quality at the farmer level.
- Understand ways to control and manage mastitis.

7.1. Hygienic milk production

The consumer wants a safe product and the processor needs good quality milk for processing. The handling of milk strongly affects the quality of the finished product. On leaving the udder milk from a healthy cow contains a negligible quantity of bacteria and no dirt. If good hygiene is practiced the contamination outside the udder can be kept to a minimum.

Milk quality and hygiene activities play a vital role in the dairy production system and should not be underestimated. Milking activity, transportation, storage and processing activities can determine milk quality and hygiene.

7.1.1. Characteristics and composition of hygienic and quality milk

Clean milk production refers to the withdrawal of clean milk from the animals' udder and maintenance of the quality of that milk till consumption or processing. Clean milk should not:

- Have visible matter such as hairs, dust and organic matter.
- Have odd flavours, smell or colour.
- Have pathogenic organisms that may cause disease to both humans and animals.
- Have certain chemical residues, which are used at the farm such as antibiotics and pesticides.
- Exceed the legal minimum requirements for water, butterfat and solid non-fat.

7.2. Sources of contamination in milk at the farm level

There are several sources of milk contamination at the farm level. These are:

- The animals (cows); much of the dirt and dust that goes into milk comes from the cows' flanks, udder and belly during milking and therefore the animals should be fairly clean. In addition the dairy herd should be free from diseases that might spread to human beings through the milk e.g. mastitis. Drug withdrawal periods must also be observed.
- Milk handling and storage equipment; all the milking equipment should be kept free from odours and dust. When cleaning they should first be briefly rinsed then thoroughly washed before a final rinsing so as to avoid formation of milk stones on the equipment.
- Environment (especially around the milking parlour); the milking facility should be located in a well-drained area. The area must also be regularly cleaned and disinfected.
- Milkers and milk handlers; all the personnel handling milk must be clean and free from communicable diseases. They should also follow the proper milking procedures.

7.3. Factors that affect clean milk production

Factors that influence clean milk production are:

- **Milking techniques:** The milking routine that each farmer adopts will greatly influence the quality of milk produced at that farm. The milker must seriously follow the laid down milking techniques, habits and use of sanitary procedures.
- **Cooling and storage of milk:** In many farms proper cooling and storage facilities do not exist and as a result milk with a high bacterial count is sent to the market.
- **Feeding routines:** Feed flavours are among the common taste defects in milk. Feeds that impart an off-flavour to milk, such as silage, should be fed after milking. It is also recommended that cows for milking be brought from the pastures one hour before milking begins.
- **Control of flies:** The presence of large numbers of flies in dairy buildings apart from irritating the animal and milker, also add to the bacterial count in milk. Breeding places for flies such as manure piles and mud pools near the milking area should be eradicated.
- **Water supply:** Water is a more acute problem to small-scale dairy farmers who cannot afford a permanent supply. Adequate water supply is very crucial in the maintenance of cleanliness at the farm.

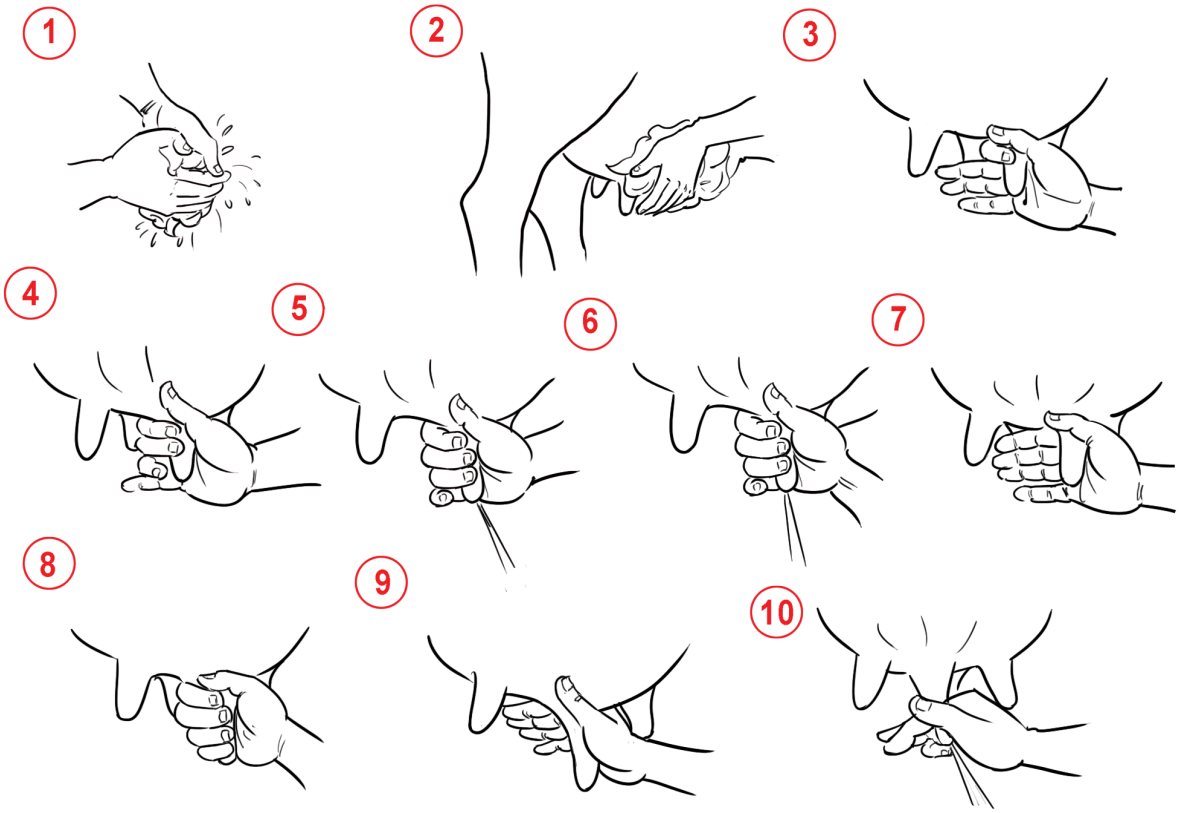
7.4. Hygienic milk production practices and procedures

7.4.1. Hand milking

The utensils to be used for milking should be made of non-absorbent, corrosion resistant material, could not be scratched easily, should have a smooth surface and should be free from dents as well as easy to clean. Aluminum and stainless steel equipment are mostly preferred.

Steps in hand milking

1. Ensure the milkers hand is clean.
2. Clean the udder of the animal and clean the hands again.
3. Dry the hands.
4. Take hold of the base of the teat.
5. Squeeze with thumb and forefinger.
6. Close the other 3 fingers and squeeze them in turn.
7. Repeat this in a rhythmic way.
8. Milk quickly and evenly (remember 7 minutes of let-down).
9. Sit at the right side of the cow preferably and use both hands alternating during milking.
10. Start milking both front teats, turn milking the hind teats and crosscheck to finish in the same order.



After milking

- Dipping the teats with a special teat dip right after milking can help to prevent udder infections.
- Next to that it will help to keep a cow standing for more than an hour directly after milking.
- By recording the amount of milk of each cow regularly, it is easy to keep an eye on the production performance of each cow.

7.5. Mastitis control and management

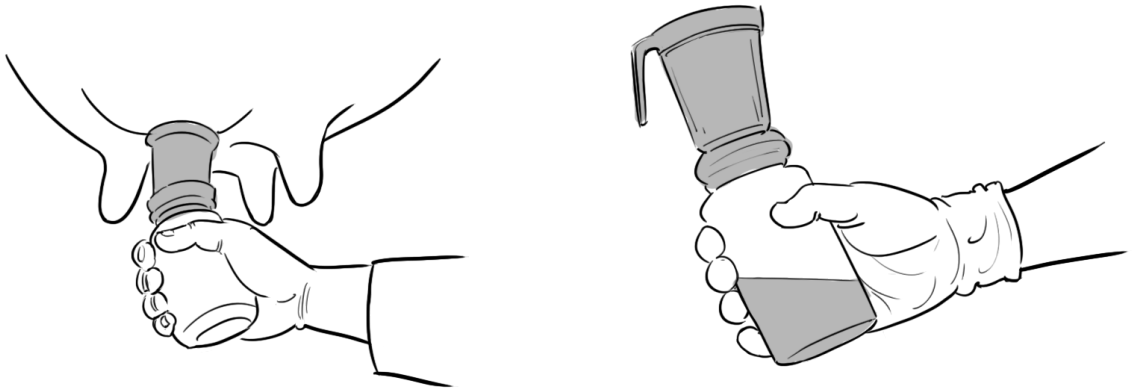


Figure 7:5: Dipping teats in disinfectant

Mastitis is an inflammation of one or more quarters of the udder usually caused by bacterial infection. Several types of bacteria cause distinctly different mastitis infections.

Mastitis causes direct economic losses to farmers in several ways:

- Milk yields are reduced.
- Milk that is abnormal or contaminated with antibiotics is unsaleable.
- There are veterinary and antibiotic costs.
- A higher culling rate and occasional fatalities.
- The milk processing industry also incurs losses because of problems that result from antibiotic residues in milk.
- Mastitic milk has a reduced chemical and bacterial quality.

7.5.1. Causes of mastitis

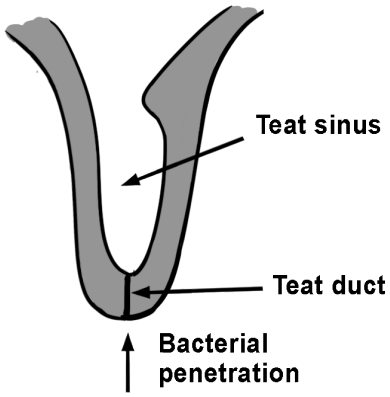


Figure 7.5.1: Anatomy of an udder

An udder quarter becomes infected when

- the teats are exposed to pathogens.
- the pathogens penetrate the teat duct.
- the infection is established within the udder.

7.5.2. Mastitis control methods

A detailed description of the control method can be found in section 6.5.5

7.6. Summary

- On leaving the udder, milk from a healthy cow has a negligible quantity of bacteria and no dirt. Practise good hygiene to limit subsequent contamination.
- The cows themselves, as well as the milking equipment, the environment, and the milk antlers, are all potential sources of contamination on a farm.
- Farmers can produce clean milk by using sanitary techniques, proper cooling facilities, good quality feed and an adequate water supply. Keeping the milking area clear of flies is also advisable.
- The process of hand milking a cow starts by observing optimum hygiene standards.
- Mastitis causes economic losses for farmers in a number of ways, e.g. by limiting milk yields and/or rendering the milk produced unsaleable.

7.7. Review questions

1. What are the characteristics of clean milk?
2. What are the main sources of contamination in milk?
3. What are some of the factors that affect clean milk production?
4. What is the process of hand milking and why is it important to follow the right procedure during milking?
5. Apart from the ways listed in the summary above, how else does mastitis cause direct economic losses to farmers?

8. Reproduction and breeding management

Topic objectives

The overall objective of this topic is to enhance knowledge and skills of the farmers on dealing with reproduction challenges in the herd and to help make prudent decision when breeding.

Topic aim: By the end of the topic, the learner should be able to

- Know how to detect heat in cattle to increase Artificial Insemination (AI) conception rates.
- Identify and decide on the most appropriate breeding method to use.
- Understand the factors to consider when breeding dairy cattle.

8.1 Factors affecting reproductive performance of dairy cattle

To improve the reproductive performance of the herd, several ways to obtain optimal results must be explored.

Better reproduction results improve the economic results of the herd in two ways:

- A higher total life-time milk production of the cows.
- A higher number of calves per year.

An additional advantage of a larger number of calves means that the selection opportunities within the breeding herd will increase further and consequently a higher income can be realised by selling calves or heifers.

There are a number of management factors that affect reproduction of a dairy animal.

8.1.1. Heat Detection

Heat detection has a major influence on the length of the calving interval. An optimal calving interval can be achieved only if the farmer maintains a healthy, properly fed herd in which each mating is carefully planned.

Planning starts months before the contemplated mating. It is important to have a well-planned and properly executed heat detection program. There are a number of factors which make heat detection less easy, notably

- The length of the oestrus cycle varies from 18 to 24 days.
- Heat signs often occur over a shorter period only.
- The sexual behavior of cows in heat varies.
- The duration of heat varies from cow to cow, especially in maiden heifers.
- Sexual activity tends to be greatest between 6 pm and 6 am and mainly depends on the ambient temperature.

Early heat period

A sexually mature, non-pregnant cow comes in heat every 18 to 24 days. It starts with the development of an ovum in the ovary. At this stage the cow shows early signs of heat. The length of this period varies from 6 to 24 hours. Signs of early heat are

- Not standing when mounted.
- Attempts to mount other cows.
- Sniffing at other cows.
- Looking for the company of other cows.
- Chin resting.
- Being restless.
- Being extra attentive.
- A wet and slightly swollen vulva.
- Bellowing.

Standing heat period

Early heat becomes standing heat. The length of this phase of heat ranges from 6 to 18 hours.

The signs of heat are

- Standing while being mounted. This is the clearest sign of heat.
- Mounting other cows.
- Chin resting.
- Frequent bellowing and restlessness.
- Attentiveness, 'ear play'.
- Bending backbone, loin part downward and sacrum upward.
- regular sniffing at reproductive organs of other cows.
- Red and swollen vulva and clear mucus discharge.
- Ruffled tailhead due to mounting.
- Less appetite and generally less milk.
- Slightly higher body temperature.
- Glistening mucus on tail and hindquarters.

Late heat period

After the period of standing heat some cows continue to show behavioral signs of heat. This period is called the late heat period and can last for 12 to 24 hours.

Signs of the late heat period are

- Not standing when mounted.
- The cow is sniffed by other cows and is sometimes sniffing other cows.
- Clear mucus discharge from the vulva.
- Dry mucus on tail.

About two days after the end of heat, cows may show a bloody mucus discharge from the vulva. This can be of help in case of unclear or doubtful signs of observed heat. The next heat period should then occur about 19 days (21 days - 2 days) after the bloody discharge.

8.1.2. Regular observation

Most cows show signs of heat better during the cooler periods of the day. Good detection results will be obtained when the cows are observed three times a day, preferably:

- In the morning, before and after milking.
- In the afternoon, before and after milking.
- In the evening around 10 o'clock.

Additionally, all other possibilities of detecting cows in heat should be used. The time required for good heat detection depends upon the:

- Experience of the person in charge.
- Number and breed of cows.
- Environment of the cows.

Generally, at least 20 minutes are needed each time to do a good heat check. In larger herds in very hot climates it may be wise to keep the cows also under surveillance at night.

8.1.3. Good recording

One of the most useful aids in heat detection is good record keeping. Good systems for proper fertility recording are, for example: a cow calendar, a herd fertility and health monitor chart and individual cow records. Even an ordinary calendar can be very useful. All data relating to the cow's reproductive status should be recorded, i.e. calving date, ease of calving, date of heat, insemination date, name of sire, fertility disorders and their treatment, etc. They also indicate when cows can be expected to be in heat, which cows need special attention and which cows should be inseminated when in heat.

For instance, when a cow is seen in heat, this should be marked on the calendar or chart for a close observation of the cow three weeks later.

8.1.4. Inseminating at the Right Time

Inseminating a cow at the end of the standing heat period or at the start of the late heat period ensures the best results. Inseminating when the cow is still in early heat is useless. Where the insemination is done by an AI technician, all cows which were seen in heat in the morning should be inseminated later that day. Cows that are still in heat the next morning, should be re-inseminated. When heat is first seen in the afternoon or evening, insemination can safely be postponed until the next morning (AM-PM rule). Figure 8.1.4 below illustrates the best time to inseminate a cow.

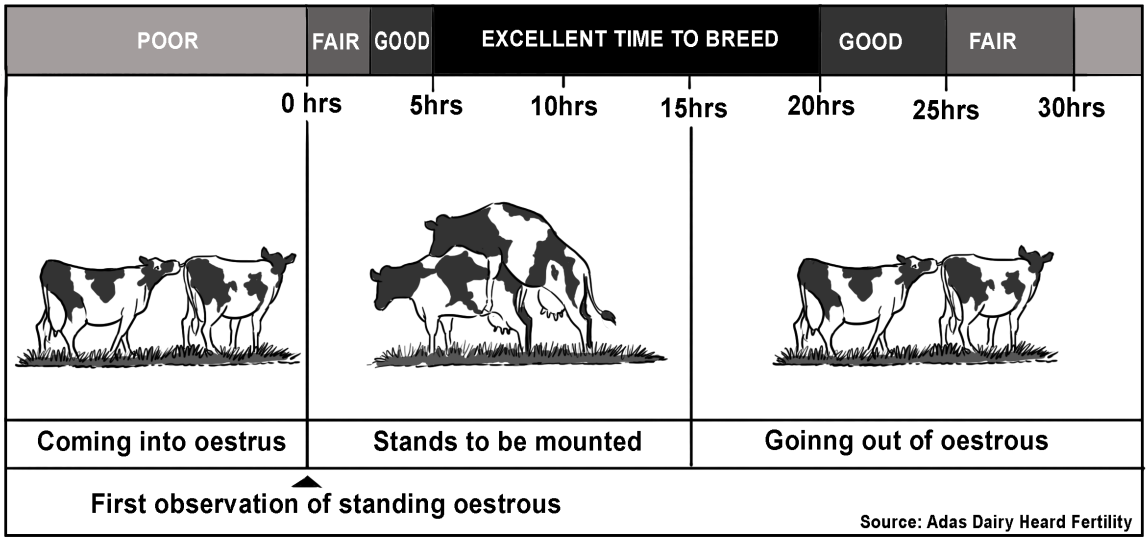


Figure 8.1.4: Timing the insemination of a cow

8.1.5. Interval from calving to first insemination

Although advancing the date of first service after calving will also advance the average date of conception, it is not wise to serve the cows as soon as possible after calving because

- All cows need time to restore body reserves in early lactation.
- First-calf heifers require time to establish themselves in the herd before a new pregnancy is proceeded to.
- The conception rate will be very low.
- Calving intervals of less than 365 days are not advisable.

To achieve the best pregnancy results, a cow must be in perfect physical condition. This means that a cow must be fed according to her nutritional needs and must not have any health problems.

In order to maintain an average calving interval of one year, the average cow should be pregnant 90 days after calving. Therefore, cows should generally be inseminated for the first time between 50 and 75 days after calving. This usually means the second or third heat after calving.

With regard to high-yielding cows or cows with fertility problems, such as a retained placenta or endometritis, it may be advisable to postpone the first insemination for a while.

Cows which do not show heat within about 60 days after calving should be checked by a veterinarian.

8.1.6. Repeat breeders

Unfortunately, not all inseminations result in a successful pregnancy. Sometimes a cow does not conceive at all after several inseminations.

It also happens that cows conceive well, but sometimes the embryo or foetus dies after conception. The loss of conception during the first 42 days of pregnancy is called embryo death, and foetal death between 43 and 151 days of pregnancy. After this period we speak of an abortion. Embryo loss can happen without any clear visible sign.

It is very important that heat detection is continued after a cow has been inseminated. Continued observation should take place at intervals of 3 and 6 weeks after insemination. If the cow comes back in heat (repeats), she should be inseminated again to avoid losing time and money.

Cows without any signs of heat should be pregnancy-tested by a veterinarian about 6-8 weeks after the last insemination in order to be absolutely certain that the cow is in calf. This may prevent disappointments.

If a cow is not pregnant after several inseminations, one should consider culling the cow. If there are more cows with such problems, it is advisable to contact the veterinarian.

The choice between giving a cow another chance or culling it because of its reproductive problems should mainly depend on economic considerations, e.g. the milk production and the breeding value of the cow should be taken into account. Problem breeders can be early identified by means of accurate recording and regularly scheduled visits by a veterinarian.

8.1.7. Quality of inseminations

The person performing the inseminations has a great influence on the pregnancy rate. The best results will be obtained by an experienced AI technician. In hot climates, where cows have a shorter heat period, AI service should be available during the whole day.

However, proper training in AI techniques is essential to obtain optimal results. Monitoring the individual results of the technicians performing the inseminations helps to evaluate and improve the pregnancy results.

The quality of the semen also has a major influence on pregnancy rates. There is a considerable difference in the quality of semen from different bulls. Furthermore, in order to get good pregnancy results, semen should be stored in a regularly tested storage tank.

8.1.8. Nutrition

Good nutrition means the provision of sufficient energy, proteins, minerals and vitamins. Providing a well-balanced ration does not only result in more milk, but also in better reproductive performance. In early lactation, when the milk production is at its peak, it is very hard to adjust the daily dry matter intake to the nutrient requirements of the cow, especially a high-yielding cow.

A cow's dry matter intake develops slowly during early lactation, and as a consequence an energy deficit per day is common at this time. This deficiency can be made up by mobilising the body reserves, mostly fat and a little protein. Therefore it is important for the cow to have the required level of nutrition during the preceding lactation and dry period.

Cows that are (too) fat at calving seem more likely to get problems at calving and to develop insufficient dry matter intake in early lactation compared with cows calving at the right condition. If the diet of the cows does not contain sufficient green roughage or contains a high level of by-product fodder, deficiencies of vitamin A, phosphorus, copper, cobalt, iodine and/or selenium may arise. This may cause problems in high-yielding cows.

It is important that cows continuously have access to good quality minerals of the required composition. Feeding rations with sufficient and good quality roughage, and formulated for correct levels of protein, energy, minerals, vitamins and trace elements will normally result in a short period between calving and first heat.

8.1.9. Hygiene

Good hygiene, especially around calving is essential. Cleaning of the cow's vulva, birth-ropes and your hands before the calving process and having a clean, disinfected pen for the cow to calve will normally be sufficient. If these things are neglected, uterine inflammation (endometritis) may occur. It affects the cow's subsequent fertility and it will take longer before the uterus is ready for another pregnancy. Endometritis can be diagnosed by a white mucus discharge from the vulva. It can be treated by a veterinarian, but on the other hand, the uterus may also clean itself naturally when the cow returns into heat.

8.2. Breeding dairy cattle for economically important traits

Breeding is the planned (deliberate) mating of male and female to propagate specific traits beneficial to man. It is a long term solution for high milk production and good genetic pool for the farmer. The continued use of a pedigree bull to upgrade the cows is a worthwhile venture and pay by increasing the traits desired by the farmer.

8.2.1. Upgrading

This is a system of breeding whose objective is to improve the standard of progeny of a certain poor performing individual by a crossing it with superior individuals in each succeeding generation moving up till a standard considered necessary for pedigree status is recorded or the desires of the farmers are met.

8.2.2. Traits of economic importance in dairy cattle

8.2.2.1. Production traits

Mainly refers to milk volume and solids in milk i.e. percent butter fat content, protein and other non-fat solids. Milk volume should be considered relative to the amount of feed consumed since more milk from relatively lesser feed is proof of a high feed conversion efficiency and more solids in milk generally increases milk quality. It is of no use at all to breed a fantastic looking cow which produces no milk. Therefore one must select animals that are positive for milk production.

8.2.2.2. Type/conformation traits

These traits give a good indication of the performance of the dairy animal and include the udder structure, nature of feet/legs, stature and general dairy character. The udder should be pliable, silky in texture, sack-like in nature and non-pendulous but firmly attached with strong suspensory ligaments high up near the vulva region. A huge udder is not necessarily a sign of a high milk yield and in fact it is recommended that one should choose a cow with a medium sized (but wide base) udder which should not hang below the cow›s hock joint. The teats should be average-sized and evenly placed and oriented (pointing straight down) on the udder.

Good feet and strong legs lead to longevity of a dairy cow and helps it to be able to feed comfortably especially when in-calf (on average, a dairy cow is in-calf for about 80% of its lactation duration). For a bull, strong feet and legs enable it to mount successfully though in dairy animals more emphasis is on cows and heifers due to the preference and comparative advantages of artificial insemination over natural mating. Observed from behind, a cow's hind legs should stand straight and wide apart while the side view should show a slightly set back hock (sickled) ending with slightly angled feet. The front legs should also be straight with a steep strongly attached pastern. The ideal cow's stature should portray a deep, long body with wide, sprung ribs to provide ample space for the rumen and other digestive system organs. A dairy cow should have a wedge shape, long neck, width between fore legs, wide pin bones, broad muzzle and strong straight backline. The classic dairy character is indicated by sharpness across shoulders and slight general leanness all over the body ending with a thin fine tail. A good dairy cow is not stocky or beefy as this shows poor feed conversion efficiency. Generally, pedigree dairy cows portray flatness of bone usually most evident on the inner thigh.

8.2.2.3. Fertility traits

Number of inseminations per conception will always determine the success of a breeding program and the fewer the number of inseminations per conception the better the fertility of a particular animal. It is important to choose animals with (or from a family renowned for) a good conception rate since difficult/repeat breeders are expensive to maintain and cause immense losses. This will enable a farmer to target a calving interval of one calf annually per cow. For farmers using natural mating, one should choose bulls that do not shy away from mounting receptive cows/heifers nor exhibit excessive libido. A bigger scrotal circumference and fully descended testes are normally indicators of good fertility.

8.2.2.4. Longevity traits

Longevity determines the amount of total lifetime milk production of a cow but it is usually influenced greatly by other traits such as health and fertility. Choose heifers or bull semen from families with a history of cows that can maintain high production ability across many lactations as well as have as many normal calvings as possible in their lifetimes.

8.2.2.5. Health traits

As much as disease prevention and control measures are important in ensuring sustained productivity, some emphasis should be laid on choosing disease resistant and hardy animals so as to remain in production for long as well as animals with a very low somatic cell count in milk. In harsh climate areas with a higher prevalence of tropical diseases (such as East Coast Fever and Foot and Mouth Disease) it may be wiser to undertake crossbreeding between exotic dairy breeds and indigenous lines since in such conditions, hybrid animals normally perform better than purebreds.

8.2.2.6. Calving ease traits

Physical traits that facilitate easy calving include a wide pelvic diameter (observed from behind) and a gentle slope from pin to hip bone (observed from the side). A cow's body frame should portray a strong straight back/loin which is essential during gestation in enabling the animal to comfortably feed as well as carry its foetus to term.

8.2.2.7. Workability

Milking speed is of essence in maximising yield since milk let-down is controlled by oxytocin hormone whose concentration levels in blood diminish with time. It is therefore important to choose animals with the right teat size, teat shape and teat opening (position and orifice size). Bad temperament interferes with oxytocin flow during milking, thus one should likewise consider docility when choosing a dairy animal.

8.3. Breeding methods

8.3.1. Natural mating

This method uses bulls to naturally mate with cows when they are in heat.

Advantages of natural mating

- Perfect heat detection.
- Due to large number of spermatozoa (sperm) deposited, conception rates are very good.
- The charges for natural mating services are cheaper.

Disadvantages of natural mating

- Spread of venereal diseases, such as brucellosis, trichomoniasis and vibrosis.
- Lack of recordkeeping increases the risk of inbreeding, which results in an inferior herd.
- Bulls lack proper health records, thus inferior bulls are often used for mating.
- It is costly to keep a bull, in terms of feeding, labor and veterinary costs.
- Lame bulls cannot be used even if they are superior.
- Bulls are limited by the number of cows they can mate with each day.
- Bulls can become rowdy and be a danger to farmers and their households.

8.3.2. Artificial insemination

Artificial insemination (AI) is a process by which semen is collected from the male, and then processed, stored and artificially introduced into the female reproductive tract for the purpose of conception. The most common technique used with cattle is the rectal-vaginal technique, where instruments are used to do the insemination. A sterile catheter is inserted into the vagina and guided into the cervix by means of the grooved hand method in the rectum. The semen is then deposited by the inseminator/AI technician at the end of the cervix.

Advantages of AI

- Through use of selected and tested sires AI has been an important tool for herd improvement of both production and type traits as well as other economic traits such as fertility, longevity, disease resistance, etc.
- By use of screened bulls and hygienic semen production procedures AI has been used for control of breeding diseases and other diseases of the female reproductive tract.
- By using AI, a superior bull can be used on hundreds & thousands of cows within a short period.
- AI technology allows safe and cheap exchange of genetic material across borders.
- AI technology offers diversity and reduces incidences of inbreeding.
- It is more economical and cost effective than keeping a bull.
- Safety. It eliminates dangerous males from the farm.
- Preservation of selected lines: use of frozen semen allows use of males after they are long dead.

Disadvantages of AI

- AI is labor intensive in terms of heat detection.
- It can be a perfect mode of disease transmission from farm to farm through the AI technician and/or dirty AI equipment.
- Genetic abnormalities may spread fast using AI if proper selection of the males is not done.
- Proper timing and insemination technique are necessary.

8.3.2.1. Factors to consider prior to using artificial insemination

- **Staffing for AI Service:** Execution require well trained staff. Inseminators must be well trained and must undertake their job effectively.
- **Organisation of field services:** AI services must be readily available for the farmer. This must be facilitated to ensure that field services are on time and reliable
- **Heat detection:** Timely and reliable detection must be made by the farmers and personnel.
- **Recording:** Records on conception rate per bull, per inseminator and per area
- **Cost:** This is mainly influenced by the cattle density and number of cows serviced.

8.3.2.2. Causes of AI failure

Human Factors:

Human causes could either be attributed to the farmer or inseminator. The farmer can contribute to AI failure through

- Failure to keep records such as date of last calving, date of last heat. This increases the chances of failing to observe the next cycles, due to lack of anticipation.
- Inaccurate reporting of heat and when cow started showing signs of heat. This may lead the inseminator into serving the animals either too early or too late leading to conception failure.

An inseminator can cause failure by:

- Using dirty equipment, like pistolettes, socks, scissors, paper and towels.
- Rolling the semen between arms, under arm pit, exposing it to low or high temperature.
- Improper handling of semen - Lack of liquid nitrogen in storage container.
- Exposing the semen straws to sunlight.
- Failure to dry straw.
- Failure to deposit semen at target area.
- Injuring the reproductive tract/uterus .

Animal factors:

These include

- Failure of the cow to show clear signs of heat due to either; an abnormal reproductive tract (difficult cervix), an infected reproductive tract (vagina, cervix, uterine horns) or hormonal imbalance (FSH/LH balance).
- Poor nutrition i.e. imbalance or inadequacy in energy, proteins, minerals and vitamins.

8.3.2.3. Management of AI Failure

Human Factors. Farmers need to know about the following:

- Signs of heat.
- Optimum time to inseminate.
- Nutrition.
- Health care.

The inseminator should emphasise:

- Hygiene when handling AI equipment & self.
- Proper handling of semen.
- Proper thawing of semen.
- Depositing semen in target area.

8.4. Most important breeds and their characteristics

8.4.1. Friesian

Figure 8.4.1: A Friesian cow

Potential yield: 30-50 litres milk/day

Average body size: Large (500-550kg)

Description: Black and white short haired coat, short horns.

Advantage: High milk production potential with low butter fat content of about 3.2%.

Disadvantages:

- Heavy feeder.
- Susceptible to diseases, susceptible to milk fever.
- Susceptible to high temperatures.
- Consumes large amounts of water

8.4.2. Ayrshire

Figure 8.4.2: An Ayrshire cow

Potential yield: 20 - 30 litres/day.

Average body size: Large (average live-weight 450kg)

Description

Body colour: Brown and white patches in almost equal amounts with some cows tending to dark mahogany colour.

Advantages

- High milk production potential (30 litre/day). The average milk yield from this breed in Kenya is roughly 3,000 litres in 305 days. The cow's milk has moderate butter fat content 4.0%.
- Fairly hardy and adaptable to varied climatic zones.
- They are relatively resistant to diseases.

Disadvantages

- Heavy feeder.
- Needs plenty of clean water.

8.4.3. Guernsey

Figure 8.4.3: A Guernsey cow

Average body size: Medium (average live-weight 400kg).The cow weighs 450 to 500kg

Description

- The colour varies from yellow to reddish-brown with white patches.
- They have a finely tuned temperament, not nervous or irritable.
- Physically the breed has good dairy conformation and presents the visual impression of a plain animal bred for utility rather than good looks.
- They have an attractive carriage with a graceful walk, a strong back, broad loin, wide rump and deep barrel, strong, attached udder extending well forward, with the quarters evenly balanced and symmetrical.
- The Guernsey bull has an attractive individuality, revealing ample vigour and masculinity. It has smooth-blending shoulders showing good refinement, strength and even contour.

Advantages

- High milk production potential (25lt/day).
- Milk has moderate butter fat content 4.3%.
- Feed requirements: Moderate (65-85Kg fresh forage/day).
- Guernsey are efficient converters of feed to product, being of intermediate size, Guernsey produce their high quality milk while consuming 20 to 30 percent less feed per pound of milk produced than larger dairy breeds.
- Guernsey reaches reproductive maturity at an early age and can calve at 22 months of age. This provides an early return on investment.
- Guernsey are well known for having the minimum of calving complications.
- Guernsey are adaptable to all climates and management systems and lack any known undesirable genetic recessives.

8.4.4. Jersey

Figure 8.4.4: A Jersey cow

Average yield: 22 litres/day and about 5.3% butter fat.

Average body size: Small – medium (350kg)

Description

- Jerseys in Kenya are typically light brown in colour, though this can range from being almost grey to dull black. They can also have white patches which may cover much of the animal. A true Jersey will however always have a black nose bordered by an almost white muzzle.
- They have protruding eyes.
- This breed is well known for milk with high quality – it is particularly richer in protein, minerals and trace elements than those from the larger dairy breeds. The milk is also rich in colour which is naturally produced from carotene.
- Milk production potential is moderate (20 t/day), depending on feeding and management regime.

Advantages

- Feed requirements are relatively low (65-85kg fresh forage).
- Milk has high butter fat content 5.2%.
- It is hardy and adaptable to varied climatic zones.
- The Jersey's hard black feet are much less prone to lameness.
- They perform well under a wide range of systems and are known for their high feed conversion efficiency.
- Jerseys generally produce milk components at a lower cost compared to the other major breeds.
- They stay in the herd longer than any other dairy breed. Their milk has greater nutritional value, plus the highest yield and greater efficiency when processed into cheese and other value-added products.
- The breed has little or no calving problems, greater fertility, a shorter calving interval, and earlier maturity.

8.5 Summary

- Good recording, regular observation, heat detection, insemination at the right time and length of interval between calving and the first insemination are among numerous factors that affect the reproductive performance of dairy cattle.
- Breeding is the deliberate mating of male and female to propagate specific traits beneficial to man. It is a long term solution for high milk production and good genetic pool for the farmer.
- Cows are bred either through natural mating, or through artificial insemination (AI).
- Friesian, Ayrshire, Guernsey and Jersey cows are the most important breeds.

8.6 Review questions

1. What are the main factors that affect reproductive performance in dairy cattle?
2. What are the advantages and disadvantages of using artificial insemination as a breeding method?
3. The disadvantages of natural mating far outweigh the advantages. Describe what these advantages are.
4. Why is heat detection an important component for farmers practicing zero-grazing?
5. How can you tell when an animal is in heat?
6. What are the economically important traits for dairy production in smallholder dairy production systems?
7. List some of the breeds commonly kept by farmers. Give reasons why farmers prefer specific breeds.
8. Describe some of the ways in which good hygiene and good nutrition influence reproductive performance of dairy cattle.

9. Dairy cattle feeding and management

Topic objectives

The overall objective of this topic is to impart knowledge on raising calves from birth to weaning as well as feeding the heifers, milking animals and dry animals in the herd.

Topic aim: By the end of the topic, the learner should be able to

- Feed calves from birth to weaning.
- Understand management practices essential for calf comfort and growth.
- Feed heifers for fast growth to enhance breeding and milk yield.
- Feed both lactating and dry animal for optimum production.

9.1. Calf rearing

9.1.1. Pre-calving management

Pregnant cow management is important for successful calving and this achieved by proper management such as: feeding the cow with high quality and balanced ration, appropriate health management and housing system. Calf management begins before birth at the last stage of pregnancy (one-two weeks before the calf is born). At this stage the pregnant cow is transferred to a maternity paddock and the paddock should be near the homestead for closer observation, well ventilated and provided with good quality feed and water.

Separation and hygiene measures:

- 1-2 weeks before the expected date of calving, the pregnant cow may be shifted to the individual calving pen or maternity house.
- The maternity house/calving pen should be thoroughly cleaned and disinfected before moving in the cow/ in-calf-heifer.
- Keep the cow/in-calf heifer separate from the herd in a clean place (that is not slippery) on a clean bedding (the maternity pen).
- Maintain fresh bedding or cow mat.
- Allow the cow to show natural behaviour as much as possible.

9.1.2. Cow handling around calving

- Dry off the cow nearer the parturition 60 days before the expected calving date, so that she will be able to recoup and get ready for the next lactation, so stop milking forthwith.
- The probable dates of parturition can be known if the date of insemination was accurately recorded.
- On average, the calf is born at 280 days with 7 days difference after the conception/ last insemination.
- Steaming up (start feeding some concentrates) the cow about 4 weeks before the expected calving date. Proper, highly palatable, feed is most important in this stage to help the cow to make a good start of the lactation and give a strong calf.

During the transition period in the 5–6 weeks prior to calving major changes are occurring within the cow:

- The foetus is growing at a rapid rate.
- The udder starts producing colostrum.
- The cow's appetite is decreasing as the increasing size of the foetus reduces the room available for the rumen to fill.
- Additional hormonal and lactational changes also suppress cow appetite and immune function.

During the last 3–4 weeks of pregnancy, failure to provide the correct balance of nutrients such as energy, calcium, magnesium and phosphorus can result in sick cows. This may affect their ease of calving and the quality and quantity of their colostrum. Ultimately, the health and survival of their calf is at risk.

9.1.3. Management at birth

The most critical period of a calf's life is the first hour after birth. Correct calf management and feeding practices during this time influence the subsequent health and development of the calf throughout its life, and its overall lifetime performance.

After the calf is born:

- Clear the mucus from the calf›s mouth and nostrils.
- Ensure the calf is breathing. If it is having difficulty in starting to breathe, gently sliding a clean straw or twig up the calf's nose. This should cause the calf to sneeze. Or, hold the calf upside down.
- The umbilical cord should be disinfected (use iodine).
- An assessment of the calf's vigour should be made immediately after calving. The following individual indicators should be monitored: responsiveness to external stimuli, muscle tone, sucking reflex, the time it takes for the calf to lift its head and the time to first stand.

9.1.3.1. Calf resuscitation

In general, most calves will not require resuscitation. However, calves that experience difficult or problem births may benefit from resuscitative care during and/or immediately after calving. In order to identify calves that need resuscitation the farmer must be present at the calving and look out for signs of calf distress.

Take any of the following steps, to perform successful calf resuscitation:

- Suspend the calf upside down for a short period of time (never longer than one minute).
- Pour cold water over the calf's head.
- Sit the calf upright on its chest.
- Dry off very weak, cold, wet, shivering calves and place them in a warm environment.
- Rub their chest and flanks with straw.

9.1.3.2. Successful umbilical care

The spread of infection from the environment into the calf via the navel cord is the cause of navel or joint ill. Preventing navel ill is based on a number of farm hygiene and calf care/immunity principles that must be optimized at, and shortly after, birth.

In the first week of life, the navel should be checked for excessive bleeding, pain, abnormal swelling, odour or pus, and treated as recommended by the vet.

How to prevent navel ill:

- Good maternity pen hygiene. Ensure calves are born in a clean, freshly bedded calving unit.
- Minimize the length of time a calf spends in calving pens.

- Ensure adequate early intake of good quality colostrum (Colostrum 1, 2, 3 rule, see chapter 6).
- Practice navel hygiene.
- Practise antisepsis (chlorhexidine or iodine) if navel ill is a problem on farm and hygiene is already optimal.
- Check the calf regularly for signs of navel ill.

9.1.4. Feeding management of calves (feeding colostrum)

Colostrum is the first mammary secretion produced after calving. Unlike in humans, the placenta of the cow keeps the maternal blood supply separate from that of the developing foetus. This means that the calf is born without antibodies in its bloodstream.

Colostrum provides maternal antibodies for the newborn calf that help it fight disease. A calf that does not receive colostrum has a higher risk of illness until it develops antibodies of its own at around 6 weeks of age.

Colostrum begins forming in the udder about 5 weeks before calving and production ceases completely once the cow gives birth. It is most concentrated and of highest quality at the point of calving.

Colostrum is a unique mixture of factors derived from the cow's udder and blood that work together to provide nutrition, growth factors and immunity for the newborn calf.

- **No additional colostrum is produced by the cow from the moment the calf is born.**
- **The protective quality of the cow's colostrum declines after calving even if the cow is not milked or suckled.**
- **Colostrum collected straight after birth maintains its protective capacity if stored correctly in the fridge or freezer.**

There are four factors that need to be considered when feeding colostrum. These are:

Quality of colostrum

High quality colostrum has a high antibody concentration. To ensure good quality ensure that colostrum is milked immediately and in a clean environment that allow the quality to be retained. In case you are feeding colostrum that has been stored, ensure that the colostrum is of good quality before feeding. Poor quality colostrum should be reserved for feeding calves over 24 hours of age.

Timing of feeding the colostrum

Time is of the essence in the transfer of immunity to the newborn calf. The clock starts ticking as soon as the calf is born because the calf's intestine can only absorb antibodies for a short time.

- Straight after birth – the calf's intestine absorbs the antibodies easily.
- Within 6 hours of birth – the intestine's ability to absorb antibodies decrease by 30 – 50%.
- Between 24 to 36 hours after birth no more antibodies can be absorbed.

Leaving the calf to suck colostrum from the dam is no guarantee of successful transfer of immunity.

Continuing to feed colostrum to calves beyond the initial 24 hours (after the calf gut 'closes') may also have advantages, as the antibodies can still bind to pathogens in the gut and help protect the calf from infections. Colostrum is also a highly nutritious food for calves. See Figure 9.1.4. for the optimum timeline to follow.

Figure 9.1.4. Timeline for feeding colostrum to calves

Amount of colostrum to be fed

The first feed of colostrum should be at least 3l. This should be fed within the first two hours of birth. This provides the calf with immunity to disease before pathogenic organisms can become established in the calf's gut.

Another guide to colostrum feeding is calf birth weight. As this varies depending on breed and gestation length, the rule is to feed 8.5% of their birth bodyweight for their first feed (e.g. 35kg calf requires three litres).

Greater volumes and more frequent feedings can be used to increase the likelihood of transfer of immunity.

Hygiene

Excellent hygiene is necessary to maintain colostrum quality and minimize the growth of bacteria. Large numbers of bacteria in collected colostrum may bind to the antibodies and interfere with absorption by the calf. Bacteria present in colostrum and other pathogens may also cause disease in the newborn calf.

Controlling contamination of colostrum

- Remove the calf from the dam as soon as possible after calving to limit the amount of suckling and contact with contaminated udder skin.
- Clean, disinfect and dry teats prior to harvesting colostrum.
- Do not use colostrum from cows that are sick or suspected of being positive for disease, such as Johne's disease, Salmonellosis or Mycoplasma.
- Discard colostrum if you can see evidence of contamination i.e. faecal or other organic material present.
- Do not pool raw colostrum - it increases the risk of spreading bacteria.

9.1.5. Replacement milk

In case colostrum is not available then artificial colostrum can be used. Note that artificial colostrum does not contain antibodies.

Formula 1

- One egg
- half litre fresh warm water
- half litre whole milk
- one teaspoonful castor oil
- one teaspoonful of cod liver oil

Formula 2

- 3 litres cow's milk
- 1.5 litres water
- 5 eggs (beaten)
- 25 ml cod liver oil
- 75 g dextrose powder

9.1.6. Nutrition management for calves

Providing calves with good quality colostrum straight after birth gets them off to a great start. The next challenge is to help the animal make a smooth transition from being a 'drinker' to an 'eater'.

The effect of good nutrition provided at the start of a calf's life has a big impact in terms of

- General health status.
- Growth rate and weaning age.
- Fertility and mating.
- Production levels.
- Longevity in the herd.

Initially, milk provides the main source of nutrients for the newborn calf. As the calf ages, it obtains more and more of its nutrients from solid feed.

Fresh, clean water is essential throughout an animal's life and must be provided to all calves from day one.

9.1.7. Facts about calf digestion

Understanding the basics about how a calf digests milk, water, grain/concentrates, fibre and pasture allows you to work with a calf's digestive system to achieve successful weaning and future production.

Absorption of milk and water

Milk

When a calf drinks milk, the liquid travels down the oesophagus and is channelled via the oesophageal groove. This groove allows milk to bypass the rumen and enter the abomasum directly.

Once the milk enters the abomasum, it forms a clot and nutrients are slowly released into the calf's blood stream. After a while this clot moves into the intestine where it is digested further.

Water

The pathway that water takes is different from milk. When a calf drinks water it travels down the oesophagus but is mainly channelled towards the rumen.

Fresh water, rather than the water present in milk or milk replacer, is essential for a calf's health.

Later on water plays a critical role in the healthy function and development of the rumen.

9.1.7.1. Digestion of grain/concentrates

The difference between a poorly developed rumen and one that is well developed comes down to the size and numbers of papillae on the rumen wall.

Papillae are the small projections that grow on the wall of the rumen that absorb nutrients. The two key things to remember about papillae are

- The more papillae there are, the greater the surface area available to absorb nutrients.
- The presence of certain chemicals in the rumen promotes the development of papillae.

Figure 9.1.7.1. Rumen development in weaned calves. From left to right: "Diet: milk only - 6 weeks", "Diet: milk and hay - 6 weeks", "Diet: milk and grain - 6 weeks". (Source: Penn State University, USA)

9.1.7.2. The role of fibre

The role of roughage or fibre is to promote the growth of the muscular layer of the rumen and to maintain the health of the rumen lining.

- Papillae can become too long and clumped if exposed to high levels of the volatile fatty acids contained in grain.
- The abrasive effect that dietary fibre has helps maintain papillae in optimal condition.

Choose a source of fibre that is different from the bedding.

If straw is used as bedding, it should not be used as a feed supplement. Calves may eat contaminated bedding and consume disease causing organisms.

9.1.7.3. From liquid to solid feed

As a calf makes the transition from absorbing nutrients from milk to dry feed, its digestive system adapts and changes.

The images above illustrate the changes that occur.

- The digestive system of a calf is geared up to process milk so the abomasum is large in comparison to other parts.
- At birth the abomasum makes up 65–70% of the total volume of the four stomachs of the calf.
- The rumen is designed to handle 'concentrates, grass and roughage'.

It grows as the animal eats more solid feed. At weaning the rumen should make up 65–70% of the total volume of the stomachs.

9.1.8. Managing liquid feeding

Farmers manage the feeding of milk or milk replacers in many different ways and achieve good results. While there is no single, best way to rear calves, it is important to be aware that recommendations may change based on new research and farmer experience. Before making use of saleable milk or milk replacer, proper use should be made of stored excess colostrum.

Calves should be reared on fresh, clean milk. Wherever possible avoid feeding milk from mastitic cows or antibiotic contaminated milk. Milk destined for calves should be collected as cleanly as possible.

Milk that is contaminated with organic material and faeces is a potential disease source for calves. Milk collection and feeding equipment needs to be kept scrupulously clean and well maintained. Milk from sick cows may contain pathogens or antibiotic residues. Feeding milk containing antibiotics may also lead to increased risk of antimicrobial resistance. If mastitic milk must be fed, use only for feeding older calves. Calves under 14 days of age are more vulnerable to infections due to their immature immune system.

9.1.8.1. Frequency of feeding milk to calves

Studies have shown that calves can be reared using a variety of feeding frequencies.

- Once or twice daily liquid feedings can produce the same outcomes in terms of weight gain, nutritional status and metabolic stress.
- Twice daily feeding makes sense as it allows calves to be closely observed. Reluctance to drink or other signs of disease can be detected and action taken.
- If necessary once daily feeding should not be implemented until calves are at least 14 days of age. Calves are at a very high risk of scours and infections in this critical first two weeks of life.

9.1.8.2. Best temperature for feeding milk

- Consistency of temperature appears to be the most important thing to get right – avoid feeding warm one day; cool the next.
- Liquid milk should be fed at around body temperature (38°C)
- Very cool milk has the potential to lower the body temperature. The calf will then need to use energy to increase its body temperature, diverting energy away from growth and development.
- If using cool milk in cold climates the effect could be significant, however there is likely to be little impact in warmer climates.

9.1.8.3. Amount of milk to feeding

The newborn calf receives approximately 10% of its body weight in milk daily, which generally equates to 4–5 litres per day, and roughly this same daily volume of milk is maintained throughout the pre weaning period. It provides sufficient energy from milk for normal body maintenance but only a small amount is available for tissue growth.

9.1.8.4. Feeding roughages to calves

- Should consist of high quality fodder, which should be offered to the calf early to stimulate rumen development and also to cut down on costs.
- It should not make up the entire diet of the calf and therefore should be supplemented with concentrates (calf starter).
- If hay is used, it should be of high quality, fine texture, mixed with legumes and fed *ad libitum*.
- Pastures should be the best and calves should always be grazed ahead of others for parasite control.

9.1.9. Weaning management of calves

Weaning is a challenging time for a calf for two reasons

- The primary source of nutrients moves from liquid to solids.
- Exposure to pathogens increases as the calf enters a new environment.

By the time weaning occurs, the development of the calf's rumen should be sufficient to permit good growth from a non milk-based diet. This solid nutritional status is critical as change often induces stress.

Calves may be weaned as early as six weeks of age, although it is commonplace for calves to be weaned between 8 - 12 weeks of age depending on the availability of milk.

Most dairy calves are weaned at 12 weeks of age. Early weaning is possible if more milk is fed and the calf is introduced to pre-starter and starter early in life. Weaning should be done gradually. The twice a day milk feeding should be reduced to once a day, then to once every other day to allow the calf›s digestive system to adjust to the new diet.

Time of weaning will depend on

- When calf attains twice the birth weight (80kg).
- Can consume 1.5%bwt (1kg) of dry feed.
- Free from any health problems.
- Age (approx. 12 wks) .

9.1.10. Health management of calves

Pay particular attention to the following:

- If the calving was assisted – clean airways, stimulate breathing (e.g. pinch nose), position correctly (on sternum with legs either side up towards nose, rub with a towel.
- Navel cord – spray with disinfectant early and stop any excessive bleeding by applying pressure.
- Colostrum intake – make sure all calves receive colostrum, pay particular attention to injured or sick newborn calves.
- Clearly identify – ensure all calves are clearly identified for traceability and treatment/ health monitoring.

Over the next few days:

- **Navel cord:** Continue to monitor the navel cord for signs of infection like swelling, pain and/or discharge.
- **Signs of dehydration:** Monitor for sunken eyes or skin tenting which may indicate dehydration or serious bacterial infection.
- **Signs of ill health:** Reluctance to rise or drink, signs of dehydration.

Identifying sick calves

The behaviour and appearance of a calf clearly gives an indication of their state of health.

A sick calf is more likely to:

- Sit away from the group.
- Lay around more.
- Have a fever.
- Not get up and move with the herd.
- Be less interested in feeding or drink slower.
- Breathe faster.
- Look bloated.
- Have a rough, dull coat.
- Look skinnier.
- Cough.
- Have a wet mouth or chin.
- Grind its teeth.
- Vocalise.
- Have droopy ears.
- Hold its tail up and strain.
- Be lame or have a swollen joint.
- Have a large, swollen navel cord.

Common calf diseases

Refer to topic 6.5.1 to read about management of calf diseases.

9.2. Heifer management

After weaning, a female calf becomes a heifer, which will eventually replace the culled animals, increase the herd size or be sold to generate income. After weaning, heifers should be grouped according to size in small, uniform groups that have adequate access to forage and concentrate. Balance the ration and consider feeding a total mixed ration.

Heifers should achieve a growth rate of 500–700 g/day. This ensures that they will come on heat at the right time, as puberty is related to size rather than age.

9.2.1. Feeding

Feeding should cater for the needs of every animal. Group feeding may not guarantee sufficient feed especially if the groups are not of similar ages. Care should be taken to ensure that groupings put together animals similar in size or age.

Heifers can be reared on good-quality pasture as their nutrient requirements are low (growth and maintenance). Supplementation with concentrate should be at 1% of body weight with 12–14% crude protein for heifers on legume forage and 15–16% crude protein on grass forage.

While designing heifer feeding programs, it is important to consider the following:

- Puberty, which is related to calving age, is also related to size (a feeding indicator) rather than the age of the heifer. The consequences of poor feeding are therefore manifested in delayed first calving and commencement of milk production.
- Feeding heifers too much energy leads to fat infiltrating the mammary glands, inhibiting development of secretory tissue, thus reducing milk yield.
- Underfeeding results in small-bodied heifers, which experience difficulty during calving (dystocia).
- The size of the animal is related to milk yield. With twins of the same genetic makeup, every kilogram advantage in weight one has over the other results in extra milk.
- Overfeeding heifers on feed high in energy but low in protein results in short, fat heifers; high protein and low energy feed results in tall, thin heifers.

9.2.3. Growth rate (weight and height) vs. age

To monitor the performance of heifers, measure the body weight and the height at withers and plot on a chart. Growth of the heifer should be such that any increase in weight should be accompanied by a proportionate change in height.

Standard charts have been developed for different breeds with the expected weight and height at different ages for different breeds. Where weighing facilities are unavailable, the weight may be estimated based on the heart girth in centimeters.

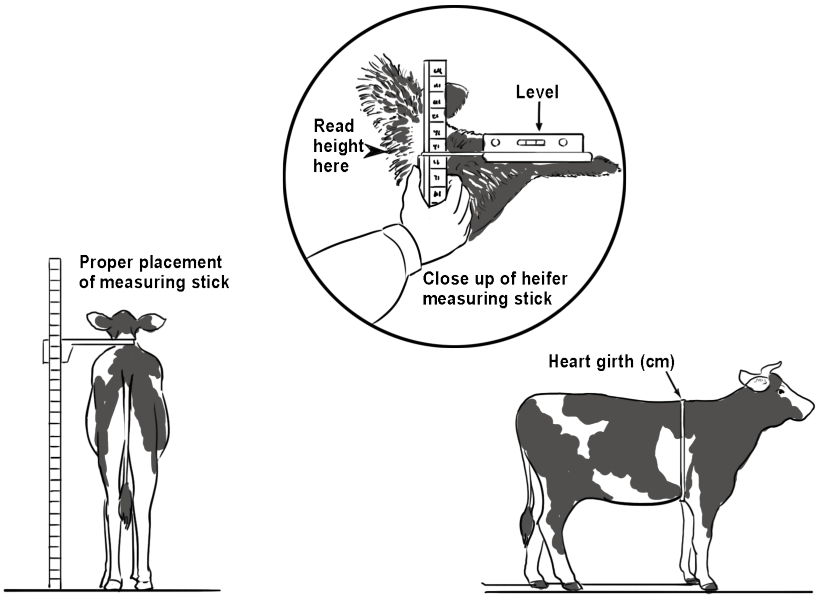


Figure 9.2.3: Measuring the height of the heifer and estimating the weight based on heart girth

Measurements taken are plotted on a chart (Figure 9.2.3.1) that shows the expected weight and height at a particular age for a particular breed. If the weight falls below what is expected, the heifer is underweight, thus underfed and vice versa. Short heifers indicate low protein in the diet.

Fat, over-conditioned heifers, at the same weight as leaner heifers, are normally younger with less skeletal growth. The pelvic opening is therefore narrow. Due to overfeeding, the calf is normally bigger, leading to dystocia. Underfed heifers will also require assistance and have a higher death rate at calving than normal-size heifers.

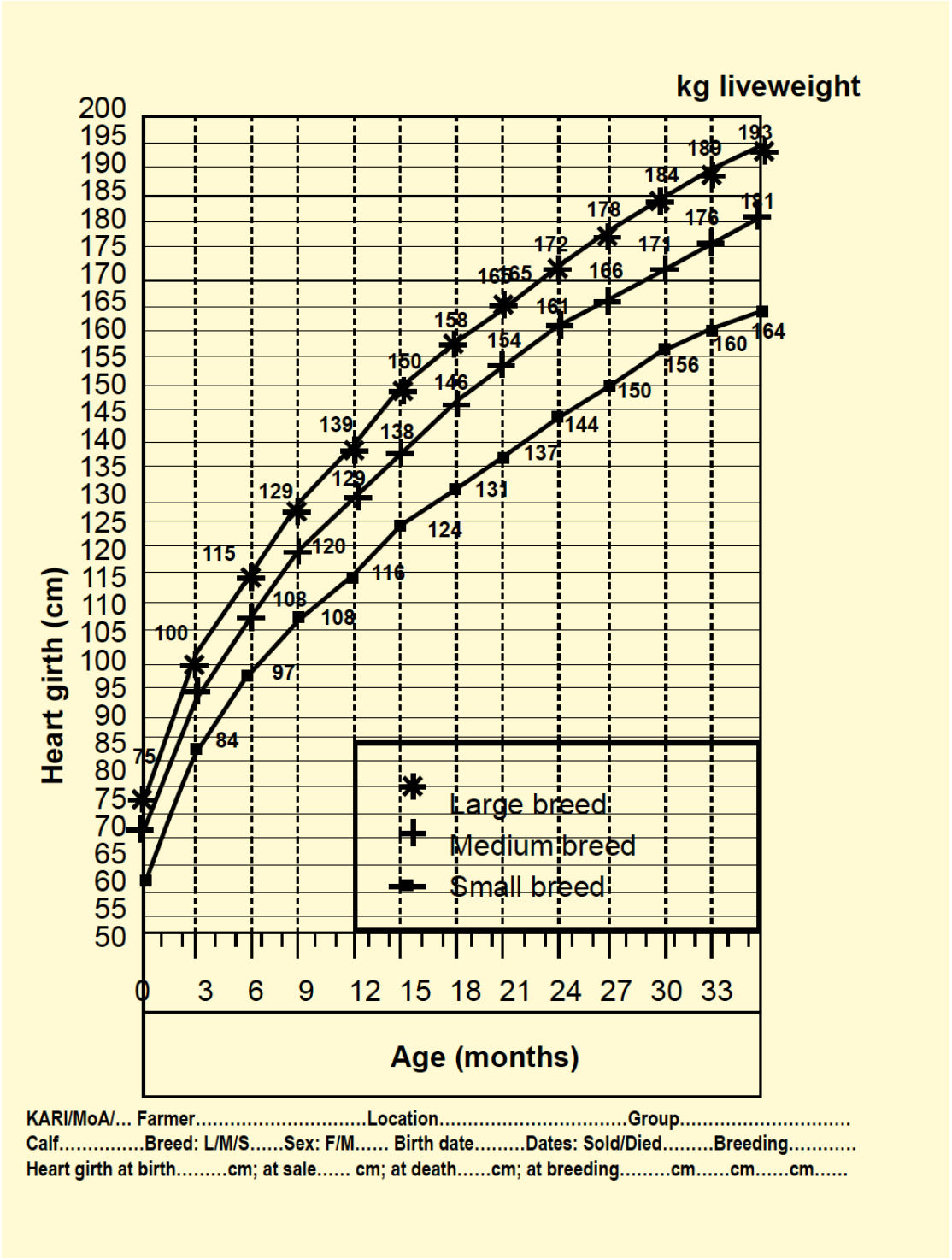


Figure 9.2.3.1: Heifer growth chart

9.3. Feeding lactation and dry cows

The aim of proper feeding for lactating cows is to maximize milk yield by meeting the cow's nutritional requirements. Milk production follows a lactation curve, hence the amount of nutrients required will depend on the point on the curve. During the dry period, the aim should be to feed a diet that provides for the fast-growing foetus, deposition of an energy reserve and regeneration of the mammary gland.

Download the eWeigh app to use heart girth to determine liveweight.

The lactation period is divided into four phases based on the cow's physiological cycle and nutrient requirements. Feeding should be based on these phases.

Phase 1: Calving to peak milk production (1–70 days)

- The first phase lasts from calving to peak milk production, which occurs at about 70 days. During this phase of lactation, milk production increases rapidly such that the voluntary feed intake cannot meet the energy demand.
- The health status and feeding of the cow during this phase are critical to its entire lactation performance.
- Feed the cow to achieve peak lactation. Feeding later in the lactation period will not result in any appreciable increase in milk yield.
- Excessive concentrates should not be added too rapidly to the rations of non-accustomed cows, they may lead to digestive disturbances (e.g. rumen acidosis, loss of appetite, reduced milk production and low milk fat content). It is therefore recommended that concentrates be limited to 50% of diet dry matter, the rest being forage to ensure rumination (proper function of the rumen).
- Ensure that the ration has a high protein diet especially from fodder (but also concentrates) since the cow cannot mobilise the needed protein from itself.
- A protein content of 18% crude protein is recommended in rations for high-yielding cows.
- Animals that are well fed during this phase come into heat and achieve a 365-day calving interval—a calf every year.

Phase 2: Peak lactation to mid-lactation (71–150 days)

- Feed the cow to maintain peak milk production for as long as possible (milk yield should decline at the rate of 8–10% per month).
- Ensure that the forage is of high quality.
- Concentrates high in digestible fiber (e.g. wheat or maize bran rather than starch) can be used as an energy source.
- A whole ration with 15 –18% crude protein content is recommended.
- The cow should be inseminated at this phase (approx. 90 days).

Phase 3: Mid-lactation to end-lactation (151–305 days)

- During this phase the cow weight increases as the feed consumption meets the energy requirement for milk production.
- Ensure that the forage is of high quality.
- Concentrates high in digestible fiber (e.g. wheat or maize bran rather than starch) can be used as an energy source.
- The amount of concentrate fed can be reduced based on the milk production levels.

Phase 4: Dry period (306–365 days)

- Balanced ration should be given to the cows in order to realise the full potential of the cow in the next lactation and minimize health problems at calving time (e.g. ketosis, milk fever and dehydration, dystocia).

9.3.1. Drying a cow

- Reduce high protein and high energy feed intake to maintenance level (withdraw concentrates).
- If the cow is a low yielder, just stop milking. Pressure builds up in the udder and cuts off milk production.
- If the cow is a high yielder, practice intermittent milking, milk only in the morning so as to reduce milk synthesis caused by pressure building up in the udder.
- After milking is stopped, treat (infuse) all the quarters with long-acting antibiotics to prevent mastitis from developing.
- At the time of drying, the cow should be fed a ration that caters for maintenance and pregnancy, but 2 weeks before calving the cow should be fed on high-level concentrates in preparation for the next lactation.

The aims of drying a cow are to:

- Build up body reserves in time for the next lactation period—if a cow is not dried in time, milk production will be reduced during the next lactation period.
- Allow the cow to regenerate alveolar tissue (milk-synthesizing tissue) that might have degenerated during the lactation period.
- Save nutrients for the fast-growing foetus. During the last phase of pregnancy, the calf grows rapidly and the cow's drying saves nutrients for the calf's growth.

9.3.2. Steaming up a cow

- This extra concentrate (steaming) enables the cow to store reserves to be used in early lactation.
- To avoid over-conditioning, cows should not be fed large amounts of concentrate. If the diet is rich in energy, limit the intake of concentrates. Feeding bulky roughages can help increase rumen size to accommodate more feed at parturition (birth).
- Before calving, feed concentrate progressively to adapt the rumen microbial population. This will minimize digestive disturbances in early lactation when the diet changes to high concentrate.
- The amount of calcium fed during the dry period should be restricted to minimize incidents of milk fever in early lactation. A ration providing 15 g of calcium per day for the last 10 days of the dry period or an intake of 30–40 g/day over the whole dry period should reduce the number of incidents.
- During the 3 weeks immediately before and after calving, the cow should be given high-energy, highly palatable and digestible feed (e.g. commercial dairy meal and maize germ) or starchy fodder and molasses.

9.4. Summary

- The time before, during and after the birth of a calf requires a lot of management, preparation and awareness of animal health protection practices.
- Colostrum is the first mammary secretion produced after calving. Unlike in humans, the placenta of the cow keeps the maternal blood supply separate from that of the developing foetus.
- After weaning, a female cow becomes a heifer. Heifers should achieve a growth rate of 500–700 g/day to ensure that they come on heat at the right time.
- During dry periods (when cows are not lactating), the aim should be to feed them a diet that provides for a fast-growing foetus, deposition of an energy reserve and regeneration of the mammary gland.
- During the 3 weeks immediately before and after calving, the cow should be given high-energy, highly palatable and digestible feed, or starchy fodder and molasses.

9.5. Review questions

1. What arrangements are essential to ensure safe calving for dairy animals?
2. What are the key aspects to take care of when a calf is born?
3. Why is colostrum important for the calf within the first 3 hours of birth?
4. What amount of colostrum should be fed to a calf?
5. What factors should be considered before weaning a calf?
6. What parameters would you use to identify sick calves?
7. Describe the four phases, which run the course of a year, that constitute the lactation period.
8. Describe the measures you would take to dry a cow.

Annex 1: Weight Conversion Table (Heart girth to live weight)*

Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)
60	30	87	63	141	235
61	31	88	65	142	240
62	32	89	67	143	244
63	33	90	69	144	248
64	34	91	71	145	252
65	35	92	73	146	256
66	36	93	75	147	260
67	37	94	77	148	264
68	38	95	79	149	268
69	39	96	81	150	272
70	40	97	83	151	276
71	41	98	85	152	280
72	42	99	87	153	285
73	43	100	89	154	290
74	44	101	92	155	295
75	45	102	95	156	301
76	46	103	98	157	307
77	47	104	100	158	313
78	48	105	103	159	319
79	49	106	106	160	325
80	50	107	109	161	345
81	51	108	112	162	353
82	53	109	115	163	360
83	55	110	118	164	366
84	57	111	121	165	372
85	59	112	124	166	378
86	61	113	127	167	385

Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)	Heart girth (cm)	Live weight (kg)
168	392	175	443	182	500	189	561
169	399	176	451	183	508	190	570
170	406	177	459	184	516	191	580
171	413	178	467	185	525	192	590
172	420	179	475	186	534	193	600
173	427	180	483	187	543		
174	435	181	491	188	552		

*You can also use the eWeigh app to do the above calculations

Scan here

Annex 2: Nutritive Value of Common Feed Resources

Feed	Class	DM*	Ash**	CP**
Banana leaves	Crop residue	12.20	8.80	9.90
Banana pseudostem	Crop residue	5.10	14.30	2.40
Banana thinnings	Crop residue	13.00	13.10	6.40
Bone mean	Concentrate	75.00	49.00	6.00
Calliandra leaves	Tree fodder	25.00	4.30	26.30
Couch grass	Grass	30.20	7.40	8.80
Cottonseed cake	Concentrate	92.00	7.00	33.0
Fish meal	Concentrate	92.00	21.40	64.30
Grazing	Grass	28.00	7.00	10.00
Hay	Grass	90.00	5.60	4.30
Maize (green thinnings)	Crop residue	25.00	4.50	6.20
Maize (whole)	Concentrate	90.00	1.70	11.20
Maize bran	Concentrate	85.40	2.20	9.40
Maize germ	Concentrate	88.00	4.20	22.60
Maize stover (dry)	Crop residue	85.00	7.00	3.70
Maize stover (green at harvest)	Crop residue	13.00	8.50	7.70
Napier grass	Grass	15.00	13.00	6.00
Napier grass (30cm)	Grass	12.10	12.10	9.20
Napier grass (60cm)	Grass	12.60	12.40	7.40
Napier grass (1m)	Grass	13.40	12.60	7.00
Napier grass (1.3m)	Grass	14.40	13.10	6.50
Napier grass (1.6m)	Grass	15.50	13.00	6.20
Napier grass (2m)	Grass	18.70	12.90	6.00
Napier grass (>2m)	Grass	24.00	13.00	5.00
Rhodes grass	Grass	90.00	9.10	6.30
Sesbania leaves	Tree fodder	28.00	4.50	28.20
Star grass	Grass	30.00	11.60	11.00
Sugar can tops	Crop residue	30.50	9.10	5.90
Sweet potato vines	Other	25.00	9.40	19.20
Wheat bran	Concentrate	88.00	2.40	17.80
Wheat straw	Crop residue	86.00	9.40	3.80

DM - dry matter, CP - crude protein, * dry matter (%), **% dry matter

Source: Lukuyu et al., 2012

Annex 3: Homemade dairy concentrates (All measures in kg)

Ingredients	Formula 1	Formula 2	Formula 3	Formula 4
Maize bram, wheat bran	35.0	20.0	48.5	75.0
Rice polishing	15.0	20.0	-	-
Sunflower, cotton, kapok cake	18.0	32.0	16.0	12.0
Groundnut, coconut, simsim, palm kernel cake	6.0	20.0	-	-
Yellow gram (chickpea)	15.0	-	20.0	-
Fodder tree, herbaceous legume meal (such as leucaena)	4.0	-	10.0	10.0
Limestone, bone meal	3.0	-	4.0	2.5
Maclick super, cattlemix, Bayslick, superlick	-	2.5	0.5	-
Common salt	0.5	0.5	1.0	0.5
+Dry yeast	3.0	5.0	-	-
Premixes (lysine and methionine)	0.5	-	-	-
Total mix	100.0	100.0	100.0	100.0
Crude protein %	12.5	18.6	18.6	11.5

Source: EADD training Leaflet

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