Conserving Feed

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DAIRY RESEARCH AND DEVELOPMENT CORPORATION

NSW Agriculture

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Foreword

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Dairying is one of the most progressive rural industries in NSW. This is evidenced by substantial changes in herd sizes and increases in production by cows and from farms.

An outcome of these increases is that management has become more complex, requiring greater knowledge and technical skills.

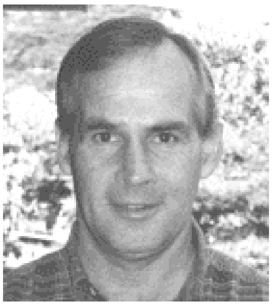
As farmers become more competitive through increases in both production and productivity, they will require even better technical information and management skills. Most important, they will need to know how to use the information in improving whole-farm performance and profits. This statement is supported by results of various Dairy Research and Development Corporation workshops and NSW Dairy Farmers' Association surveys, which have clearly indicated that farmers require technical packages that are current and relevant.

DairyLink is a series of integrated information packages that look at aspects of pasture, herd and feed management, and suggest practical ways of getting the best from your cows and pastures. The DairyLink series is a result of collaboration between NSW Agriculture officers, agribusiness and farmers.

The packages will be the basis of workshops and meetings for NSW dairy farmers.

DairyLink has much to offer the NSW dairy industry in helping improve farm productivity and profitability. We encourage farmers to attend and participate in the DairyLink workshops and meetings.

Preface



DairyLink is an innovative concept that introduces you to some important technical areas to help improve farm productivity and profits.

The modules in the series are of value to farmers, students, consultants and extension service providers.

DairyLink consists of the following information packages:

Establishing Pastures
Managing Pastures
Growing Heifers
Realistic Rations
Conserving Feed

The modules have been developed as technical manuals and farmer-friendly booklets, and are linked to the Tocal Dairy Home Study course.

I acknowledge and thank the various technical teams for doing an excellent job. I also appreciate the funding and support provided by the Dairy Research and Development Corporation.

Alex Ashwood
DairyLink Series Coordinator

Contents

Introduction

Forage conservation is a valuable pasture management strategy. In a good season it allows excess forage to be removed from a paddock so that high-quality regrowth is available for grazing, rather than letting old, rank forage accumulate. In a bad season or during seasonal shortages, the conserved feed can be fed to maintain milk production or as a longer-term emergency feed. Forage conservation can be the link between growing and managing pastures and providing realistic rations for dairy cows.

Hay and silage are the main forms of conserved forage.

All forage conservation involves cost and waste. The challenge to producers is to minimise both and to ensure that the returns from feeding conserved forage justify the effort and expense involved in growing, harvesting, storing and feeding it.

When to conserve a forage is often a compromise between feed quantity and quality. Do you want maximum quantity or quality per hectare of forage harvested? Do you want to maximise milk production per cow or per hectare? The best choice is usually a compromise.

This manual is designed to improve your whole-farm feed management. It will help you decide what type of forage to grow and when to conserve it. You will learn the best ways to harvest, store and feed out hay and silage and understand what can happen when things don't go to plan.

Neil Griffiths

1. Common questions

What are the types of forage conservation?

Hay and silage are the main methods of conserving forage. Hay is preserved by drying and will generally keep while it is kept dry. Silage involves natural fermentation, which produces lactic and other acids, which ‘pickle’ or preserve the forage. This fermentation takes place only under anaerobic (oxygen-free) conditions, so the forage must be packed to remove air and sealed to keep air out. Silage will generally keep while it remains sealed and anaerobic.

See the table below for a comparison of different fodder types.

Why conserve forage?

- To preserve feed at optimum nutritional value
- To shift available feed from the present to the future
- To move feed from one location to another location
- To assist pasture management

Why use conserved forage?

- To fill feed gaps
- For production feeding
- For drought, flood or disaster management.

What forage can be conserved?

- Pasture or crop in excess of present requirements
- Crop planted specifically for fodder conservation
- Opportunity crops (e.g. grain may not set or fill because of frost or insect damage).

Options are home-grown or bought; irrigated or dryland.

What is it worth?

You must know the cost per tonne, not cost per bale, to work out the value. Compare cost on the basis of dry matter and feed value. For example:

- hay @ $130/t and 85% DM costs $153/t DM
- round bale silage @ $80/t and 45% DM costs $178/t DM

You should know the feed quality, including energy and protein, to make a true comparison.

Where do I store conserved forage?

Where used: Feeding out will be a daily activity over a period of time. Convenience and efficiency when feeding out are critical. Site must be accessible

Forage type	Percentage dry matter (DM)	Notes
Hay	79%–88%	• small square (rectangular) bales • medium square (rectangular) bales • big square (rectangular) bales • round bales
Heavily wilted silage (also called ‘balage’ or ‘haylage’)	35%–50%	• square bales • round bales • Silopress® bags • tower silo
Bulk chopped silage	30%–45%	• pit • bun or stack • bunker
Green chop	15%–25%	• use within 24 hours

when feeding out is required. Consider problems of feeding out in times of flood.

Where harvested: This can save time and money at harvest but often incurs greater expense and inconvenience when feeding out.

Where storage already exists: Use existing facilities if it is cost-effective after considering site requirements for both harvest and feeding out.

Who will conserve forage?

You:

- Is machinery operational and ready to go?
- Can you operate the machinery effectively?
- Will the machinery do the job you want?
- Is additional labour organised and trained?
- Is additional equipment required (e.g. trucks)?

Contractor:

- Has a contractor been lined up for the appropriate time?
- Does the contractor know what you want?
- Will the contractor's machinery do the job you want?
- Is additional equipment required (e.g. trucks)?

Consortium:

- Can you get the machinery when you need it?
- Will it do the job you want?
- Is it operational and ready to go?
- Can you operate it effectively?

How long does it take to dry?

Hay: It depends on the material and weather, but it can be as quick as 3 days in summer and impossible in winter.

Heavily wilted silage: It depends on the material, but it can be as quick as a couple of hours in summer or slow or impossible in winter.

Wilted silage: It depends on the material, but it can be as quick as an hour in summer or as slow as 3 days in winter.

Note: Rapid drying is always needed to retain maximum feed value. Direct harvest is possible with some crops.

Rainfall probabilities can help you decide which method of fodder conservation may be the most successful at any given time of year (if you don't already know through experience).

How do I assess dry matter content?

- A good quality meter can be used for hay.
- Dry a sample in a microwave oven and weigh it with digital scales.
- By feel. Manual indicators such as squeeze or scratch tests can be effective with experience.

What can go wrong?

When conserving fodder, always aim for a perfect, high-quality result. In practice, however, useable hay and silage can be made under less-than-perfect conditions.

Common problems are:

- low-yielding, low-quality crop or pasture owing to weeds or inadequate fertiliser
- slow drying, which always reduces quality
- grass too old (mature) before harvest
- rough handling, which causes leaf loss from hay
- hay that is too wet
- silage that is too wet or too dry

- silage not adequately compacted and sealed
- inefficient feed out, causing excessive waste

Note that hay-making is far more susceptible to damage from wet weather than silage making.

What are other farmers doing?

Silage is becoming more popular on NSW dairy farms. A 1995 survey of dairy farmers in the Dungog–Gloucester area showed that 52% of farms had made silage in the past 3 years, and 62% intended to make silage in the next 3 years. Eighty-two per cent of the silage was made into round bales.

The main reasons for making silage were pasture management (27%), drought or flood reserve (17%) and regular production feeding (14%). Forty-two per cent said all 3.

Round bales are popular with farmers because they are convenient, and ideal when used for pasture management. However, they are expensive, and disposal of plastic wrap is becoming an important issue.

A national survey[(1)] in 1996 confirmed these trends and found that 36% of hay made on dairy farms suffered some weather damage.

Where can I get more information?

A wide range of information on making and using hay and silage is available from advisory organisations and commercial companies as leaflets, books and videotapes. To get you started, we suggest the following:

Forage Conservation: Making Quality Silage and Hay in Australia by John Moran, Agriculture Victoria, 1996. Available from Agmedia , PO Box 258, East Melbourne, Victoria 3002; phone 1800 800 755

Silage for Beef by Ian Blackwood, 1997. Available from NSW Agriculture, Locked Bag 21, Orange, NSW 2800; phone 1800 028 374

Cut and Dried, edited by Mark Casey, 1994. Available from the Kondinin Group, PO Box 913, Cloverdale, WA 6105; phone 1800 677 761

Fodder Costs, edited by Mark Casey and Mark Evans, 1997. Available from the Kondinin Group

Reference

1. Kaiser, A. G. and Evans, M. J. 1997. Forage conservation on Australian dairy farms. Animal Industries Report 3, NSW Agriculture, Orange

2. Conserving forages—what can be used

Cow requirements and feed quality

Feed quality requirements will depend on the class of stock being fed and the purpose of supplementary feeding. If dry stock are being fed for survival (maintenance), a low-quality roughage may be acceptable. Milk production requires more energy, which comes from high-quality forages.

The costs of producing high- and low-quality hay or silage are similar, but because feed quality determines the level of animal production, the return from low-quality fodder is lower and may not cover the cost of production. Always aim for high-quality conserved fodder.

As a guide, dairy cattle need the metabolisable energy (ME) and crude protein levels shown in table 2.1.

Table 2.1. Metabolisable energy (ME) and crude protein needed by milkers, drys and yearling heifers.

Animal	ME (MJ/kg DM)	Crude protein (%)
Milking cow	> 10	> 14
Dry cow	8	8
Yearling heifers	9–10	10–11

Quality and production

Digestibility is the main factor influencing milk production. For each 1% change in digestibility, milk production is altered by 0.37 kg/day[2] If a diet is 10%–20% less digestible, milk production can be reduced by 3.7–7.4 kg a day Figure 2.1 shows how this relationship works. The increased milk yield with more highly digestible feed is a result of greater intake of this more nutritious feed. Good quality, conserved temperate pasture should be at least 65% digestible. (Note that metabolisable energy (ME) is calculated from digestibility.)

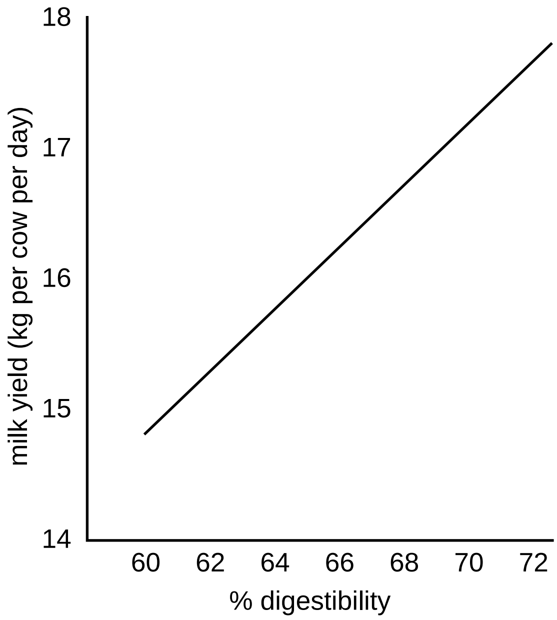


Figure 2.1. As silage digestibility increases, milk yield increases too.[1]

The quantity of conserved feed needed depends on the stocking rate, feed management strategies and stock requirements. For milking cows, quality is very important.

Cows eat 1 kg of early-cut (good quality) hay per 100kg liveweight, compared with 0.75kg of late-cut (medium quality) hay. Concentrates have to be fed to make up the difference. Table 2.2 shows how this difference adds up.

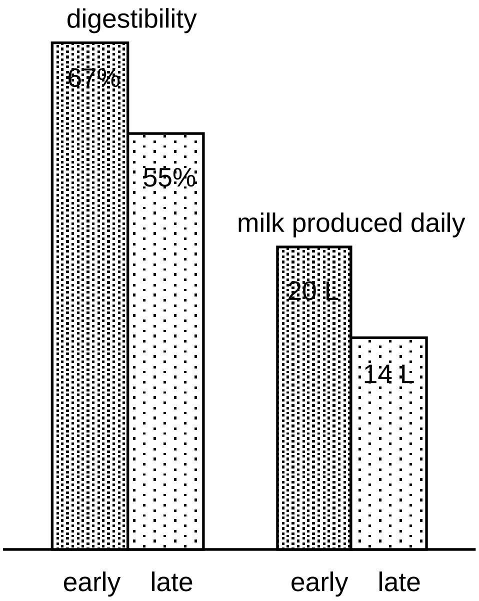
The incentive for good-quality conserved feed is real—good-quality feed produces up to 40% more milk (Figure 2.2). Feeding good quality conserved feed to milkers shows up in the bank balance.

Further information on feed requirements of dairy cows is available in the DairyLink *Realistic Rations* manual.

Table 2.2. Supplements are needed to make up for lower-quality hay.

Intake of good-quality hay (kg/day)	Intake of medium-quality hay (kg/day)	Extra grain needed per cow (kg/day)	Extra grain needed per 100 cows per week (kg)
6	4.5	1.5	1050
8	6.0	2.0	1400
10	7.5	2.5	1750

Figure 2.2. Early-cut forage is more digestible and produces up to 40% more milk.



Feed quality—what makes good forage?

The quality of conserved forage is only as good as the pasture or crop used.

The end use of the conserved feed often determines the type of pasture conserved. Cows in early to mid lactation need highly digestible feed, whereas stock on maintenance rations can handle low-quality feed.

Top-quality conserved feed has two advantages: it has a feed value only slightly lower than that of concentrates, it is consumed in large amounts, and it produces high volumes of milk.

Factors affecting the feed value of conserved fodder

Crop or pasture type

All feedstuffs set an upper limit on the quality of silage or hay that can be conserved. Young temperate grasses, and legumes such as clover or lucerne, naturally have high feed value (good digestibility, energy and protein levels), which has potential to be conserved as high-quality hay or silage. Maize is normally high in energy and low in protein. Mature grasses and rank forage have low feed value (low digestibility, energy and protein) and can never be made into good-quality silage or hay. ‘You can’t make a silk purse from a sow’s ear.’

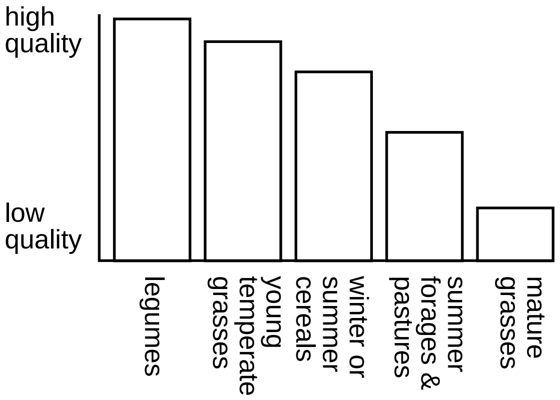
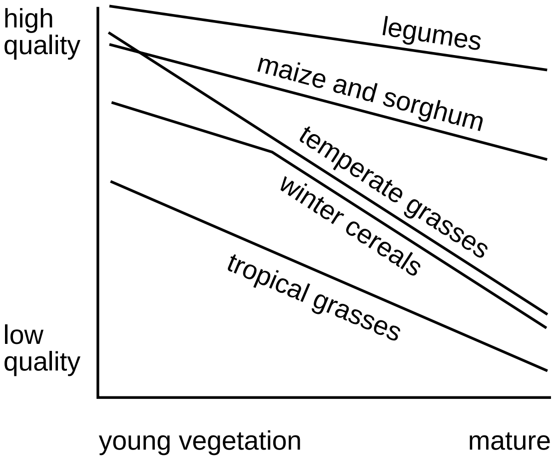


Figure 2.3. Feed value of fodder depends on crop or pasture type.

Growth stage

Young leafy pastures and crops have the highest digestibility, energy and protein levels. As grasses mature they become more fibrous, and their feed value declines rapidly. Legumes tend to lose feed value slower than grasses. Cereals, such as wheat and oats, have their highest digestibility and protein content when they are young and leafy. When they mature, energy becomes concentrated in the grain; stems become more fibrous and less digestible and some leaves are lost. Feed value of maize and grain sorghum does not fall off as quickly as that of winter cereals.

Figure 2.4. Feed value of fodder decreases with growth stage at harvest.



The best growth stage for harvest is often a compromise between quality and quantity. Mature crops have a larger bulk of lower-quality forage than young, vegetative crops. Late-cut crops are usually unsuitable for feeding for milk production.

Moisture content and wilting time

Moisture content of conserved fodder obviously affects how well it stores. Wet hay will become mouldy; it can heat up and lose feed value and could even catch fire. Very dry hay will be dusty and often of lower feed value, because leaves have become brittle and broken off, leaving only lower-quality stems. Wet silage will lose quality as soluble sugars are lost in effluent, and there is a risk of poor fermentation. Dry silage may be difficult to compact, so there is a risk of poor fermentation and overheating. Spoilage losses can increase.

The time taken to wilt a crop to the desired moisture content is critical. A quick wilt is a good wilt. If wilting takes longer than 48 hours then feed value can drop significantly. While the crop is wilting it continues to respire and burn up sugars: this reduces feed value. A slow wilt also allows growth of aerobic bacteria, yeasts and moulds, which increases losses of dry matter (DM) and feed value.

If wilting is going to take much more than 48 hours then it is worth using different machinery, such as a conditioner or tedder, to speed up the rate of drying, or various chemical or microbial additives to reduce spoilage or improve fermentation. Either way, the savings in feed value must pay for the cost of any extra machinery or additives.

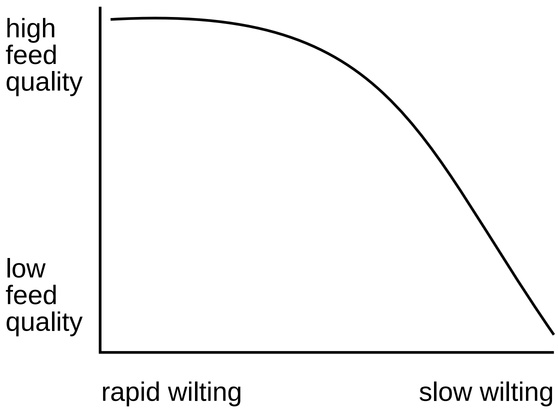


Figure 2.5. Feed value declines when fodder is wilted slowly.

Figure 2.6. High soil fertility encourages high feed value.

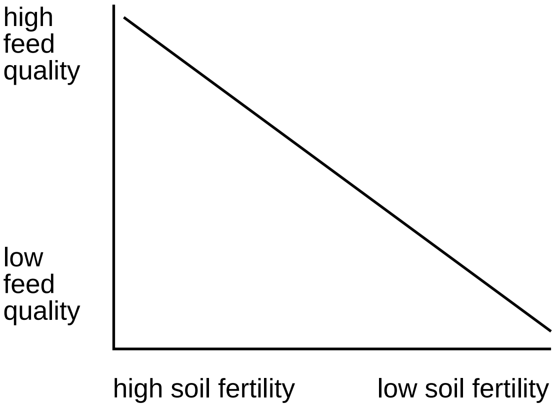
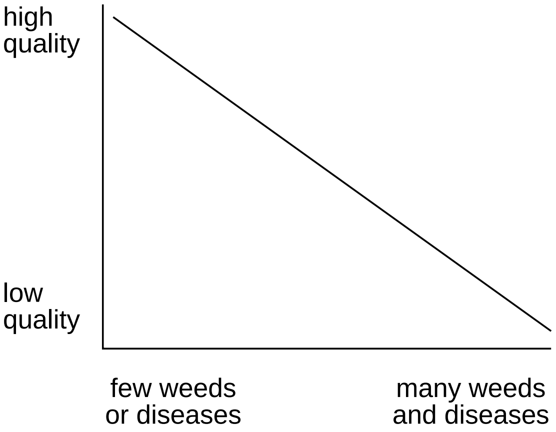


Figure 2.7. The fewer weeds, pests and diseases the crop or pasture has, the higher the feed value of the fodder.



Soil fertility

Soil fertility influences potential yield but it can also influence feed quality. For example, a grass pasture or crop that is nitrogen-deficient will show reduced protein and energy levels when analysed. Other nutrient deficiencies that affect yield will also often affect feed quality.

High soil fertility and good crop growth can sometimes contribute to lower feed quality if a crop is not harvested early enough. For example, a very vigorous forage sorghum crop can quickly become tall and rank if harvest is delayed.

Soil fertility must be maintained if long-term productivity is to continue. This is particularly important where large amounts of nutrients are removed in conserved forages.

Weeds, pests and diseases

These will never improve feed quality and may well cause a decline in both quality and yield. Some weeds, such as thistles and barley grass, can damage animals' mouths, cause ulcers and affect feed intake. Other weeds are poisonous, can cause milk tainting or can be unpalatable.

Some weeds are difficult to make into hay or silage and could spoil the whole harvest. Pests and diseases will reduce yield and quality by causing leaf loss. They may cause toxicity in plants through stress (e.g. forage sorghum) or may be poisonous themselves (e.g. ergot).

The best management is to select and prepare paddocks for conservation well in advance of harvest. If necessary, control weeds or select an alternative paddock for harvest.

Lucerne

Potential for hay or silage

Lucerne is the traditional, prime summer-growing hay crop. It can be made into both hay, which is readily traded, and silage. Lucerne silage is becoming more popular, particularly in cooler months and wet seasons, when high losses are likely from attempts to make hay. Lucerne silage is a high quality fodder, and is often of higher feed value than hay because dry leaf is not lost when raking and baling. Growing costs are similar for both hay and silage and range from $30–$65/t DM. The cost of making silage or hay must be added to this.

Lucerne management before cutting hay or silage

- Aim for the best feed value possible.
- Control all weeds (grasses may increase the bulk available but usually will be of lower feed value).
- Irrigate as required.
- If cutting is delayed by rain, silage will lose some feed value but normally is still acceptable.

Lucerne management after cutting hay or silage

Replace nutrients removed in hay and silage. Expect each tonne of lucerne DM removed as hay or silage to remove:

Nitrogen (N)	40kg
Phosphorus (P)	3.5 kg
Potassium (K)	25.0 kg
Sulfur (S)	2.5kg
Calcium (Ca)	15.0kg
Magnesium (Mg)	3.0kg

These nutrients must be replaced by fertiliser in these amounts to prevent long-term losses of soil fertility. Lucerne, being a legume, will fix its own N. P and K would normally be applied in spring and early autumn. Use split applications where high rates of fertiliser are needed. Ca is applied as lime before planting.

Growth stage to harvest

Early flowering (10% flower) is preferred for both hay and silage. For highly-winter-active varieties, new growth from the crown is also an indicator that the crop is ready to cut. Cutting earlier (late bud) will improve feed quality but will reduce yield.

Wilting requirement for silage

Wilting is essential. Aim for 35%–45% DM for chopped silage, or 40%–45% DM for round-bale silage. Expect 24–36 hours in summer, 48 hours in cooler weather. Note: If wilting takes longer than 48 hours then loss of both feed quality and feed quantity becomes significant.

Type of silage

Round-bale and chopped.

Number of cuts: 4–7 a year.

Other comments

Bloat is not common but has been reported from silage.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative (30 cm)	10–11	22–28	Very high	650–1400
Late vegetative – budding (45 cm)	9–10	18–24	High	1100–2400
Early flower (50 cm)	8–9.5	15–22	High	1500–3200
Late flower (60 cm)	6–8	6–15	Medium	1800–4000

Perennial ryegrass & clover

Potential for silage or hay

Perennial ryegrass – clover pastures are ideally suited to grazing.

An excess of feed in spring is best managed by conserving as silage. Hay is possible late in the season. Locking up for hay is more likely to thin the pasture and remove seed from the paddock.

Silage may be considered a management tool for this perennial pasture; therefore, growing costs need not be considered when budgeting for silage.

Perennial ryegrass – clover management before silage

- Aim for best possible feed value.
- Graze heavily then mulch, slash or mow back to a 5cm stubble if needed.
- Topdress with 50kg N/ha if ryegrass is dominant.
- If clover is dominant, 50–100kg K/ha may be required.
- Irrigate as required.
- Some perennial ryegrass – clover pastures tend to be short and fine and may be difficult to harvest for silage.

Ryegrass – clover management after silage

Replace nutrients removed. Expect each tonne of ryegrass – clover DM to remove:

Nitrogen (N)	36 kg (most from clover)
Phosphorus (P)	3.5kg
Potassium (K)	25kg
Sulfur (S)	2.5kg
Calcium (Ca)	8kg
Magnesium (Mg)	3kg

Use split applications where high rates of N, P or K fertilisers are required.

Perennial ryegrass – clover pasture can be returned to grazing management or locked up for another silage cut, depending on feed availability and time of year.

It may be better to make silage from forage crops and graze perennial ryegrass – clover pasture to maintain dense, high-quality pastures.

Growth stage to harvest

Whenever excess feed is available. Aim for early head emergence stage of ryegrass or early to mid flowering of clover (~30 d growth in spring) if legume is dominant.

Wilting requirement

Wilting is essential. Aim for 30%–45% DM for chopped silage, or 40%–45% DM for round-bale silage. If wilting takes longer than 48 hours then loss of feed quality becomes significant.

Type of silage

Round-bale and chopped.

Number of cuts

1 or 2 if excess pasture available. Repeated lock-up will tend to thin the pasture.

Other comments

A short lock-up in spring (e.g. 4 weeks) will ensure high-quality silage (10–11MJ ME/kg). Longer will increase bulk but may lower feed quality.

Feed quality and potential yield (depends on proportion of clover)

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative (25 cm)	10–11	15–25	High	1500–3000
Head emergence (40 cm)	9.5–11	12–22	High	2500–4000
Flowering	8.5–10	10–20	Medium	2500–5000

Forage ryegrass

Potential for silage or hay

Ryegrass can be made into both hay and silage. Traditionally, hay has not been made until late in the season when ryegrass is mature and the weather is warm. This hay is normally of very low quality.

Silage is made during the main spring growing season when the pasture is of high feed value. It is normally made from a genuine excess of pasture. Therefore, growing costs need not be considered when calculating the cost of silage.

Silage is a valuable management tool, allowing adjustment to grazing rotations to ensure optimal feed quality for grazing herds and conservation of excess forage.

Ryegrass mgmt before silage

- Aim for the best feed value possible.
- Graze heavily then mulch, slash or mow back to a 5cm stubble if required. Remove any heavy mulch to allow rapid, even regrowth.
- Topdress with 50–100kg N/ha to ensure rapid growth.
- Irrigate if necessary.

Ryegrass mgmt after silage

Replace nutrients removed. Expect each tonne of ryegrass DM to remove:

Nitrogen (N)	32kg
Phosphorus (P)	3.5kg
Potassium (K)	25kg
Sulfur (S)	2.5kg
Calcium (Ca)	3.6kg
Magnesium (Mg)	2.4kg

These nutrients must be replaced by fertiliser to prevent long-term loss of soil fertility. Phosphorus and potassium may be best applied during autumn or at the end of winter.

Ryegrass can be returned to grazing management or, depending on the time of year, locked up for another silage cut. Expect tillers to thin out after locking up for silage. Thinning may be temporary, depending on grazing management.

Growth stage to harvest

- Hay—when season warms up. Plants normally mature and low in feed value.
- Silage—whenever excess feed is available. Aim for early head emergence.

Wilting requirement for silage

Wilting is essential. Aim for 30%–45% DM for chopped silage, or 40%–45% DM for round-bale silage. If wilting takes longer than 48 hours then loss of feed quality becomes significant.

Type of silage

Round-bale and chopped.

Number of cuts

- Hay—1 late cut only.
- Silage—normally 1 cut, but 2 are possible if first is early and weather allows regrowth for a second cut.

Other comments

Feed quality, especially protein, depends on soil nitrogen levels and growth stage.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative (30 cm)	9.7–11	14–22	High	2000–3200
Boot or head emergence (45 cm)	9–10.5	12–20	High	2500–4100
Flowering	8–9	8.5–18	Medium–high	2500–5500
Mature seed	6–8	3.5–7.5	Low	2200–5000

Oats and winter cereals

Potential for silage or hay

Oats and winter cereals can be grown deliberately for storage as conserved fodder or can be grazed and then locked up for conservation.

Winter cereals will produce a good yield of medium- to high-quality hay or silage. Protein levels and hence feed quality can be improved by sowing with a legume. Early sowings can include a clover suitable for grazing. Later sowings can include field peas or vetch.

Oats management before silage

- Aim for the best feed value possible.
- First grazing of oats when the crop is well rooted so it won't pull out (20–30cm high) to encourage tillering.
- The crop may be grazed again if required or locked up for silage or hay production.
- Ensure that adequate fertiliser has been used, particularly nitrogen, which should be applied at 50–100kg N/ha after each grazing.

Oats management after silage or hay

Replace nutrients removed. Expect each tonne of oats DM to remove the following:

Nitrogen (N)	24kg
Phosphorus (P)	3.5kg
Potassium (K)	24kg
Sulfur (S)	3kg
Calcium (Ca)	3kg
Magnesium (Mg)	3kg

Do not expect oats to recover after silage; the paddock will have to be replanted.

Growth stage to harvest

Winter cereals can be cut for hay or silage from the boot stage through to the dough grain stage. Be aware that mice may be a problem if grain is allowed to develop. Harvest of more mature crops will optimise energy yields but will sacrifice protein. Cutting for silage at the flowering stage is usually preferred.

Wilting requirement for silage

Optional. Wilting is necessary if cutting at the flowering stage or earlier. Crops can be direct-harvested if at the dough grain stage.

Type of silage

Round-bale and chopped.

Number of cuts: 1.

Other comments

Where soil fertility is low, crops may have very low crude protein content, even when nitrogen fertiliser is applied. Yield and energy levels may still be acceptable.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Late vegetative or boot (60 cm)	9.5–10.5	10–18	High	1500–5000
Flowering	8.5–9.5	6–12	Medium–high	3000–9000
Dough grain	7.5–9	4–10	Medium–low	3500–10 000

Kikuyu

Potential for silage or hay

Kikuyu can make abundant medium-quality hay or silage. Hay is possible but tends to be difficult to make and often of low quality and poor palatability. Kikuyu silage has become more popular as a way of using excess growth in good seasons.

As the silage is usually only medium-quality, it must be conserved cheaply to have a useful place in farm management. It can be used to control excess growth and ensure that better pasture is available for grazing. N fertiliser, baling and harvesting are the main costs in making silage.

Kikuyu mgmt before silage

- Aim for the best feed value possible by cutting early (25–35 days' growth).
- Graze heavily then mulch, slash, mow or forage-harvest back to 5cm stubble (low as possible). Remove any heavy mulch to allow rapid, even regrowth.
- Topdress with 50–130kg N/ha (e.g. urea or ammonium nitrate) 7–10 days after cutback to improve silage quality.
- Irrigate if necessary.
- If kikuyu has already become rank, harvesting for silage may be a way of cleaning up the paddock. This silage will be of low quality and will require supplementation for dry stock. It will only be a long-term emergency feed and must be harvested cheaply and put in a pit for cheap, long-term storage. Do not waste money wrapping rubbish.
- White clover will improve the quality of forage from a kikuyu-based pasture.

Kikuyu mgmt after silage

Replace the nutrients removed. Expect each tonne of kikuyu DM to remove:

Nitrogen (N)	24.0kg (at 15% cp)
Phosphorus (P)	3.5kg
Potassium (K)	27 kg
Sulfur (S)	2.5kg
Calcium (Ca)	2.7kg
Magnesium (Mg)	3.0kg

These nutrients must be replaced by fertiliser to prevent long-term loss of soil fertility. P and K may best be applied to suit companion clover or oversowing of winter grasses.

Return to grazing management.

In autumn, silage may be excellent preparation before sowing ryegrass or clover into kikuyu.

Growth stage to harvest

Young leafy growth, approx. 30 days after cleaning up the paddock and topdressing with nitrogen (maximum green leaf).

Wilting requirement for silage

Essential. Expect 24–36 h wilting. Aim for 30%–45% DM for chopped silage, or 40%–45% DM for round-bale silage.

Type of silage

Round-bale and chopped. Use precision or double-chop machines.

Number of cuts

1 or 2 per season; extra may be possible but you would normally rotate silage and grazing after the second silage cut.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative (25–30 d growth); high N	9–10.5	15–20	Med–high	2000–3000
Late vegetative (40–50 d growth)	8–9	11–15	Medium	2500–5000
Rank (> 50 d growth); stemmy	6–8	6–10	Low	3000–8000

Maize

Potential for hay or silage

Maize is a premium silage crop producing a large bulk of good-quality forage. All growing and harvesting costs must be considered when assessing silage (some growing costs may be ignored when only storing excess pasture). Maize requires specialist row-crop planting and harvesting equipment and is suitable only for chopped silage.

Expect maize to cost $50 per tonne to grow and $47 to conserve, giving a total cost of $95–$100 per t of DM conserved.

Maize management before silage

Maize should be grown in rotation with lucerne, pastures or other crops to avoid build-up of disease, weeds and insects and to maintain soil fertility.

- When growing maize, select the best available variety. Avoid late-maturing varieties as these have lower digestibility and occupy ground for too long.
- Expect to use high rates of fertiliser.
- Control weeds. When sowing, ensure that the planter is calibrated to achieve a plant density of 65000 plants/ha (up to 80000/ha for early-maturing varieties and irrigation or good rain).
- Sow into good soil moisture.
- Sow at correct depth.
- Irrigate as required.
- Topdressing with N may be required.
- Maize for silage can achieve very high yields but there is a risk of crop failure during the growing season (see next 2 points).
- Crop establishment can be affected by soil temperatures, moisture at planting and attack by African black beetle.
- Harvesting may be delayed by wet weather in the autumn. Losses may not be complete and crops can usually be allowed to mature for a grain harvest.
- See sowing guides for more detail.

Maize management after silage

Maize should be rotated with legumes or pastures. Ensure that herbicide residues do not affect establishment.

Replace nutrients removed. Expect each tonne of DM to remove the following:

Nitrogen (N)	14kg
Phosphorus (P)	2kg
Potassium (K)	17kg
Sulfur (S)	10kg
Calcium (Ca)	2kg
Magnesium (Mg)	2.5kg

One bag of urea is needed per tonne of grain produced.

Deep tillage may be required if trucks and harvesters have compacted soil.

Growth stage to harvest

The milk or maturity line on the grain (colour change; Figure 2.8) should be halfway down the grain when the cob is broken in half (milk line score 2.5). At this stage silage should be an ideal 33% DM.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Milk line halfway (dough grain) (milk line score 2–3)	9–11	4.5–8.5	Medium to high	10 000–25 000

Wilting requirement for silage

None—harvested at milk line score 2–3.

Type of silage

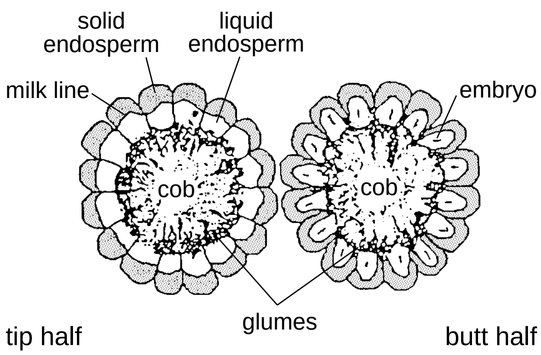
Chopped; short chop length preferred.

Number of cuts: 1.

Other comments

One tonne of grain equals 5.2–6.0 tonnes of silage, depending on growing conditions.

Figure 2.8. Harvest maize for silage at milk line score 2.5.



Grain sorghum

Potential for silage

Grain sorghum has potential to make high-quality silage containing up to 50% grain. It is a useful alternative to maize silage on drier areas and on poorer soils.

Grain sorghum management before silage

- Dual-purpose graze and grain types are available. Current varieties of grain sorghum can also be used to produce silage.
- See supplier for details of each variety. As a guide, sow 5–7kg/ha dryland or 7–10kg/ha irrigated.
- Ensure that adequate fertiliser is used.
- Control weeds if necessary. Consider possible herbicide residue effects on next crop.
- Irrigate as required.

Grain sorghum management after silage

- Replace nutrients removed from the paddock in silage.
- Grain sorghum can be followed by another crop in rotation or pasture.
- One bag of urea is needed per tonne of grain produced.

Growth stage to harvest

Early dough-grain stage of maturity at the centre of the grain head.

Wilting requirement for silage

None. Direct harvest at dough-grain stage.

Type of silage

Chopped.

Number of cuts: 1.

Other comments

- One tonne of grain equals 5.2–5.6 tonnes of silage from grain-bearing forages.
- The best yielding grain varieties are not necessarily the best silage yielding varieties. Avoid harvesting at late-dough to hard-grain as some grain may not be digested.
- Grain sorghums tend to maintain energy content even where drought has reduced yield.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Dough grain	9.5–10.5	6.0–9.5	Medium–high	4–6 (dryland), 6–10 (irrigated)

Sweet sorghum

Potential for silage or hay

Sweet sorghums have the potential to produce high yields of medium-quality roughage, which can be chopped as silage or carried over into winter for use as green chop (this practice is not commonly used now). It has a reputation for being cheaper and easier to grow than maize, but silage is often inferior to maize silage. Sweet sorghums may give reasonable yields under conditions that are unsuitable for maize.

Sweet sorghum management before silage

- Aim for maximum yields. Fertiliser, weed control and good plant establishment are essential. Use irrigation if available.
- Sow 10–15kg/ha dryland or 15–20kg/ha irrigating.
- Lodging can be a problem: grow as a row crop, avoid high populations, especially where fertility is high, and choose a less susceptible variety.

Sweet sorghum management after silage

Replace nutrients removed. Expect each tonne of sweet sorghum DM to remove the following:

Nitrogen (N)	28kg
Phosphorus (P)	3.5kg
Potassium (K)	20kg
Sulfur (S)	2.5kg
Calcium (Ca)	3.0kg
Magnesium (Mg)	3.0kg

After sweet sorghum has been harvested for silage, a paddock may be fallowed or planted to a rotation crop or permanent pasture. Some varieties may regrow for a second silage harvest.

Growth stage to harvest

Sweet sorghums are best harvested at the dough-grain stage of growth. Sweet sorghums have juicy stems; this maintains digestibility and slows down drying, allowing an extended harvest. Sweet sorghum can be direct-harvested successfully between the milk and hard-grain stage of maturity. Earlier harvesting will require wilting; this may be difficult to handle and will reduce yield.

Wilting requirement for silage

Can be direct-harvested at dough-grain growth stage, provided DM is 25%–35%.

Type of silage

Chopped.

Number of cuts

Generally 1 large cut only. Some varieties may be managed to give a second cut.

Other comments

- Sweet sorghums harvested at recommended times should cause no prussic acid poisoning worries.
- High sugar makes these crops easy to ensile.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Dough	8.0–10	5–7.5	Medium	10 000–25 000

Hybrid forage sorghum

Potential for silage or hay

Forage sorghum and sudan grass hybrids can be used for both hay and silage. Fine-stemmed varieties are preferred for baled hay or silage. Most varieties can be used for chopped silage. Feed quality is normally medium.

Forage sorghum can be grown deliberately for silage when a large bulk of medium-quality roughage is required. Alternatively, growth excess to needs can be ensiled in favourable seasons.

Management before silage

- Aim for the best feed value possible.
- Control weeds.
- Ensure young fresh growth by removing any old stems and topdressing with nitrogen before locking up for silage.
- Expect to use 50–100kg N/ha per cut.
- Irrigate if necessary.

Management after silage

Replace nutrients removed. Expect each tonne of forage sorghum DM to remove following:

Nitrogen (N)	24kg
Phosphorus (P)	3.5kg
Potassium (K)	20kg
Sulfur (S)	2.5kg
Calcium (Ca)	3kg
Magnesium (Mg)	3kg

After cutting for silage, forage sorghum can be returned to grazing management or locked up again for another silage cut, or the paddock can be resown to another crop or pasture.

Growth stage to harvest

About 1m high is normally the best compromise between quality and quantity. Feed quality often drops quickly when forage sorghums exceed 1.2m high. To maximise feed quality, cut when the crop is 60cm high, but this will significantly reduce DM yield per hectare.

Wilting requirement for silage

Wilting is essential. A large bulk of material can be slow to dry and difficult to handle in windrows. Aim for 30%–45% DM for chopped silage or 40%–45% DM for round-bale silage.

Type of silage

Round-bale (1 m high) and chopped.

Number of cuts

1 or 2 large cuts of medium to low quality or up to 4 smaller cuts of higher quality.

Other comments

- Well managed forage sorghum can produce a bulk of medium- to high-quality forage. Uncontrolled forage sorghum will produce a large bulk of low-quality forage.
- Forage sorghum that is less than 60cm high or moisture-stressed may cause prussic acid poisoning. Storage as silage will reduce prussic acid content.
- Cattle should receive sodium and sulfur supplements when fed forage sorghum.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative (60 cm)	9–10	12–18	Medium–high	500–1500+
Vegetative (100 cm)	8–9.5	7.3–17	Medium	1000–3000+
Vegetative or heading (> 200 cm)	7.0–8.0	4.5–11.5	Low	6000–12 000+

Millet

Potential for silage or hay

Many millets can be grown for forage and can be harvested for hay or silage. Varieties include Japanese (Shirohie), Siberian, and Pearl (pennisetum forage).

Generally millets are cheaper to grow than forage sorghums and should have higher feed quality, but they do not have the yield potential of the forage sorghums. Feed quality is very dependent on growth stage and management.

Millet mgmt before silage or hay

- Sowing details depend on variety.
- Ensure that plant density, weed control and fertiliser are adequate.
- Millets should be grazed early; e.g. at 30–45cm depending on variety , to encourage tillering and allow regrowth. Early-maturing varieties will thin out severely if grazed late (high).
- If grazing, topdress with nitrogen fertiliser at 50–100kg N/ha then lock up for silage or hay.
- If not grazing, ensure that adequate nitrogen is applied at sowing or by topdressing when the crop establishes.
- Millet is sensitive to waterlogging.

Millet mgmt after silage or hay

Most millet varieties will not recover to provide useful grazing after they have been harvested for silage or hay.

After harvesting, the paddock can be fallowed, sown to another crop in rotation or sown to pasture.

Replace nutrients removed. Expect each tonne of millet DM to remove:

Nitrogen (N)	25kg
Phosphorus (P)	3.5kg
Potassium (K)	20kg
Sulfur (S)	2.5kg
Calcium (Ca)	3kg
Magnesium (Mg)	3kg

Growth stage to harvest

Millets can be harvested for hay or silage any stage to dough-grain. Most millets do not produce a lot of grain; therefore, conserving at the more mature stage is likely to produce a larger bulk of lower-quality forage. Harvesting before seed heads emerge is best.

Wilting requirement for silage

Wilting is essential. Drying time will depend on yield, size of windrows and weather. Aim for 30%–45% DM.

Type of silage

Round-bale—young fine stems are best; chopped.

Number of cuts

Normally 1 . May be grazed before cutting but may not recover well after cutting.

Other comments

- Pennisetum types will give best yields.
- Mature stands being harvested to clean up a paddock should be chopped and stored in a pit for cheap drought roughage. Stems will puncture plastic.

Feed quality and potential yield. Actual values depend on variety.

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Vegetative	9–10.5	10–18	Medium–high	1000–4000
Heading	8–9	8–12	Medium	2000–6000
Dough-grain	7–7.5	6–7.5	Low	2500–10 000

Summer legumes (cowpeas and soybeans)

Potential for silage or hay

Summer forage legumes are useful in crop rotations and as a source of high-quality summer feed. They can be made into hay, but they are often difficult to dry adequately and so that they retain their leaves, so silage is becoming more popular.

Summer forage legumes do not produce the high yields of DM per hectare produced by forage sorghums, but they will have higher feed value. Work on the NSW North Coast has shown that soybeans have the highest yield and potential quality for silage.

Summer legume management before silage

Aim for the best feed value possible.

- Cowpeas or lablab may be grazed and then locked up for silage, but a one-off silage harvest should give high yields.
- Do not graze soybeans.
- Variety selection and planting time depend on location.
- Ensure good weed control.
- Fertilise as required at planting time.

Summer legume management after silage

Replace nutrients removed. Expect each tonne of cowpea or soybean DM to remove the following:

Nitrogen (N)	38 (legumes supply their own)
Phosphorus (P)	3.5
Potassium (K)	25
Sulfur (S)	3.5
Calcium (Ca)	13
Magnesium (Mg)	4.0

After harvest, the paddock can be fallowed, sown to another crop in rotation or sown to pasture.

Growth stage to harvest

- Early flowering is the preferred time to harvest cowpeas or lablab for silage, but yields are low.
- Harvest soybeans at the mid-pod-fill stage.
- Retain as much leaf as possible.

Wilting requirement for silage

Wilting is essential. Aim for 35%–45% DM for chopped silage, or 35%–45% DM for round-bale silage. Expect 12–24 hours' wilting in late summer.

Type of silage

Round-bale, chopped.

Number of cuts: 1.

Other comments

- Summer legumes such as cowpeas or soybeans can be an ideal crop before sowing a permanent pasture.

Feed quality and potential yield

Growth stage	Energy (ME, MJ/kg DM)	Crude protein (%)	Overall quality	Potential yield (kg DM/ha)
Cowpea, early flower	9.0–10.5	14–18	High	1500–3000
Cowpea, pod full	8.0–9.5	9–14	Medium	3000–8000
Soybean, mid-pod-fill	9.5–10.5	17–20	High	8000–10 000

Thanks to Peter Desborough, Senior Research Agronomist, Grafton, for information on soybeans.

Caution—pesticides

When growing crops and using surplus pasture for silage or hay, you must:

- **always read the label**
- **always observe the withholding period**

for any chemical product that you use on the crop or pasture.

Many chemicals do not break down during the ensiling process; observe the withholding period for grazing, and cut **after** that date for silage. Failure to observe withholding periods is asking for trouble and is illegal.

Animals fed on silage or hay made from crops treated with endosulfan require slaughter withholding periods in addition to the harvest withholding period.

Risks for residues from ensiled crop or pasture increase when:

- sprays are used late in the growing season and there is little plant growth to 'dilute' the chemical
- intended use changes for the crop or pasture. This would be more common in a crop where the plan had been to harvest grain but the intention changed to make silage. You would need to ask whether chemicals were used that may compromise silage use.

Some products registered in Australia are not used by our trading partners. As a result, they do not accept beef or dairy products carrying residues above low tolerance levels.

Best practice to avoid chemical residues from silage

- Minimise use of chemicals (especially insecticides) on crop or pasture to be ensiled.
- Do not grow forage where spray drift from nearby chemical usage is possible. For example, forage crops could be put at risk if crops requiring high chemical usage are grown in an adjacent paddock.
- Keep up-to-date with the acceptable domestic and export MRLs for chemicals used in your forage production. Review them regularly.

Advice on MRLs

- Talk to your district veterinarian at your nearest Rural Lands Protection Board.
- Talk to NSW Agriculture agronomists or livestock officers.

References

1. Castle, M. E. 1975. Silage and milk production. *Agricultural Progress* 50, 53–60
2. Gordon, F. J. 1989. The principles of making and storing high quality, high intake silage. In: *Silage for Milk Production*, ed. C. S. Mayne. British Grassland Society, Occasional Symposium No. 23, pp. 3–19.

Exercises

What are the main factors that affect the feed value of conserved fodder?

Can legumes such as lucerne and clover be used for both hay and silage? Which is best?

When is the best growth stage to harvest for hay or silage?

Can insecticides or herbicides be used on crops or pasture before harvesting for hay or silage? What problems could occur? Where can you find out about withholding periods?

Which crops have the highest yield potential?

Which crops have the highest potential feed quality?

Can you make hay or silage from old, rank forage? What is it worth? When could it be used?

3. Harvesting forage

Cut fodder should be dried as quickly as possible. This will retain as much leaf and as much feed value in the stored forage as possible. Anaerobic (no oxygen) conditions should be introduced as quickly as possible for silage.

Selecting a mower

There are three main types of mowers used in fodder conservation. In the past, the **reciprocating mower** has been used for clean standing crops that need to regrow quickly. The cleaner cut of the knife does not damage the growing crop as much as rotating mowers. Disadvantages are the slower ground speed, the inability to handle down and tangled crops, a tendency to block, and problems with sticks and stones.

The **drum mower** is suited to a wide range of pasture and standing crops. These machines can be driven faster than reciprocating mowers and will handle tangled crops and trash much better. However, the overhead drive catches tall crops and leaves clumps, the mower cannot leave a full-width swath (which can slow down drying), and it gives little opportunity to adjust the cutting height.

The **disc mower** is suited to either pasture or standing crops. It has the advantages of both the previous mowers as well as height adjustment, better tall-crop flow and a full-width swath.

Cutting

The height of the stubble after mowing is important to allow for rapid drying, and in the case of some crops, to allow for quick regrowth. A stubble height of 5–8 cm allows air movement through the mown material and reduces the moisture uptake from the ground. Most summer forages require a stubble height of 10–15 cm. For quicker regrowth from a lucerne crop the cut must not damage the plant crown.

Keep the swath as wide as possible to reduce drying time, and as uniform as possible. Blockages, clogging, dragging or missed areas will build into lumps or gaps when raking. This unevenness causes problems when baling and eventually results in misshapen or unstable bales.

Cutting time depends on the ability of the weather to wilt the crop rapidly and must fit into the farm routine. In hot dry conditions, rapid wilting may be possible with a late afternoon cut. In mild conditions, however, it may be necessary to allow a full day’s wilting by cutting early in the morning as soon as the dew has lifted. The main factors affecting plant sugar content are crop type and growth stage. The effect of time of day is small by comparison.

Conditioning

In conditioning, the material is crimped as it passes between rotating rollers or is bruised by high-speed impact in flail conditioners. Conditioning can shorten drying time of some crops by as much as 24 hours (but does make the material more susceptible to moisture damage by rain). It can be done at mowing or can follow as a separate operation.

The crimping setting is critical, as excessive crimping of fragile leaves can cause them to fall from the plant during the later operations. This is especially important when making hay.

Conditioning the crop requires more

power and can slow the cutting operation but can be of use when making hay from lucerne, cereals and thicker-stemmed legumes.

Roller conditioners usually have two rollers, rotating at different speeds, through which the mown forage passes. The conditioner is either trailed or attached to the mower. **Crushers** split the stems along their length; **crimpers** kink the stems at intervals. A few machines do both, and most direct the conditioned material onto the cut stubble in a 'fluffed up' condition that allows faster and more even curing.

Flail conditioners use high-speed impact to lacerate the surfaces of the plants as they pass through the machine. The effect is similar to that of the rollers but the flail conditioner can be more aggressive, sometimes chopping stemmy forages such as lucerne and cereals. The material should be laid evenly and lightly across the full width of the swath for fast drying.

Hay

Drying hay

The first principle of hay drying is to stop respiration as soon as possible. This is achieved by rapid drying, because respiration slows as the crop dries and ceases when moisture content is reduced to 35%–40%.

For baling hay, the moisture content should be 15%–18% (up to 21% in hot, dry weather). Higher moisture content than this will result in mouldy hay unless a preservative is used. In extreme cases (above 30% moisture), spontaneous combustion can occur. Overdrying can cause leaf loss during raking and baling.

Once a crop has been cut, leave it in the swath until it is half to two-thirds dry (well wilted) to minimise leaf losses during raking. Then rake it into windrows to allow air movement for drying. Do not rake too early as the windrow will become tight and ropy. Leaving it too long before raking, however, leaves it exposed to unnecessary bleaching, leaching and potential leaf loss. When raking, take care to rake evenly and in the same direction as mowing (to turn the leaves in and the stalks out) to form even windrows so the curing will be uniform. Do not rake too fast or leaves will be lost. On hot days, rake early in the morning or when dew is present to reduce leaf loss.

If windrows are not drying underneath, or if they become wet, ted them or turn them with a rake.

Quality losses due to rain are usually less in windrows than in the mown swath.

Raking hay

Use rakes with the gentlest action for haymaking.

Finger wheel rakes have a main frame with beams attached, on which overlapping raking wheels are mounted. These wheels are partially supported by a tension spring,which allows them to follow ground contours without excessive pressure on the fingers. Direct contact with the ground and forward movement cause the wheels to rotate, moving the hay forward and sideways. The hay keeps moving until it rolls off the end of the rake, forming a windrow. Rakes come in trailed, front- or rear-mounted, and 'V' formations.

Because of the constant motion, and because they are spring-mounted, finger wheels rake paddocks cleanly and can operate successfully on rough terrain. However, because the drive wheels are in constant contact with the ground, a lot of trash can be raked into the windrows. This can damage the baler and reduce hay quality.

Finger wheel rake teeth travel more slowly than parallel bar teeth (below), but the extra distance the crop is moved can result in more damage and excessive leaf loss. Finger wheel rakes can also produce a tight and more rope-like windrow than parallel bar rakes.

Parallel bar rakes have several parallel bars, along which several short raking tines are attached. The bars are joined together at each end by a common reel to form an assembly called a basket. When this is rotated by a drive, the raking action delivers the hay swath into a windrow to the side of the rake. Rakes can be trailed or front- or rear-mounted, and can be hydraulically, PTO- or ground-driven. They can be set to rake in tandem or to rake two windrows into one.

The major advantage of parallel bar rakes is the short distance the crop has to move from swath to windrow. The gentle raking action and short distance minimise crop damage and leaf loss. The easy adjustment of the basket angle allows these rakes to form loose fluffy windrows or tight compact windrows.

Most **rotary or tedder rakes** can perform a range of operations, including windrow spreading, tedding, tedding hay from a swath, and fenceline raking. Tedding involves the lifting and spreading of either a swath or a windrow and fluffing it up to let air circulate freely to increase the rate of drying. These rakes are better for wilted silage production as they enable more rapid wilting under unfavourable drying conditions.

Rotary rakes come in a range of configurations. Usually they consist of horizontally mounted rotors driven by the tractor's PTO. Single rotors deliver the hay to one side, but cannot ted the hay. Double-rotor inward-turning rakes produce a windrow between the rotors. Machines can be switched from windrowing to tedding. Some machines can also be adjusted to alter the aggressiveness of tedding.

It is essential to use the recommended PTO speeds when using a tedder rake, otherwise there could be excessive leaf loss.

Baling hay

The type of hay baler must match the bale handling system.

Small rectangular balers produce bales that can be handled by people and machines.

Large rectangular balers have at least double the capacity of small rectangular balers. The bale size is designed for machine handling and transport, and so saves labour compared with the small rectangular baler. Ensure that bale size will fit neatly onto the tray of your truck and that your equipment can handle large bales.

Large round balers have a capacity up to that of large rectangular balers. The bales (250–650 kg) are designed for use with a tractor and a front-end loader. They are not as efficient to transport as large rectangular bales because of uneven stacking, but they can unrolled easily to feed to stock.

Carting hay

Small rectangular bales

The **manual system** uses a truck with a bale loader. The truck is then driven to the stack and unloaded using an elevator. This system requires a very high labour input.

The **bale juggler** or **accumulator and impale loader** system gathers the bales into groups that can then be picked up at a later stage using the impaler fitted to a front-end loader. The bales can be stacked up to 14 high, depending on the front-end loader used.

The **bale carrier** loads and carts the small rectangular bales. A short elevator picks up the bales in the field and transfers them onto a long conveyor. The load is carried to the stack and unloaded from a chute at the rear of the carrier.

Automatic bale wagons can be either self-propelled or tractor-drawn. They automatically load, stack and unload small rectangular bales. A short elevator transfers the bales onto a platform that, when full, lifts the bales onto the wagon. The wagon carries the load to the stacking area, where it can be tipped to form a stack.

Round bales

These machines may be linkage-mounted, front-end-mounted or trailed.

Impalers are the simplest machines for handling round bales. They consist of a spindle or spike, which is thrust into the centre of the bale to lift and carry it. Bale core density can greatly affect the operation of an impaler. Hard cores can be hard to penetrate, and soft cores deform easily.

Fork handlers consist of a 2-pronged arrangement that can be attached to a tractor by several different methods. The forks are tapered so they can easily slip under the round bales and sometimes are adjustable in separation. Fork carriers have good bale stability, and front-mounted versions are very effective for loading onto trucks and trailers.

Grabs consist of 2 hydraulically operated side arms, which clamp the bale on either its sides or its ends. They can be rear-mounted or attached to a front-end loader. Grabs are used mainly for feeding out. The bale is gripped centrally on its ends by the rotating cones or spindles, then lowered to the ground and unrolled as the tractor moves forward. Some models have hydraulically driven spindles, which rotate the bale and feed it out without relying on ground contact. Front-end-mounted grab units that can manipulate the bale (for example, turn bales on their ends) are extremely useful for stacking.

Forklift units are generally multipurpose machines that can be used for a wide range of stacking and carting operations in addition to round bale work.

Carriers are usually self-loading and -unloading and are suited to carting 3 or more bales at once. A centre-mounted, hinged side arm gathers the bale and moves it up onto the cradle. A plunger then pushes bales forward or back until the cradle is full. Unloading is done by tilting the whole cradle and rolling bales off.

Another type is front-loading and has a folding side arm moving onto a feed-out device. Bales are pushed back until the cradle is full and are then transported. To unload, the whole cradle tilts backwards and stacks up to 4 bales on their ends. Recovery for feeding out reverses the procedure, and bales are continually moved to the front feed-out device as required.

Another multiple bale design straddles the bales, grips them and then lifts them for transportation.

Silage

Wilting silage

Wilt the crop down to a DM content of 30%–45% (40%–45% for round-bale silage). The length of time taken to wilt (or whether wilting is even necessary) will depend on the initial moisture content, yield and weather, but could be up to 48 hours. Longer, and quality will decline.

Wilting the crop to above 45% DM will make compaction and air removal difficult and is not recommended. Below

25% DM, however, the crop will lose nutrients draining as effluents from the stack and may experience the growth of clostridial bacteria.

Harvesting silage

Forage harvesters

The **single-chop harvester** is simple, cheap and robust. However, it generally cuts the crop into lengths that are too long and it is more likely to contaminate the forage with soil. The longer the material, the lighter are the trailer loads, the more difficult the silage is to compact, and the harder it is to remove from the stack. Silage quality is usually lower when a single-chop harvester is used. These harvesters have a lower work rate and are less capable of handling tall crops such as maize. Chop length also influences animal intake: the shorter the chop length, the higher the potential intake.

The **double-chop harvester** is similar to the single-chop harvester, but the material is cut a second time by a cylindrical or flywheel chopper. Length of chop is adjustable. The chopped material is easier to compact than that produced by the single-chop harvester.

The **precision-chop harvester** is ideal for silage, as the cylindrical or flywheel chopper cuts the material into much smaller lengths than even the double-chop machine. It has 3 attachments that allow it to direct-cut forage crops and pastures, to direct-cut row crops such as maize, or to pick up wilted material from a swath or windrow.

All 3 machine types are suited to picking up wilted material, although machines with windrow pick-up attachments may be more efficient in reducing dry matter (DM) losses.

Silage wagons have the pick-up and cutting mechanism incorporated into the wagon. Most silage wagons pick up and chop cut and windrowed material. Silage wagons can be efficient for one-operator situations, but the harvester is out of operation while the load is being transported. This may reduce work rates if extra labour and tractors or trucks are available.

Baled silage

Balers must be able to make the bale under pressure to expel air and compact the forage. Bales can be round, square or rectangular, and are wrapped in or covered with plastic.

Compared with chopped silage, baled silage is convenient to handle and store. It also suits smaller areas, where silage can be used as a management tool to improve subsequent pasture quality.

The life of the plastic wrap varies from 12 to 24 months, depending on the type of plastic, storage conditions and the number of layers. The longer storage life is achieved with some plastics by using extra layers of wrap and turning bales to sit on their flat end. Wrapped baled silage should be fed out before the plastic breaks down.

For storage beyond 2 years, store unwrapped round or square bales in stacks covered with plastic silage sheeting or store underground. This not only allows longer storage, but also saves the cost of plastic wrap. (Silage wrap is not easily disposed of. Unless an environmentally friendly disposal method is found it can be expected to become a significant pollution problem in the future.)

Round bale silage is a very convenient method of conserving a temporary excess of pasture. This improves pasture management and utilisation and reduces development of rank, low-quality pasture. Traditional haymakers who wish to make some silage will find the flexibility offered by the round or rectangular bale system well suited to their needs.

Figure 3.1. Bale formation in an adjustable-chamber baler. Left: bale core. Centre: half-completed bale core. Right: completed bale.

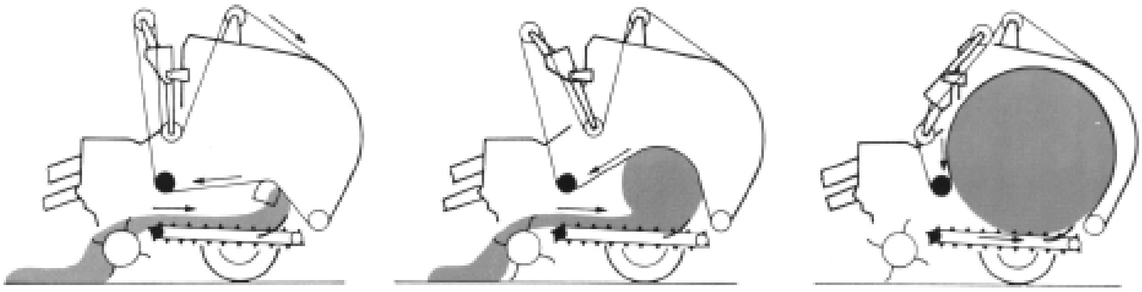
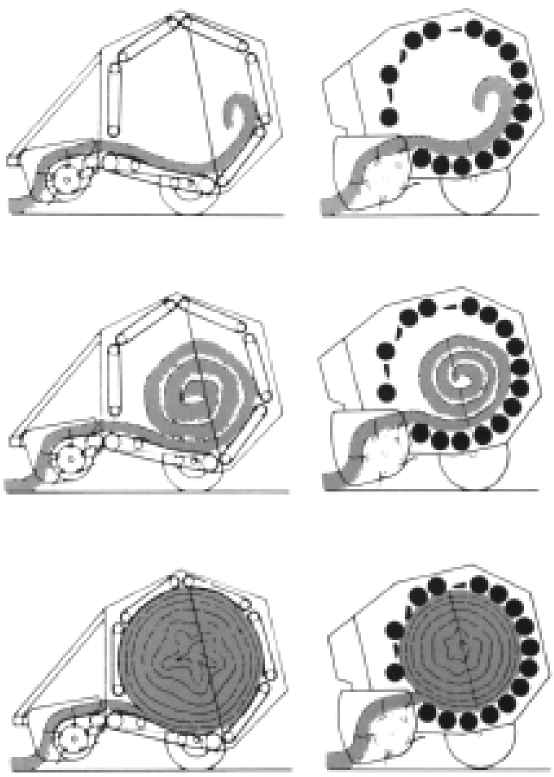


Figure 3.2. Bale formation in fixed-chamber balers. The baler on the left uses belts; the one on the right uses rollers.



Disadvantages of round bale silage include increased cost, possibly inferior-quality silage, slower work rates than a precision-chop silage system, and a longer chop length. New-generation chopping balers overcome this last disadvantage by chopping forage as it enters the baler, allowing higher bale density.

With group storage, rectangular or round bales can be packed into pits, or grouped above ground in a row or small heap (2 bales in the bottom row and 1 on top for round bales) and covered with plastic sheeting. Important considerations with round bale silage production are the need to minimise the time between baling and storage, and effective sealing. As a general rule, bales must be produced, carted and placed in storage on the same day. Wrap bales where you want to store them. Effective air exclusion is vital, so take care not to puncture the plastic. Check the bales regularly during storage to ensure that the cover has not been damaged.

Silage trailers

The most commonly used trailers are tipping trailers and self-unloading forage boxes. A trailer must have a large capacity and be able to unload quickly. Forage boxes hold 2–5 tonnes but are slow to unload. Tipping trailers are available in various sizes and can be rapidly unloaded from the hinged rear gate. Tip trucks are also used, and are becoming more popular as they are much more manoeuvrable and are quicker in delivering the material to the silo or pit.

Chop length and animal production

Silage chop length varies from short (1–3cm), with precision-chop forage harvesters, to long, with flail harvesters, some forage wagons and baled silage.

Finer chopping of low-DM forage can improve fermentation through a more rapid release of plant sugars. With heavily wilted forage (DM greater than 45%), it will also allow better consolidation and more effective air exclusion, and should therefore produce a better silage. With good management, the effect of chop length on fermentation of silages with intermediate DM content (30%–45%) should be small. The direct physical effect of chop length on animal intake is probably the more important factor influencing animal production, and operates independently of silage DM.

The response by cattle to shorter chopping has been variable and is probably influenced by a range of dietary factors, including level of concentrate feeding, proportion of silage in the diet and perhaps silage digestibility. On balance, it is likely that, given good silage management, there will be little advantage in chopping silage shorter than 5cm, especially for cattle on high-concentrate diets. Maize silage, and probably grain sorghum silage, is an exception, as chopping to about 1.5cm is required to break up the grain.

Silage additives

The quality of a silage is only as good as the parent material. Silage additives can improve the fermentation process, for example when making under-wilted legume silage, but are probably unnecessary if you can rapidly wilt the parent material to an optimum DM content.

Where weather conditions do not allow wilting, silage additives may prove cost-effective, but they will not prevent effluent losses. In fact, some additives will increase effluent losses.

Grain can be mixed with precision-chopped material to produce a higher-quality silage. This can be used for special-purpose feeding. Advantages could include eliminating the need for grain processing at feeding time, but the economics need to be looked at. Adding grain will not affect the silage fermentation as most silage bacteria cannot ferment starch (the key component of grain), but it can reduce effluent loss from wet silage as the grain can soak up the moisture. Don’t use mouldy grain or grain likely to contain chemical residues.

Types of additive

Many additives have been used when making silage. In the UK market, 126 additives were commercially available in 1990! In Australia, the list is not so exhaustive. Table 3.1 describes the different types of additives and includes products or byproducts that are easily available, are safe to handle on-farm, and can be applied during chopping or at the pit or bunker.

Are additives effective?

There is a lot of interest in the use of silage additives to manipulate silage fermentation. Many questions are being asked: are they worth the extra cost, what do they do, do they improve silage quality, do they reduce losses from aerobic deterioration during feeding?

Aerobic deterioration during feeding can cause large losses of silage. In northern NSW and southern Queensland, where conditions are warmer during feeding out, silages are likely to be more unstable when opened. Some silage additives are thought to reduce losses from aerobic deterioration.

At this stage there are no Australian data to establish whether any silage additive is cost-effective in terms of improved milk production.

Table 3.1. Classification of silage additives*[1]*. *(Not a complete list of silage additives. Commonly used examples are given under each category.)*

Additive	Examples	When to use
Silage inoculants	Lactic acid bacteria	Could be used on any crop. Do not use on low DM crops (less than 25%) that are also low in sugars
Carbohydrate sources*	Glucose, molasses, cereal grain, citrus pulp, whey	On pasture or crops low in DM and sugars
Enzymes	Cellulase, hemicellulase	Generally in combination with inoculants
Fermentation inhibitors	Formic acid, propionic acid, salts or organic acids	Pastures or crops low in DM and sugars
Aerobic spoilage inhibitors	Lactic acid bacteria, propionic acid, propionic acid bacteria, ammonia	Used when silage is prone to spoilage during feed-out
Nutrients*	Urea, ammonia, minerals, grain	To increase the energy or protein content of the silage

* Most substances listed under carbohydrate sources can also be listed under nutrients.

Inoculants

US and European studies with inoculants show their effects to be inconsistent. Although inoculants often reduce storage losses, animal production responses have been variable. Based on these results, the economic benefit of inoculants appears, *on average*, to be marginal. However, some experiments have recorded good responses. More research is required to find where we can expect economic responses.

Silage inoculants sold in Australia are mostly cultures of lactic acid bacteria. Some products now include propionic acid bacteria as well.

When poor wilting conditions exist, inoculants may be useful in improving fermentation if the forage contains high enough levels of plant sugars. Inoculants tend to be more effective when DM content exceeds 30%. With high-moisture low-sugar forages, acid additives are likely to be more effective than inoculants.

Where aerobic spoilage is a problem after the pit or bunker has been opened, then using an inoculant at the time of ensiling may have helped in reducing these losses. More research is needed to see which types of silage inoculants are suitable for this purpose.

Silage inoculants cannot prevent effluent losses, overcome contamination with soil during ensiling, or make good silage from poor-quality forage.

If you use an inoculant, choose one that provides more than 1 million CFUs (colony-forming units) per gram of forage. It is best to spread the inoculant uniformly through the silage material while harvesting. Inoculants can be applied at the storage site if necessary.

Do not forget that inoculants are not substitutes for rapid and continuous filling of the pit or bunker, good compaction or tight sealing.

Direct-chop crops such as maize and sorghum are less likely to benefit from silage inoculants, although in-storage losses and aerobic spoilage may be reduced. Where lightly wilted forages are used, silage inoculants may improve silage fermentation.

As a general rule, crops that can be cut, rapidly wilted and then precision chopped are least likely to respond to inoculants.

Wilted crops provide more suitable conditions for the growth of lactic acid bacteria, and undesirable bacteria are inhibited.

Continued research and development on inoculants is likely to lead to more effective products. It is now well accepted that there is significant variation between bacteria and bacterial strains in their capacity to improve silage fermentation and reduce in-silo losses. This would have accounted for a large proportion of the variation in the response to inoculant in earlier studies.

In the future we will probably have specific inoculants available for specific crops, in much the same way that specific rhizobial inoculants are used for inoculating each legume species. Producers will need to look for an inoculant that is suitable for their crop or pasture and has been evaluated under Australian conditions.

Making quality silage—a silage maker's guide to getting good fermentation

Harvest all forages at the correct stage of growth to produce a highly digestible silage. Use the table opposite to help you assess whether you are making the best silage you can.

Scores:

- Below 17: Possibility of poor fermentation. Wilt or use an additive.
- 17–20: Borderline.
- Above 20: High probability of a good fermentation.

Factor	Points	Your score
Available forage type		
Legumes	3	
Tropical grasses or kikuyu	3	
Millets	3	
Forage sorghums	4	
Winter cereals	5	
Temperate grasses	5	
Maize, sweet sorghum, grain sorghum	6	
Stage of growth		
Vegetative, immature	1	
Head emergence (grass), early flowering (legumes)	2	
Mature	3	
Fertiliser nitrogen (N)		
Grasses with more than:		
100 kg N/ha	1	
50–100 kg N/ha	2	
zero N	3	
Legumes, maize, sweet and grain sorghum, irrespective of N rate	3	
Broadleaf weed contamination		
Heavy	1	
Light	2	
None	3	
Weather		
Wet	1	
Dull, overcast; slow wilt	2	
Fine and mild	3	
Fine and warm or hot; rapid wilt	4	
Crop DM content		
< 15% not recommended	0	
15%–20% not recommended	1	
20%–25%	3	
25%–30%	4	
30%–35%	5	
35%–40%	6	
> 45%	3	
Chop length, harvesting method		
Flail, forage wagon baler	3	
Double chop	4	
Fine chop	5	
Total score		

Harvesting and storage losses

Losses of both quantity and quality in the field and during storage have an important effect on animal production and profitability. Losses during hay-making are generally higher than during silage-making because of greater susceptibility to rain damage and higher field losses. Field and storage losses vary with silage DM content. Table 3.2 shows typical losses from grass silage systems in Europe with good management.

Field losses

Field losses are due to plant respiration, mechanical handling losses and weather damage. During wilting they vary with forage type and the number and type of machinery operations, but weather will have the greatest effect. With good management and weather that favours a rapid wilt, DM losses should be less than 6%, less than the effluent losses that occur with low-DM direct-cut silage. Generally, respiration losses in the field are low where the crop is unwilted or is rapidly wilted, but under poor wilting conditions DM and quality losses increase. Silage fermentation can be adversely affected if there is excessive loss of plant sugars by respiration. This may be important in forages with low sugar content; for example, legumes and summer-growing (tropical) grasses such as kikuyu.

Rain damage can dramatically increase hay-making losses but has less effect on silage. In a European study, DM losses during field wilting increased from 4% without rainfall to 10% with more than one day's rain. Less than one day's rain had a negligible effect.

Storage losses

Storage losses include those due to respiration and fermentation, effluent losses and surface waste. There will be some DM losses by respiration shortly after sealing and before anaerobic conditions and the subsequent fermentation are established. These are unavoidable but are generally below 6%, provided the desired lactic acid fermentation occurs. Energy losses are less because, although the fermentation leads to a loss of DM, the fermentation products generally have a higher energy value than the original material.

Effluent losses can be eliminated by wilting forage to a DM content of at least 30%. Surface waste can be minimised by effective consolidation and sealing during the ensiling process. With good management, silage storage losses are still higher than those from hay in a shed (6% vs 3%–5%), but are considerably lower than from hay stored outdoors.

Where silage has been inadequately consolidated in the silo (or bale densities are low), and where sealing is delayed or is inadequate, storage losses can be very

Table 3.2. Typical DM losses in well managed grass silage production systems in Europe[1].

Source of loss (%)	Silage DM content (%)						
	15	20	25	30	35	40	45
Field	–	–	2	5	9	12	13
Respiration + fermentation in storage	10	9	7	6	5	5	7
Effluent in storage	9	4	2	1	0	0	0
Total	19	13	11	12	14	17	20

high. Such losses can substantially reduce the animal production per tonne of forage ensiled. Most of these losses occur as surface spoilage. When you consider that 20%–25% of the silage in bunkers or stacks is often within the top 1m, total losses can be large. The situation is similar with baled silage.

A survey of unsealed and sealed horizontal silos on farms in the USA showed that sealing reduced estimated DM losses by 27% in the 0–50cm layer and by 9% in the 50–100cm layer . The efficiency of sealing varied considerably. In controlled studies[2], where DM losses were measured more accurately, losses from unsealed silage were 78% at 25cm depth and 23% at 50cm, compared with only 7% and 2% from sealed silage. The rate of DM loss in the surface layer in this experiment was 0.7%–0.8% a day in unsealed silage. Further from the surface there was a delay in the onset of DM losses, which nevertheless occurred at the same rate.

Apart from DM losses, significant silage quality losses also occur when silage is not covered, or is inadequately sealed. These additional losses result in reduced animal performance from the remaining silage. For example, in three experiments with wilted lucerne silages in the USA, failure to seal the silage stacks with polyethylene sheeting reduced liveweight gain in cattle by 26% (0.44 vs 0.33 kg a day). Clearly the cost of poor silage management is high.

Total field and storage losses

In a well managed silage system, these should be kept to 15% of DM and 12% of energy. In a study in 8 European countries comparing silages made from wilted grass or unwilted grass + silage additive, ensiling lightly wilted forage with a 24%–33% DM content resulted in minimum silage losses of 12%–15% of DM. The time taken to wilt forage to > 30% DM would be greater under European conditions than in Australia. A more rapid wilt should thus reduce DM losses, particularly from crops with a low sugar content.

Measuring DM

Moisture probes are reliable for when you are making hay but not for silage. If you want to be more accurate you can take a representative sample from throughout the windrow, dry it in the microwave oven and compare the before and after weights. Remember that DM + moisture content = 100%.

Field experience shows that it is easy to overwilt cereal silage and underwilt lucerne and some other legumes. By keeping a close eye on the cut material it may be possible to ensile earlier than you expected.

Measuring DM content with the squeeze test

1. Take samples from the cut crop from across the paddock.
2. Mix them together.
3. Take a portion and chop it up with shears.
4. Take a handful and squeeze tightly into a ball for 30 seconds.
5. Release suddenly.
6. Work out the DM content from the descriptions in Table 3.3 (over).

For forage-harvested (chopped) material, start with a representative sample at step 4.

Table 3.3. Use the squeeze test to estimate dry matter percentage.

Result	Estimated DM content	Action
Ball retains its shape; some free juice is expressed	< 25%	Too wet; must be wilted. Risk of low-quality silage
Ball retains its shape but no free juice is expressed	25%–30%	Wilt more to ensure high-quality silage
Ball falls apart slowly	30%–40%	Good for pit silage
Ball falls apart rapidly	> 40%	40%–45% is good for round bales

Using the microwave oven to measure DM for silage

Microwave ovens provide a simple way to determine the DM (or moisture) content of pasture or fodder before ensiling. The main problem is taking a representative sample, so take several to get an average. Use the following procedure:

1. Collect average samples from your crop and mix thoroughly to make up the test sample.
2. Weigh a container or tare scales to zero.
3. Cut forage into 5–10mm pieces and weigh 100–500g of sample. Record this weight: this is the wet weight.
4. Place the sample in the microwave oven for 3–4 minutes at full power. Weigh the sample again and record the weight. Stir the sample and put it back in the oven.
5. Repeat step 4, reducing the time to 60 seconds as the sample becomes dry. Dry weight is reached when the sample stops losing weight. If the sample chars, use the previous weight for calculating moisture content.
6. Calculate DM% = dry weight × 100 ÷ wet weight. Example: wet weight = 426g; final dry weight = 95g. Therefore DM% = 95g × 100 ÷ 426g = 22.3% DM.

References

1. McDonald, P., Henderson, A. R. and Heron, S. J. E., 1991. *The Biochemistry of Silage*. Chalcombe Publications, Marlowe.
2. Bolsen, K. K., Dickerson. J. T., Brent, B. E., Sonon, R. N. Jr, Dalke, B. S, Lin, C. and Boyer, J. E. Jr, 1993. Rate and extent of top spoilage losses in horizontal silos. *Journal of Dairy Science* 74, 2940–62.

Table 3.4. Characteristics of pasture and conserved fodders.

% DM	Fodder type	Appearance	Comments
10–16	Very lush green pasture	Easy to squeeze moisture from stems or leaves	Very palatable and high feed value. High moisture content may limit animal's ability to eat enough DM for high production
16–22	**Excellent pasture**	Can squeeze moisture from stems or leaves with slight pressure	Excellent pasture for maximum production
> 25	Old pasture showing seed heads, flowers drying off, seed starting to harden; lucerne showing seed pods; moisture-stressed pasture	Ball squeezed in hand will spring open. The quicker it springs open, the drier the pasture	Increasing fibre, decreasing digestibility. Feed value of grasses declines rapidly
18–25	Direct-cut silage	Squeeze sample of chopped silage into a tight ball—will retain shape when released; moisture on hands or juice squeezed out	Save 1 operation in silage-making process. High moisture makes silage easier to compact. Moisture drainage will remove nutrients and may cause pollution problems. Risk of poor fermentation with high moisture
30–40	**Wilted silage**	Sample will fall apart slowly after being squeezed into a ball. No moisture visible	Excellent conserved fodder. Requires careful compaction. Usually very palatable. Allows high levels of DM consumption and good production
45–60	Heavily wilted silage	Appears dry, but moisture will show if stems are scratched or twisted hard. Bark lifts easily if scratched	Successful storage depends on removal of air and complete sealing of storage. Compaction is difficult in bunker: must be finely chopped. More difficult to exclude air from round-bale silage made at this DM level
		Dark	DM content above 50%. Not recommended
70–75	High-moisture hay	Stalks tough; take severe twisting to break. Bark may lift from stem when scratched. Thick stems may show moisture. Squeeze test: ball will spring open	Likely to heat. Will produce 'brown hay', which is very palatable but of low feed value. Risk of fire. Can go mouldy. Hay preservative can reduce these problems
80–85	**Ideal hay**	Hay rustles when handled. Scratch top of lucerne stalk, bark will not lift. Stalk will snap with a few sharp twists. Distinctive smell.	Excellent conserved fodder. Safe for storage. Suitable for long-term storage provided effects of weather and vermin are minimised.
> 88	Very dry hay	Brittle, dusty	Very dry. Likely to be poor quality owing to loss of leaf and dust

Exercises

What is the ideal DM percentage for bulk, chopped silage?

What is the ideal DM percentage for baled silage?

What is the ideal DM content for hay?

How quickly should silage or hay be wilted?

Is it better to cut in the morning or the afternoon?

What is the best cutting height?

What are the advantages and disadvantages of conditioning?

How can you tell when a crop is dry enough to bale or harvest?

What are the main features of rakes and tedders?

What are the advantages and disadvantages of flail, double-chop and precision-chop forage harvesters?

What is the difference between long and short chop when making silage?

Why would you consider using additives or inoculants with silage?

How can you minimise losses in feed value of silage or hay?

4. Storing fodder

How fodder is stored depends on many variables, such as type of crop, how long it will be stored, equipment available, and capital available for permanent structures.

Hay

What is good hay?

Hay is preserved by drying. Ideally it should be 82%–85% dry matter (DM). If it is too wet, losses are likely to occur from heating and mould development. In extreme cases (65%–75% DM) it can heat enough to cause fire. If it is too dry (approx. 88% DM), it is likely to be stalky and dusty.

Good hay is made from high-quality forage cut at the optimum growth stage, then dried and stored as quickly as possible. Slow drying causes loss of feed value. You can assess good hay by the following characteristics:

- Species: Legumes have highest potential quality; temperate grasses are usually better than tropical grasses.
- Growth stage: See section 2 for details. Aim for maximum leaf. Mature stems and seed heads have lower feed value.
- Colour: Green indicates quick drying, a minimum of weather damage and maximum quality.
- Smell: Mould and dust could indicate palatability problems and loss of feed value.
- Foreign matter: This can be a hazard to stock or can introduce weeds to a property.

Storing hay

Keep hay dry and protected from stock and vermin damage to minimise losses. The ideal store is a purpose-built shed with a dry floor, protection from wet weather and easy access for stacking machinery. If a shed is not available then short-term storage outdoors is possible, but losses can quickly become unacceptable.

There are various designs for stacking traditional small square bales. All are based on a pattern of interlocking bales to produce a neat, stable stack. Figure 4.1 (over) shows a simple and effective design.

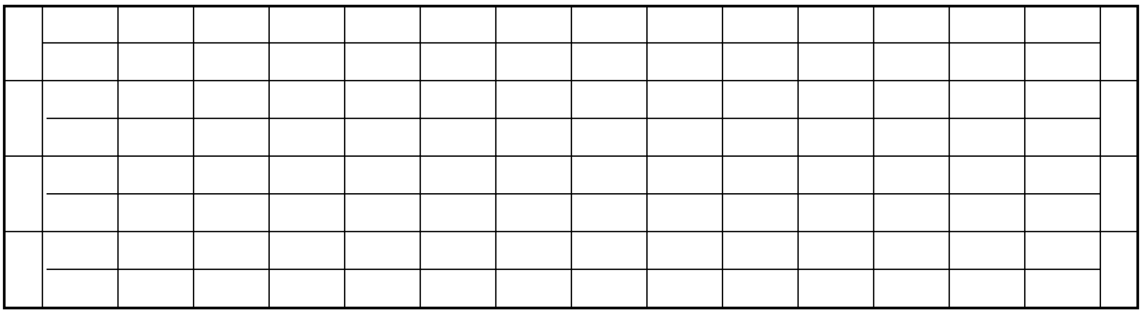
Round bales stored in a shed are normally stacked on their flat end. Most sheds and machinery will accommodate round bales stacked 3 high. Stacking 4 high is possible but may require some adjustment to sheds and handling equipment.

The rate of loss of hay stored in the paddock will depend on location and rainfall. Large and small rectangular bales must be covered with plastic if they are stacked outdoors. Round bales may be acceptable after 1–2 years in some locations provided they are tight enough that water runs off the bale and the site is well drained. In coastal areas round bales often stabilise with 5–7cm of weather damage on the top but will rot from the bottom when sitting on wet ground. Anything that reduces contact with wet ground, such as old fence posts or free-draining gravel, will reduce losses.

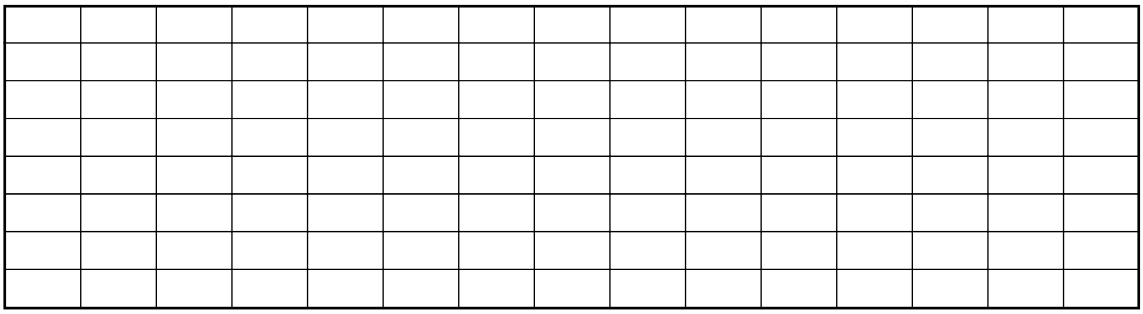
Place bales in rows, end to end. Set rows at least 30 cm apart to allow free drainage and to discourage vermin from nesting between bales. Rows should run up and down a hill so as not to catch surface runoff, and should run north–south so that both sides receive sun. If rows run east–west the shady southern side may develop mould.

Figure 4.1. A suitable design for stacking square baled hay.

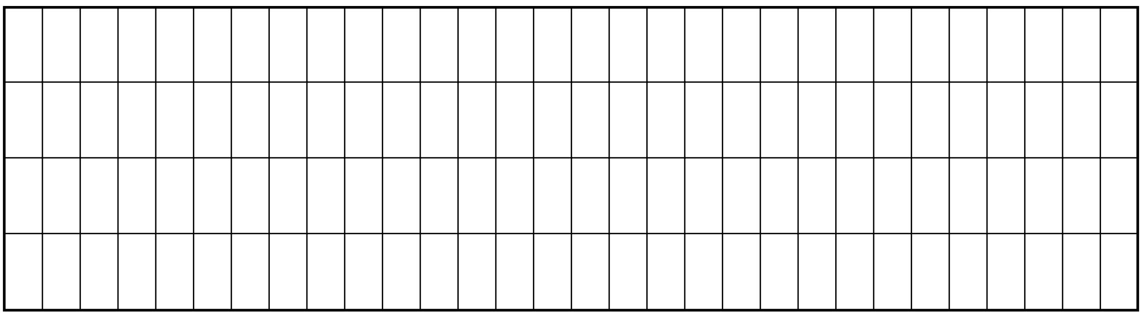
First row: bales laid on the flat side; straight bales on the outside.
Use for rows 1, 5, 9, 13, 17, 21.



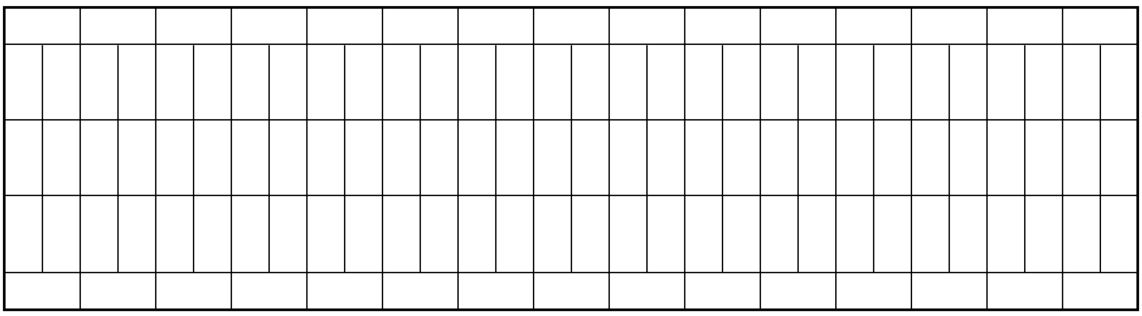
Second row: bales laid on the flat side. Use for rows 2, 6, 10, 14, 18, 22.



Third row: bales laid on the flat side. Use for rows 3, 7, 11, 15, 19, 23.

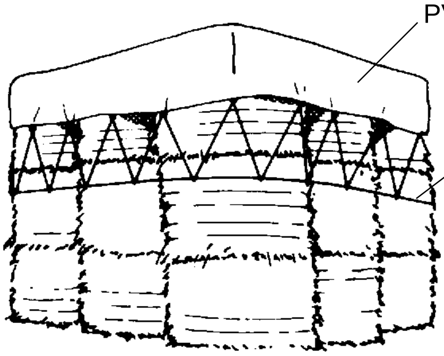


Fourth row: bales laid on the flat side. Use for rows 4, 8, 12, 16, 20, 24.



Various covers and spray-on weather protectants are available and may be useful in some situations, but their cost-effectiveness is doubtful if the bale rots from the ground up. Figure 4.2 shows round bales stacked outside.

Figure 4.2. Round bales stacked 3 high. These have a PVC cover tied down to a run of strained wire used to hold the stack together.



The main causes of losses during storage will be stock or vermin damage or loss of quality by heating or rotting of wet hay. Heating is likely when hay is stored with moisture levels above 25%; the greater the temperature the greater the loss. Ignition can occur at 200°C if enough oxygen is available or 280°C if oxygen is limited. In this event, you lose not only quality but also the hay and invariably the hayshed. Some heating of hay may improve palatability through caramelisation but feed value will be reduced. Table 4.1 shows losses in feed value at a range of temperatures.

Table 4.1. Loss in digestible protein and energy at a range of temperatures[(1)].

Maximum stack temperature	Loss of digestible protein (%)	Loss of energy (%)
Up to 45°C	None	5–10
45°C–55°C	10–30	5–15
55°C–70°C	30–80	15–30
70°C–75°C	100	40–70

The best way to reduce loss of hay quality by heating is to ensure that the hay is sufficiently dry before baling. If this is not possible then silage may be a better alternative. Drying can be speeded up by conditioning the crop when cutting or by spraying lucerne (but not grasses) with potassium carbonate when cutting.

Inoculants using bacteria or preservatives based on ammonium propionate allow safe storage of hay at up to 25% and 30% moisture respectively. These treatments are sprayed onto the hay while baling. Hay stored like this loses fewer leaves and thus has potentially higher feed value.

Buying hay

Hay is a readily traded commodity. With a much lower moisture content than silage, it makes transport relatively cheaper and more efficient.

To accurately compare the cost of hay with silage or other feeds you must allow for moisture content by comparing cost on a DM basis. Ideally moisture should be measured. If this is not possible, assume hay has a moisture content of 15%–18%.

Buy hay by weight. If you buy hay by the bale, be aware that small ‘square’ bales commonly vary from 17kg to 26kg per bale. Round bales also vary widely in weight. Diameter has an enormous effect on their volume: a 1.5m bale will contain 56% more feed than a 1.2m bale.

Storing bulk or chopped silage

The most efficient, economic, long-term storage system is chopped silage stored in above-ground buns or stacks, earthen pits, concrete bunkers (above and below ground level) and, to a lesser degree, tower silos (sealed silos). Capital cost to build and maintain systems varies but the diagrams here show some ideas that may suit your budget.

Having dedicated bunkers for different types of silage (and silage quality) is a good idea. For example, if you grow lucerne and make lucerne silage, store it separately from any cereal silage you make.

Where to put the bunker

Pits or bunkers should be close to the required feed-out area. Remember: you spent several days carting feed from the paddock to the pit, but you may spend several months carting feed from the pit to the cows.

The site chosen must be easily accessible in all weather, well drained and possibly gravelled to form an access area. Choose the site so that any leakage will not run off into creeks, dams or neighbouring property, and smells will not upset neighbours.

How big should the bunker be?

There is no correct answer to this question, but the rules are:

- Depth: 1.8–2.5m to ground level then extra for the mound
- Width: at least $1\frac{1}{2}$ times the width of the tractor used to roll the pit. If it is too narrow the centre of the pit cannot be rolled.
- Length: as long as you think you need. For less aerobic spoilage when feeding out, a longer bunker is better than a wider one.

Table 4.2 shows the capacity of silos with different dimensions.

Aim to remove at least 30cm from the face every day to minimise spoilage. Legume silage tends to be more stable so removing 20cm per day is acceptable.

Silage density is 650–800kg of fresh silage per m^3, or approximately 260–320kg DM/m^3 at 35%–40% DM. Deeper bunkers have greater silage density than shallow ones.

Example:

We need to feed 95 cows with 7 kg DM each a day. A bunker 30m long, 5m wide and 2m deep has a volume of $30 \times 5 \times 2 = 300$ m^3. At a silage density of 0.8t/m^3 this will store $300 \times 0.8 = 240$ tonnes of whole silage. At 40% DM, this is equivalent to $240 \times 0.4 = 96$t DM.

If crop yield is 10t DM/ha, this size is enough to store $96 \div 10 = 9.6$ha of forage. If we feed our 95 cows at 7kg DM each per day, it will last us $96 \times 1000 \div 95 \div 7 = 144$ days.

Are we removing at least 30cm of face a day? Our 95 cows will need 95×7kg DM a day = 665kg DM or 1900kg fresh a day. At 800kg of whole silage per m^3 we need to remove $1900 \div 800 = 2.4m^3$ a day. But to remove 30cm of face a day, we would need to remove $5 \times 2 \times 0.3$m, or $3m^3$ a day. Thus our design of 5m wide $\times$ 2m deep does not quite meet the criterion of removing 30cm of face a day for feeding the 95 cows at 7kg each per day.

Our options are to reduce the depth or the width of the bunker and add extra length to compensate, or to increase the amount of silage fed each day. The width

Table 4.2. Pit or bunker silo capacity — tonnes per metre of silo length at 700 kg silage/m³.

Average silo width (m)	Silo depth (m)		
	2	2.5	3
3	4.20	5.25	6.30
4	5.60	7.00	8.40
5	7.00	8.75	10.5
6	8.40	10.5	12.6
7	9.87	12.3	14.7
8	11.2	14.0	16.8
9	12.6	15.8	18.9
10	14.0	17.5	21.0

of the bunker must still follow the minimum of one-and-a-half tractor widths.

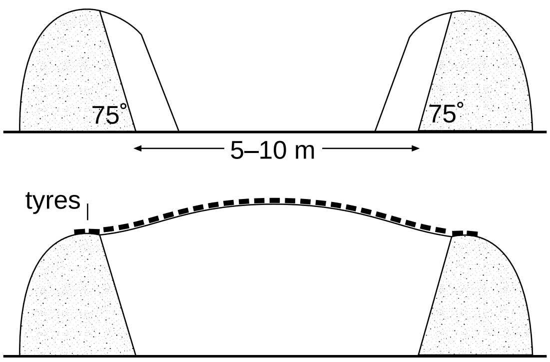
Note that the length of time the feed would last and the amount fed per day would be affected by different figures for the DM content of the feed and the silage density.

Types of storage

Earthen-wall bunkers

The advantage of this storage system is that it is relatively cheap. Many such structures have been bulldozed for only a few hundred dollars. An earthen-wall bunker offers a good safety factor—there is little chance of accidental rollover. If you are unsure of future commitment to silage then an earthen bunker is the right choice.

Figure 4.3. An earthen-wall bunker. Height is 1.5–2.5 m. The steeper the wall angle the better. Allow room to add a gravel floor and run to the pit entrance.



Concrete-lined bunkers

Concrete-lined bunkers are suggested where silage is used regularly (fed every year). The benefits are:

- cleaner silage making with reduced contamination
- excellent wall compaction for little wastage from poor fermentation
- reduced wastage at feed-out
- all weather access.

Figure 4.4 shows how a concrete-lined bunker can be built using the tilt-wall concrete technology used in the building industry.

A 240m ^{3} pit, 5m at the base, 24m long with 2m high walls will need 18m ^{3} of concrete for the floor and 10m ^{3} for the walls. At \$180/m^3 delivered, this will cost \$5040. The cost of labour and formwork needs to be added.

Order type D cement in the concrete mix; specify 25 MPA. When laying the under-floor slab, use a spray-on bond breaker that reacts with the calcium in the cement. This gives a smooth finish to the face. Don't use plastic as it leaves a ripple. For sides 1.5–2.0m high you could pour 6m lengths.

Silage acids attack concrete and steel structures and cause corrosion and decay. A film of linseed oil prevents corrosion. Apply the oil every second year. Thin the oil 1:1 with mineral thinner or turpentine to help penetration.

For more information, contact the Concrete Institute of Australia,
25 Berry Street, North Sydney 2060,
tel: (02) 9923 1244.

Mesh wall and post bunkers

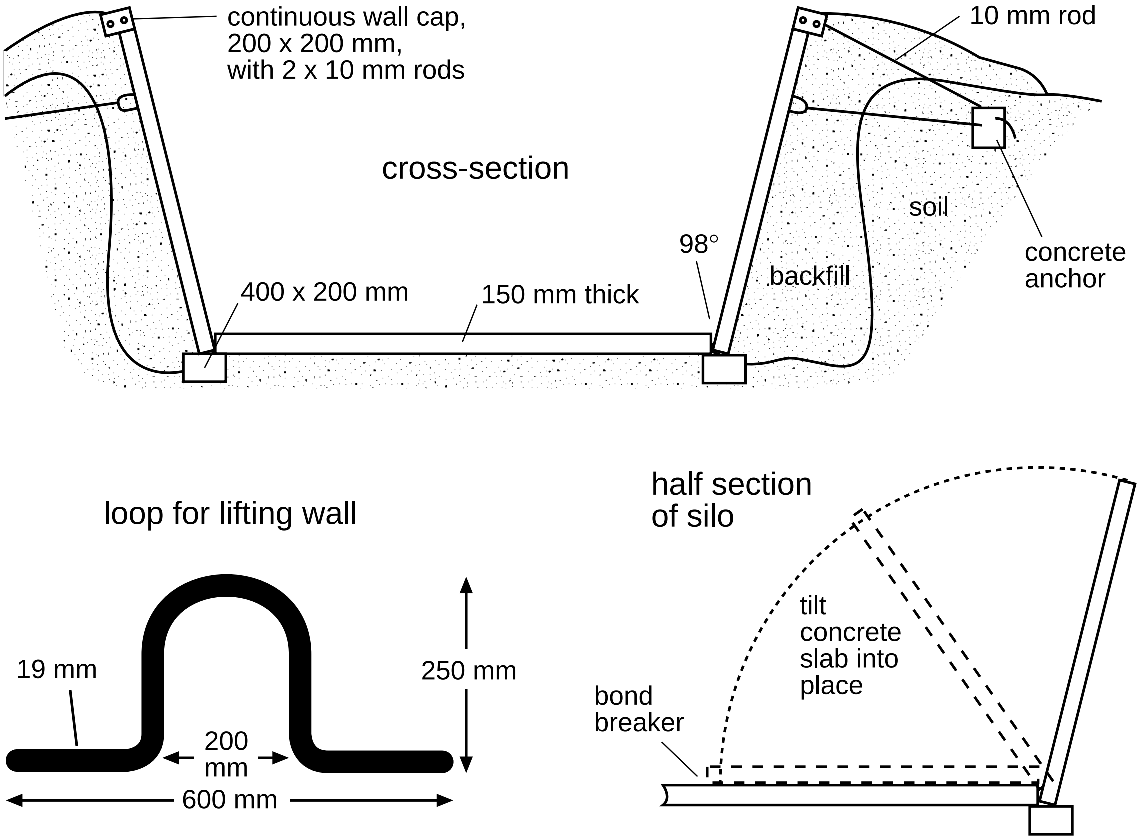
You can build a bunker out of posts supporting weldmesh sides lined with plastic. Although these are cheap to build they have a short life, and so may the tractor driver if he is not careful! Achieving sufficient side compaction is difficult. It is also difficult not to tear the plastic lining as the bunker is filled. These bunkers are an alternative only where pit construction is impossible.

Bun stacks

A bun stack is a heap of silage on the ground, rolled and covered with plastic. The main advantages are low cost and flexibility of storage site.

For rolling safety, a bun stack should

Figure 4.4. A simple way to line earthen bunkers by pouring the reinforced floor first then casting the walls on the floor before lifting into place. Traditionally, a slope on the inner face of the walls of 1 in 8 was used for strength and to aid consolidation of the silage, but vertical walls are perfectly acceptable. The concrete pad should have a slope of 1 in 60 along its length to direct drainage away from the face. The use of steel reinforcing and a concrete mix that is resistant to the destructive action of acids will make the structure stronger and more durable.



not have steep sides or be too high. If the sides are too steep, then you won't be able to drive over the bun sideways, and side compaction will not be good.

Losses from this stack during feeding out are more than from other storage systems, but with good management can be kept low. During feeding out, the bun face must be re-covered after the feed is removed. This will slow down air movement and reduce heating and spoilage.

Hillside bunkers

Other forms of bulk silage include tower silos and the Silopress®. Both require extensive capital investment.

When building above-ground storage with timber or concrete, always run the joins horizontally, not vertically. Horizontal joins are more easily sealed.

Spoilage of bunker silage

See section 3 for further discussion of silage losses.

Filling the pit

Compaction should be a constant process. Use your heaviest-wheeled tractor and keep it going on the job all day. Compaction in storage helps create desirable anaerobic conditions by reducing air through the stack.

Figure 4.5. Three views of a silo built into the side of a hill. Use drains to divert any surface runoff away from the pit.

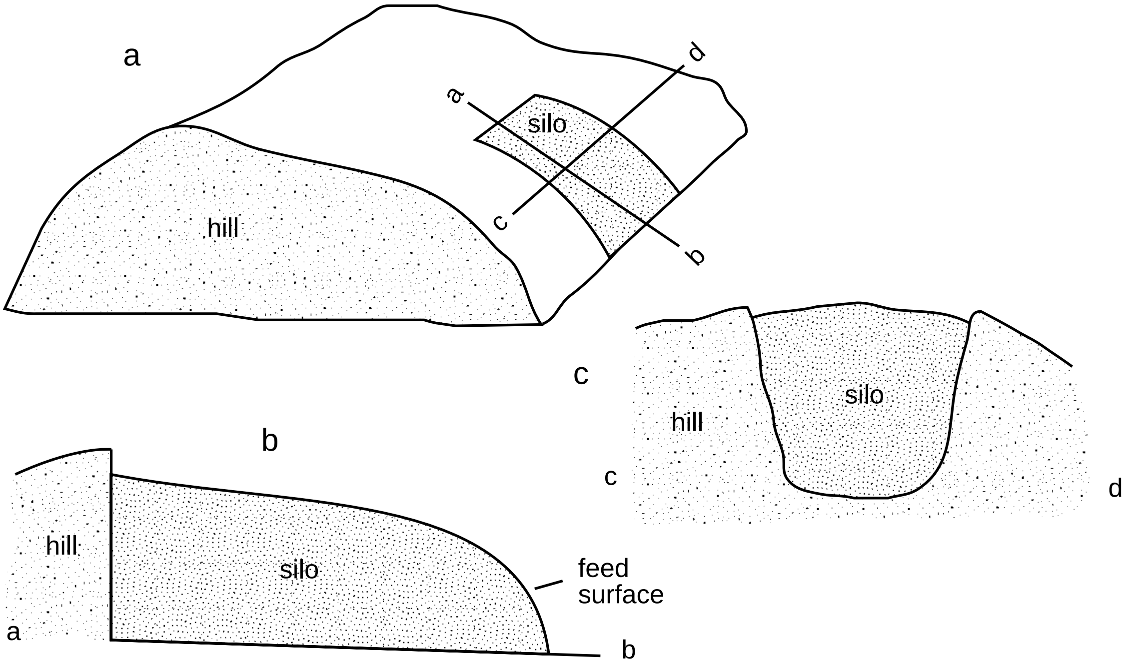


Figure 4.6. Building silage storage into a hill is the preferred method of in-ground storage for any silage. Pits built below ground level are more risky.

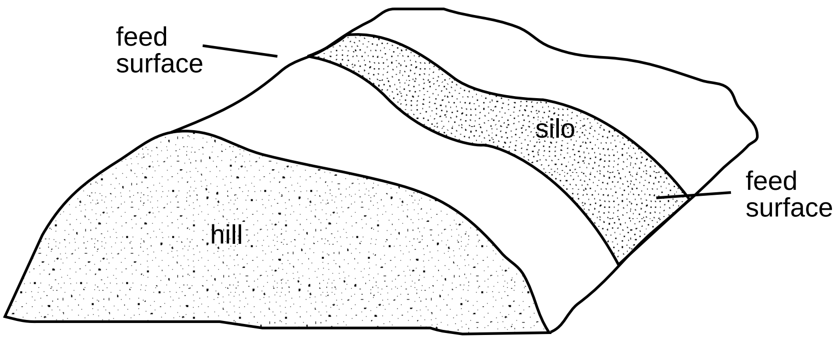


Figure 4.7. Bunker and pit silage—getting a good seal.

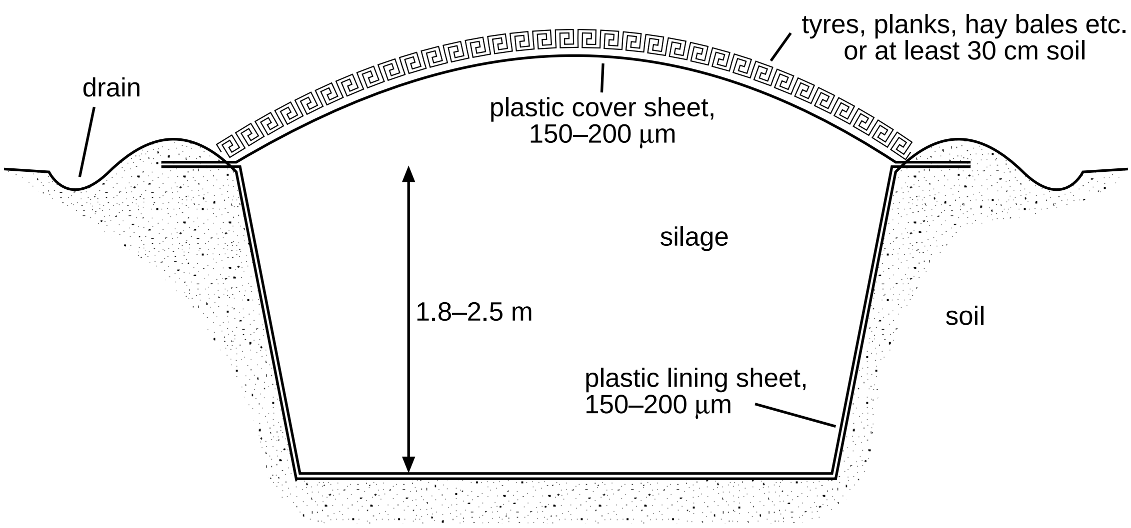


Figure 4.8. Causes of visible spoilage on opening bunker silage, and solutions.

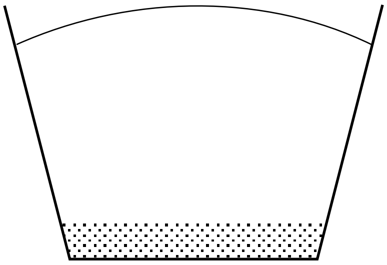
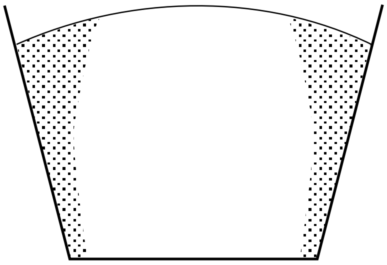
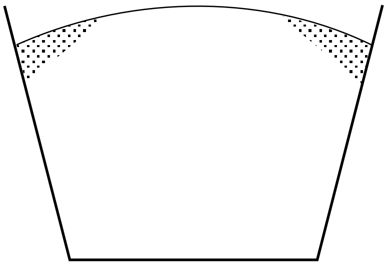
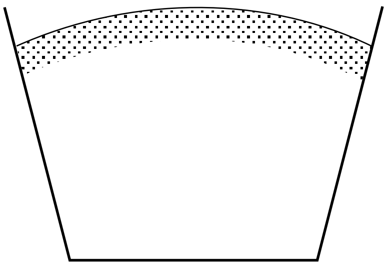
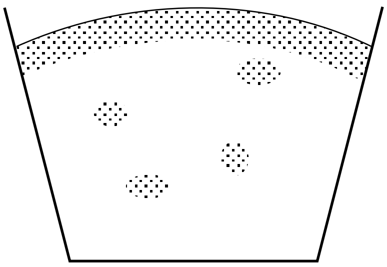
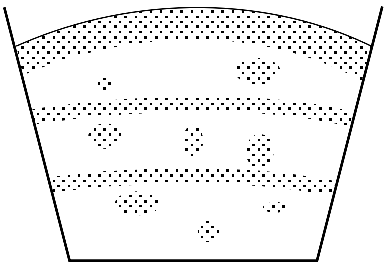
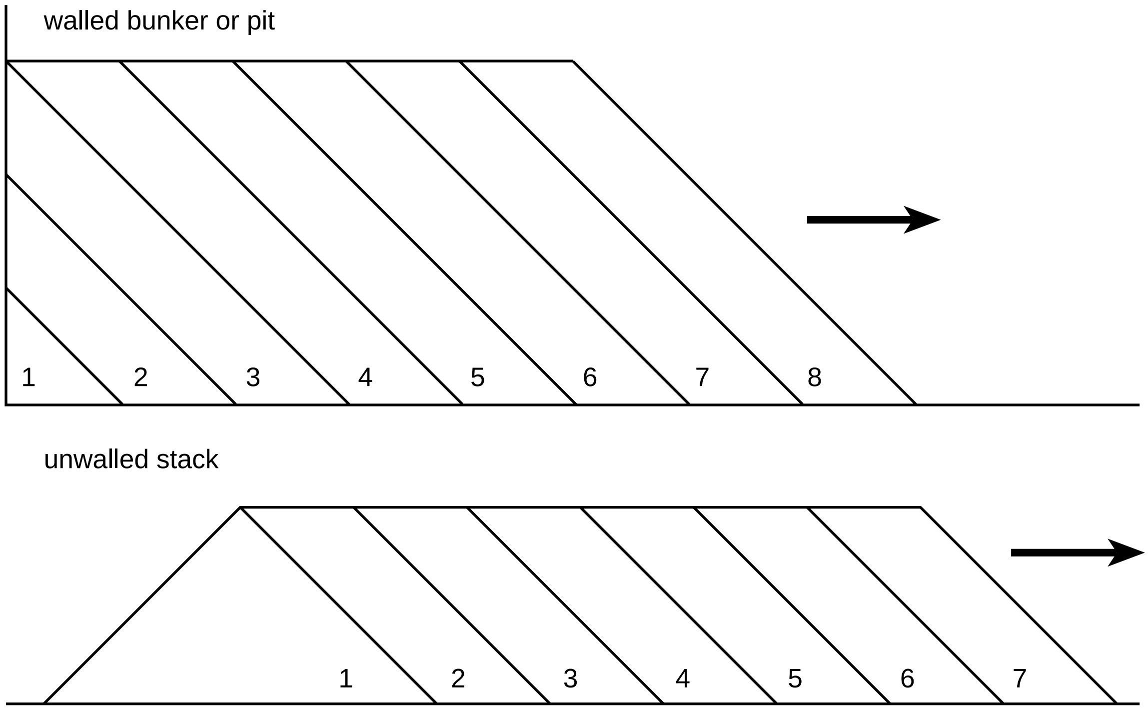
	Problem	Likely cause	Solution
	Butyric and foul-smelling lower layers	Crop too wet	Wilt
		Poor drainage	Improve drainage from silo
	Side waste	Porous walls owing to poor rendering of concrete or the use of unlined sleepers or other timber in walls	Apply a sealer to concrete walls, or plastic sheeting on silo walls.
	Shoulder waste	Lack of consolidation and effective sealing of shoulders	Improve consolidation and sealing technique. Plastic sheeting folded over from the side walls will help.
	Top waste	Inadequate sealing	Ensure plastic sheet is adequately weighed down to maintain good contact between sheet and silage. Ensure joins are airtight and there is adequate sealing around edges.
	Top waste and poor internal pockets	Inadequate consolidation of overwilted or mature material, resulting in trapped air	Improve consolidation, seal immediately and weigh down sheet. Avoid overwilting. Top off silo with loads of moist or direct-cut material.
	Poor-quality layers of dark brown, unpalatable silage	Frequent stops; lack of rolling and covering during rolling stops	If long delay occurs, seal off silo as a batch
	Rotten pockets	Contamination by soil	Avoid soil contamination

Figure 4.9. Using the wedge technique to fill bunkers and stacks.



Sealing the top simply puts the lid on the bottle. How well the top is sealed will govern what wastage ends up in the final product. Seal pits immediately after filling with strong UV-resistant plastic (150–200 microns). Bury the plastic on the sides and cover it with tyres or soil to lessen the chance of damage or removal by wind. If covering with soil for long-term storage, then you can use cheaper builders' plastic. Note that this will deteriorate quickly if exposed to sunlight.

If it takes longer than 1 day to harvest and fill the pit, then layer the material as shown in Figure 4.9.

Round and square bale silage

Round balers have revolutionised the fodder conservation business. Plastic-wrapped silage was the fastest growing form of fodder conservation up to the early 1990s, but many producers are now questioning its cost given the varied results they are getting. However, the problem is more to do with producers' expectations than the process itself. A lot of wrapped silage is too dry (more than 50% DM). With good management, round bale silage can have high feed value and little wastage.

Nevertheless, round bale silage has its limitations:

- It has a 12-month storage life (limited by breakdown of plastic).
- Is not easily moved without damaging the wrap.
- Intake by cattle may be reduced because of chop length.
- It usually costs more than bulk-chopped silage or hay.

Round bale silage is very convenient when small amounts are to be made or fed out and where silage is fed out every year. It is best suited to legumes (clover, lucerne) and pasture silage; forage sorghum can be wrapped but fine-stemmed or leafy hybrids are best.

Making good-quality wrapped silage

Start with high-quality forage and achieve a rapid wilt in the field to 35%–45% DM. Silage will rot if DM is below 25%. Start baling when the DM content is close to 40% and aim to finish when it is close to 50%. Be careful with lucerne: if it gets too dry the stems will puncture the plastic.

Compaction is important: quality improves with tighter bales. Ensure that the baler achieves a dense, hard bale. Hard-core balers should give better compaction and produce higher-quality silage, but many farmers prefer soft-core balers for ease of operation. The length of the material being baled can affect compaction; for example, long kikuyu will not compact as well as short ryegrass. Loose material has more air; this will be used up during fermentation but will allow extra heating and loss of feed value. Mould within the bale means it was not packed tightly enough.

Most round bales are individually wrapped using a stretch cling plastic capable of resisting UV breakdown. Bales should be double-wrapped and have a high degree of overlap. Areas where bales have only a single layer of plastic are prone to breakdown. Overstretching cling plastic will also lead to premature breakdown. Minimise the time between baling and wrapping.

Sealing is the most important operation of any silage making. The quality of the silage will stay the same over time providing air is excluded. Mould on the surface of the bale means it was not sealed properly.

Storage

For **short-term storage** (12 months maximum), use individually wrapped round bales.

- Select a well-drained, weed-free site.
- Check each bale for holes and repair any you find.
- Fence the site to keep stock out.
- Stand bales on-end, not on their side: wrapping puts extra layers of plastic on each end.
- Do not store them under trees, power lines or other roosts as bird droppings may damage some plastics.

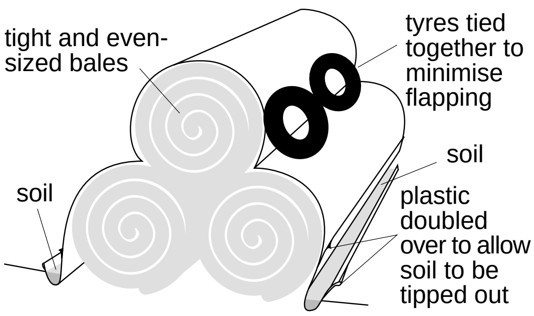
For **storage up to 2 years**, use round or square bales in a stack (Figure 4.10).

- Stack bales in stacks that can provide up to 3 weeks' supply of feed. Use at least 1 row of bales every 2 days.
- Cover each stack with opaque plastic sheeting that has a high UV rating.
- Bury plastic around the perimeter of the stack and put weights (e.g. tyres) on the top to achieve an airtight seal and reduce the effect of wind.
- Fence off.
- To increase storage life to 3–4 years, use second-hand plastic sheet as an additional top cover. Shade cloth can also prolong plastic life, and it deters birds.

For **storage of more than 2 years**:

- Store silage underground in a bunker. (Note that round bales leave too many air gaps.)
- Store it above-ground in stacks covered with a double layer of plastic.

Figure 4.10. Storing round bales for up to 2 years.



Costs

Costs are highly variable. They depend on moisture content, the number of bales made each year, the contractor used, the cost of the wrap, whether you are using a special crop or excess pasture, and the capital invested in machinery. An average cost would be $60 a tonne DM, but the range is $30–$120 a tonne. You must add the cost of feeding out. Losses or wastage during storage and feed-out will have a large effect on the final cost-effectiveness of baled silage.

Losses

Most losses are associated with plastic breakdown and air getting in. Air can get in because of damage by birds or stock, but plastic breaks down anyway over time because of exposure to sunlight. The maximum life is 2 years. Losses can also occur when wet material breaks down, bales slump and the plastic ruptures. Table 4.3 lists common problems of baled silage.

Silage plastic

(This section is based on information supplied by Gromark Packaging, WA.)

Puncture-resistance and UV stability are important in maintaining a good seal and reducing the risk of spoilage. Silage plastic must also be heat-resistant, able to stretch, opaque, tacky to enhance good seals, and able to withstand the fermentation process within the bale and the gases given off during fermentation.

Plastic wrap comes in widths of 500 or 750mm and is normally 25 microns thick

Table 4.3. Diagnosing problems in baled silage.

Symptoms*	Causes
Extensive mould growth on outside of bale, often with an accompanying layer of rotten silage	• Breakdown in plastic seal and air entry over prolonged period • Not enough plastic • Plastic wrap overstretched • Breakdown of plastic by UV light • Damage to plastic by stock or vermin, by plant stalks, or during handling
Small patches of mould on outside of bale	• Recent breakdown of plastic seal • Damage to plastic • Plastic wrap breakdown just starting
Mould inside bale (silage may also have sour or musty aroma)	• Baled too dry • Inadequate bale density at baling • Dead plant mulch picked up with silage
Discoloured dark silage but no apparent mould growth (darker brown with some black charring caused by heating). Pleasant sweet aroma	More prevalent with high DM silage
Mostly outer layer discoloured	• Delayed sealing or wrapping
Discolouration throughout bale	• Delayed sealing of low-density bales
Rotten pockets inside bale	• Soil or manure picked up during baling • Dead plant mulch picked up with silage at baling
Bales slump and lose shape. Effluent may accumulate at bottom of bale. If bale ruptures, silage will rot	• Inadequate bale density • Baled too wet
Silage sour with off flavours	• Baled too wet

* Most symptoms also apply to baled silage in stacks.

(30–32 microns is also available). Rolls are mostly 1500m long.

Which film to use?

Raw polyethylene is clear. Additives have to be added to colour it, give it UV light resistance and make it tacky. Black film offers the best UV resistance because the carbon used to colour it is a natural UV absorber. It is cheaper than other colours, allows less light transmission and has better tack. Other colours are white and green. Research shows that silage quality is comparable whatever the film colour.

Black silage film will eventually break down but will do so layer by layer, offering the silage inside the bale better and longer protection. In contrast, the layers of white and green plastic will break down all at once. However, black film absorbs more heat—the effect of this on silage quality is not known.

Black and white laminated material is thinner than single-layer black sheeting, but may be stronger and less prone to puncture. Also, the white reflects heat and reduces softening of the plastic.

Second-hand plastic sheeting can be used over the top of the new sheet on above-ground bunkers or bale stacks to keep the sun off the new sheet and increase the life of the bunker.

Cost

At least **4 wraps per bale** (i.e. 2 rotations of the bale) are required to ensure that the film will do its job. For hot climates, we recommend 5–6 wraps per bale. If more than the recommended number of bales per roll are being wrapped, either not enough layers or overlap are being used or the plastic is being overstretched. Both of these faults will lead to premature failure of the plastic and spoilage of the silage. At 4 wraps with 50% overlap, the wrapping totals 100 microns thickness. Plastic used for pit silage covers is 200 microns.

Machine operators vary on how many bales they wrap with a roll of film. A 500mm roll will wrap approximately 20 bales; a 750mm roll will wrap approximately 27. If a 750mm roll costs \$119, then the cost will be \$119 ÷ 27 = \$4.40 per bale plus the contractor's fee.

Tube wrapping (using a different type of machine) can halve the amount of plastic used.

Plastic disposal

Farmers either burn used plastic in huge wood fires or bury it. Neither method is very environmentally friendly. Silage plastic cannot be recycled as only clean, uncontaminated plastic can be recycled. The Plastics and Chemical Industry Association is working on the problem.

References

1. Simmons, E. K. and Simpfendorfer, H. H. 1983. What happens when hay heats. Agnote 2333/83, Department of Agriculture and Rural Affairs, Victoria.

Exercises

What does good hay look like?

What causes hay to heat?

What effect does heating have on hay?

Describe the look and smell of good silage.

How does silage lose quality?

How can you eliminate effluent losses from silage?

What are the advantages and disadvantages of pits, bunkers, stacks and baled silage?

How quickly should silage be compacted and sealed?

How much silage should be fed each day?

How long will silage store?

What damages plastic?

5. Feeding conserved forage

Feeding systems

Feeding-out may well be the most important and costly stage of using conserved fodder. It is a daily chore that will add up to be the most time-consuming aspect of using hay or silage.

Feed-out management of silage

When comparing different silage production systems it is important to consider:

- the cost of each, including investment in feed-out equipment, and quality and losses
- the effect of chop length on animal production
- the effect of feed-out management on animal production.

In production-feeding it may be necessary to remove the silage from the bale and feed it loose, or after processing through a bale chopper. But there is a growing trend for farmers to feed baled silage from self-feeders to reduce feed-out losses and labour requirements. This has consequences for animal production. Research summarised in Table 5.1 shows why: milk production is reduced with self-fed long chop. Another study[(1)] showed that feed-out management did not influence milk production when silage was made from short, leafy grass. Thus

Table 5.1. When silage is fed loose, there is little difference in milk yield (kg/day) between short and long chop. But when silage is self-fed, yield is reduced with long chop[(2)].

	Short (5 cm)	Long (23 cm)
Loose-fed	19.6	20.1
Self-fed	20.2	18.2

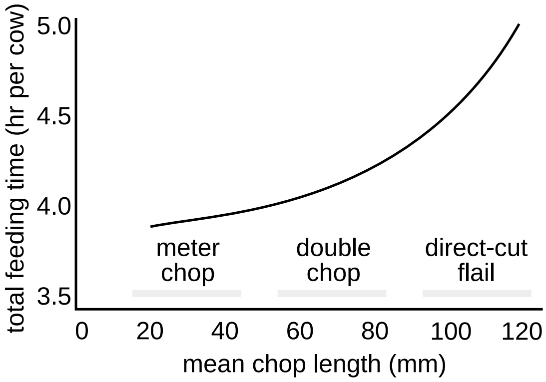


Figure 5.1. As silage chop length increases, cow feeding time also increases.

length of the pasture cut for silage is important. Silage intake will also be influenced by duration of access (Figure 5.1) and the number of animals sharing the self-feeder.

For self-feeding, the stack face must be wide enough for the number of stock being fed. For mature cattle the width should be 15–20 cm per head for 24-hour access or 25–40cm per head for limited access. Place an adjustable rail barrier or electric wire along the feeding face to restrict stock access. Provide a solid base or platform at the face of the silage to give stock a firm footing and to reduce waste. Between 10 and 35 cm of silage should be removed from the face each day so that the exposed silage remains fresh.

The higher feed intake requirements of early-lactation cows are likely to make them more sensitive to feed-out practices. By comparison, feed-out management is likely to be less critical where only small amounts of hay or silage are being fed. It is important to note that, although chop length is important in **production feeding**, it is unlikely to be important where the goal is **maintenance** or **survival feeding.**

Feed-out losses

Wastage during feeding-out is critical to profitability. By the time it comes to feeding-out, hay or silage will have cost $60–$100 per tonne of dry matter (DM). Losing an average 10% of fodder when feeding will effectively cost twice as much as losing 10% at harvest, simply because of harvest and storage costs. To put this loss into perspective, consider whether would you waste 10% of the grain you buy. If hay or silage is rolled out on a wet paddock, as much as 30% can be wasted. Physical losses from trampling and fouling that occur when forage is fed out on the ground can also be high.

Another source of feed-out loss with silage is aerobic spoilage. Silage starts to deteriorate once opened and exposed to air. The rate of deterioration depends on several factors, explained below.

Silage type: Silages with high levels of readily fermentable carbohydrates (e.g. sugars and starch), such as maize, are unstable. Those with low levels of fermentable carbohydrates, such as legume silages, are generally stable.

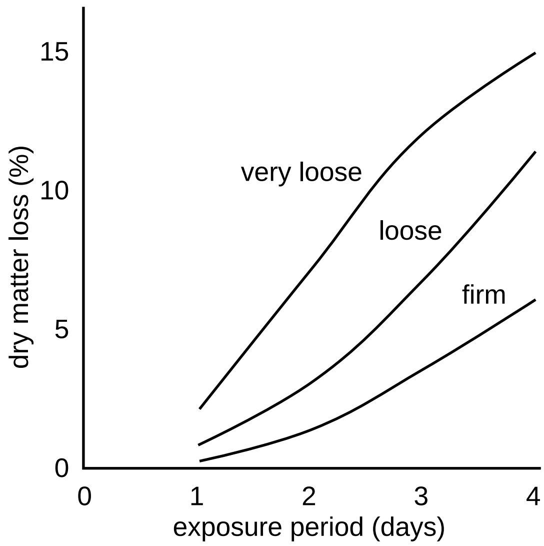
DM content: High DM, heavily wilted silages are unstable owing to more rapid entry of air during feed-out.

Temperature: Aerobic spoilage occurs more rapidly during warm weather.

Silage management: Prolonged wilting, slow filling, delayed sealing and ineffective sealing all favour the growth of aerobic microorganisms, which remain dormant in the silage until it is opened.

Feed-out management: Frequent (daily) removal of silage from the face limits spoilage. The rate of removal should be 25–35cm a day . Take into account both the number of animals that will be fed and silage density when calculating the optimum area for the silage face. Long bunkers, buns or bale stacks with narrow faces are most suitable. With bale stacks, aim at removing 1 layer of bales from the face every 2 days, and limit each bale stack, or module within a stack, to 3 weeks' feed supply. Figure 5.2 shows how retaining the compaction at the silage face is important in minimising losses.

Figure 5.2. A loose exposed silage face will lead to much faster deterioration of the silage quality than a tight face.



Feed-out equipment: Unloading equipment that minimises disturbance of the feeding face reduces aerobic spoilage. For example block cutters and shear grabs are superior to front-end loaders.

Apart from DM losses, aerobic spoilage can also reduce silage quality and lead to depressed intake, reduced digestibility and increased animal health risks. Good silage management will certainly alleviate the problem, but with problem silages there may be a role for silage additives. Research is needed to identify additives that improve silage stability.

How much to feed out?

Table 5.2 gives the weight of hay or silage needed per cow for 3, 6, 9, or 12 months' feeding at different daily rates. For

Table 5.2. Hay or silage needed per cow for various levels and duration of feeding.

Whole feed (kg/day)	Equivalent DM (kg/day)	No. of months 3	6	9	12
Hay		tonnes of hay at 82% DM			
2	1.64	0.18	0.36	0.53	0.73
4	3.28	0.36	0.72	1.08	1.46
6	4.92	0.54	1.08	1.62	2.19
8	6.56	0.72	1.44	2.16	2.92
10	8.20	0.90	1.80	2.70	3.65
Silage		t of silage at 35% DM			
10	3.50	0.90	1.80	2.70	3.65
20	7.00	1.80	3.60	5.40	7.30
30	10.5	2.70	5.40	8.10	11.0
40	14.0	3.60	7.20	10.8	14.6

example, for each cow that will receive 10kg of silage a day for 3 months, you need to have stored 0.9t of silage. For 100 cows, you therefore need 90t.

Feeding-out machinery

Manual feeding is the cheapest but most wasteful. The bale is carried to the feeding site by either forks or a bale spike and the twine is removed. The bale is then unrolled by pushing it, generally with the tractor. This method is time-consuming and very dependent on hay condition. Bales tend to unroll in lumps. Wastage is high.

Ground contact machines are reasonably popular. The bale is carried by the grab to the feeding area and the twine is removed. The bale is lowered to the ground and rotates as the tractor moves forward. These machines tend to leave a large mat of hay or silage, which is susceptible to trampling by stock.

Metered machines are more expensive but do the best job. They achieve maximum feed value by reducing spoilage and producing a windrow that is very acceptable to stock. Most have a self-loading facility, which enables the machine to be used for carting. One type is mounted on the 3-point linkage and has a long spike that is driven into the bale and lifts it. Another short spike (or spikes), mounted off-centre on the same backing plate, is used to help rotate the bale and unroll it. This method tends to leave large lumps. The most popular machine is the cradle type with continuous, moving floor chains.

Bale choppers or shredders chop or shred round bales of hay or silage and can process large or small rectangular bales as well. The aim of bale choppers is to increase forage intake and reduce wastage. Chopped material can be placed directly on the feed-out area or added to a mixer wagon for combination with other types of feed.

Other feed out machines include **silage carts** and **feed wagons**. Large square bales can be carted separately on forks or can be loaded onto a truck using a grip-type loader. **Silage trailers** are discussed in section 3.

Front-end and **3-point linkage grabs** operating from the hydraulic system of a tractor are ideal for removing silage from a stack. Grabs that shear the silage and give a clean cut are becoming favoured. This avoids the problems associated with disturbing the remaining silage. The silage is then fed into silage carts for distribution.

Block cutters are most efficient at minimising disturbance of the silage face. They are more expensive than buckets, forks or grabs and are probably best suited to larger-scale operations.

Further information

Agfact A0.6.1, *Stacking baled hay*

Agfact E4.10, *Hay packaging—rectangular bales*

Agfact E4.12, *Hay packaging—round bales*

Agfact E4.14, *Hay rakes*

Agfact E4.23, *Hay carting and feeding equipment*

Agfact P2.7.2, *Making better quality hay*

Agfact P2.7.3, *Preparing your paddock for better pasture hay*

Agfact P2.7.5, *Making hay faster*

Agfact P2.7.7, *Hay—storing round bales*

Fodder conservation. Bulletin No. 4200, WA Department of Agriculture, Perth, 1991

Hay and forage harvesting. John Deere

Hay maker's handbook. New Holland

Silage for beef. NSW Agriculture, Orange, 1997

Telling good silage from bad

The best way to tell good silage from bad is to have a sample tested by a feed testing service, such as the Feeds Evaluation Service at the University of New England, Armidale. If you plan to send samples to laboratory, send the samples frozen.

In the field, observation of the smell, colour and parent material will give some indication of silage quality. Good silage will smell sweetly acid, not musty or mouldy. Dark silage with a burnt sugar smell has overheated during the ensiling process. It will be very palatable but will have suffered some protein degradation, digestibility will be substantially reduced, and it will have lost energy (feed value) in the heating process.

The quality of a silage is limited by the quality of the parent material. The ensiling process can only preserve, not improve, quality. Silage containing weeds and mature grass heads will be of lower quality than material cut early at head emergence or budding. Calculations indicate that cutting early for quality is more profitable than cutting late for quantity.

Listeriosis

Where aerobic conditions allow the silage pH to rise above 5, any *Listeria* organism present will multiply rapidly. Listeriosis can therefore be a potential problem. Extensive mould damage in the top few centimetres can be a good indicator. Research in the UK has shown that removal of the mouldy silage from baled silage before feeding will reduce *Listeria* contamination.

Low material density and limited fermentation can sometimes allow *listeria* multiplication. The incidence of listeriosis in baled silage is therefore greater than with chopped silage.

Good silage is produced when anaerobic fermentation occurs and a very low pH is reached, commonly less than 4. Listeriosis is not a problem with these well-preserved silages.

References

1. Gordon, F. J. 1989. The principles of making and storing high quality, high intake silage. In: *Silage for Milk Production*, ed. C. S. Mayne. British Grassland Society, Occasional Symposium No. 23, pp. 3–19.
2. Murphy, J. J. 1983. Silage for dairy cows—Conservation ad method of feeding. *Irish Grasslands and Animal Production Association Journal* 18, 50–58.

Exercises

How and why should feed wastage be minimised?

What effect does chop length have when feeding silage or hay?

Why is mouldy hay or silage a concern?

How can you tell good silage or hay from bad?