Chapter 6

Mowing and wilting pastures and crops

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In this chapter

The authors

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The Key Issues

Crops and pastures are mown and wilted to increase the DM content of the ensiled forage. Wilting should occur as rapidly as possible to minimise the loss of DM and quality in the field. Monitor weather forecasts to decide when to mow.

- Mow in the morning after the dew has lifted, later if harvest is possible within 24 hours.
- Ensure mower blades are sharp and set to cut at the correct height.
- Ensure tractor power is sufficient to maximise mower output.
- Wilt to the correct DM content as quickly as possible:
    - Low-yielding crops wilt more quickly than high-yielding crops.
    - Vegetative (leafy) plants wilt more rapidly than more mature (stemmy) plants.
- Increase wilting rate by:
    - conditioning the plants at mowing,
    - maximising the surface area of the swath, leaving the mown swath as wide and thin as possible, OR
    - spreading or tedding immediately after mowing, AND
    - respreading or tedding when and if necessary after the dew lifts.
- If possible, harvest no later than 48 hours after mowing.
- The fastest wilt is achieved with a thin swath, warm temperatures, low humidity, long periods of sunshine, and with a breeze.

Section 6.0

Introduction

Most crops and pastures cut for silage have to be mown and windrowed so that the forage can be harvested by machinery fitted with windrow pick-up attachments. This includes all balers, most fine and precision chop forage harvesters, and double chop and flail harvesters operating in Australia (see Chapter 8). Direct harvest (e.g. 'Kemper') fronts are available for some forage harvesters, but they are not common and are only suitable for harvesting certain crops when the DM content of the standing crop is already at the desired level.

The DM content of most standing crops and pastures is low (<20%) when they are at the growth stage recommended for silage cutting (see Chapter 4, Table 4.1, and Chapter 5, Table 5.2). The forage must be wilted prior to ensiling to ensure a good silage fermentation and to eliminate effluent losses (see Chapter 2, Section 2.1.1).

Wilting occurs between mowing and harvest, and describes the process of plant moisture loss prior to the forage being harvested or baled. Crops and pastures should be wilted as quickly as possible to the desired DM content, to minimise loss of DM and quality.

The period of wilting required will depend on the original DM content of the crop, extent of wilting required, quantity of material (yield), time of day when cut, prevailing weather conditions, wetness of the ground surface and mechanical treatments used to enhance the speed of wilt. These factors are discussed in this chapter.

Safety First

- Operate all equipment to the specifications laid down in the manufacturer's manual and/or warning stickers on the machinery.
- Never approach machinery until all mechanical motion has completely stopped.
- All PTO shafts, belts, chains, etc, must have strong, tamper-proof coverings that are only removed for servicing and repair work after machinery has been turned off and all moving parts are stationary.

What it means ...

- Swath – the material left by a mower or mower-conditioner.
- Tedded swath – mown material that has been spread or respread by a tedder.
- Windrow – the mown material that has been raked in preparation for harvest.
- Harvesting – the picking up and baling or forage harvesting of the mown material from a windrow.
- DM loss – the quantity of material lost during the conservation process, e.g. for every tonne of forage cut, if DM loss is 10%, then 100 kg of DM has been lost. DM loss is sometimes confused with DM content, which is the DM present in each unit of forage.
- Quality loss – the reduction in the content of nutrients (e.g. ME, crude protein) during the conservation process.

Section 6.1

Assessing likely weather conditions

Ideally, forage should be cut and harvested under good drying conditions, without risk of rain damage.

Before mowing, use weather forecasts to select a 'harvest window' when weather conditions are likely to be favourable for silage making. As well as local and regional weather forecasts, the Internet provides up-to-date forecasts. The Australian Bureau of Meteorology has a website containing valuable weather information <www.bom.gov.au>.

A number of other commercial and free sites also exist, including:

- <www.myweather.com.au>
- <www.theweather.com.au>

Plate 6.1

Perennial ryegrass pasture cut with a mower-conditioner set to produce a wide swath (left of photograph) and a narrow swath (right).

Photograph: F. Mickan

Section 6.2

Time of day to mow

Photosynthesis is the process by which plants use solar radiation (sunlight) to produce WSCs. Respiration is the process by which plants break down WSCs to produce energy for growth. It is the reverse of photosynthesis. Under normal growing conditions, both processes occur in plants.

How WSC content varies during the day

As discussed in Chapter 2, Section 2.1.2, the conversion of WSCs to lactic acid is essential for a good silage fermentation. High WSC content allows production of more lactic acid, more quickly, thus increasing the chance of a rapid and favourable fermentation.

Accumulation of WSC is greater than respiration during sunny periods, while respiration leads to a reduction in WSC content when it is overcast or at night. So, WSC content is usually lowest in the morning and accumulates during daylight hours. On cool, overcast days WSC content may not vary much at all during the day.

Respiration continues after mowing if plant moisture content is high and while WSCs are still available. For a short period after cutting, a small accumulation of WSC may occur at the top of the swath, which is exposed to sunlight, but this contribution to the WSC content is negligible.

It is not possible to provide general guidelines to cover every silage-making scenario as the effect of weather conditions on wilting rate is a major consideration. Although it is sometimes suggested that mowing should start mid-afternoon to maximise available WSC, in all cases the primary aim should be to achieve the target DM content (see Chapter 4, Table 4.1, and Chapter 5, Table 5.2) with a rapid wilt. This, not the WSC content of the uncut forage, should determine cutting time.

How time of day of cut affects wilting rate

Cutting early in the day maximises the amount of moisture loss that can be achieved on the day the forage is mown. Cutting later in the day often results in the forage requiring an extra day of wilting to reach the desired DM content, and can increase respiration loss of forage DM and quality. The following points should be considered:

- Mowing should not begin until the dew has lifted. This surface moisture evaporates much more rapidly from the standing crop than from mown material.
- If the day of cutting is very hot, dry and windy, and similar conditions are expected the following day, it may be advisable to delay cutting until early to mid-afternoon, to reduce the risk of the forage becoming too dry by the following morning.
- Some forages, such as legumes and young, leafy crops or pastures, wilt more rapidly (see Section 6.5), and require a short wilting period, particularly if the yield is not high. For these, cutting later in the day may reduce the risk of over-drying, and excessive mechanical damage and leaf loss in subsequent operations.
- Where there is a definite risk of over-drying, mowing may be staggered and the swath width should be narrowed. It is important to match mowing and harvesting operations so that cut material is not left too long.

Extending the wilting period also increases the risk of rain before harvesting. This can be particularly important in coastal areas that are prone to unpredictable, afternoon rain during the summer silage-making season.

Timing the cut

When to cut is often a compromise between quality and yield.

The digestibility of most temperate pastures and crops used for silage production is highest in early spring, before maximum yield is achieved. This often coincides with lower temperatures, shorter days and, in southern Australia, a greater chance of rainfall. As a result, many farmers delay harvest until later in the season – towards what is often the more traditional haymaking season. When planning harvest times, consider the following points:

- Cutting earlier in the season, the forage has a higher nutritive value. Cutting later, when the crop or pasture is more mature, will give higher yields, but the forage will be of lower quality (see Chapters 4 and 5).
- Cutting early increases the risk of losing quality because of poor wilting conditions and rainfall but, in most cases, the average loss in quality is unlikely to be as great as the decline in ME content when cutting is delayed by three or more weeks.
- In many cases, and depending on forage type, even with reduced yield the animal production per hectare of cut forage is higher from silage produced early in the season. With very mature forage, the quality decline may be so great that the silage is only suitable as a maintenance ration (see Chapters 13, 14 and 15).
- The costs of production are very similar per tonne of silage conserved for early-cut, lower-yielding and late-cut, higher-yielding crops or pastures. When costed on an ME basis, the higher-quality, early-cut silage is less expensive (see Chapter 11, Section 11.3.5).
- Early cutting should produce a greater quantity of high-quality regrowth and a greater total forage yield (silage and regrowth) (see Chapter 3, Section 3.1.1).

Section 6.3

Mowing

The mower's efficiency will have a major impact on the success and speed of the wilting process. Mowing rates should be more than 1.5-2.0 ha/hour. It is important to avoid any factors that may extend the mowing period, such as using small mowers, blunt mower blades or under-powered tractors. It may be more economical to employ a contractor with the latest and largest machinery to mow and condition the crop. (The economic reasoning behind the use of contractors is discussed in Chapter 11, Section 11.2.3.)

Using conditioners and increasing swath width can increase wilting rate (see Section 6.6). Formation of lumps in the swath behind the mower must be avoided because the material takes longer to dry and can slow down the harvesting operation.

Table 6.1

Suggested cutting heights for various forage types.

Forage type	Height of cut (cm)
Pastures	4-7
Summer forage crops (e.g. sorghum)	10-15
Lucerne	5-7 (above plant crowns)
Cereals	7-10 (>15 for increased quality)
Maize	10-40 (see Chapter 5, Section 5.2.4)
Kale	7-8
Peas	10-12
Lablab	10-12
Soybeans/canola	6-10

6.3.1

Height of cut

The ideal cutting height depends on a number of factors, including the type of pasture or crop, yield and quality, potential for regrowth, wear and tear on blades and machinery, soil and manure contamination and provision of a stubble on which the mown material can lie for drying.

The optimum height of cut to maximise regrowth will vary with the pasture or crop, but is usually 4-7 cm for pastures and 10-15 cm for summer forages such as sorghum. Cutting crops and pastures with multiple-cut potential too short (<5 cm) may slow the rate of regrowth and reduce total yield over the season. Table 6.1 gives suggested cutting heights for various crops and pastures.

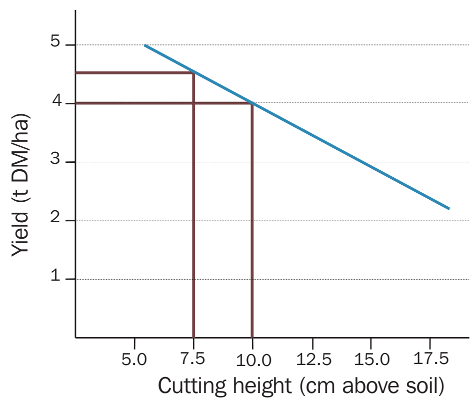
Although cutting material very short will slightly increase yield, depending on the plant species, this may be offset by the poorer quality of the lower stems and leaves. If cutting height is increased to avoid low-quality stems, stubble management strategies may be needed if the paddock is to be returned to crop or pasture in the near future.

Figure 6.1 shows the results of some recent American research on cutting height with lucerne. On average, total yield for each cut increased about 0.5 t DM/ha for each 2.5 cm reduction in cutting height. The shorter cutting height did not reduce the yield of the next harvest when cut at the mid-bud to early flowering stage. Although quality decreased slightly with decreasing cutting height, when both quality and quantity were taken into account, the potential milk yield rose when cutting height was reduced.

It is important to have the mower properly adjusted for height and to maintain sharp blades. Poorly maintained and badly adjusted equipment needs more power and so increases operating costs. Mowers set at too great an angle will 'scalp' the sward and leave a 'mane' of crop between the cutting discs. This can substantially reduce regrowth.

Poorly adjusted mowers also cause problems if they come into contact with the soil regularly, increasing the wear and tear on blades. This increases 'down time', with more frequent sharpening or changing of the blades. At very low cutting heights, the contact between blades and the soil can put undue stress on the gears driving the rotors, reducing the mower's potential life.

Figure 6.1



Effect of cutting height on lucerne yield per cut.

Source: Adapted from Wiersma et al. (2001)

Cutting low also increases the risk of soil and manure contamination of the silage. This can introduce undesirable bacteria to the forage and adversely affect the silage fermentation. It may even have implications for animal health (see Chapter 2, Section 2.3.5).

Exposed stones can damage mowers, forage harvesters and chopping balers. Rolling after sowing can be an advantage where the surface is uneven or stones or clods are present.

Leaving a stubble ≥10 cm high provides support for the mown material, reducing contact between the swath and the ground. This increases the drying rate, allowing greater movement of air under and through the swath. The mown material is also kept above the ground, reducing the movement of moisture into the cut forage.

6.3.2

Types of mowers

Mower types include:

- reciprocating finger-bar (sickle bar);
- flail;
- drum;
- rotary disc; and
- mower-conditioners (roller type, tyned or flail type).

Mowers and mower-conditioners are usually mounted to a tractor three-point linkage or trailed. The development of combination front- and rear-mounted mowers, trailed tandem-mounted and self-driven mowers have increased mowing rates.

Reciprocating finger-bar mowers

Lucerne growers often favour reciprocating finger-bar (also called sickle or cutterbar) mowers because they leave a 'cleaner cut' or reduced fragmentation of the stubble. They have a relatively low power requirement, about 1.5 kW/m width of cut, but forward speed is restricted to 3-8 km/hr, giving a mowing capacity of about 0.6 ha/hr in good cutting conditions.

They have generally been superseded by rotary disc and drum type mowers that have a faster cutting speed, less chance of 'blocking' in wet or lodged material, and greater durability on stony ground.

Flail mowers

Flail mowers are modified flail harvesters, which leave the mown crop on the ground in a windrow. After wilting, the chute is changed to allow the material to be picked up and delivered to a cart. Output ranges from 0.4 to 1.2 ha/hr for a 1.5 m width of cut, and up to 1.5 ha/hr with a 1.8 m width of cut, but requires at least 35 kW to operate at 8 km/hr.

They are no longer common, due to their inefficiency as mowers, lack of speed and high power requirement. The action of flail mowers can cause the forage to be contaminated with soil or manure.

Drum mowers

Drum mowers usually consist of one or more pairs of large drums, each fitted with several knives. The two drums in each pair rotate in opposite directions, forcing the mown material between them and leaving the swath in a windrow. Drum mowers have a much greater capacity than finger-bar mowers but require 4-8 times the power, typically 7-15 kW at the PTO per metre width of crop cut. The swaths left behind these mowers tend to 'sit higher' than those left by rotary disc mowers.

Leaving the mown material in a windrow is a disadvantage. To increase wilting rate, the material should be tedded immediately after mowing (see Section 6.6).

Disc mowers

Multi-disc mowers are the most popular mowers due to their speed of operation and durability. Disc mowers consist of several pairs of small rotating discs, each usually fitted with two knives. The pairs of discs rotate in opposite directions, like drum mowers, but because the discs are much smaller in diameter, the material is essentially left where it is cut. Disc mowers are fitted with swath plates, which allow the swath width to be adjusted, from a narrow windrow to one almost the width of cut.

Disc mowers have a similar throughput capacity to drum mowers. Cutting widths and work rates of individual mowers have increased substantially in recent years. They (and drum mowers) can be operated at forward speeds of 10-13 km/hr, giving a cutting rate of 1.0-1.5 ha/hr/m width of cut, depending on crop and ground conditions, and operator skill.

There is some evidence that forage cut with a disc mower dries more quickly than that cut with a drum mower. In these studies, both in Australia and overseas, the principal advantage appears to be the wider swath width. One disadvantage is that the forage drops to the ground with minimal disturbance, so the thickest and wettest parts of the crop remain at the base of the swath, on the ground. In very heavy crops, the base of the swath can be still very moist after several days unless the drying conditions are very good or the crop is tedded after mowing (see Section 6.6).

Mower-conditioners

In the past, conditioners required two operations, with separate implements, to pick up and condition the crop. With higher capacity tractors and a need for greater efficiency, mowers (usually disc type) that incorporate conditioners have been developed. There are now mower-conditioners with a cutting width of about 5.5 m that are capable of cutting 1.0-1.5 ha/hr/m width of cut. They require up to twice as much power as mower-only machines, to maintain output and performance, typically 15-25 kW at the PTO per metre width of crop cut.

There are essentially two main types of conditioners – roller and flail.

Roller conditioners operate by either 'crushing' or 'crimping' the cut forage with rubber and/or steel rollers of various designs. The crimping types leave a number of breaks at intervals along the stem, whereas the crushing types split the stem along its length.

The flail-type conditioners use a variety of metal, polyethylene or nylon spokes or tynes, which may be either straight or vee shaped, a series of rotating nylon brushes, or various combinations of these.

Conditioners vary in their suitability for various crops and pastures. Research has shown that roller conditioners are the most suitable for 'stemmy' crops, such as sorghum, cereals and stemmy leguminous crops with a tall growth habit such as balansa, Persian, berseem and arrowleaf clovers and lucerne, but can be used for all crops and pastures.

As a general rule, the tyned conditioners should only be used for grass-type pastures and crops such as ryegrass, early cut millet and cereals, and non-stemmy legumes, such as sub and white clovers and medics. Conditioners fitted with nylon brushes have a role in 'softer' pasture-type forage. The way the machine is set up and the skill of the operator will have a bearing on the effectiveness of the operation. Machines adjusted incorrectly may either over- or under-condition the forage.

Plate 6.2

Disc mower. *Photograph: F. Mickan*

Plate 6.3

Disc mower, with flail conditioner. *Photograph: F. Mickan*

Plate 6.4

Rear view of disc mower with roller conditioner. *Photograph: F. Mickan*

Conditioners increase the rate of wilting in two ways. They damage the outer waxy protective layer (cuticle), allowing moisture to pass through the plant surface more freely. They also damage the stem, increasing the rate of moisture loss from these areas.

Forage should not be over-conditioned; this will cause increased loss of DM. The leaf fraction, which is the highest quality component of the forage, is particularly susceptible to over-conditioning.

If a separate conditioner is used, this operation should follow as soon as possible after cutting to be most effective and to minimise DM losses.

Many mower-conditioners and conditioners now have adjustable swath boards or deflector plates to allow mown forage to be left in very wide swaths. The ideal drying swath will have the stems of the crop on top of the swath, be widely spread and left 'fluffy' to allow airflow through the swath and for the moisture to escape. The advantages of rapid wilting, and the use of mower-conditioners and other practices to increase wilting rate are discussed in Sections 6.5 and 6.6.

The demand for greater capacity has resulted in longer cutter bars on mower-conditioners. Combinations of front- and rear-mounted mower-conditioners or tandem-mounted mower-conditioners have also increased cutting widths. These can have overall mowing widths above 7 m, and cutting rates up to 10 ha/hr.

The latest development has been the self-driven mower-conditioners, incorporating two side mower-conditioners and a front mounted mower-conditioner with cutting widths of about 9 m and cutting rates of up to 10 ha/hr.

Table 6.2

Increase in drying rate achieved using various machines.

Type of machine	Increase in drying rate (%)
Windrow inverter	20-30
Tedder	30-60
Mower-conditioners	20-40
Maceration, super conditioning, mat making	100-200

Source: Adapted from Savoie et al. (1993)

Intensive mechanical conditioning

Recent research in the United States, Canada and Australia has compared drying rates of forage using various machines – those that heavily condition crops at mowing, and high-performance or intensive mechanical conditioners (maceration, mat making or super conditioning). These high-performance conditioners are in the early stages of development. Table 6.2 shows the relative drying rates that can be expected from a range of machines designed to increase forage drying rates.

The maceration system combines four steps into one machine: mowing, macerating it through a series of serrated rollers, compressing the mashed forage into thin mat, and depositing it on the stubble for field drying. Macerated forage can dry 2-3 times faster than conventional windrows. Although use of maceration systems has been shown to improve quality of lucerne hay produced, with significantly less field losses, its role in silage production is still being evaluated.

Section 6.4

Dry matter content

All forages are composed of dry matter (DM) plus water. Therefore, a silage which has a DM content of 45%, contains 55% moisture, for a total of 100%. When completely dried in an oven, only the DM remains. It is the DM that contains the energy, protein, fibre, minerals and vitamins that livestock require for maintenance and production (see Chapters 13, 14 and 15).

6.4.1

Target DM content at harvest

A good silage fermentation depends on the forage being harvested in a target DM range (see Chapter 2, Section 2.1). The target DM content will vary with factors such as crop type, growth stage at harvest, and the type of equipment and storage method being used. Table 6.3 shows recommended DM content and wilting requirements of a range of crop and pasture types. Chapters 4 and 5 give more detail on recommended DM content and growth stage at harvest, potential yield and quality of specific crops and pastures.

The DM content for baled silage is usually higher than that recommended for silage harvested with a forage harvester and stored in pits or bunkers. Figure 6.2 shows the target DM content for various forms of forage storage options. The maximum DM content recommended for most Australian

Table 6.3

Wilting requirement and target DM content at time of ensiling for a range of crops and pastures.

Crop type	Wilting requirement	Target DM (%) content at ensiling	
		Forage harvested	Baled
Lucerne Legume-dominant pastures Legume forage crops Grain legume crops Cereal/legume mixtures	Yes	35-40	35-50
Temperate grass/ clover mixtures	Yes	30-40	35-50
Kikuyu grass	Yes	35-40	35-50
Whole crop cereal	Boot – Yes Dough – No*	35-40	35-50
Forage sorghum	Yes	30-40	35-50
Japanese millet Forage pennisetum	Yes	30-40	35-50
Grain sorghum	No*	30-35	NR
Sweet sorghum	No*	25-35	NR
Maize	No*	33-38	NR
Brassica spp. (canola, kale)	Yes	30-35	35-45

** Direct harvested.*

NR – not recommended.

See Chapters 4 and 5 for more detail.

silage storage systems does not exceed 50% DM, the level for most baled silage systems.

If the forage becomes over-dry, very fine chopping and using balers that can compact the material well may allow an adequate preservation of the silage. However, harvesting at DM contents above the target ranges in Table 6.3 is not recommended because of the high field losses that can occur (see Chapter 2, Section 2.5.1).

In reality, if most of the crop is to be harvested at the desired DM content, harvesting will usually start when it is slightly lower than recommended. Minimising time delays – by using extra or larger equipment, or contracting operations, for example – ensures quality losses during harvesting are kept low, and that most or all the silage is harvested within the target DM range.

Effluent loss can be a major problem with low DM silage (see Chapter 2, Section 2.1.1), but is less significant when DM content of the silage is more than 28-30%.

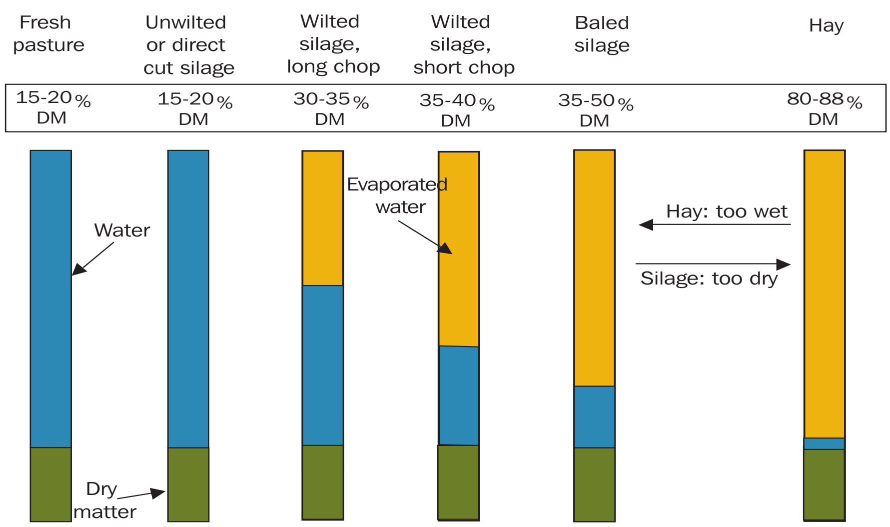
The contamination of waterways and groundwater with silage effluent is a potential problem that can be avoided with good wilting management (see Chapter 2, Section 2.1.1). Contamination of water systems is a growing concern, receiving increasing attention from the various environment protection authorities.

As well as being an environmental concern, effluent loss results in a decline in silage quality. Silage effluent contains many nutrients, with up to 5-10% solids, comprising soluble crude protein (20-30%), soluble sugars (4-30%), fermentation products (0-30%) and ash (20-30%) on a DM basis. A silage of 20% DM may lose 5% of its DM as effluent, most of which is highly digestible.

- Legumes have relatively low WSC content and, for chopped silage, need to be wilted to DM levels at least 2-5% units higher than grasses or cereals, at the lower end of the target range.
- More mature plants with lower leaf:stem ratio need to be ensiled at the lower end of the recommended DM ranges to ensure adequate compaction (see Table 6.3).
- Haylage is an American term used to describe high DM silage (50-60% DM) stored in large tower silos using the Harvestore® system. The enormous weights inside the towers compacts the silage.
- Some producers have successfully ensiled large square bales at 55-70% DM. However, field losses (DM and quality) at these high DM levels are greater.

Figure 6.2

The target range of DM content for various forms of forage.



6.4.2

How to determine DM content of forages

Sending samples of fresh forage to feed analysis laboratories for accurate DM assessment is not practical. Simple and relatively quick DM assessment can be done on-farm using one of two methods:

1. Hand squeeze method.
2. Microwave oven method.

At the time of publication, hay moisture meters, although accurate for measuring low moisture content in hay, for example, were not sufficiently accurate for forages in the DM range recommended for silages. However, further evaluation is required.

Standard kitchen ovens are not suitable for drying forage samples. As well as the risk of the sample burning, the process is very slow and may take 10 to 24 hours to dry completely.

The sample of forage to be dried must be representative of the mown material, with samples from various locations in the paddock and to the full depth of the windrows. Areas not representative of the paddock, such as capeweed infestations or wetter sections, should be sampled and treated separately. These sections of the paddock may need to be harvested last, particularly within a baled silage system.

Plate 6.5

Silage quality and DM losses can be high if the forage is not adequately wilted. These bales were ensiled when DM was too low.

Photograph: F. Mickan

Hand squeeze method

This is a quick and easy method for use in the field. It is more accurate than 'wringing' a handful of unchopped grass. Initially, you may need to calibrate this method (or some other test devised by your own experience) by using a microwave oven to determine the correct DM content, or be guided by someone with experience in using the technique.

1. Take representative samples of the mown forage across the paddock. (In uniform crops, a small section may be forage harvested and a sample collected.)
2. Mix the samples thoroughly and take a sub-sample.
3. Cut the sub-sample into 1-2 cm lengths.
4. Tightly squeeze a handful into a ball for about 30 seconds.
5. Quickly open hand.
6. Estimate approximate DM content from Table 6.4.

Table 6.4

DM content determination from hand squeeze method.

DM content	Condition of the sample
Below 25%	Free moisture runs through fingers as material is being squeezed. When pressure is released, the ball of chopped forage holds its shape. A lot of free moisture is present on hand.
25-30%	Ball just holds its shape. No free moisture expressed. Hand moist.
30-40%	Ball falls apart slowly. No free moisture. Little or no moisture on hand.
Above 40%	Ball springs apart quickly.

Warning

Place a 250 mL glass three-quarters full of water in the oven during drying to prevent the forage sample charring or igniting as it becomes completely dry. Maintain the water level during oven use.

You may need to replace the water with cold water if it starts to steam or boil as this steam may be absorbed by the drying forage.

At the same moisture content, stemmy material will tend to feel drier than leafy material. For example, grasses and lucerne will feel drier than clover. Forage that has surface moisture from heavy dew or rain, may feel wetter than it is. In both cases, the effect will be less for chopped material than for longer material.

Microwave oven method

A reasonably accurate estimate of DM content may be obtained using a standard domestic microwave oven. Digital scales, which measure to units of one gram, are essential.

Follow steps 1 and 2 of the hand squeeze method, then:

3. Cut the sub-sample into 3-4 cm lengths.
4. Tare a container suitable for use in a microwave. The size of the sample to be weighed should be equivalent to the amount that could be heaped onto a large dinner plate (about 150 g). Weigh the sample of the chopped forage in the tared container, measuring to the nearest gram. Record this as the *initial wet weight*. Spread the material evenly over the container and place in oven with a glass of water (see 'Warning' at left).
5. Dry on full power (high) for intervals of 3-5 minutes to begin with until the sample begins to feel dry (time depends on sample size, shortness of chop and initial DM content), reducing to 30 seconds to one minute as the sample becomes drier. Samples should be turned and 'fluffed-up' at each weighing to improve evenness of drying. This initial drying may require up to 10 minutes of microwave time for very wet samples.
6. Record weight of the sample and continue to heat, initially for 30-second periods, at reduced power. Record weight at the completion of each period in the microwave.
7. If the weight of the sample does not change after two or three drying intervals, it is 100% dry (to within 1-2% units). This is the *final dry weight*. If the sample chars or burns, use the previous recorded weight. Occasionally, the weight may increase if the sample absorbs some moisture from the glass of water; if this happens use the last recorded weight.
8. See box below for the method to calculate DM content.

8. Calculate the DM content

$$\text{DM (\%)} = \frac{\text{Final dry weight (g)}}{\text{Initial wet weight (g)}} \times 100$$

Example: $\frac{48\text{ g}}{112\text{ g}} \times 100 = 42.8\%$ DM

Remember: Tare the container (set the sclaes at zero before adding the sample) or subtract its weight from both the initial and final weights.

Forage and silage DM content is usually expressed as a percentage of the total weight. It is calculated using the following equation:

$$\text{DM (\%)} = \frac{\text{dry weight (g)}}{\text{wet weight (g)}} \times 100$$

DM content may sometimes be expressed as g/kg. In this case, the following equation is used:

$$\text{DM (g/kg)} = \frac{\text{dry weight (g)}}{\text{wet weight (g)}} \times 1{,}000$$

Conversion: 1% = 10 g/kg

Section 6.5

Wilting

Wilting is the process where moisture evaporates from the mown forage to increase DM content to the desired level for harvesting.

To minimise losses (DM and quality) the mown material must be wilted as quickly as possible to the target DM content (see Table 6.3). Ideally, wilting should take no longer than 48 hours. The longer the wilting period needed to achieve the target DM content, the more extensive the DM and quality losses due to continued plant respiration and microbial (bacterial and mould) attack. The risk of rain will also increase.

Wilting beyond the target DM content also results in higher quality and DM losses due mainly to leaf loss before and during harvest (see Section 6.7).

Weather conditions directly affect wilting rate. Warm days with low humidity and extensive periods of solar radiation (sunlight), accompanied by wind, result in the fastest rates. During cool, overcast weather, when the humidity is high, wilting rates are slowest because of low evaporation rates. Weather conditions also affect loss of forage DM and quality during the wilting period (see Section 6.7).

Wilted silages are usually more palatable and result in greater animal intakes than unwilted silages produced from the same forage. However, whether or not animal production is improved will depend on the length of time taken to wilt the forage (see Section 6.5.2).

6.5.1

How wilting occurs

Moisture loss from mown forage is initially quite rapid. It occurs primarily through the stomata (microscopic pores) that are concentrated on the leaves and, to a lesser extent, the stems. Most of the water loss from both grasses and legumes is from the leaves, although some moisture (up to 30% in grasses) is drawn from the stems and evaporates through the leaves.

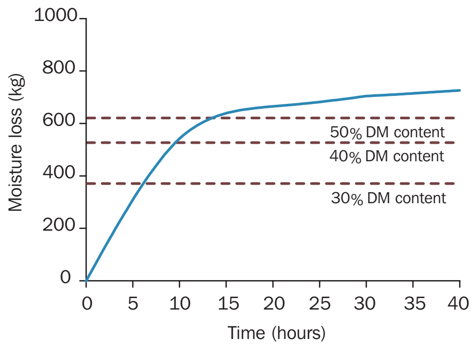
After the forage is cut, the stomata usually close to conserve moisture. This is a plant survival mechanism and occurs more quickly on a hot, drying day than a cooler, overcast day. The delay in closing of the stomata will depend on plant moisture content and the humidity within the swath, but usually occurs between 30 minutes and two hours after cutting. For most species, this stomatal closure occurs before 30% of the initial moisture has been lost.

When the stomata are fully closed, water vapour can still move through the epidermis or cuticle (outer skin) of the leaves, leaf sheaths and stems, although the rate of moisture loss is reduced to about 10% of that of open stomata.

A young, vegetative crop or pasture contains significantly more leaf than stem; as plants mature, the proportion of leaf declines. Typically, lucerne contains 55-60% leaf at the vegetative stage of growth, declining to 35-40% when in the full bloom to early pod stages. In perennial ryegrass, the percentage of leaf falls from 85% at the early vegetative stage to 20% when fully in head. As plants mature, the proportion of soluble cell contents in the stems also falls as more structural fibre is produced. These changes explain the more rapid wilt achieved with leafier material compared to more stemmy material.

Figure 6.3

Simulated water loss over time from 1 tonne of fresh grass with a DM content of 18.9% (81.1% moisture) at mowing.



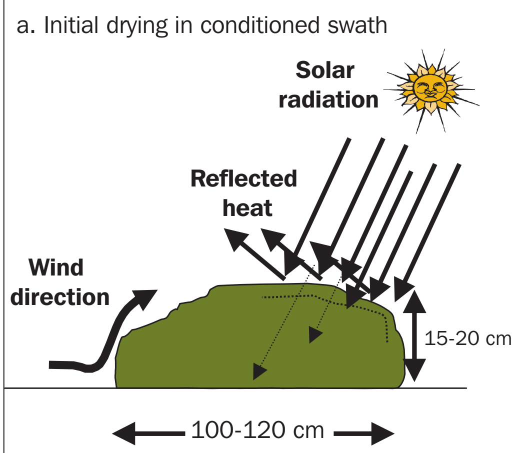
Source: Adapted from Jones and Harris (1980), using thin layer, temperature 20°C, relative humidity 50%, air speed 1 m/sec

Rate of moisture loss slows further as the forage DM content approaches 40-50% DM (50-60% moisture). This is largely due to the moisture now being drawn from inside the stems and larger plant fractions. This change in rate of moisture loss occurs at about the ideal moisture content of heavily wilted silage (see Figure 6.3).

Baled silage produced at 50% DM content will require more extended wilting, with a relatively slow rate of moisture loss during the later stages of wilting. As a result of the longer wilting period needed for baled silage, DM and quality losses during wilting are likely to be greater for these systems. The leaf fraction of some plant species may become quite dry during this period, increasing the risk of mechanical

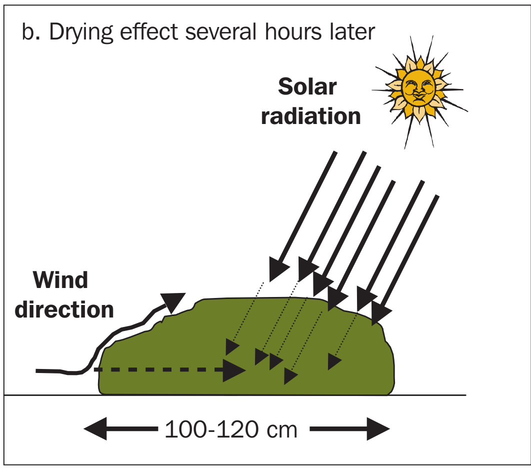
Figure 6.4

Drying dynamics in a conditioned swath.



Initial drying in conditioned swaths - depth of 15-20 cm:

- Heat generated in the swath due to continued plant respiration rises to the surface.
- Approximately 50% of solar radiation reaches ~2-3 cm into swath and about 10% to the base.
- About 20% radiation initially reflected.
- Wind initially deflected over the swath.



Later drying in conditioned swaths - depth of 15-20 cm:

- Much more solar radiation reaches the swath base.
- Little solar radiation reflected.
- More wind flows through the swath.
- Swath dries out more rapidly than if mown and left behind standard mower, with no conditioning.

losses during harvest. This is especially a problem with legumes.

The early and later stages of drying in a mown swath are presented diagrammatically in Figure 6.4. In the early stages of drying, about 20% of the sun's heat is reflected from the swath's surface, so is not available for drying. Radiation at about 2 cm below the surface is half that at the surface and only 10% at the base. There is minimal air movement in the middle of a swath, even on windy days.

The density of the swath is reduced as moisture is lost and drying continues at greater depth. As shown in Figure 6.4b, this allows greater penetration of solar radiation into the swath and more airflow through the swath.

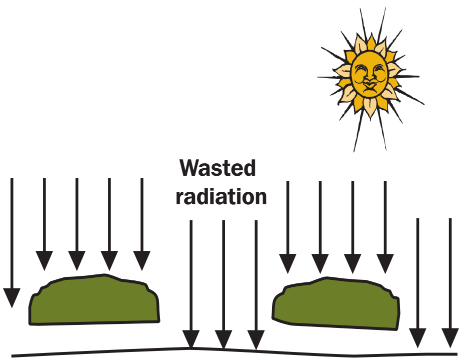
Figure 6.5 shows the impact the swath width has on drying rate. If the swaths occupy only 50% of the ground, only 50% of the solar energy is available (see Figure 6.5a). If the swaths are spread over most of the ground surface, density is reduced and exposure to wind and the drying force of solar radiation is increased, thereby maximising drying rate (see Figure 6.5b).

The humidity in and around the swath becomes quite high as moisture evaporates. Forming a low-density swath, which allows airflow through and around it, will reduce the relative humidity and improve moisture loss.

Figure 6.5

The effect of swath width on solar radiation interception and drying rate.

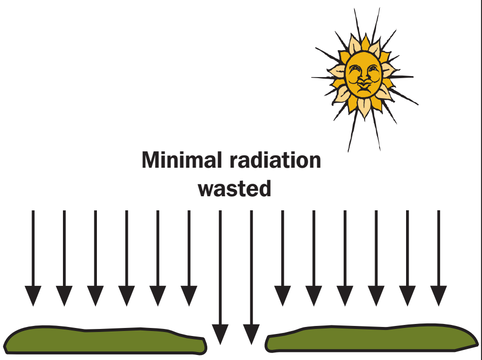
a. Utilisation of solar radiation in narrow, deep swaths



Narrow and deep swaths (very dense)

- Approximately 50% of solar radiation is not utilised for drying.
- Drying rate is slow.

b. Utilisation of solar radiation in wide swaths



Wide and thin swaths (much less dense)

- Approximately 85% of solar radiation is utilised for drying, increasing drying rate.

6.5.2

The effect of wilting on animal production

In a number of overseas studies, the effects of wilting on animal production have been variable. There have been no similar studies in Australia.

A large number of studies in Europe have compared unwilted and wilted silages produced from the same crop. Most silages studied were produced from perennial ryegrass pastures, although some contained other grasses or white clover.

These results, shown in Table 6.5, suggest that the benefits of wilting were inconsistent, and it did not guarantee any improvement in liveweight gain or milk production. However, it was found that achieving animal production benefits from wilting, as indicated by increased intake, depended on three main factors – wilting rate, final DM content and silage fermentation quality.

Further details of the effects of wilting on beef cattle production, and the study in Table 6.5, are discussed in Chapter 14, Section 14.2.3, and in Chapter 13, Section 13.2.3, and Chapter 15, Section 15.2.3, for dairy cattle and sheep production, respectively.

Table 6.5

A comparison of production from dairy and beef cattle fed wilted silages compared to unwilted silages produced from the same forage.

	Response to wilting	
	Average	Range
Dairy and beef:		
% increase in DM intake	16.4	-14 to 85
Dairy:		
Milk production (kg/day)	0.22	-2.0 to 2.2
% increase milk production (kg/day)	1.4	-10.0 to 16.7
Milk fat (kg/day)	0.03	-0.08 to 0.15
Milk protein (kg/day)	0.02	-0.07 to 0.11
Beef:		
Liveweight gain (kg/day)	0.03	-0.23 to 0.25
% change in liveweight gain	7.1	-22.2 to 64.1
Carcase weight gain (kg/day)	-0.04	-0.13 to 0.03

Source: Adapted from Wright et al. (2000)

Wilting rate

DM intake was found to be higher for silages that achieved the target DM content for ensiling more quickly (see Figure 6.6). Producers should aim for a wilting period of less than 48 hours. Where wilting is extended, the intake of wilted silage will not differ greatly from the unwilted silage. An extended wilt will increase loss of forage quality (ME) and could cause total ME intake to be reduced for wilted compared to unwilted silages.

A survey of 140 dairy farms in western Victoria (summarised in the box below) found that the average time taken to wilt was 3-6 days and the average DM content of the forage at ensiling was 45.5%. The length of wilt was longer for baled systems compared with chopped silage in order to achieve a higher DM content.

These results highlight that the majority of producers in this survey may be over-wilting and that wilting period is much too long. These producers are likely to be suffering production losses.

Summary of wilting survey results

- Average wilting period – 3.6 days.
- Average DM content of forage at ensiling – 45.5%.
- Average of 4.2 days wilting period for baled silage to achieve 49.6% DM.
- Average of 2.2 days wilting period for chopped silage to achieve 35.7% DM.

Most forages in this survey were perennial ryegrass pastures.

Source: Jacobs (1998)

Final DM content

As a general rule, for forages within the recommended DM range, DM intake increases with DM content. At high DM contents (>55%), additional field losses may reduce the silage ME content. As a result, there may be no further increase or even a relative decline in DM intake (see Figure 6.7).

If wilting is ineffective and there is little increase in DM content, intake will be very similar or less than that of unwilted silage produced from the same forage.

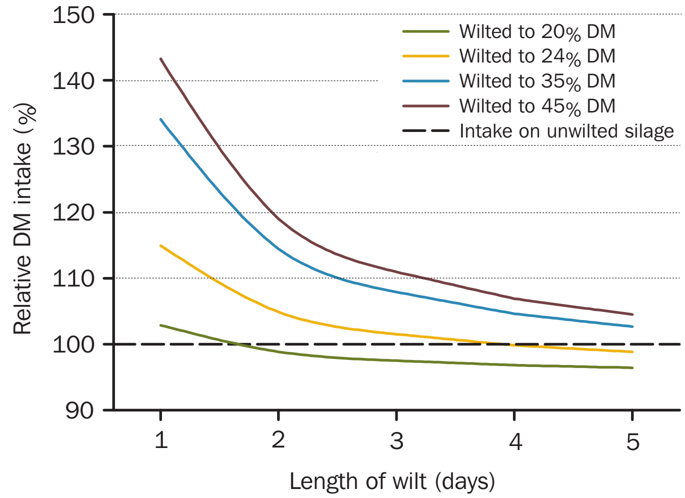
Silage fermentation quality

Where the unwilted silages were poorly preserved, as indicated by a high ammonia-N content, or where the unwilted silage contained significant amounts of acetic acid, the increase in intake due to wilting was greater. Temperate grasses (see Table 6.5) contain more WSC than legumes or legume-dominant crops and pastures, or tropical species. The increase in intake due to improved silage fermentation quality is likely to be greater with low WSC content forage.

Chapter 2, Section 2.2.2, and Chapter 12, Section 12.4.5, contain further information on silage fermentation quality.

Figure 6.6

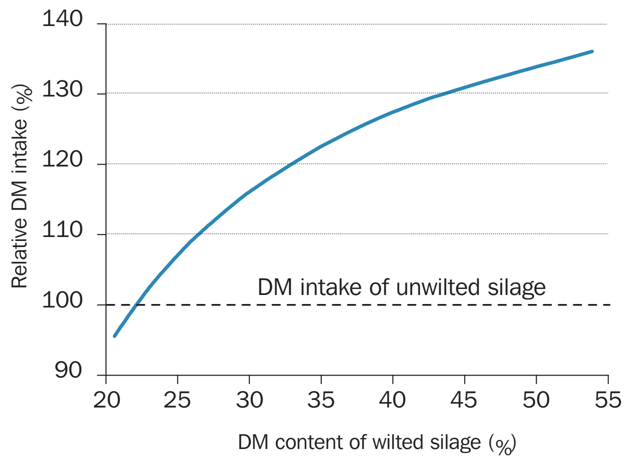
Effect of length of wilt on relative DM intake of wilted perennial ryegrass silage by cattle compared to unwilted silages with a DM content of 18%.



Source: Adapted from Wright et al. (2000)

Figure 6.7

Effect of DM content of wilted perennial ryegrass silage on DM intake compared to unwilted silage (18% DM content) from the same forage.



Source: Adapted from Wright et al. (2000)

Section 6.6

Increasing wilting rate

A rapid wilting rate is necessary to maximise the potential benefits of wilting. A number of management strategies and mechanical processes are available to increase wilting rate. They can be used independently or in combination.

Cut at an earlier growth stage

Cutting early, when crops are lighter (lower yielding) and of higher quality, will increase the wilting rates. For heavier crops, DM and quality losses during the wilting process are likely to be higher because they dry more slowly than lighter crops. This can be particularly important early in the season, when drying conditions are less favourable and even light crops do not dry as rapidly.

Given the choice, it may be worthwhile to harvest a greater area of early-cut (lower yielding) forage to ensure rapid wilting. Although, when costed on a $/kg DM basis, the silage produced from the lighter crop is more expensive, on a quality basis ($/kg ME) it may be cheaper. Chapter 11, Section 11.3.5, discusses this quality/cost comparison in detail.

Before mowing, consider the impact of cutting time and growth stage at harvest on regrowth potential and consequences for feed budgeting (see Chapter 3).

Mow after the dew lifts

Overnight dew on a standing crop or pasture can contain up to 2 t/ha of 'free' moisture. Mowing should be delayed until most of it has evaporated. If not, the moisture 'trapped' under the mown swath will delay drying. Drying will be even slower if the swath is left flat, rather than loose and 'fluffy'.

Condition forage

Using a conditioner at mowing can increase the drying rate by 20-40%. Table 6.6 shows the increase in wilting rate due to conditioning, for a range of swath widths and drying conditions. See Section 6.3.2 for the various types of conditioners and their mode of mechanical operation.

The increase in wilting rate of conditioned forage is due to increased rate of moisture loss through damaged stems, leaves and other plant parts. In addition, the swath produced tends to be loose or fluffy, allowing more air to pass through, which also helps to promote rapid drying.

Conditioning can have the following disadvantages, but these are outweighed by the benefits:

- In the event of rain, conditioned material will reabsorb more moisture than unconditioned forage.
- Over-conditioning or using the wrong type of conditioner can increase DM loss, mainly leaf.

Table 6.6

Results from Irish studies showing the effect of conditioning, swath type and sunshine on ryegrass DM content (%) after 8 and 32 hours.*

Source: Patterson (1998)

Treatment	Dull sunshine				Average sunshine			
	Unconditioned		Conditioned		Unconditioned		Conditioned	
	8 hr	32 hr	8 hr	32 hr	8 hr	32 hr	8 hr	32 hr
Double swath	14.4	15.5	14.6	16.0	15.6	18.2	16.1	19.3
Single swath	15.5	18.0	16.0	19.0	18.3	24.6	19.4	27.3
Spread swath	17.6	22.9	18.6	25.3	23.5	38.0	26.1	44.7

Double swath – two swaths combined immediately after mowing.

** The initial grass DM content was 13.2% yielding 3.96 t DM/ha. No rain fell during the experiment.*

Note: With the more favourable wilting conditions usually experienced in Australia, the drying is likely to be faster, and after the same length of time the final DM contents would be substantially higher than in these Irish studies.

- In very hot weather, particularly with light crops, the forage can dry too quickly. Cutting later in the day, reducing swath width and lessening the severity of conditioning will minimise the losses.

Increase swath width

The rate of moisture loss is greater from a flat swath spread over the total mower width than from a high, narrow swath. A wider swath allows more of the mown forage to be exposed to solar radiation (see Figure 6.5) and significantly increases the wilting rate.

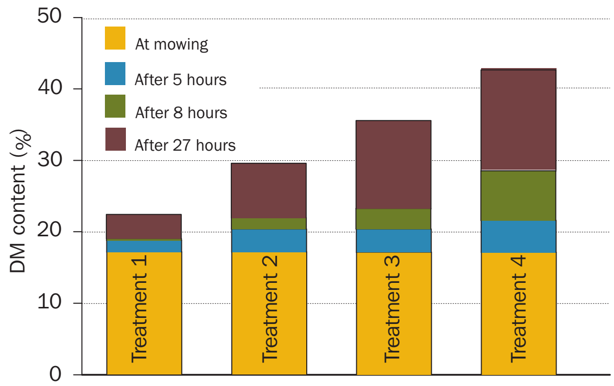
The rate of moisture loss differs throughout the swath, being highest at the outer surfaces and lowest internally, where a 'microclimate' develops and further restricts moisture loss. In fact, the sun has far more drying power than wind, although the two in combination are most effective.

In Irish studies, with heavy ryegrass crops, conditioning the forage and having a wide swath increased wilting rate (see Figure 6.8).

At Berry on the NSW south coast, kikuyu grass was either windrowed at mowing or left in a wide swath. The windrowed kikuyu took 54 hours to achieve the same DM content as the kikuyu in the wide swath achieved after 30 hours (see Figure 6.9).

Figure 6.8

Effect of swath treatments on the DM content of ryegrass (originally 17.2% DM content with a yield of 3.87 t DM/ha) after 5, 8 and 27 hours.

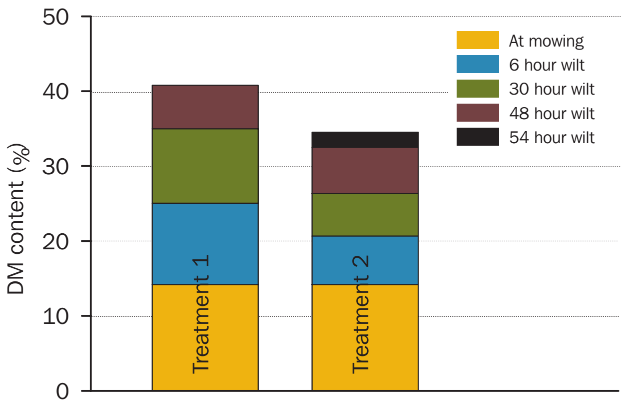


Treatment 1: One swath produced from 6 m cut of mown forage. Not conditioned.
Treatment 2: Mower conditioned, 2.4 m cut, left in a swath 1.2 m wide.
Treatment 3: Mower conditioned, 2.4 m cut, left in a swath 1.6 m wide.
Treatment 4: Mower conditioned, tedded twice daily.

Source: Forristal, O'Kiely and Lenehan (1996)

Figure 6.9

Effect of swath width on the drying rate of kikuyu grass at Berry, NSW.

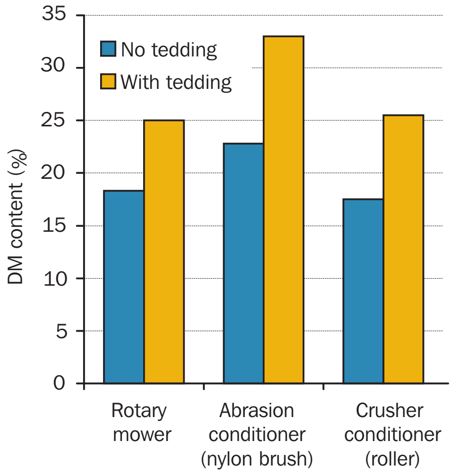


Treatment 1: Mown and left in a wide swath at near-mower width.
Treatment 2: Windrowed at the time of mowing.

Source: Kaiser et al. (unpublished data)

Figure 6.10

Effect of drying treatments on DM content of pastures.



Source: Wilkinson (1995) citing the results of a Dutch study

Plate 6.6

Tedding the mown forage spreads the swath and increases wilting rates.

Photograph: F. Mickan

Tedding

Tedding is the mechanical action of a tedder rake, which spreads the mown material. It should be done as soon as possible after mowing and may be repeated. Tedding or spreading the mown material straight after mowing will increase the rate of drying by 30-60%, depending on such factors as crop yield and climatic conditions.

Early in the season, when drying conditions are not ideal, two or three teddings may be necessary to achieve the desired DM content, especially if the crop is to be harvested as baled silage. The initial tedding should be at a relatively slow speed to ensure the crop is well spread. Later teddings may be at faster speeds, but not so vigorous as to cause leaf loss. Leaf losses are minimal when the tedder is used straight after mowing and if tedded later at low DM contents (see Section 6.7.3). Particular care needs to be taken with forages such as lucerne, where the leaf may be much drier than the stems.

Tedding a crop mown by a mower-conditioner may increase the drying rate by a further 20-30%, depending on factors such as crop yield, conditioner type and drying conditions. Tedding increased the wilting rate in the previous Irish study (see Figure 6.8) and a Dutch study (see Figure 6.10). These improvements occurred with both conditioned and unconditioned forage.

In studies on the south coast of NSW, the time taken to wilt grass to greater than 30% DM content was reduced substantially by leaving the swath at mower width and tedding the grass during the afternoon (see Figure 6.11).

Use windrow inverters

Windrow inverters have been developed specifically to invert the windrow, picking it up and gently replacing it back on the ground to the side of its original location. Research has shown that the rate of drying can be increased by about 20-30% (see Table 6.2). The windrow is 'fluffed up', reducing the density and encouraging a greater rate of drying in the centre.

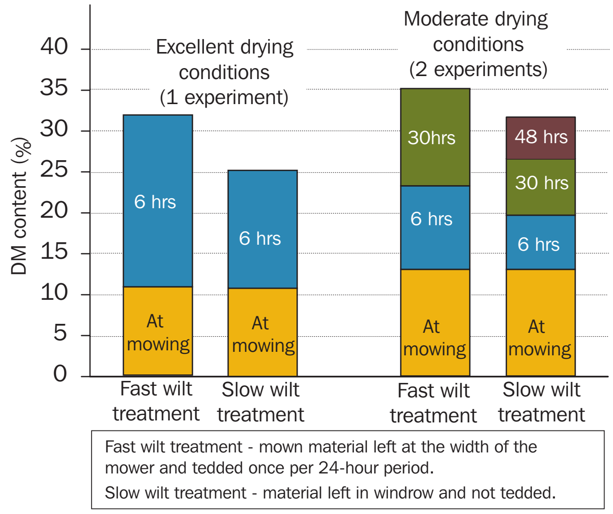
Invert windrows with rakes

If machinery is not available to increase the rate of drying by conditioning or spreading, the last resort for material that has been left in a windrow is to invert the windrows by using a rake. Rakes are not designed to handle very moist material so the 'turning' of the windrow is usually not successful. How effectively the material is inverted depends on the type of rake, DM content of the cut material, speed travelled, set-up of the rake and the experience of the operator.

A common problem experienced when using rakes to invert windrows is that the windrows become very 'ropey', being twisted and becoming narrower, leading to uneven drying. They are difficult to re-rake and harvest. These windrows are even more difficult to handle if rain falls before the harvest is completed.

Figure 6.11

Effect of swath treatment on the DM content of kikuyu grass after different wilting intervals



Source: Kaiser et al. (unpublished data)

Chemical conditioning

Chemical conditioning, sometimes called 'K-hay', involves spraying a drying agent such as potassium carbonate onto plant stems at cutting. The waxy cuticle or layer on the outside of the stem is dissolved, reducing resistance to water loss from the plant after mowing.

Early research in Australia and the United States has confirmed that 5 kg potassium carbonate in 200 litres of water/ha has been very beneficial for hay production with lucerne and medic crops and, to lesser extent, other legumes such as red clover. They are less effective in high-yielding crops and where drying conditions are favourable.

Drying agents have proven of no benefit on kikuyu forage and limited benefit in pastures and other crops. Although no research has examined its usefulness for silage, the lower DM content required for silage and continued developments in conditioning machinery suggest chemical conditioning may not have a role in silage production.

Section 6.7

Field losses

Once cut, a crop immediately begins to lose both DM and energy (ME).

There are three sources of field loss:

- Plant respiration loss
- Weather damage loss
- Mechanical loss.

Some losses, such as leaf shatter, are visible during mechanical operations. Other losses, such as plant respiration, residual plant enzyme activity and microbial degradation, are invisible.

DM and energy losses increase as the forage is wilted to higher DM contents, and are higher for hay compared to silage. Losses are higher when wilting is slow and if rain occurs. Additional information on the various sources and extent of losses throughout the silage making process are discussed in Chapter 2, Section 2.5.

DM and quality losses are usually greater in younger versus older crops, in legumes versus grasses, from long versus short wilting periods, from prolonged rain falls, from incorrect timing of mechanical handling and incorrect equipment set-up.

Factors affecting extent of field losses

- ➤ Higher-yielding crops and pastures wilt more slowly, increasing field losses.
- ➤ The type of machinery used for mowing and conditioning (and operator proficiency) will affect mechanical losses.
- ➤ Losses increase with the number of mechanical (tedding and raking) operations, and depend on the DM content at the time.
- ➤ Losses are less with rapid compared to slow wilts.
- ➤ Wide, thin swaths wilt more rapidly than narrow windrows, reducing losses.
- ➤ Increasing amount, frequency and intensity of rainfall will delay wilting and increase losses.
- ➤ Rainfall late in the wilting process, at higher DM contents, will cause higher losses.
- ➤ Losses increase as the forage is wilted to higher DM content at harvest.
- ➤ Time and effectiveness of follow-up drying weather.
- ➤ Type of machinery used in follow-up drying and harvesting.

6.7.1

Plant respiration losses

Plant respiration converts WSCs into water, carbon dioxide and heat, resulting in a loss of DM and energy (hence ME content) in the forage.

Respiration rate is highest at cutting when plant moisture content is high; as the moisture content decreases so does the respiration rate. Temperature also directly influences the respiration rate – it is higher at higher temperatures. The effect of DM content and temperature on respiration rate is shown in Chapter 2, Figure 2.6.

Although some respiration losses are unavoidable, a rapid wilt will minimise them. Respiration losses are typically about 2-8% of the DM, but may reach up to 16% under poor drying conditions when making hay. Although losses may not be as high when making silage, prolonged wilting and periods of rain, particularly soon after cutting, will cause significant losses.

6.7.2

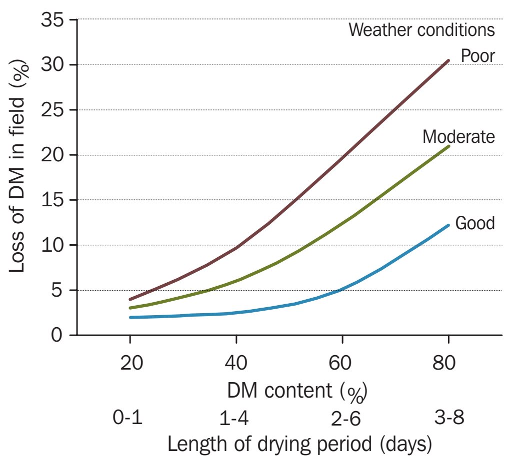
Weather damage losses

Cloudy skies, cool temperatures, high humidity, no breeze, heavy dews and rainfall typify poor wilting conditions. They lead to significant increases in field losses (see Figure 6.12) and increased growth of undesirable moulds, bacteria and yeasts in the swath before harvest. A large proportion of the WSC content may also be lost during respiration. If ensiled at low DM content, as a salvage operation, this loss of fermentable substrate may result in a poor fermentation and unpalatable silage. See Chapter 7 for recommended treatments using additives.

As well as slowing wilting rate, rainfall can also cause direct losses of DM and nutrients due to leaching, leaf shatter and increased mechanical losses if additional tedding/raking operations are required.

Table 6.7 summarises the results of a number of European studies with ryegrass pastures, where the loss of forage DM was determined for good, moderate and poor weather conditions. The ryegrass was tedded to increase drying rate, and the total number of tedding operations increased with deteriorating weather

Figure 6.12



Effect of weather conditions and final forage DM content on loss of DM during wilting for grass.

Source: Wilkinson (1981), citing Zimmer (1977)

Table 6.7

Effect of length of wilt and amount of rainfall on DM losses in ryegrass during wilting.

	Weather conditions		
	No rainfall	Rain on only 1 day	Rain on more than 1 day
Number of studies	2	3	3
Length of wilt (days)	2.0	4.7	8.3
Total rain (mm)	0	1.9	23.5
Average maximum temperature (°C)	25.0	17.6	17.7
Number of teddings:			
total	2.0	3.3	3.7
per day	1.0	0.76	0.5
Increase in DM content (%)	31.3	33.4	29.8
DM losses (%):			
total	6.5	8.1	13.1
per 1% increase in DM content	0.21	0.25	0.43

Source: Van Bockstaele et al. (1979)

conditions. The losses would have included direct losses due to rainfall, increased respiration loss and mechanical loss, but did not take into account the likely decline in energy content (ME) of the remaining DM.

These studies showed that the length of the wilting period more than doubled and total DM losses rose 25% when there was only a small amount of rain on one day. Significant rainfall, where rain fell on more than one day, led to a more than four-fold increase in the length of wilting period, and DM losses doubled.

Table 6.8 shows the effect of rainfall over 24 hours and crop maturity on DM losses in lucerne/red clover hay. Leaf loss, and leaching and respiration losses, rose substantially from no rain to 63 mm rain. The losses were highest in the less mature crops (bud stage) due to their higher proportions of soluble nutrients. The same trends are likely with rain-damaged lucerne silage, although the extent of losses are likely to be less.

Mown forage lying in a narrow swath absorbs less moisture than material in wide swaths. However, the wide swaths are quicker to dry out after the rain stops. Although not always practical, if rain is imminent, the mown material should be windrowed to reduce moisture uptake. The windrows should be spread out after the rain stops to increase the rate of drying.

Crops which have been conditioned or tedded soon after mowing will re-absorb more moisture after rainfall than an unconditioned swath.

The tedding and conditioning operations aim to maximise the drying rate to reduce DM and quality losses, and to greatly reduce the time the crop is at risk or exposed to rainfall before harvest. However, there will be occasions when the tedded and conditioned forage will be rain affected, increasing DM and quality losses.

Table 6.8

Effect of stage of maturity and quantity of rain on DM losses in lucerne/red clover hay in America (% DM lost).

Loss	Stage of maturity	No rain	25 mm rain	42 mm rain	63 mm rain
Leaf loss	Bud	7.6	13.6	16.6	17.5
	Full bloom	6.3	9.1	16.7	19.8
Leaching and respiration	Bud	2.0	6.6	30.1	36.9
	Full bloom	2.7	4.7	23.5	31.8
Total	Bud	9.6	20.2	46.6	54.4
	Full bloom	9.0	13.7	40.2	51.5

Source: Holland and Keszar (1990) citing Rohweder (1983).

6.7.3

Mechanical losses

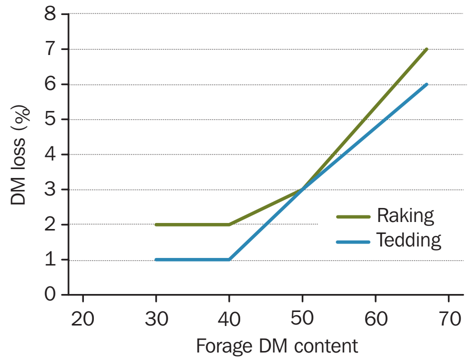
Mechanical losses of DM occur at mowing and conditioning, and at each raking and tedding operation. Figure 6.13 shows the level of DM loss that can be expected in lucerne harvest operations. This study highlights that losses caused by raking or tedding increase with increasing DM content of the forage. Raking into windrows should be carried out before the DM content reaches 50%.

Leaf shatter losses in lucerne and most other legumes may be four times greater after mowing, conditioning and tedding than for grass or cereal crops.

In the case of lucerne, there should be minimal mechanical treatments after mowing and conditioning, and preferably none, as even freshly mown crops suffer some leaf loss with tedding. Conditioning with a roller-type conditioner to speed moisture loss from the stems is recommended. Lucerne leaves dry 3-5 times faster than the stems and quickly become brittle. Over-wilting of lucerne and other legumes should be avoided.

The leaf fraction of legumes remains on the plant in well-managed silage systems, even baled silage at 50% DM content. However, under extreme drying conditions, particularly in unconditioned crops, the leaf may become brittle at DM contents of 35% or less.

Figure 6.13



Loss of DM at each raking or tedding operation for lucerne at various DM contents.

Mowing losses:

Mower without conditioner 1%

Mower with roller conditioner 2-3%

Mower with flail conditioner 4%

Source: Adapted from Pitt (1991)

Plate 6.7

Large losses of the valuable leaf fraction can occur when lucerne and most legumes are over-wilted. *Photograph: A. Kaiser*