Chapter 8

Harvesting silage

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In this chapter

The authors

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The Key Issues

The objective with an efficient harvesting system is to minimise costs, and DM and quality losses. The important steps in the harvesting process are:

Before harvesting begins

- Plan and prepare well before harvesting begins.
- Decide which system of forage conservation to use, e.g. hay or silage, baled or forage harvested.
- Harvest the crop at the correct stage of maturity for optimum quality and yield.
- Determine to what extent contractors will be used, if at all.
- Monitor weather forecasts.

When harvest begins

- Mow and wilt the crop to the desired DM content.
- Harvest as soon as the required wilt is achieved, preferably within 48 hours of mowing.
- Compact well for high silage density.
- Seal the stack immediately after harvesting is completed. Use a temporary cover if there is a break in filling of the stack or pit.
- Seal bales as soon as possible after baling.
- Ensure the stacks and bales are effectively sealed – the seal is airtight.
- Regularly inspect storage sites and repair holes in the plastic, immediately, with recommended tape.

Section 8.0

Introduction

The method of forage conservation chosen will depend on many factors – type of farming operation, future plans (either to extend or reduce the size or scope of operations), economics and lifestyle choices. These issues are discussed in detail in Chapters 1 and 11.

Many producers adopt a small-scale, low-input cost system to begin with, to gauge how silage will affect their existing enterprises. This usually involves a small number of individually wrapped round bales that can be produced and handled using equipment that is on-hand, with only the wrapping operation being contracted out. Although this silage system is usually quite expensive per tonne of DM conserved, only a small initial financial outlay is required.

It is possible to produce well-preserved, high-quality silage using any of the systems discussed in this chapter. However, for forages of similar feed quality, there can be differences in animal production due to the form of the silage (baled versus chopped silage, short versus long chop). These issues are discussed further in Chapters 10, 13, 14 and 15.

Harvesting losses are higher for forages that are wilted to higher DM contents (see Chapter 6, Section 6.7).

Safety first

The operator(s) of machinery should, at all times, operate the equipment to the manufacturer's specifications as directed in the manual supplied with the machine and as per warning stickers on the machinery.

Operators should never approach machinery until all mechanical motion has completely stopped. All PTO shafts, belts, chains, etc, must have strong tamper-proof covering, only being removed for servicing and repair work when the moving parts are stationary.

Section 8.1

Planning and preparing for harvest – a checklist

Too many producers leave preparations for the silage harvest far too late. Delays before and during silage making can increase costs and reduce silage quality.

Paddock preparation

- Ensure that paddocks are cleared of any objects that may damage harvesting machinery. This can include tree limbs and branches, machinery (e.g. harrows) or steel posts.
- Remove any animal carcases; they can damage machinery and contaminate the silage, posing an animal health risk from botulism (see Chapter 2, Section 2.3.5, and Chapter 8, Section 8.7).
- Make sure any holes and depressions in the paddock are filled in or are well marked.
- Ensure access for transport between the paddock and storage area is unimpeded by narrow lanes and gateways (fences may need to be cut), and that laneways are trafficable and safe.
- Manage the grazing program so that the better-drained paddocks are dropped out of the grazing rotation early and are ready to be harvested first.

Equipment preparation

Preparing and maintaining equipment will minimise breakdowns and time delays and maximise work rates:

- Ensure that all machinery has been serviced and adjusted properly, and any broken or worn parts are replaced.
- Ensure that there are sufficient spare parts on-hand for those components that regularly break or need replacing.
- Ensure the agents for machinery parts not held on-farm can be contacted and that parts are available.
- Ensure there is enough twine, net wrap and plastic on hand to complete the job.

Site preparation

- Clean out earthen pits well in advance.
- Correct any problems from previous season, e.g. water seepage, poor accessibility or vermin infestations.
- Storage sites for wrapped or stacked bales, or above-ground bunkers, should be cleaned up to remove long grass and rubble to provide an even work area and to minimise shelter for vermin.
- Avoid grazing or grading pit or bunker sites just before harvest to prevent dust, mud or faeces collecting on tractor tyres and contaminating chopped bunker silage.
- If bale stacks are to be covered with plastic sheeting, dig trenches (20-30 cm deep) along one side and one end to make it easier to align the bales, and bury and seal the plastic (see Chapter 9, Figures 9.10 and 9.11).
- Fence off the storage site to prevent damage from animals during and after harvest. If space is limited, erect the fence immediately harvest is finished.

Contract silage making

- Contact contractors well ahead of the harvest period to ensure they are available. Keep them up-to-date with:
  - expected date harvesting is likely to begin (based on the maturity of the pasture or crop);
  - the number of paddocks and total area to be harvested;
  - equipment and labour you can provide (these resources must be available and fully operational to avoid delays and potential conflicts);
  - equipment and labour the contractor is to provide or arrange.

Chapter 11, Section 11.2.3, discusses the use of contractors compared with buying your own equipment, organising the contractor and contractor agreements.

Section 8.2

Harvesting options

In this chapter there is no attempt to detail the price of machinery, the operating costs or throughput capacity, and there are no recommendations on which is the 'better buy'. The choice of silage system and equipment required will vary widely between operations. A checklist of points to consider before buying equipment is:

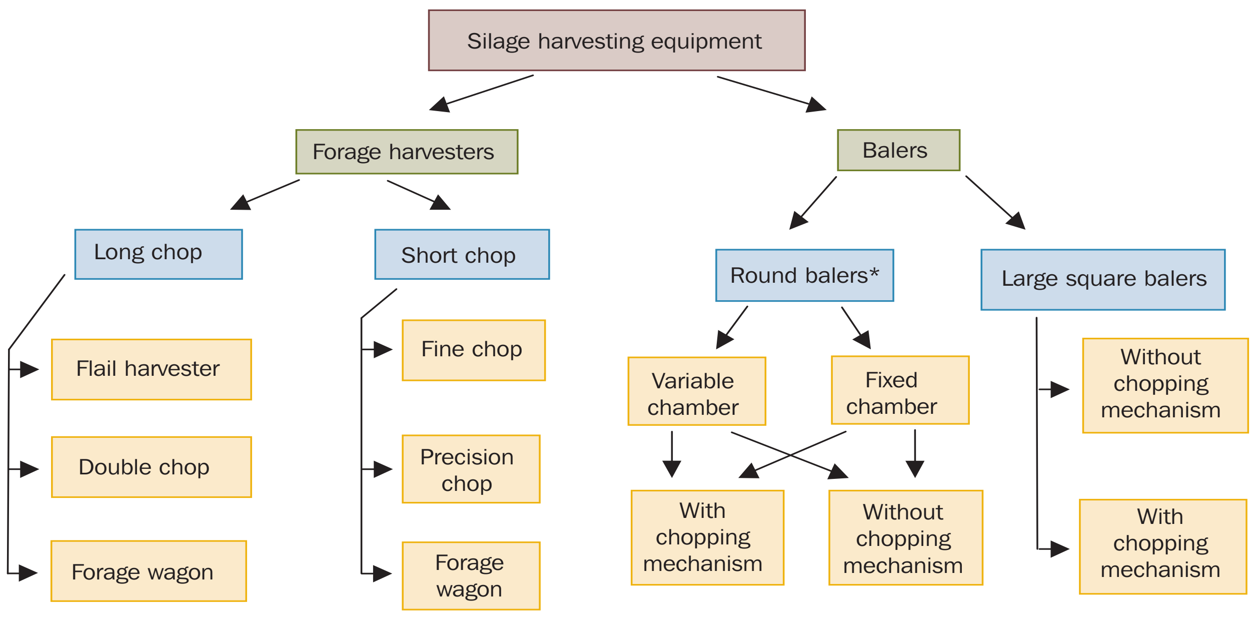
- Cost
- Throughput capacity
- Possibility of contract work to off-set cost
- Dealer proximity and service
- Resale value
- Ease of use and maintenance
- Labour requirement
- Operating costs
- Is using a contractor a better option?

There is a wide range of equipment and systems available for making chopped or baled silage to suit all farm sizes, with more robust, higher-capacity equipment more suited to contractors.

The equipment available for harvesting can be categorised as either forage harvesters or balers. Within each of these there are a number of categories/types of machinery (see Figure 8.1).

Figure 8.1

Types of silage harvesting equipment currently available.



* Combination baler/wrappers now commercially available

8.2.1

Forage harvesters

Forage harvesters are designed to either pick up mown forage from a windrow, direct-harvest standing crops, or both. In the latter case, this is achieved by changing the pick-up mechanism on the front of the forage harvester.

Most forage harvesters on the Australian market are precision chop machines, which are capable of picking up mown forage from a windrow and/or direct harvesting, depending on the front attachment. There are also a number of forage wagons available.

Forage harvesters and forage wagons are discussed in this section.

Flail harvesters

- Outdated.
- Consist of a rotor with several banks/rows of free-swinging flails designed for direct cutting of forage. Some capable of picking up windrowed forage.
- Sucking action of the flails often picks up soil, contaminating the silage.
- Variable chop length – from about 100 to >250 mm.

Double chop harvesters

- Superseded flail harvesters but are now outdated.
- Mown swath is picked up by various flail arrangements on a rotor, and then conveyed to a flywheel type chopper for extra cutting.
- Chop length highly variable, shorter than flail harvester.

Plate 8.1

Self-propelled forage harvester loading into a semi-trailer. *Photograph: K.Kerr*

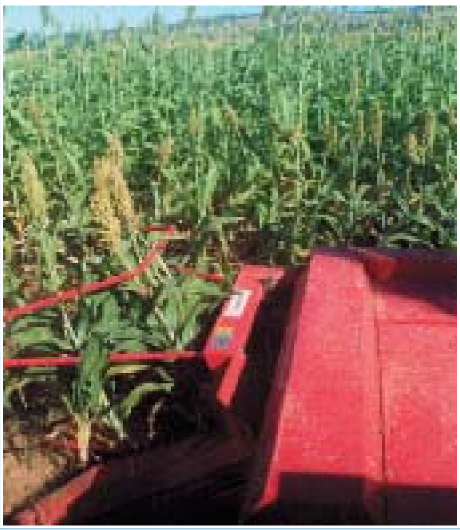
Fine chop forage harvesters

- Usually fitted with windrow pick-up front.
- In most models the cutting mechanism is a rotating cylinder with fixed flails that cut the forage against a shear bar.
- Require more power to operate than precision chop forage harvesters for the same throughput (t/hour).

Precision (metered) chop forage harvesters

- Can be fitted with various fronts for harvesting of crops or windrowed forage.

Plate 8.2



A precision chop forage harvester fitted with a row crop front harvesting sorghum.

Photograph: K. Kerr

Plate 8.3

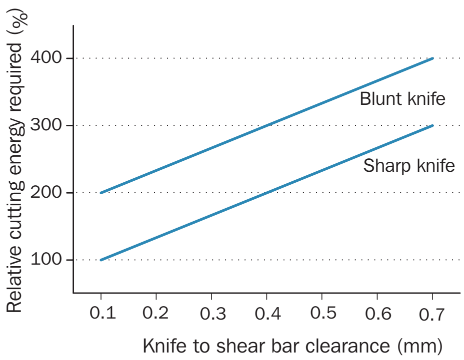
Forage wagon. *Photographer: J. Piltz*

The Theoretical Length of Chop (TLC) or nominal chop length setting on a forage harvester may not be the same as the actual length the forage is chopped – see Section 8.3.

- Available as tractor-mounted, trailed or self-propelled units.
- Forage is delivered into the chopping chamber, at a steady rate, where knives fixed to a rotating cylinder cut the material against a shear bar. Chop length is uniform, and can be altered to suit requirements.
- Contain either two, four or eight knives or banks of knives.
- Can be fitted with 'cracker plates' or other devices to further damage grain. These require increased tractor power to operate.
- Capable of high throughput.
- The most widely used forage harvester.

Figure 8.2

Effect of knife sharpness and clearance from the cutterbar on energy requirements for precision chop forage harvesters.



Source: Adapted from McClure (1990)

Forage wagons (self-loading forage wagons)

- Self-loading machines where the forage is picked up from a windrow and harvested into an attached wagon. The chopped forage is unloaded directly from the wagon at the storage site.
- Most wagons have chopping mechanisms that are only capable of producing longer chop length forage of highly variable length. However, there are wagons that have precision chop machines attached which are capable of producing chopped forage identical to precision chop forage harvested material.
- Because harvesting stops during unloading and travelling to and from the storage, work rate is relatively slow. These units are really only practical when the storage site is close to the paddock being harvested.
- Advantage – less labour and machinery is required.

Effect of knife sharpness and adjustment

Regular sharpening of the knives and adjustment of the cutter bar is essential. Blunt knives and poor adjustment of the distance between the knives and cutter bar will:

- increase the power required at the cutting chamber (see Figure 8.2); and
- result in a less uniform chop length, with an increase in average chop length (Chapter 2, Section 2.4, and Chapter 8, Section 8.3, discuss the importance of chop length).

Metal detectors

Foreign metal objects, broken machinery fragments and rocks can cause substantial damage to precision chop forage harvesters – chipping and breaking knives. Large, solid objects can even damage the chopping chamber and knife holders.

Wire picked up during harvest will be chopped into small pieces. Damage to the knives may only be minimal and go unnoticed, but there is a potential health risk to animals that consume the contaminated silage.

Machines can be fitted with metal detecting units, which immediately disengage the feed and chopping mechanism when metal is detected. These units can be a valuable investment, preventing substantial machinery damage and downtime.

Most machines are now fitted with banks containing several knives rather than a number of individually mounted blades. Damage is often confined to one or two smaller knives, which is easier and less expensive to repair.

Grain processors

The high energy levels of maize and grain sorghum silages are due to a high grain content.

Machinery manufacturers have produced a range of add-on equipment that can be fitted to forage harvesters to damage whole grain, increasing utilisation of the grain component by cattle. These include recutter screens and cracker plates. More recently, larger forage harvesters have been fitted with rollers.

Use of grain processors for maize silage is common in the United States, where the trend is for chopping at longer particle lengths. However, when the forage harvester is set up to harvest maize with a short chop length, a significant proportion of the grain is damaged without the need for additional processing. In Australian studies, the grain in maize silage which had been finely chopped (4.2 mm theoretical length of chop – TLC) was well digested by cattle (See Chapter 14, Section 14.2.5).

There may be a benefit in using grain processors when harvesting grain sorghum for silage. Even at short chop lengths, much of the sorghum grain escapes damage because of its small size.

Chop length and digestibility of the grain in maize silage are discussed in more detail in Chapter 5, Section 5.2.4, and for maize and sorghum silage in Chapter 14, Section 14.2.5, where results of the Australian studies mentioned above are presented.

Reducing chop length or using a grain processor will increase the tractor power required to harvest maize for silage. The additional advantages of reducing chop length – increased load capacity during carting, improved compaction in the pit or bunker, and an improved fermentation are discussed in Section 8.3. These advantages will help offset the additional expense.

8.2.2

Balers

Variable versus fixed chamber round balers

Variable-chamber balers compress the bale from the initial filling of the chamber and make a bale with a 'hard' centre. Fixed-chamber balers do not begin compressing the bale until the whole chamber is full; as a result the bales are not packed as densely in the middle as at the outsides – they have 'soft' centres.

The soft-centred bales produced by the early model fixed-chamber balers were not ideal for silage production. Air trapped in the centre of the bales increased the risk of poor fermentation and mould growth. The problems increased with drier or more heavily wilted forages. New models produce higher-density bales, with firmer centres and less risk of fermentation problems. No research data are available on the quality of silage produced from these bales at higher DM contents (>50%).

Square balers

The bales made by square balers are called 'large squares' to differentiate them from the traditional small square hay bales.

Bale sizes (width x height) vary, depending on which of the many commercially available square balers are used. Most produce bales with a maximum length of about 2.4 m, but this is often adjusted to 1.5 m when making silage for wrapping and ease of handling.

Most large square bales produced by current-model balers have the advantage of being denser than round bales, but do require more power to produce. The shape of the square bales is more suited to a range of storage systems, with better utilisation of space and ease of sealing effectively. The storage systems commonly used are covered in Chapter 9, Section 9.5.

Chopping balers

Round and square balers are available with a series of knives that chop the forage just after pick-up and before entering the baling chamber. Most have a nominal chop length (Theoretical Length of Chop) of about 75 mm; the actual chop length will depend on whether the forage has passed lengthways (unchopped) through the chopping mechanism or across the knives (chopped). The length of the chopped material will usually vary between about 40 and 110 mm. The baler can be operated with or without engaging the knives.

The Orkel® is another version of the chopping baler, incorporating flails to chop the forage. An advantage of this type of baler is claimed to be in the flail action, which chops the forage more than knives

Plate 8.4

Round baler. *Photograph: K. Kerr*

Plate 8.5

Square baler. *Photograph: F. Mickan*

(used by most other balers); the forage stems are split, releasing more WSCs for fermentation.

Potential benefits in chopping the forage at the time of baling include:

- less air is trapped in the bale – reduced respiration and risk of mould growth (see Chapter 2, Section 2.5.2);
- greater release of water soluble carbohydrates (WSC) resulting in a more rapid fermentation and reduced fermentation losses (see Chapter 2, Section 2.4);
- increased bale density (and weight) – reduced storage (plastic, wrapping) and transport costs for each tonne of silage;
- increased intake by animals, less selection and reduced wastage (see Chapter 10, Section 10.3);
- possibly more thorough mixing of silage additives sprayed onto the material before chopping (although there is no hard evidence to support this); and
- chopped, baled forage is easier to process in mixer wagons.

In a Danish study, whole crop barley was ensiled with a variable-chamber baler either with or without chopping knives. As can be seen in Table 8.1, chopping the bales increased silage density, reduced losses, and there was a slight improvement in fermentation quality (lower pH).

Combined round baler and wrapping machines

In an attempt to reduce labour costs, several manufacturers have developed machines that bale the forage and then wrap the bale. The wrapper can be built within or behind the baling chamber, or trailed behind as a separate unit.

A disadvantage of these machines is that the bale has to be moved after wrapping, increasing the risk of damage to the plastic wrap. Chapter 9, Section 9.5, covers recommendations for wrapping and storing bales.

Table 8.1

Whole crop barley silage ensiled with a variable-chamber round baler either with or without chopping knives.

	Silage density (kg DM/m³)	DM loss (%)	Silage pH
Chopped	192	7.0	4.38
Unchopped	176	8.3	4.53

Note: Average silage DM was 38%.

Source: Ohlsson (1998)

Net wrap versus twine

Round silage bales can be tied using twine or net wrap. Net wrap, although more expensive than twine, is a more convenient and faster method of tying round bales.

Net wrap is recommended for use in very stemmy crops such as lucerne, cereal crops and summer forages, or over-mature pastures, to help avoid stems poking holes in the plastic seal.

Sisal twine that has been treated with oil should not be used as it can chemically react with the plastic, with holes forming along the string line.

Heavy-duty twine must be used on square-baled silage.

Plate 8.6

Because the plastic wrap is easily punctured, it is best to wrap bales at the storage site. Wrapped bales should be handled with exteme care and using special equipment such as this bale handler/stacker. *Photograph: J. Piltz*

Section 8.3

Factors affecting the efficiency of forage harvester systems

8.3.1

The importance of DM content and chop length

Increasing the DM content and/or decreasing the chop length will increase the amount of material that can be transported by trucks, carts and trailers. However, once forage DM content approaches 40-45% the carrying capacity may plateau or even decline because the chopped material does not pack down as much. Shortening the harvest chop length will result in an increase in load weights for a range of DM contents. Table 8.2 shows the combined effects of increasing DM content and reducing chop length.

The density at which silage is stored varies with chop length and DM content. Stack height and the degree of compaction will also affect density. In the UK, silage density is often estimated by the following equation, based on the silage DM content:

$$\text{Density of fresh silage (kg/m}^3) = 496 + \frac{4{,}590}{\text{DM \%}}$$

Example: Density of stack with 35% DM silage =

$$496 + \frac{4{,}590}{35} \cong 630 \text{ kg/m}^3$$

Chop length is referred to in terms of Theoretical Length of Chop (TLC) and is sometimes called nominal chop length. TLC is the machine setting or design specification. However, in practice, the actual chop length can be 2-3 times longer due to factors such as speed and power of equipment, clearance settings and sharpness of blades.

In the United States study presented in Table 8.3, increasing TLC from 6 mm to 38 mm reduced silage density by nearly 14% and forage wagon capacity by more than 30%. Increasing TLC also increased the percentage of forage particle lengths above 38 mm.

The shorter the chop, the greater the power requirement. Twenty-two per cent more PTO power was required when the TLC was reduced from 38 mm to 6 mm. Table 8.4 shows the increase in kilowatt-hours per tonne (kW/t) of maize chopped as the TLC is reduced.

Besides increasing power requirement, forage harvester throughput can decrease if chop length is decreased, even by small amounts.

Table 8.2

*Effect of harvesting equipment and crop DM content on the quantity (tonnes) of chopped forage transported in each trailer load.**

Crop DM content (%)	Harvester type	DM capacity (t)	Relative capacity (%)	Number of loads per ha
Direct cut (20%)	Flail	0.43	100	14.0
	Double chop	0.71	165	8.5
Wilted (30%)	Flail	0.64	149	9.4
	Double chop	0.96	223	6.3
	Precision chop	1.07	249	5.6
Wilted (40%)	Precision chop	1.00	233	6.0

* *Trailer capacity of 14.2 m^3; assumes a yield of 6 t DM/ha.*

Source: Adapted from MAFF (1976)

Table 8.3

Percentage (%) of particles longer than 38 mm for a range of theoretical chop lengths.

	Theoretical length of chop (mm)			
	6	13	25	38
Percentage of particle size >38 mm (%)	10	18	40	70

Source: Savoie et al. (1989)

Table 8.4

Chop length and power requirements to harvest maize.

Nominal Chop Length* (mm)	Energy Requirement (kW/t)
7	1.6
4	2.1
Recutter screen	3.5

* *Theoretical length of chop.*

Source: Honig (1975)

8.3.2

Distance travelled between harvesting and storage

Harvesting systems using a precision chop forage harvester usually rely on independent trucks or carts to take the chopped forage from the paddock to the storage site. If there are several transport vehicles, it is usually not necessary for harvesting to stop between loads.

Sometimes, particularly in the past, carts have been hooked behind forage harvesters and towed. This reduces labour requirements, but there is a delay when hitching and unhitching trailers/wagons.

Because trucks can travel faster than tractors towing wagons, when using trucks the travelling distance to the storage site can be greater without delaying harvest.

Systems that use a forage wagon have to stop harvesting while the chopped forage is delivered to the storage site and unloaded. It is critical that the storage site is near/in the paddock to be harvested to minimise harvesting downtime.

In all cases, even if it does not affect harvesting time, there are costs associated with the distance travelled.

Plate 8.7

When harvesting with a forage wagon, the storage site should be close to the paddock being harvested to reduce downtime.

Photograph: F. Mickan

Advantages of short chop length

A short chop length is an advantage when ensiling most crops:

- It increases the amount of DM transported per trailer or truck load.
- The forage is more evenly and easily spread in the bunker or pit.
- The forage is more easily compacted.
- Less storage capacity is required.
- More WSCs are released resulting in greater bacterial activity – improved fermentation (see Chapter 2, Section 2.4).
- Well suited to mechanised feeding systems and mixer wagons.
- There is increased intake by some classes of livestock (see Chapter 13, Section 13.2.5; Chapter 14, Section 14.2.5; and Chapter 15, Section 15.2.5).
- The rate and extent of aerobic spoilage at feedout is reduced.
- Forage is easier to remove at feedout.
- It can improve animal production when self-feeding (accessibility).

(The last three points are discussed in more detail in Chapter 10.)

Note: Extremely short chopped material will not be a concern in Australian feeding systems unless this silage supplies a large portion of the dietary fibre in diets for dairy cows (see Chapter 13, Section 13.2.5) or where large losses might occur if the silage is fed directly onto the ground.

Section 8.4

Factors affecting the efficiency of bale systems

The efficiency, and therefore the cost, of bale silage production is affected by:

- Size and density of the bale, which depends on:
  - baler type and operator technique
  - characteristics of forage, i.e. DM content, forage length and ease of compaction.
- Speed of baling, efficiency of bale transport, and time taken to wrap or cover and seal bales, which depends on:
  - baler type and adjustment, tractor capacity and operator technique
  - transport distance from paddock to storage site
  - method of wrapping or sealing.

Plate 8.8a

Low-density bales are prone to greater air infiltration, increased risk of losses during storage and are harder to handle.

Photograph: F. Mickan

Plate 8.8b

Lower storage losses and reduced handling and storage costs are advantages of well-formed, dense bales.

Photograph: F. Mickan

Table 8.5

The influence of DM content and speed at baling on round bale density.

Source: Summary by Ohlsson (1998)

DM content	Bale density (kg DM /m^3)	
(%)	Low speed[1]	High speed[2]
30	140	134
36	181	167
57	182	176

1. Speed at baling = 6.0-6.4 km/hr
2. Speed at baling = 8.0-8.8 km/hr

8.4.1

The effect of DM content on bale density

Weight is not always a good indicator of bale DM density. DM density is the weight of DM in a bale of a given size (volume). Bales of the same size produced from high DM forage will weigh less at the same DM density as bales produced from lower DM forage because of the reduced water content. Maximising DM density will reduce handling and storage costs, and reduce the amount of air trapped in the bale.

Increasing DM content of the forage at baling has been shown to increase the DM density of round baled silage (see Table 8.5). However, at DM contents higher than recommended, round bale DM density can decline because the drier forage is more difficult to compact.

The effect of DM content on the density of square bale silage is not known. However, it is reasonable to expect that increasing DM content will increase bale density within the recommended DM content range at harvest.

Plate 8.9

Stemmy crops can puncture the plastic wrapping particularly if harvested when too dry. *Photograph: F. Mickan*

The density of silage in bales is less than in well-compacted chopped silage pits or stacks.

The recommended DM content ranges for baled silage are provided in Chapter 4, Table 4.1, and Chapter 5, Table 5.2. Baling at DM contents higher than recommended will increase field and harvesting losses. The stems of some forages are less pliable and so are more likely to puncture the plastic during wrapping if allowed to over-dry.

The DM content of large square-baled silage should be similar to that of round-baled silage, although some contractors are storing large squares at DM contents above 55% DM. This may be possible because the high density of the large square bales limits the amount of air that is trapped, allowing preservation of the high DM forage. However, ensiling large square-bale silage at these higher DM contents is not recommended because of the increased losses during wilting and mechanical handling.

Poor compaction can be a problem with thick, stemmy crops, and it is difficult to produce dense bales from such forage. Reduced bale density results in more air infiltration and an increased risk of losses during storage. Cost per tonne of ensiled forage also increases with more bales/ha to be baled and wrapped.

If the silage is wet, <30% DM content, the bales will be heavy and harder to handle, and there is an increased risk of a poor fermentation.

When 'wet', wrapped round bales are stored on the round side, there is a risk of the bales 'slumping' and the plastic splitting. Store round bales on the flat end.

8.4.2

Chopping at baling

Chopping balers improve efficiency of the silage-making system by increasing the density (and weight) of bales, so reducing transport and storage costs. In five Irish studies, unchopped and chopped round bales were produced with the same fixed-chamber round baler. As can be seen from the data in Table 8.6, chopping increased bale DM density by 11.5% and reduced the number of bales produced per hectare by a similar amount.

Table 8.6

*Effect of chopping on the weight of bales produced from ryegrass pasture with a DM content of 41%.**

	Unchopped	Chopped
Average bale weight (kg DM)	206	228
Density (kg DM/m^3)	151	168
Number of bales/ha	24.3	21.8

* *Mean of five experiments. Bales produced with a fixed-chamber, roller-type baler.*

Source: Adapted from O'Kiely et al. (1999)

Plate 8.10

Wrapped round bales should be stored on their end to maximise the number of plastic layers exposed to UV sunlight and protect against sharp objects on the ground. This also reduces the risk of bales slumping.

Photograph: K. Kerr

8.4.3

Baling technique

The weight and density of the bale produced will depend on the type of baler used (see Section 8.2.2). However, the expertise of the operator also has a major effect on the end product.

Tractor power must at least match the baler's requirement to be capable of producing firm bales, with an acceptable throughput. The density control mechanism must also be adjusted correctly to match the forage type and DM.

Baling more slowly will produce heavier bales (see Table 8.7). In three of the Irish studies mentioned previously, the impact of increasing tractor speed on bale density (and weight) was measured. When tractor speed was increased from 6.4 to 8.8 km/hr bale weight fell 3.8%.

Figure 8.3

Direction of driving for windrows narrower than the pick up.

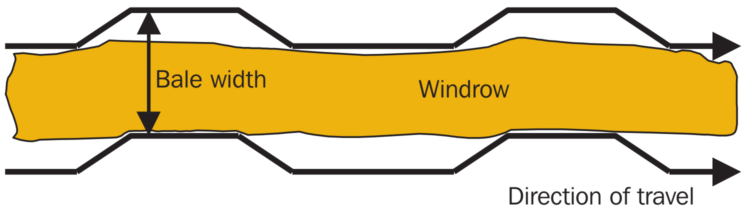


Table 8.7

The effect of tractor speed on the weight of round bales produced from ryegrass pasture with a 38% DM content.

	Speed (km/h)	
	6.4	8.8
Average weight of bales (kg DM)	212	204
Density (kg DM/m³)	156	150
Number of bales/ha	22.4	23.4

* *Mean of three experiments. Bales produced with a fixed-chamber, roller-type baler.*

Source: Adapted from O'Kiely et al. (1999)

8.4.4

Presentation of windrow to the baler

Uniformly shaped round or square bales, with tight, square edges are easier to wrap, stack and seal. Driving technique and windrow shape and density are important in producing well-made bales. The ideal is a regular, dense, rectangular-shaped windrow.

For evenness of baling and maximum bale density and weight, round balers should approach the windrow square-on, so that the windrow feeds evenly into the baler (see Figure 8.3). Because the windrow is often narrower than the bale chamber, it is necessary to drive from side to side, but rapid zigzagging should be avoided as this will produce misshapen bales which are difficult to wrap and store.

The windrow for square balers is ideally even or perhaps slightly thicker at either edge and should be wider than the baling chamber. This ensures that the bales are even and don't have soft sides. Windrows formed by V-rakes or tedder rakes are best for square bales.

8.4.5

Bale size

Bale size will greatly influence the final bale weight. Increasing the bale size will result in fewer bales per hectare or per tonne of silage. Fewer bales will reduce handling and transportation costs. Increasing bale size will also reduce the surface area to volume ratio, and for wrapped bale silage, reduce the amount of plastic used per tonne of silage stored.

The size of the bales produced will depend on the dimensions and adjustment capability of individual balers. Round balers in Australia have chamber widths of either 1.2 or 1.5 m, which limits the width of the bale, and can produce bales that are 1.2, 1.5 or 1.8 m in diameter. Variable chamber balers can be adjusted to produce bales of reduced diameter. Increasing bale diameter will have a greater impact on bale weight than changing bale width from 1.2 to 1.5 m. The effect of altering round bale size on bale weight was calculated and is given in Table 8.8.

Table 8.8

*Effect of bale dimensions on the fresh weight (kg) of round bales.**

Bale diameter (m)	Bale (chamber) width (m) 1.2	1.5
1.2	544	680
1.5	849	1,060
1.8	1,384	1,729

* 45% DM content and a density of 180 kg DM/m^3.

Note: In practice the actual bale density will depend on the baler type, pressure setting, DM of the forage and the speed of baling.

The weight of square bales will depend on the dimensions and also the amount of pressure used at baling. In most cases, the length of square bales for silage is reduced to about 1.5 m, which is less than the maximum length which can be produced by the balers. The reduction in length is necessary for wrapping and makes handling of the bales easier. The major difference in weights of square bales between balers will be due to the height and width of the bales that are produced.

Section 8.5

Harvesting losses

Physical loss of DM during harvesting falls into the following categories:

- Pick-up losses – forage that is not picked up from the windrow or, in the case of direct harvested crops, isn't cut, and is therefore left in the paddock.
- Chamber and ejection losses – applies to baled systems only.
- Drift losses – forage harvested material that is blown away or overshoots during the filling of transport vehicles.

Pick-up losses during baling and forage harvesting are usually small. An Irish study, comparing round balers and forage harvesters, showed pick-up losses were less than 1% with perennial ryegrass (see Table 8.9). Total baling losses were greater for chopped round bales than unchopped round bales from the same baler due to higher chamber losses. Even so, total losses were only about 1%.

Mechanical losses are usually greater with legumes, particularly if the valuable leaf fraction has been allowed to become over-dry and brittle. However, total losses of DM with lucerne made into round bale silage are still low if the wilting period is short and the lucerne does not become over-dry (see Table 8.10). In these studies, losses were higher on one occasion where wilting was delayed due to poor weather, and the lucerne then became much drier. Rain can leach the leaf fraction of the forage; it then dries more rapidly and can become over-dry and brittle.

Losses were also higher for chopped round bale silage in this study, and were likely to have been due to increased chamber losses. Chamber losses with hay are predominantly (up to 80%) leaf and are likely to be similar with silage, particularly at higher DM contents.

The losses with a square baler are not known, although pick-up losses are likely to be similar to round bales. Chamber losses will probably be lower because the forage is not rubbing against the baling chamber, as is the case with round balers.

Drift loss for most forage-harvesting situations has been estimated at 1-3%. Although not measured, estimates suggest that as DM content rises from 25% to 50%, drift losses could increase from 0.5% to 5%. Drift losses increase with wind speed. Anecdotal evidence also suggests that the wind effect is greater and drift losses higher with low-yielding crops. Poor operator technique or trying to overfill the transport vehicle will also increase drift losses.

Table 8.9

Comparison of forage DM losses (%) at harvesting with a round baler, either chopped or unchopped.

	Unchopped	Chopped
Pick-up loss	0.66	0.67
Chamber loss	0.15	0.33
Ejection loss	0.02	0.03
Total loss	0.83	1.03

Perennial ryegrass based pasture, harvested at 26% DM content.

Note: Pick-up loss from a precision chop forage harvester was 0.60%.

Source: Forristal et al. (1998)

Table 8.10

DM losses from lucerne at baling and DM density of unchopped and chopped round bales.

Study	DM content at baling (%)	Hours of wilting	DM losses (%) Unchopped	DM losses (%) Chopped	Bale density (kg DM/m³) Unchopped	Bale density (kg DM/m³) Chopped
1	35	7	0.5	0.7	175	182
1	49	28	0.6	1.2	195	203
2	61	104*	2.0	4.7	156	162
3	38	5	0.7	1.7	149	153
4	44	5	0.6	1.3	231	237

** Rain for four days.*

Source: Adapted from Borreani and Tabacco (2002)

Section 8.6

Harvesting when conditions are less-than-ideal

The importance of weather forecasts when deciding when to mow a silage crop is discussed in Chapter 6. Section 6.7.2 covers the effect of humid or wet weather on drying rates and field DM losses.

'Difficult' harvesting situations will occur from time to time; some of which are out of the control of the producer. Possible solutions to some of the more common problems appear below.

Situation	Potential problems	Possible solution	
		Forage harvester system	Bale system
1. Forage too wet	Poor fermentation, effluent production at <30% DM, loss of DM and quality (see Chapter 2, Section 2.1.1).	Use an additive if effective wilting is not possible (see Chapter 7).	Baling wet forage should be avoided.
2. Forage too dry	Compaction is difficult, air not excluded, respiration prolonged, loss of DM and energy, mould growth; silage unstable at feedout (see Chapter 2).	Reduce chop length; pay extra attention to rolling of stack; alternate loads of dry material with lower DM forage (if available); as a last resort, water may be sprayed on the stack (see Appendix 8.A1). Consider hay as an option.	Bale before dew lifts. Use baler with a chopping mechanism. Adjust baler to increase bale density. Consider hay as an option.
3. Prolonged silage harvest due to machinery breakdown or low harvesting capacity/poorly matched equipment.	Prolonged respiration, DM and quality losses.	Seal material within 3 days of mowing. Plastic sheeting over stacks each night will minimise air movement into the stacks. If harvesting is interrupted, seal the portion of the stack already formed, creating a separate compartment when harvesting recommences. Reopening the end of the stack to store fresh silage is a more practical option, but needs care to avoid spoilage. In this case, some spoilage is likely at the interface between the two batches.	Bales should be wrapped within 1-2 hours of baling. If bales have to be left unwrapped, overnight, losses will occur. It is sometimes recommended that round bales be pushed onto their end; bales will hold shape and are easier to wrap.
4. Rain during harvest	a) Forage becomes too wet (a lot of rain is needed to significantly increase the forage DM). b) Reduced trafficability. c) Contamination of the forage with mud (especially in bunkers or buns).	Keep harvesting, stopping if field operations cause the harvested forage to be contaminated with mud. A 'sacrifice' pad of fresh forage at the entrance to the bunker/bun can reduce contamination. If wet harvests are common, consider concrete flooring.	Keep harvesting, stopping if field operations cause the harvested forage to be contaminated with mud.
5.Transportation of forage over long distances (mainly applies to baled silage).	Prolonged respiration, DM and quality losses. Cost of transporting lower DM forage long distances must be considered.	Minimise transportation time. Cover load to reduce transport losses and aeration of forage. Compact and seal quickly on arrival.	Bales have been transported long distances (>500 km). *Wrapped bales* – high risk of damage to plastic seal. Extreme care needed during any handling between wrapping and final storing. Inspect bales at the storage site and repair any damage to plastic. *Unwrapped bales* – Some DM and quality losses are likely. Critical to minimise interval between baling and loading onto transport (ideally 1-2 hours). Cover load to minimise airflow. Transport without delay to final storage site. Wrap and/or seal bales immediately on arrival.
6. Flooded crops	Mud on forage can introduce undesirable micro-organisms, which can adversely affect silage fermentation. Any flood debris must be removed to avoid damage to machinery.	Depending on the crop/pasture type, other options are to cut for hay, grow crops through to grain harvest, wait for rain to wash off mud or graze pastures. For silage making: • raise cutting height to avoid thick mud; • remove flood debris; • use silage inoculant to ensure desirable bacteria are present; and • if only part of crop is flooded, store that portion separately to avoid contamination of the unaffected portion.	

Section 8.7

Contamination of silage

Contamination of forage with soil, dead animals or straw and rank grass during harvest should be avoided. Undesirable bacteria may be introduced that will adversely affect the silage fermentation, aerobic stability of the silage at opening, and the health of animals fed the silage.

Soil

Soil-borne bacteria (e.g. clostridia) can cause undesirable fermentations or lead to diseases in livestock (listeriosis, caused by listeria) (see Chapter 2, Section 2.3.5). Dirt and mud may be carried into the stack as clods picked up by the harvester, from the wheels of unloading trailers or the rolling tractors.

Rolling paddocks after sowing to break up or bury large clods can reduce soil contamination of the mown forage. Setting the tedding and raking machines at the correct height will also reduce soil contamination.

A cement apron in front of the stacks will prevent the forage coming in contact with the soil during loading and unloading. Ideally, the tractor rolling and spreading the forage should remain on the stack surface until filling is completed.

Old straw and rank grass

Old straw, rank or rotting stems of previous crops and lodged plants are usually contaminated by a range of bacteria, yeasts and moulds (see Chapter 2, Section 2.3.4). Harvesting this material can adversely affect fermentation and reduce aerobic stability at feedout.

Ensiling a significant proportion of this inferior quality material will also decrease the energy (ME) content of the silage.

Dead animals

Animals are at risk from botulism if they eat silage that contains dead animals trapped in the forage at harvest. All animal remains should be picked up before mowing, although it is often difficult to see bird, snake or rodent carcases as they are picked up during harvest (see Chapter 2, Section 2.3.5).

There is also a risk of botulism when burrowing animals die in the stored silage.

The risk of botulism increases with lower DM silages.

Effluent

Risk of contamination from animal effluent (e.g. from piggeries, dairies or feedlots) used on silage crops or pastures can be minimised if it is not applied within six weeks of the crop being harvested. The risk is further reduced if it is applied onto bare ground, before the crop is sown or while the crop is very short.

Contamination risks increase if the effluent contains large particles that may be picked up by the harvesting equipment. See Chapter 4, Section 4.2.2, for more detail on guidelines for the use of effluent.

Toxic weeds

There are inadequate Australian data on the impact of ensiling on the poisoning risk of toxic weeds. The level of risk will vary with the type of weed, the amount fed to the animal and the concentration of weed in the silage. The type and class of animal is also likely to affect the risk level.

Weeds suspected of being toxic should be controlled, or infested portions of the paddock avoided at harvest. Producers should seek appropriate advice on weeds of concern.

Also to be considered when harvesting broadleaf weeds is the potential for reduced quality and the effect on silage fermentation (see Chapter 3, Section 3.3.1).

Section 8.8

Appendix

8.A1

Adding water to lower the DM content of over-dry forages

Step 1.

Weight of forage DM (kg) = Weight of original fresh forage x $\frac{\%\,DM}{100}$

Step 2.

Total final fresh weight of material (forage + added water) = Weight of forage DM x $\frac{100}{\%\,DM\ desired}$

Step 3.

Amount of water to add = Total final weight of material – weight of original fresh forage

Example:

How much water should be added to 1 tonne (1,000 kg) of 70% DM forage to obtain a 50% DM forage.

Step 1.

1,000 kg x $\frac{70}{100}$ = 700 kg DM

Step 2.

700 kg DM x $\frac{100}{50}$ = 1,400 kg

Step 3.

1,400 – 1,000 = 400 kg water to lift DM content to 50%

= 400 litres of water