3

Soil and forage management on the new home farm

This chapter discusses the key principles to good forage agronomy.

The main points in this chapter

- The basis of economic dairy farming is producing and using quality forage.
- The four basic principles of producing quality forage are:
  1. Selecting the most appropriate forage species for the region.
  2. Preparing the forage production area for sowing.
  3. Managing the agronomy of the crop.
  4. Harvesting the crop at the best stage of maturity for maximum nutritive value.
- The key to good forage agronomy is providing sufficient soil nutrients to overcome nutrient constraints to plant growth.
- Forage crops should be harvested to optimise the supply of the key nutrients for milk production, namely energy and protein.
- There are 10 key steps that should be followed to make quality silage. There are no short cuts!
- Silage also allows the long-term storage of a variety of wet agro-industrial by-products.

Because this is a manual about dairy stock management, this chapter is likely to be of less interest to the reader than other chapters. However, it is essential to be aware of the basics of growing a year-round supply of quality forage to ensure the dairy herd has a regular feed supply with which to produce the farm's livestock products.

Milking cows require a year-round supply of feed nutrients, with the cheapest source usually being from home-grown fodder or grasses, shrubs, trees and other types of forage grown specifically for livestock feed. These supplies can also include forage by-products from other cash crops, such as sweet corn stover (leaves and stems) from sweet corn grown for sale. Milking cows require concentrates to supplement their forage and some of these can be sourced from by-products from cash crops, such as rice bran or coconut meal.

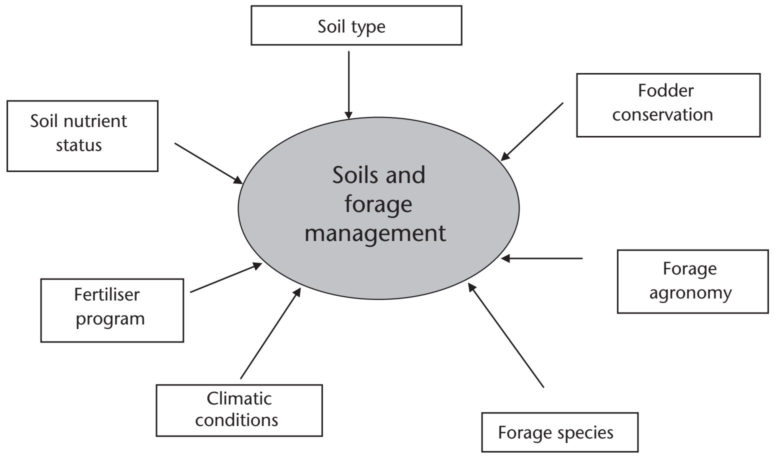


Figure 3.1. The key factors to consider when implementing soils and forage management on the new home farm

Home grown forage is generally the cheapest source of feed nutrients for the dairy herd, because if someone else grows it, they usually require a return for their labour, equipment and transportation, thus charging a higher price than if it was grown on the home farm. In addition, feed nutrients from home grown forages are invariably cheaper than feed nutrients from purchased concentrates and by-products (Moran 2005). Depending on sourcing most of the herd's forage requirements off farm adds yet another uncertainty to the farm program.

Another benefit of home-grown forages is that their management is under the control of the farmer, who can decide how much fertiliser to apply and when to harvest the crop. This should lead to a higher quality fodder: one essential basis of profitable dairy farming.

The basis of economic dairy farming is then producing and using quality forages. To maintain milk composition, milking cows require diets comprising 30–40% forages (on a dry matter or DM basis). Milking cows have very high nutrient requirements and poor-quality forages will just not supply them, because of the physical limitations of rumen capacity. Furthermore, the physical demands of hand harvesting and carrying forages to stalled cows also reduces the likelihood of cows being supplied with sufficient quantities of forages. Because most forages are harvested by hand, tall erect forage species are preferable to prostrate species. Forage quality can be ensured by selecting improved varieties of forages with optimum agronomic practices, such as those described in this chapter.

There are four basic principles of producing quality forages. These are:

1. Select the most appropriate forage species for the region.
2. Prepare the forage production area for sowing.
3. Manage the crop, particularly with adequate fertiliser to optimise growth and quality.
4. Harvest the crop at the best stage of maturity for maximum nutritive value.

This farmer wilts the grass before feeding it to his cows (Indonesia).

3.1 Selection of forage species

The forage must suit the local conditions. Farmers should ask the following key questions when selecting forage species:

- Are they adapted to the climate and soils?
- Do they suit their intended use?
- Do they fit into their particular farming system?

More specific questions to ask are:

- Are there advantages over local varieties?
- Have they been tried and found successful in the region?
- Do they suit local farming systems and ecological conditions?
- What extra inputs are required, such as seed costs, labour and fertilisers?
- Will their extra cost return a profit?
- What are the risks of crop failure?
- Do the seeds come from a reliable source of supply?

No forages grow well everywhere. Some grow well in acidic soils, while others do not. Some grow well in cool areas, while others do not. Forages can survive in areas where they are not adapted, but they will not thrive. It is important to choose forages that are adapted to the local soils and climate.

Important climatic factors affecting forage adaptation are the length of the growing season, temperature, soil fertility, soil pH and drainage.

The key properties of soil that influence plant growth are:

- soil texture: light (sandy, sandy loam), medium (loam, clay loam), heavy (heavy clay)
- soil fertility: low, medium, high. Soil fertility is the ability of the soil to hold and release nutrients for plant growth, rather than the amount of nutrients in the soil at any one time.
- soil pH: strongly acid (<5.0), acidic (5.0 to 6.5), neutral (6.5 to 7.5), alkaline (>7.5)
- drainage: well drained, moderately drained (occasionally waterlogged), poorly drained (frequently waterlogged)
- level of soil salinity: low, medium, high
- level of available Al (aluminium) and Mn (manganese): low, medium, high.

Other important descriptors of forage plants are:

- latitude: tropics, subtropics
- altitude (m above sea level): 0–1000, 1000–2000, 2000–2500, >2500
- rainfall: from 200 to 6000 mm
- family: grass, legume, other (e.g. trees)
- life cycle: annual, perennial
- longevity of forage crop: short term (<4 yr), long term (>4 yr)
- purpose: grazing, cut and carry, conservation, hedgerow or living fence
- defined dry season: <6 months, >6 months
- inundation: 1 week, 1 month, >1 month
- stem habit: erect, prostrate, climbing, stoloniferous (stems growing along the ground), rhizomatous (root nodules that convert atmospheric nitrogen into plant nitrogen)
- shade environment: moderate (30–50% shade), dense (>50% shade)
- frost intensity: light, heavy.

The key forages grown on many SHD farms around Asia include:

- *Pennisetum purpureum* (and hybrids) or Napier (often called Elephant), Mott or King grasses
- *Brachiaria ruziensis* or Ruzi grass
- *Panicum maximum* or Guinea grass
- *Leucaena leucocephala* or Leucaena (legume tree)
- *Gliricidia sepium* or Gliricidia (tree legume).

In recent years, several excellent sources of information have been developed to assist with forage selection for Asian livestock producers. These include:

1. A concise bulletin on selecting forages for livestock feeding in SE Asia by Horne and Stur (1999).
2. The growing and conserving of quality tropical forages for Asian SHD farmers has been covered in detail in Chapters 8 and 9 of *Tropical Dairy Farming* (Moran 2005).

3. A CD presents a process for forage species selection based on their optimum climate, soils, production system and management (Cook *et al.* 2005).
4. A webpage has collated the FAO database of 600 species of tropical forages and legumes (FAO 2005a).
5. A webpage has collated the profiles of 14 Asian countries detailing their climate, livestock and forage resources (FAO 2005b).

3.2 The agronomy of forage crops

The key issues to ensure high yields of quality forage from any forage crop are:

- preparing the soil for sowing, to ensure a good establishment of the crop and minimum weed invasion
- fertilising the crop with sufficient soil nutrients, using inorganic fertilisers to supplement dairy shed effluent and ensuring fertilisers are routinely applied after every (or at least every second) forage harvest
- employing a crop harvesting program to ensure quality forage, as well as adequate forage yields.

3.2.1 Fertilising forage crops

To ensure consistently high yields of quality livestock fodder, forage crops must be 'fed properly' with soil nutrients.

Fertilisers cost money, but they return more through improved yields and quality of forage, hence more milk is produced. Provided other soil nutrients are not limiting plant growth, urea fertiliser can produce an extra 9 kg forage DM/kg urea or 18 kg DM/kg N applied. When harvested and fed to milking cows, this extra forage can yield an additional 9 kg milk/kg urea N (STOAS 1999).

One major limitation of forage production on most small holder dairies throughout Asia is the poor adoption of inorganic fertilisers. Use of cow manure only to fertilise grasses is common practice in most SHD areas, with most farmers not even aware of the economic gains through using inorganic fertilisers. Cow manure supplies organic matter to the forage area, but insufficient N to maximise forage yields and quality. SHD farmers should apply at least 100 kg urea/ha/yr to their forage production area, in addition to the recycled manure (Moran 2005).

Many Western dairy farmers base their fertiliser decisions on the nutrient status of the soils. This is just not possible for most Asian small holder farmers because of the lack of soil testing laboratories and/or the cost of such analyses. However, such advice may be available from local agronomists who service cash crops such as rice or cassava.

A visual and very simple method of assessing the likely response to fertiliser applications is to demonstrate it to farmers through test strips, whereby they apply different fertiliser regimes to small sections of their forage area, such as rows two or three plants wide, to visually assess any response. Erect tropical forages such as Napier grass

A well-managed crop of grass on a Vietnamese small holder dairy farm.

rapidly respond to improved N status by producing dark green coloured foliage plus a more rapid growing, hence taller, plant. By trialling different fertiliser regimes after each harvesting, say nil urea, 50 kg urea/ha, 100 kg urea/ha, urea plus phosphorus fertiliser, and with and without cow manure, farmers can assess whether they should be applying P as well as N. Because they can associate extra, darker green forage with more milk, in most cases, they should respond accordingly by changing their fertiliser management.

3.2.2 Harvesting forage crops

When harvesting forages, farmers tend to place too much emphasis on forage yield rather than forage quality. If forages are too mature and of poor quality, cows might even produce less milk per ha per yr. In the wet season, there is always a compromise between harvesting high yields of low-quality forages (7–8 MJ/kg DM of metabolisable energy or ME) and harvesting lower yields of higher quality forage (9–10 MJ/kg DM of ME). The data presented in Table 3.1 clearly shows that Napier grass must be harvested frequently during the wet season (every 4 weeks) to produce a milking-quality forage.

In a recent review of published data on Napier grass, Muia *et al.* (2000) classified grass quality according to the crude protein requirements for various categories of milking cows. These were for cows at maintenance (5–7%), or producing low (8–10%), medium (11–13%) and high (14–16%) yields of milk. Predicted forage maturity, yield and nutritive value for these various swards are presented in Table 3.2.

High-yielding cows then require Napier grass no more than 42 cm high and harvested every 30 days. Annual pasture DM yields are then likely to be only 60%.

Table 3.1. Quality of Napier grass cut at various stages of regrowth during the wet season

Regrowth (weeks)	Height (cm)	Crude protein (%)	ME (MJ/kg DM)	Total digestible nutrients (%)	Crude fibre (%)
4	50	10.8	9.6	62	28.5
6	75	8.8	8.1	54	32.2
8	135	8.0	7.9	53	32.8
10	150	7.8	7.7	52	33.0
12	150	4.6	7.5	51	31.9

Napier grass harvested for low-yielding cows give annual yields of CP and ME of 105% and 73%, respectively. Therefore, although forage yields will suffer, milk yields will be less adversely affected.

The general recommendations for moderate milk yields (10–15 kg/cow/day) in 450 kg dairy cows consuming 13.5 kg DM/day, is for Napier grass containing 8–13% protein and 7–8 MJ/kg DM of ME. This can be supplied from forage harvested at 42–70 days, when 60–100 cm high, providing a carrying capacity of 4–4.5 cows/ha. For high milk production (<15 kg/cow/day), harvest intervals would have to be increased to 30 days. Milk yields per ha would be high even with low carrying capacity, because of the increased protein yields. However, the increased cost of more frequent harvestings and greater fertiliser applications to maintain soil fertility will reduce the economic benefits of the higher milk yields.

3.2.3 Harvesting tree legumes

With tree forages, regular harvesting of leaves is necessary to maintain favourable leaf-to-branch ratio. For example, *Leucaena* and *Gliricidia* should be harvested every 6–12 weeks. A 12-week harvest interval of *Gliricidia* can yield 9.2 t DM/ha/yr when planted as a block or 1.1 t DM/ha/yr (with forage containing 25% crude protein) when planted as a 40 cm fence around 1 ha of cropping land (Humphries 1999).

Table 3.2. Forage quality and yield of Napier grass cut at various protein contents (Muia *et al.* 2000)

Forage protein content	5–7%	8–10%	11–13%	14–16%
Age (days)	99	63	53	30
Height (cm)	128	95	61	42
DM content (%)	20	17	16	14
NDF content (%)	68	63	61	54
ME content (MJ/kg DM)	7.1	7.7	8.3	8.9
Yield of DM (t/ha/yr)	28.5	21.8	19.7	13.7
Yield of CP (t/ha/yr)	1.7	2.0	2.4	2.1
Yield of ME (000 MJ/ha/yr)	202	168	164	122

It is difficult to recommend specific harvesting regimes for all crops in every situation because the rate of forage growth depends on many factors, such as:

- the forage variety; different varieties have differing optimum harvest intervals
- rainfall and/or irrigation
- soil fertility and additional fertiliser used
- the harvest interval.

3.2.4 Wilting to improve forage intake

The high moisture content of young, freshly harvested forages limits the appetite of milking cows through high loads of water in the rumen. Wilting the forages for up to 24 hr removes intracellular moisture without adversely affecting forage quality, provided the forage does not become heated. Data collected during the wet season in Indonesia (Moran and Mickan 2004) showed that freshly harvested young Napier grass can have DM contents as low as 12% and wilting for 24 hr can increase this to 25%.

Wilting racks can easily be constructed from bamboo and built off the ground to encourage air movement under the freshly harvested forage and so aid water removal from the leaves. Conditioning the thicker parts of the forage, to fracture the epidermal layers, will result in faster rate of water removal from the plant. Forage can then remain on the wilting racks for up to 24 hr.

It is essential to stack the forage loosely on wilting racks in thin layers: no thicker than 10 cm. If the forage heats up during wilting, its nutritive value will decrease, due to plant sugars being used by bacteria and fungi during the heating process. In case of heavy rain, a roof made of tarpaulin or thick plastic should be positioned above the wilting racks, allowing easy removal during periods of sunshine. Rewetting of partially wilted forage requires longer wilting times, which will almost certainly reduce its nutritive value.

To quantify the benefits of wilting, cows in mid-lactation were fed chopped Napier grass plus concentrate (6 kg/cow/day), in Indonesia (Moran and Mickan 2004). Wilting the grass for 8 hr increased intakes of fresh grass from 40 to 50 kg/cow/day and increased milk yields from 14.2 to 15.7 L/cow/day. Assuming the concentrate contained 90% DM, the fresh grass 17% DM and the wilted grass 20% DM, the wilting then increased total DM intakes from 12.2 to 15.4 kg/cow/day, an increase of 3.2 kg/cow/day. Clearly, wilting is a simple and practical method to improve intakes of freshly harvested forages, leading to increases in feed intakes, and hence cow performance.

3.3 Making quality silage

The seasonality of rainfall and soil temperature does not allow for regular growth of forage crops throughout the year. High growth rates during the wet season provide the opportunity to harvest excess forage for conserving and storage to be fed out during the dry season when forage sources are usually in short supply. Conserving forages requires multiple handling: namely cutting, then dehydration and storage, and finally feeding out. Farmers do not like the extra work of handling bulky forages and often do not fully understand the benefits. Consequently, conserving forages on SHD farms is not widely practiced and if tried once or twice, rarely becomes a routine.

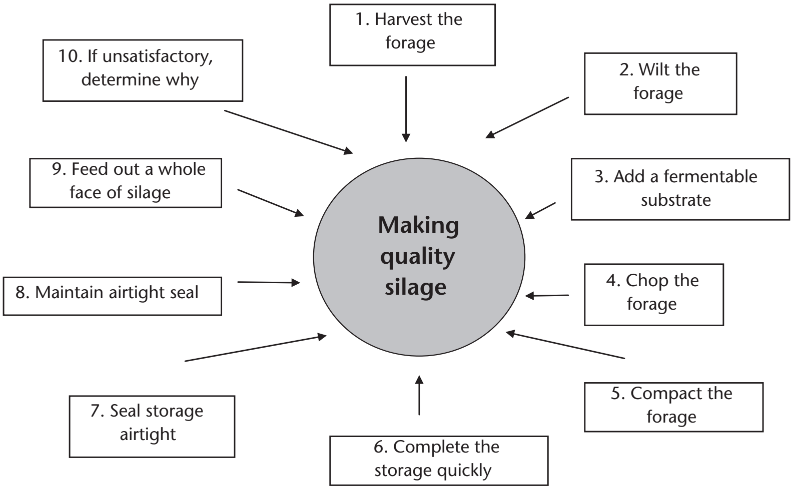
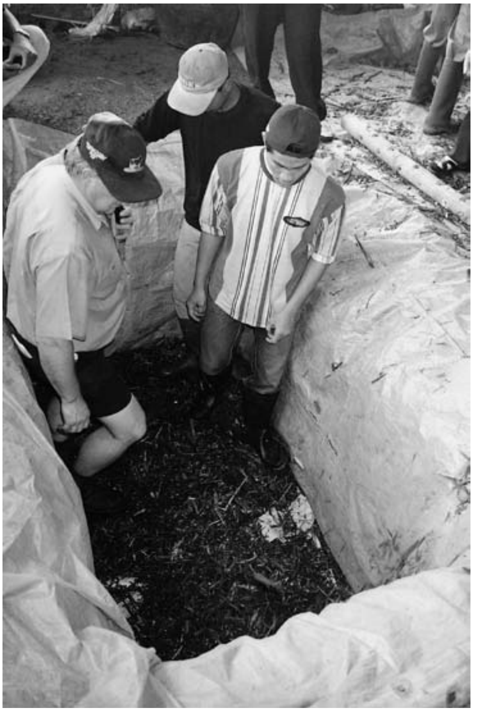


Figure 3.2. The 10 key factors to follow when making quality silage

Excess forages can be conserved as hay or silage. However, ensiling generally produces better quality roughage than hay because less time is required to wilt the feed, when the forage loses nutrients, causing a reduction in feed quality. Hay making requires a longer period of rain-free days, which are often rare in the tropics during the wet season when feed excesses generally occur.



A small holder farmer's silage pit (Indonesia).

The principles of silage making are the same regardless of the size of the operation, the major difference being in the type of storage used (Moran 2005). However, the process or mechanics of silage making (labour, timing and resources) for individual small holders is completely different to those in larger communal farms, where labour and other resources can be shared or amalgamated for efficiencies of size of operation.

All the major forages (grasses, forage legumes, tree legumes and by-products) can be stored as silage. Rice straw is sometimes mixed with very moist forages to reduce effluent losses, but this results in a poorer quality silage. It could be used at the bottom of a silage pit, to absorb the highly polluting silage effluent.

Unfortunately, tropical forages and legumes are not well suited to ensiling due to their inherent low concentrations of water-soluble carbohydrates (that is, sugar, or one of the storage carbohydrates), compared with temperate species. However, rapidly wilting the forage or adding a fermentable substrate, such as molasses before ensiling, will usually result in well-fermented silages.

During the wet season, tropical forage species grow at very fast rates, with forage yields often exceeding animal requirements. If not cut and fed, it will continue to grow, producing very long and fibrous material, which is low in energy and protein.

If this forage was harvested and successfully stored as silage at the same stage as it is cut for producing milk, then it could be fed back during the following dry season. Although the quality of the forage will be slightly lower than its fresh state (10–15% lower in good ensiling conditions), it will still be better quality than many of the forages only available for dry season feeding. Conversely, in some locations, the silage can supplement other good quality, but very slow growing, forages.

Silage can be stored in small plastic bags, 120–200 L plastic and steel drums (plastic lined or bagged), small or large pits dug into hillsides and in stacks above ground. Steel and plastic drums should be stored on their lids to minimise losses when/if air enters the lid. When stored on their base and air enters (as it often will), then decomposition of the silage continues as more air enters. However, when stored upside down, the weight of the silage causes it to drop down inside the drum and minimise air entry.

3.4 The 10 steps to making silage

The success or failure in making quality silage is affected greatly by practices and requires a strict set of guidelines. There are no short cuts! Sections 3.4.1 to 3.4.10 describe the 10 steps to making good quality silage.

3.4.1 Harvest the forage

Forages should be harvested when excess to feed requirements but also when high in quality. In the wet season, tropical forages, such as Napier grass and sorghums, can grow rapidly to heights in excess of 2–3 m. Following this rapid growth, preferably even before it produces more forage than the small holder needs, this excess should be ensiled. This will allow the entire supply of forage to be maintained as high quality into the dry season, rather than it becoming long with a reduced leaf content, and hence low in quality.

It is important that forage harvested for silage should be the same stage of maturity; that is, at its optimum for feeding fresh. For example, Napier grass should be harvested following 30–40 days regrowth in the wet season, at about 75–150 cm in height, for optimum quality and for ease of transporting to livestock in small holdings. At this stage, the Napier grass will have about two to three nodes showing on the stem.

Native roadside forages should be harvested when leafy and contain no prickly species. Tree legumes should be cut while leaves are still green and contain minimal twigs or branches.

3.4.2 Wilt the forage to 30% DM

Tropical species are difficult to ensile due to their high buffering ability; that is, their resistance to changes in pH. To enable them to undergo a more satisfactory fermentation, two techniques are available to small holders: wilting the forage before and/or adding a fermentable substrate at ensiling.

Napier grass will be about 12–15% DM at harvest and should, if possible, be wilted to at least 30% DM. Wilting involves laying the cut forage on racks or against walls to allow the sun's heat to evaporate some moisture from the plants. If rain is likely to fall, the material must then be covered (with plastic or palm leaves) or moved under shelter.

When harvested in the morning, wilting may only require the heat of the afternoon of that day, but when cut later in the day or on cloudy days, it may need wilting till midday of the following day. The layer of material to be wilted should be no thicker than 10 cm, and should be turned over two to three times to encourage wilting. If too thick, the forage will heat and begin to decompose and encourage the wrong types of bacteria to grow. Forage quality and DM will be lost.

3.4.3 Add a fermentable substrate at ensiling

If the fresh forage cannot be wilted, the fermentation of the silage will be improved by mixing the chopped material with 3–5% molasses (on a fresh weight basis) just before ensiling. Although this is a time consuming and messy job, the rewards are well worth it. Adding water to the molasses is not recommended because the forage is already too moist and extra water will just reduce the fermentation quality.

Rather than mixing it in thoroughly, the molasses can be spread as layers in the forage, say every 10–15 cm. Where the molasses is applied, the silage ferments better and is sweeter smelling, but the overall silage quality is still good. Other suitable fermentable substrates include rice bran or formulated concentrates (mixed at 10%) in layers with molasses (5%) poured on top of the rice bran.

3.4.4 Chop the forage into short lengths

The shorter the chop length the better the compaction, so less air is trapped in the forage, resulting in better silage quality. Chop lengths should be from 1 to 3 cm. Mechanised forage choppers will chop quickly to very short lengths. However, small holders can manually achieve similar chop lengths using knives, but this requires high labour inputs and is much slower.

If chop lengths are longer, additional molasses (5–6% on a fresh forage basis) may improve the fermentation. However, it is important that the stems should be chopped to small lengths because they are harder to compact. Leaves can be left at 3–8 cm.

Where the forage has become too long, but is still in a vegetative state (not yet in head), only the leaves and the top end of the stems should be chopped and ensiled, to produce a higher quality silage.

3.4.5 Compact the forage as tightly as possible

Regardless of the system of silage storage, the forage must be compacted as densely as possible – it must be so compact that it is difficult to insert your fingers into the stack. As mentioned above, the shorter the material is chopped, the more dense it can be packed and the less air that will be trapped inside the stack.

If compaction is by human trampling, pockets of air may be trapped inside the stack. The edges of the storage must be well packed. Poles or feet may be used to compress the edges in drums and material must be pushed into corners of plastic bags by hand. Care must be taken not to puncture the plastic bags with fingers, wooden poles, and so on.

Larger stacks of silage in cement boxes or in pits in the ground will require continual trampling while the forage is being delivered. It should be spread evenly and thinly (no more than 5–7 cm thick) over the stack to enable it to pack more densely.

3.4.6 Complete the entire storage quickly

The entire silage storage should be filled and sealed in 1 day, and at a maximum, 2 days. This is easily achieved with bags, drums and small concrete boxes.

In larger stacks, where the forage may require several days to be delivered, the forage from each day should cover that from the previous day to a depth of at least 1 m. The current day's forage then acts as a 'seal' for the previous day. If some of the previous day's forage is not covered sufficiently, it will suffer from aerobic deterioration, causing the stack to heat up, with subsequent losses in both quantity and quality.

Each night until it is filled, the stack should be covered with a sheet of plastic or a thick layer of banana or palm leaves. This will minimise the amount of warm air leaving the stack, which sets up convection currents, thus encouraging more air to enter. This is particularly important with wilted tropical forage, because it is more prone to aerobic deterioration than are temperate forage species.

3.4.7 Seal storage airtight

Silages in well-sealed storages, which prevent the entry of air or water, will maintain their quality for much longer than will silage in poorly sealed storages.

Plastic bags: Forages ensiled inside small bags should be stored inside a second bag because the thin plastic is easily punctured. Furthermore, non-punctured stretched plastic can allow entry of air. To ensure a tight seal, the neck should be twisted and then tied/taped, then doubled over and retied/taped.

Bags must be stored under cover and protected from vermin, rodents, birds, poultry, children, and so on, to avoid punctures. To prevent the plastic breaking down, and to minimise direct heating of the bags, they should also be protected from direct sunlight.

Plastic and steel drums: The tops of the drums should be covered with a sheet of plastic before the lid is placed on top. To ensure an airtight seal once clamped or screwed in place, plastic tape should be placed around the top. The drums should then be stored upside down and preferably under cover or protected from direct sunlight to minimise heating.

Concrete silo or boxes: To reduce losses through aerobic deterioration once opened, it is useful to divide large concrete silos into smaller compartments. This can be done with straw, mud, cement bricks or by using a rectangular timber frame. At least one side of the stack should be sealed with plastic to prevent air entry during feed out. Straw placed above stones in the base of the pit allows moisture to seep to the bottom, but does not allow air entry into the stack. The stones should be approximately 2–4 cm high depending on stack size.

Silage pits or bunkers: Immediately after the filling is complete and the stack well compacted, it should be sealed airtight using plastic, preferably plastic treated with ultraviolet light inhibitor. If such plastic is not available (e.g. if only builders plastic is available), it should be entirely covered with about 10–15 cm of soil to protect it from direct sunlight.

When using ultraviolet-light-treated plastic, it must be weighted with tyres cut in half or sand/dirt filled bags to maintain the plastic close to the silage, thus preventing air entry and movement under the seal. Covering the plastic with soil would be ideal.

3.4.8 Maintain airtight seal

All storage types must be sealed then kept airtight throughout the entire storage. If the plastic is punctured, or stacks start to shrink too much, the cause of air entry into the silage must be determined and repaired as soon as possible.

Effluent flowing out of the storage for longer than 2–4 weeks is indicative that the silage is slowly deteriorating (rotting) due to entry of air. The cause of the air entry should be identified and stopped. If it cannot be stopped, ensure that the same mistake is not made in the future. A mistake is something wrong that happens more than once!

Wilted silage should have little or no effluent unless the stack is poorly sealed. Unwilted silage will produce some effluent, which may leak out of drums and stacks into the soil. Silage effluent should be prevented from entering waterways and drinking water because it causes pollution. It can kill plants or fish if in large numbers.

Only small amounts of silage effluent will leak from well-sealed drums and plastic bags, and may even leak slowly from upturned drums. It is important not to remove drum lids, untie bag tops or hole their bottoms to let moisture out, or to 'see how they are going!' This will allow far too much air to enter, leading to very poorly fermented silages or even just compost.

3.4.9 Feed out a whole face of the storage

As soon as the storage is opened for feeding, air will enter and the silage will begin to deteriorate. Silage in small storages should be fed out completely within 1–3 days of opening. If drums are being fed out over more than 3 days, plastic and weights should be placed over the open face to minimise air entry to the silage.

Unless the forage has been chopped very short (1–3 cm) and well compacted, air enters silage stacks of tropical species very easily. For large silage storages, the whole face of the stack should be removed every day to a depth of at least 20 cm. If the silage is only fed out every 2 days, at least 30–40 cm should be removed every second day. Stack widths should be designed to ensure it takes no longer than 2–3 days to feed out the entire feeding face.

The weighting material on top of the stack should be removed only as required to prevent air moving back into the stack under the top seal. If the silage is warming once opened, it starts to deteriorate and lose yield and quality. If steam is rising from the stack, or if the silage becomes very hot, aerobic deterioration is extreme and the feeding rate must be increased rapidly, unless the problem is due to air entry via other means.

3.4.10 If silage is unsatisfactory, determine the reason

It is important to learn from your mistakes and ensure that the silage is consistently of good quality from year to year.

Silage that has undergone an unsatisfactory fermentation will be unpalatable, and in some cases even poisonous, to animals. Once opened, such silage may be recognised by the following characteristics:

- it has a strong, pungent, very unpleasant smell
- it has a strong ammonia smell
- it contains excess moisture when squeezed or continually oozes from the base
- it is mouldy or slimy
- it has undergone much deterioration (>20% DM loss)
- it is slightly damp and dark brown
- the plastic sheet or lid has not stopped air entry for many days.

Even though animals may not initially eat the spoiled silage, they may do so once the silage has been left in feed troughs for an hour or so, thus allowing some of the pungent smells to escape. However, animal production will suffer as a result. To avoid any possible animal health problems, mouldy silage should never be fed to pregnant and lactating animals.

Silage has a characteristic odour unfamiliar to most livestock. Therefore they may not immediately consume the silage offered without some incentive, such as molasses or fresh forage mixed in with the material. It is very unusual for stock to refuse silage if a slow introductory period has been employed.

Even when they make good-quality silage, farmer adoption rates of silage making have not always been high. As with other feeding technologies such as chemically treated rice straw, farmers do not like to double handle forages. Often, they need to see the benefits (i.e. higher milk yields) of feeding better quality roughages before they accept the higher workloads in silage making rather than purchasing other forages, which are generally of poor quality, for dry season feeding. Another problem is the shortage of excess wet season forage with which to make silage, because they may have high stock numbers on limited areas.

3.5 Storing wet by-products as silage

Fruit, fish waste, vegetables and root crops are increasingly integrated into tropical farming systems and provide a wide range of valuable wet by-products and residues, which are often underused or wasted. The ensiling of such by-products is a simple conservation method and a most effective way to improve animal feed resources through the rational use of such potential feedstuffs to small holder farming.

The major problems usually encountered are the seasonality of supply and their high moisture content. High moisture by-products often have high nutritive value. It is difficult and expensive to dry them, so all too frequently such by-products often become contaminating wastes that quickly go sour, mouldy and lose much of their soluble nutrients as effluent. The advantages of ensiling such material include:

- enabling feeding when such by-products are not being produced
- increasing feed resources and an insurance for high nutrient demands, such as those of milking cows
- reducing demands on home-grown forages
- reducing total feed costs (if low cost)
- improving their palatability
- reducing toxicity to safe levels (in vegetables or cassava leaves)
- destroying harmful bacteria (in poultry litter or fish wastes)
- its use as a major proportion of diets.

The basic principles are the same as those for fresh forages, so attention must be paid to ensuring anaerobic conditions and there should be sufficient acid in the silage to restrict the activities of undesirable bacteria. To achieve successful silage, attention should be given to:

- **moisture content**, which should be at least 50% for ease of compacting to eliminate air. Excessive moisture (>75%), can lead to an undesirable fermentation, producing a sour silage that reduces palatability hence intake. Adding water or using absorbent materials will allow the manipulation of moisture content.
- **length of chopping** – the finer the chopping the better the compaction
- **time to fill the stack** – the quicker the better, and it should be covered each night during filling to reduce invasion of air
- **fermentable energy** – these silages require a stable low pH to minimise biological activity. The final pH depends on the carbohydrate content, which may be sufficient in the material being ensiled or from added sources. For example, protein-rich by-products with low sugar or starch content are difficult to ensile, so should be mixed with energy-rich by-products such as waste bananas, molasses or root crops.

Once opened, every effort must be made to reduce aerobic deterioration. Ensiling in layers separated by plastic sheets can reduce the size of each package of silage. Plastic bags are easy to handle, as well as making excellent mini silos.

Well-made silage can be opened within a month or stored for 6 months or more, provided the cover doesn't break down and allow air to enter the stack.

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