McHale

Baled Silage Guide

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McHale Baled Silage Guide

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Introduction

The baled silage guide will enable you to make more cost effective use of this environmentally friendly system. As you can see from the list of contributors (page. 34) we have consulted some of the world's leading experts on forage production.

The magazine's contents centre on several areas of interest to farm contractors and livestock producers. Hopefully, the information assembled here will enable you to minimise costs, make better quality silage and significantly reduce storage losses.

An executive summary gives you a brief resumé of the areas where farmers, agri-contractors and their staff should focus their attention in order to maintain forage quality and make the best use of their machinery and labour.

In addition, it is hoped the research findings and practical tips supplied will help you to improve safety and on-farm performance in what are challenging times for farm families everywhere.

Any comments on this guide and any recommendations you may have on the McHale range of forage machinery will be much appreciated.

As you know, McHale Engineering manufactures the award winning Fusion integrated baler wrapper. McHale's current product range also includes trailed and linkage round and square balewrappers, a mini balewrapper, round and square bale handlers and a bale splitter. This machinery has been designed for ease of operation and optimum output.

Finally, on behalf of the sponsors - McHale Engineering - may we take this opportunity to wish you every success during the year with your machinery operations, forage conservation and farming business.

The benefits of big bale silage

- The quality of silage made in big bales can be equally as good as clamp and much better than hay.
- Losses in storage due to aerobic spoilage are much lower in baled silage than in clamp (ADAS/DANI trials).
- The large capital investment required for clamp storage is not needed for big bales, making the system cheaper than clamp.
- Big bales can be stored almost anywhere so long as they are stacked more than 10 metres from any watercourse or drain into which effluent could enter (e.g. close to the place of feeding).
- Bales can be fed according to nutritional value making the best use of available forage stocks.
- Bales surplus to requirements can be sold as a cash crop providing an extra source of income.
- Chopped bales are 8-12% heavier than conventional round bales, save on twine, netwrap and stretch film, take up less storage space and are easier to feed out.
- Better quality silage can be made resulting in increased feed intakes, improved feed conversion and higher daily liveweight gains in livestock.
- Easier handling and feeding systems (e.g. bale choppers, unrollers and diet feeders) make the system more attractive to the livestock farmer.

In-store losses from big bale and conventional silage (G/Kg grass Dry Matter ensiled)

Source	Wrapped	Conventional
McCullogh (1981)	ND	290
Stewart & Kennedy (1982)	ND	300
Weddell & Mackie (1987)	135	ND
Kennedy (1987)	30	240
	110	200
	120	330
Mean	99	272
ND = not determined		
Average	9.9%	27.2

For silage, light green or white film reflects sunlight, so bales remain cool and storage life is extended.

Attention to detail is the key to success

Dermot Forristal
Teagasc, Crops Research Centre, Oak Park

- **Film wrap** must not be damaged because air entry will cause extensive damage e.g., mouldy silage.
- **Costs** are determined by the number of bales produced. This is influenced by crop yield, wilting and baling.
- **Wilting** eliminates the need for an additive, reduces the number/weight of bales and minimises effluent production.
- **High dry matter** (DM) silage is less efficiently used by stock and significant losses can occur during the wilting process.
- **Wilt** quickly as this reduces the risk of poor weather and mould growth. The drying rate is determined by the thickness of grass on the ground
- **Spread and ted** on two or more occasions for fast wilting. Avoid creating lumpy swaths. A slow forward speeds also help.

Introduction

Baled silage is made on many intensive and extensive farms that conserve silage, however, it differs from conventional silage in many ways:

- Bales have six to eight times more silage in contact with the polythene film.
- More than half of the silage is within 200mm (8 inches) of the surface.
- The thickness of the polythene film on the bale is just 70 microns compared to 200 microns for a normal clamp cover.
- The density of silage within the bales is less than in pit silage and bales are usually handled after wrapping.

These factors make it imperative that the film wrap is not damaged, because air entry will cause a lot of damage. Attention to detail is necessary to ensure reliable and cost effective forage conservation.

Preparing an even swath makes baling easier and helps to improve bale shape.

Key areas

In most situations, cost reduction and mould prevention are key targets for this system. As regards forage quality, the same principles that determine quality/feed value in conventional silage apply to baled silage. The main factor that influences costs is the number of bales produced per acre/ hectare. This is influenced by crop yield, wilting and baling. Mould requires oxygen or air to grow. If air enters, the ease with which it moves through the silage will influence the level of spoilage caused.

Wilting is an essential part of the baled silage system, as it:

- eliminates the need for a preservative/ additive;
- reduces the number of bales/hectare;
- reduces/eliminates effluent and makes bales lighter;

Grass should be wilted to a minimum of 25% dry matter (DM), however a greater reduction in bale number and costs will be achieved by wilting to 35% DM. However, high DM silage is usually less efficiently used by the animal and significant losses can occur during the wilting process.

The objective is to wilt as quickly as possible and reduce the risk of poor weather. The most important factor determining the drying rate is the thickness of grass on the ground – a thin layer of grass will dry out much more quickly.

The degree of spreading or percentage ground cover achieved after mowing or spreading/tedding is therefore critical.

Conditioning the grass, by abrading the stems and leaves, will result in more rapid moisture loss only if that moisture can get away from the swath. If conditioned grass is heaped in a narrow swath occupying just 30% of the original cut area (e.g., a 1m wide swath after a 3.2m mower), most of the swath cannot dry.

Wilting should be fast. A target of one night on the ground should be set. This will reduce wilting losses and lessen the risk of rain damage. It may also help to reduce microbial development within the swath that could initiate mould growth.

To achieve a fast wilt, it is necessary to spread the grass as thinly as possible on the ground. With light crops (e.g. second cut), a mower/conditioner with its swath doors set wide may be adequate. For heavy crops, mowers capable of achieving 80-100% ground cover (i.e. with spreading attachments) may be adequate, provided the grass is cut dry and weather conditions are good. Otherwise separate tedding will be necessary to get a fast wilt.

Practical wilting options

1) Where yields are light and drying conditions are good, a mower conditioner with the swath doors open to give 60%+ ground cover may be acceptable. The grass should be cut dry however.
2) Over the top tedders can be used to speed up the drying of grass in mower swaths. Their performance is still dependent on the level of ground cover achieved.

Table 1: Effect of swath treatment on drying rate.

	% Ground cover	% Dry Matter Day 1 9 a.m.	Day 1 2 p.m.	Day 1 5 p.m.	Day 2 2 p.m.
Double Swath M/conditioner	23	16.0	18.1	16.8	17.9
Standard M/conditioner	55	16.0	19.5	20.6	22.4
Wide M/conditioner	75	16.0	22.2	24.5	30.4
Spreading/tedding	100	16.0	24.0	28.9	38.7

3) In more 'normal' conditions, a mower conditioner with a spreading hood could be used to give 90-100% ground cover. The grass will need to be raked separately. The grass should be dry when cutting.
4) The fastest wilting option is to spread and ted on two or more occasions with a tedder. Care must be exercised to avoid creating lumpy swaths. Early cutting facilitates this, as lower yielding crops are easier to spread. Slow forward speeds will also help.

- Net wrap speeds up baling and makes wrapping easier. Heavier bales can become misshapen if insufficient net is applied.
- Target a minimum of 200kg of DM per bale. At 35% DM, this would require a bale weight of 570 kg.
- Swath formation, grass type, baler type and setting and speed all influence the level of density achieved.
- Conventional chopping with 12 to 14 knives will typically increase bale density by 8-12%.

Advice on baling

The objective is to produce well-packed, evenly-shaped bales. Good swath presentation will help this and, therefore, a conflict between optimum wilting and good baling sometimes occurs. The use of net wrap speeds up baling and makes certain types of bale easier to wrap, but heavier bales can become misshapen when handled, particularly if insufficient net is applied.

Grass sample (ball of grass)	Dry matter content
If juice drips while squeezing	Less than 25%
No juice - ball retains shape when released	25-35%
Ball unfolds when released	More than 35%

Net wrapped bales are also easier to strip at feeding time.

The aim must be to pack as much DM into the bale as possible. The target should be a minimum of 200kg of DM per bale. At 35% DM, this would require a bale weight of 570kg. Swath formation, grass type, baler type and setting, and speed all influence the level of density achieved. High DM bales are more prone to mould development. The physical structure of the grass often allows easier air movement within the bale and the less acidic environment does little to inhibit mould growth. More film should be applied to high DM bales and film damage must be avoided.

Conventional chopping with 12 to 14 knives will typically increase bale density by 8-12%. Newer balers, with more than 20 knives, allow greater densities to be achieved. In addition to reducing costs, greater densities should result in a more restricted environment for air movement within the bales.

The only concern with high-density bales, on farms with limited tractor lifting capacity, is their heavy weight. However, wilting to 30%+ DM should prevent this being a problem.

Wrapping

Shortage of labour has made combined baling and wrapping operations attractive, as only one tractor and labour unit are required. In the past the most popular McHale combination was the combination or "combi" unit. In recent years the McHale Fusion has become the most popular machine. This machine has been designed as a high output integrated unit, which is compact and due to it unique patented design offers a very reliable bale transfer even in the most testing ground conditions.

Baling

- Prepare a uniform box shaped swath, which will fit the baler pick-up width.
- To avoid soil contamination, do not set the mower or pick up reel to low.
- Drive the baler at a steady speed and produce bales of even, cylindrical shape.
- Soft bales are difficult to wrap properly and may not ensile successfully.
- Misshapen bales do not rotate evenly on the wrapper and to ensure a minimum coverage with four layers of film, extra revolutions may be required.
- Do not wrap bales that have been tied or netted with any material which may cause a chemical reaction with polythene (e.g., impregnated sisal twine).
- Some chemicals - fertilisers, sulphuric acid, herbicides, mineral oils etc. - can accelerate film degradation. Film should not be allowed to come into contact with these materials.

Bale handling – how to avoid damage

Incorrect handling will damage the silage film, resulting in aerobic spoilage and mould growth. Mould reduces the value of silage and can make it a dangerous feed.

Wrapper and stubble damage

The wrapper table, drop table/mat and the stubble are all potential sources of damage. All surfaces that come into contact with the bale should be checked for damage or rough areas. The drop table/mat should lower the bale gently to the ground.

Certain types of stubble can puncture the bale in very sunny, dry conditions. Gentle dropping of the bale should help to minimize this, as would dropping on damp ground from where the swath was lifted. Extra film (six layers) would also protect the bale. Wrapping at the storage site or a nearby grazing paddock, would also eliminate stubble damage.

Handling damage

- The wrapper table, drop table/mat and the stubble are all potential sources of damage. The drop table/mat should lower the bale gently to the ground.
- Stubble can puncture the film in sunny, dry conditions. Wrapping at the storage site or a nearby paddock, will eliminate stubble damage.
- Handle wet / soft bales immediately after wrapping. Heavy bales are more prone to damage if transported long distances.
- Hydraulic handlers can handle wide/sagged bales and are essential for stacking or loading bales - they need careful and skillful operation.
- Careful manoeuvring when handling the bale is essential. An appropriate speed should be used for safety and other reasons.
- Slow transport often results in the bales being left overnight in the field, where they are prone to bird attack, become misshapen and difficult to handle.
- Self-loading, multi-bale transporters can speed up the operation. Ownership/use strategies for transport systems need to be developed.

Handler damage

Factors that influence the damage caused by handlers to bales include:

- Bale size, shape and weight
- Time of handling
- Handler type, size and adjustment
- Operator technique
- Transport distance, speed and terrain
- Number of handling events
- Quantity of film on the bale
- Grass type in the bale (soft or stemmy)

While silage bales are nominally 1.2m x 1.2m (4' x 4'), many bales are closer to 1.3m in diameter. Most bales are carried by three-point, linkage-mounted, fixed handlers that are reversed beneath the bale. Oversize bales, or bales that have sagged, are easily damaged. Wet/soft bales should be handled immediately after wrapping. Heavy bales are more prone to damage if transported long distances over rough paths/fields.

Handler type

The bars of fixed handlers should be straight, rust-free and smooth to prevent film damage. These handlers will damage bales that are too wide or have sagged. The top link should be adjusted to slide under the bale without damaging the film. Some older handlers are too narrow for bigger bales.

Hydraulic handlers can handle wide or sagged bales and are essential for stacking more than one bale high, or for loading bales onto flat trailers - they need careful and skillful operation.

Operator advice

Careful manoeuvring when loading or unloading the bale is essential. An appropriate speed should be used, as bouncing during transport will increase the pressure on the film. Self-loading trailers should preferably be used on unwrapped bales.

Extreme care must be taken when these are used to lift and transport wrapped bales.

Particular care is needed when tipping bales on their end. Similarly, off-loading loader-mounted bales onto a stack is a demanding task.

Time of handling

Bales should be handled immediately after wrapping - preferably within hours. This will prevent damage to sagged bales and avoid disturbing the seal when fermentation is underway. Bales are more easily damaged if left overnight. Very high dry DM bales are more easily handled, as they retain their shape better. Loading and transporting wrapped bales requires particular care, as multiple handling and the trailer itself can be sources of damage.

Labour and bale transport

Slow transport often results in the bales being left overnight in the field, where they are prone to bird attack, and become misshapen and more difficult to handle without causing damage. The transport operation is a particular constraint where large numbers of bales are involved and where there is considerable distance involved.

Self-loading, multi-bale transporters can speed up the operation. In a Teagasc trial at one site, a five-bale, self-loading trailer had a work rate of about 30 bales/hr with a 500m transport distance which would equate to the output of three single bale transporters. More consideration needs to be given to bale transport. Ownership/use strategies for bale transport systems also need to be developed.

Storage method

Bales are usually stored singly on their sides or ends, or alternatively they can be stacked two to three-high on their sides. Storing bales on their ends (tipping handler) will leave any damaged

Quick and effective wilting reduces the number of bales and associated costs.

Storage and film damage

- Storing bales on their ends will leave any damaged areas open to the atmosphere. Bales stored on their sides often suffer less from handler damage.
- Examine bales carefully after handling. Damage should be repaired immediately while access is still possible.
- Teagasc Research shows that one small (3mm) hole resulted in an 8% loss of silage, while one large hole (24mm) resulted in one third losses.

areas open to the atmosphere. Bales stored on their sides often suffer less spoilage from handler damage. The damaged area is invariably at the bottom and the weight of the bale often forms a seal between the damaged area and the ground. Bales should be carefully examined after handling. Any damage should be repaired immediately while damage is visible and access is still possible.

Importance of film damage

The importance of small holes (1-3mm diameter) should not be overlooked. In a Teagasc trial at Oak Park, the presence of six holes (4mm x 2mm) per bale resulted in mould covering 26% of the bale surface. Undamaged bales had less than 1% mould. At Grange Research Centre one small (3mm) hole per bale resulted in an 8% loss of edible silage, while one large hole (24mm) resulted in one third of the bale being lost.

Film quality and cost

Standard wrapping procedure is typically four layers of 25 micron film applied with 70% stretch level. For most bales, 16 turns of the wrapper turntable are required to ensure that the entire circumference gets the intended four layers. The wrap monitor should always be checked to ensure the correct number of turntable turns is used. Some bales may need more than 16 turns to achieve four layer cover.

Many countries recommend six layers of cover. Teagasc research has shown the effect in terms of mould prevention of using six layers. (See Tables 1 and 2). Agri-contractors should note that trial conditions are often less arduous than farm conditions. Six layers of cover should be considered where: dry matters are high; considerable handling is anticipated; and/or sheep/horses are being fed. Twenty-four turntable turns are often required to achieve six layers of cover.

The concept of using more layers of a thinner film has been suggested as a better barrier to gas movement. The use of thinner films must be approached cautiously, as much more research is needed to determine whether thinner overall cover levels can give adequate protection.

Silage film will be significantly more expensive in years when oil/resin prices are high. However the temptation to skimp on film quality/quantity should be avoided. The emphasis must be on producing high quality forage that justifies expenditure on adequate film protection.

Applying six layers will increase the film cost by 50%, but the overall cost of the end product will be increased by about 10%. Where good quality grass is being conserved at 30%+ DM in dense bales, it is both prudent and not unduly expensive to use six layers of cover.

High DM silage bales destined for animals sensitive to mould (sheep, pregnant animals or horses) should have a minimum of six layers of cover.

Table 1: The effect of film cover on silage composition and mould growth

No. of layers	DMD (g/kg)	pH	NH3N (g/kg N)	Visible mould (% area)
2	763	4.9	100	21.5
4	764	4.7	86	1.7
6	775	4.7	84	0.7

Table 2: Film layers and mould results: 4 experiments

No. of layers	Surface mould (%)			
	Trial 1	Trial 2	Trial 3	Trial 4
2	21.5	20.4	26.0	55.0
4	1.7	0.5	1.3	7.5
6	0.7	0.1	0.2	1.4

Four layers of film will cost as much per tonne of silage dry matter when applied to a loose wet bale (22% DM, 640kg) as six layers on an extremely well-packed dry bale (35% DM, 600 kg).

Occasionally, there are problems with batches of film. It is imperative to keep the product identification information (usually a sticker inside the film core) to identify the batch of film if problems develop subsequently.

Film quality and cost

- Standard wrapping procedure is typically four layers of 25 micron film applied with 70% stretch level.
- For most bales, 16 turns of the wrapper turntable are required to ensure that the entire circumference gets the intended four layers.
- High DM silage bales for animals sensitive to mould (sheep, pregnant animals or horses) should have a minimum of six layers of cover.
- Four layers will cost as much per tonne of DM when applied to a loose wet bale (22% DM, 640kg) as six layers on a well-packed dry bale (35% DM, 600kg).

Making quality forage in square bales or for haylage

By Mick Roberts

- Plan the silage harvest and cut the crop at optimum maturity (before flowering). Aim to mow in the afternoon when the sugar content is highest.
- Take care to keep soil contamination out of the swath. Leave long stubble when mowing and operate rakes and tedders carefully.
- Use a 24-hour wilt and aim for dry matters of at least 25-35% for square baled silage and 55-60% for haylage. Do not ensile over-dry haylage.
- Aim to make dense, well shaped bales. Do not drive too fast. Invest in pre-cutters to increase density by up to 20%.
- Use a reliable, good quality wrapper that has an output to match the baler. Maintain machine, paying particular attention to the prestretch rollers.
- Wrap the bales immediately after baling – within at least two hours - as this improves fermentation
- Apply at least six layers of a quality wrap, correctly stretched to match the bale size and shape. Regularly check that the correct overlap and pre-stretch are being achieved
- Transport field-wrapped bales to stack immediately after wrapping. If this is not possible, leave for a day to allow the film to deflate and reduce the risk of punctures.
- Handle bales carefully with a specialist grab - never spike unwrapped/wrapped bales.
- Store bales carefully and select the site with care. Sheet down stack to protect from water. Use nets to keep birds from landing on bales. Place vermin traps and bait around outside edges.

Plan for quality

Probably the biggest mistake when making square baled silage or haylage is not to give the crop the attention it deserves. Grass left too long, gone to seed or simply missed out for first cut, will not magically convert itself into quality fodder! Although this commonly happens, it's simply not fair to blame the contractor, baler, wrapper, film or the system.

Adopt a flexible management approach - the entire area does not need to be cut in one go. The system also allows small amounts of different forages to be grown, harvested and ensiled. Crops such as red clover and whole crop can be baled, wrapped and mixed in the feed to provide a complete forage ration.

Rolling fields improves the sward, presses stones into the ground and helps prevent soil

McHale square bale wrapper.

contamination at harvest - absolutely vital when making haylage for horses and sheep.

Clostridium botulinum is commonly found in soil and can cause botulism - toxins enter a horse's body causing weakness and even paralysis. The anaerobic conditions and lower dry matter in wrapped haylage, compared with dry hay, plus a pH above 4.5 are ideal conditions for these bacteria.

Maintain this vigilance when mowing, leaving a decent stubble height to avoid the risk of soil contamination, as well as helping air circulate through the swath. After mowing, wilt the crop for at least 24 hours – longer if possible. Aim for dry matters of at least 25-35% for square baled silage and 55-60% for haylage. Do not, however, allow haylage to become over dry because the lack of moisture will impede fermentation.

While mowing, adjust the conditioner to the most aggressive setting that does not damage the crop. Take care to ensure that machines' tines do not rake soil and other contamination into the swath. Set the mower or rake to make a square, boxy swath that is just narrower than the baler's pick-up. Set the pick-up height so the tines do not touch the soil, but lift the swath from the top of the stubble.

For both square and mini-bales, set the baler to its highest possible density. The aim is to compress the crop to exclude the air. Pre-cutter (chopper) units increase density by up to 20%, depending on make and available chop length. Aim to make dense, well-shaped bales and avoid excessive forward speeds.

Set the square baler or mini-wrapper up as per the manufacturer's instructions and keep checking the operation throughout the day. It is now generally accepted that six layers of a quality film provides the best seal for both mini and square bales. The extra cost is more than made up by the reduced risk of spoilage.

Pay particular attention to the wrap dispenser pre-stretch rollers. Clean the rollers regularly, particularly in warm weather. Wipe the rollers with white spirit or similar solvent to remove any build-up of tack. Always align the dispensers with the centre of the bale or to the maker's instructions (if different) for mini or square balers.

Never move bales with a spike. Spiking unwrapped bales allows air to permeate the tight package and damages the film on wrapped bales. It is simply pointless making good dense bales, wrapping them with expensive film to put a hole it! If air gets into bales it allows mould to grow. This can be accompanied by bacteria such as *Listeria moncytogenes* which can cause abortion in ewes - humans can also be infected.

Mini-bales

Mini-bales weighing about 50kg are very saleable, particularly as haylage for horse feed. They are easily handled and stored – preferably in a building and, at the very least, under waterproof sheeting. Buyers can pick up the bales and put them in the boot of a car. Conversely, the disadvantage is that the smaller packs are not so suitable for mechanical handling. Whatever the case, it imperative they are handled and stacked carefully to prevent damage to the film which will lead to spoilage. For users, these bales are easy to feed out and are usually used up before the fodder can develop undesirable moulds.

Large square bales

For big square bales measuring about 1.2m x 1.0m, up to 2.5m long, and weighing in excess of 750kg, mechanical handling is essential, requiring specialist squeeze grabs. While contractors making silage or haylage will have the necessary equipment, a suitable loader may not be available on the user's farm.

However, as tractor power and loader size increases, this is less of an issue. There are also safety implications - serious or even fatal injuries - if a bale were to fall onto a person from a height.

Care needs to be taken when making stacks, particularly with lower dry matter material. Stacking too high will result in the lower bales being squeezed by the weight, putting the wrap under stress.

Sensible stacking is required, and it is important to 'tie' the square bales together to ensure stability. These are much easier to stack than round bales, making better use of the available area in yards.

The square bales also make far more economical use of lorry space. This makes the bales an easily-traded commodity. Despite the size, most users prefer feeding square bales compared with their slightly smaller, round counterparts.

This is because the square baling processes forms wads that are more easily managed by complete diet feeders and other units. It is also much easier to cut, and pull out the strings from a square bale, compared with unwrapping net off a round bale.

Research on conserved forage for ponies

By M. I. S. Moore-Colyer and A. C. Longland,
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Introduction

Grass hay is the traditional conserved forage offered to horses in Britain, yet good quality hay is often scarce and expensive. Working or breeding horses frequently require a higher plane of nutrition than that provided by hay, which has a typical digestible energy (DE) value for horses of 8MJ/kg dry matter (DM).

In order to meet the higher energy demands of these animals, high levels of cereal-based concentrates are offered, which can lead to a number of metabolic disorders such as colic and laminitis.

Even good quality hay contains a high level of dust (fungal spores, plant fragments, mites and bacteria) which can elicit the onset of the debilitating disorder, chronic obstructive pulmonary disease (COPD). Horses that have COPD remain sensitised to such dust for the rest of their lives and cannot be given hay without developing the disease.

The most popular low-dust alternative to hay is commercially produced haylage, which is grass conserved under anaerobic conditions at a DM of 550g/kg. However, haylage is expensive and there is increasing interest in feeding cheaper, alternative fibrous forages (fibre = non-starch polysaccharides; NSP + lignin), which have both an enhanced nutritive value and a low dust content.

Clamp silage and big-bale silage are conserved at an earlier stage of growth than hay and, as a consequence, they have a higher nutritive value, with typical metabolisable energy (ME) values for ruminants of 12 to 14MJ/kg DM (Ministry of Agriculture, Fisheries and Food (MAFF), 1992). These forages form the basis of winter rations for many farm ruminants, but they are seldom given to horses.

Clamp silage is considered to have too low a pH and too high a moisture content to be either palatable or practical to feed to horses.

Although conserved in a similar manner to haylage, big-bale silage may occasionally contain *Clostridium botulinum* and/or *Listeria spp.* to which horses are particularly susceptible and this has made some people wary of feeding it to their horses. However, anecdotal evidence suggests that increasing numbers of owners are feeding grass silage to horses with no detrimental effects.

These silages contain an additional 4 to 6MJ/kg DM (MAFF, 1992) compared with hay, which enables productivity to be maintained with a reduced reliance on feeding concentrates.

The aims of this research were

(a) to determine the intake and digestibility of four types of conserved fibrous forage by ponies;

(b) to ascertain if grass silage is a suitable replacement for hay in equine rations; and

(c) to measure the contribution of the carbohydrate fraction of fibre, the non-starch polysaccharides (NSF) to the DE of the forage.

Material and methods

Four mature, Welsh, cross pony geldings (live weight Ca.320 to 370kg) were used in a 4X4 Latin-square change-over design experiment, consisting of four 21-day periods. The ponies were individually housed in pens, with rubber mats covering the floors and water was available ad libitum. Hay (H), haylage (HY), big-bale silage (BB) or clamp silage (CS) were offered at 1.65kg DM per 100kg LW per day.

During the five-day collection phase, in viva apparent digestibility (AD) of dry matter (DMD), organic matter (OMD), crude protein (CPD), gross energy (GED), along with total and individual non-starch polysaccharide (NSPD) constituents, were determined by total faecal collection.

Food composition and animal performance

The average chemical compositions of the four experimental forages are given in Table 1.

Energy and protein parameters

The daily digestible energy (DE) intakes of big bales, clamp silage and haylage met or exceeded the calculated daily energy requirement of the ponies, but hay did not. The digestible crude

Table 1: Average corn position of the four experimental forages, hay (H), haylage (HY), big-bale silage (BB) and clamp silage (CS) (g/kg dry matter (DM) unless otherwise indicated)

	H	HY	BB	CS±
Organic matter	946	934	937	916
Crude protein	44	70	111	154
Starch	90	50	40	33
Gross energy (MJ/kg)	17.4	17.5	17.8	18.6
Calcium	3.1	5.8	4.7	5.5
Phosphorus	1.3	2.0	3.7	3.3
Magnesium	1.4	1.8	2.4	2.6
Non-starch polysaccharides (NSF)				
Rhamnose	0.5	0.1	0	0.5
Arabinose	25	17	25	23
Xylose	93	49	99	69
Mannose	2	2	1	2
Galactose	9	6	8	9
Glucose	261	210	256	224
Uronic acids	20	11	17	25
Total NSF	408	293	405	353

CS fermentation characteristics: pH 4; NH3 7% of total N; total volatile fatty acids 86g/kg DM; lactic acid 69g/kg DM; acetic acid 17g/kg DM; butyric acid <1 g/kg DM.

protein (DCP) intake for hay was only 34g/day and provided proportionately only 0.20 of the theoretical daily DCP requirements, whereas the DCP intakes of the other three forages exceeded this requirement.

The dry matter (DM) contents of the four forages offered in this experiment were notably higher than the €864,368 and 242g/kg recorded by MAFF (1992) for typical British samples of hay, big bales and clamp silage respectively. No comparative values could be found for haylage, although the DM content recorded here was 120g/kg higher than the 550g/kg quoted in the trade literature for this product. The crude protein (CP) content of hay at 44g/kg DM is typical of the mature grass hay given to horses but was less than half the value of 107g/kg DM quoted by MAFF (1992) for average grass hay in Britain.

The theoretical DCP daily requirement for horses is 0.6 X LW (kg), and therefore, for the ponies in this trial, the daily DCP requirement was Ca. 200g/day. According to these calculations, the CP content of hay resulted in a deficiency in DCP for this diet.

The other three forages either met or exceeded the calculated dietary DCP requirements of the ponies. The pH and contents of ammonia and organic acids of the clamp silage given in this experiment are well within the normal range for well preserved silages.

The GE, P and Mg contents of the four forages are similar to averages in Britain and reflect the physiological maturity of the grass at the time of conservation. The Ca levels of the H, BB and CS were markedly lower than the average values quoted by MAFF and may well reflect the low Ca content of the soil in west Wales.

Food offered

The amount of food offered was designed to meet the maintenance requirements of the ponies and food refusals were recorded. However, over the 12-week experimental period, food intakes varied between ponies and diet, with some ponies showing marked preferences for certain foods, clamp silage being the least favoured.

The preference for the bales and hay is reflected

Table 2: Live weight (LW) and voluntary food intakes of fresh weight (FWI) and dry matter (DMI), for ponies offered either hay (H), haylage (HY), big-bale silage (BB) or clamp silage (CS) at 1.65kg DM per 100kg LW per day.

	H	HY	BB	CS	s.e.d	Significance
LW (kg)	333_a	340^b	341^b	317^a	8.99	*
Voluntary food intake						
FWI (kg/day)	5.37^a	9.31^a	11.78^b	8.85^a	1.226	*
DMI (kg/day)	4.95^a	6.30^a	5.95^a	2.95^c	0.444	*
DMI (g/kg LW ~er day)	14.7^a	18.4^a	17.3^a	9.17^a	1.47	*
DMI (g/kg M07 per day)	$62•9^a$	79.2^b	74.6^{ab}	38.8^c	6.06	*

^{a,b,c} Values in the same row not sharing common superscripts differ significantly ($P < 0.05$).

in the liveweight (LW) figures, which show a significant increase when ponies were consuming these two diets in comparison with clamp silage. Fresh weight intakes were similar for the HY, BB and CS diets, although the ponies did consume 293kg/day more BB than CS, indicating that gut capacity was not a limiting factor in controlling the intake of CS.

Dry matter intake

The dry matter intake, (DMI) of baled silage and hay noted here are higher than the 4.46 and 388kg DM per day found for big bale silage and hay by Morrow (1998), when feeding two different chop lengths of silage and hay to ponies. Morrow also recorded significantly lower intakes for hay than for both chop lengths of big bale silage.
The DMI of BB and HY were similar and were higher than the 63g/kg M075 recorded by Morrow for both long and short chopped big-bale silage. In the current study, the DMI of clamp silage was significantly lower than from the other three forages but similar to that recorded by McLean et al. (1995) when feeding 'Ecosyl' inoculated Lolium perenne clamp silage to horses ad libitum and may suggest that the DMI of clamp grass silage by horses is generally lower than that of most hays. Indeed, the nutrient profile and fermentation characteristics of silage can affect food intake and indicates that low intakes by ruminants are associated with high organic acids and it is possible that similar parameters affect DMI in horses.

Calculated daily energy requirement

Although the DMI of CS was low, the calculated daily energy requirement was met due to the digestible energy (DE) of clamp silage being twice that of hay. However, as the DE intake by

Horses can thrive on quality haylage but good preservation is essential to avoid health problems.

the ponies given HY and BB were 1.66 and 1.7 times their calculated DE requirements, it is clear that meeting the daily DE requirements per se did not limit DMI in this experiment.

In vivo apparent digestibility

The apparent digestibilities of DM, GM, CP and GE for hay were significantly lower than the values recorded for the other three foods and are marginally lower than the published values for a variety of grass hays given to horses. These differences probably reflect the variation in species, soil conditions and cutting time of each of the hays.

Conclusion

The results from this experiment indicate that clamp silage, big bales and haylage were readily digested by ponies and can be used as dust-free forages to replace hay in diets for equines. The DE was similar to those encountered in many commercially available compound foods and make these ideal forages for performance horses with high energy demands.

However, for the less active horse, intakes of big bales and haylage may have to be limited to prevent obesity, whereas regulation of voluntary food intake of clamp silage is probably unnecessary as, in this experiment, DMI was self-limiting. The low DMI noted for CS however requires further investigation. The measurement of the contribution of NSP to DE is a novel and more accurate means of assessing the nutritive value of the fibrous fraction of forages.

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High dry matter legume crops for baled silage

Dr. Ed Charmley, Agriculture and Agri-food Canada, Crops and Livestock Research Centre.

Round bale silage is becoming as popular in parts of North America as in Europe. In eastern Canada, baled silage is replacing conventional tower or bunker (clamp) silage on many farms. Initially, smaller farmers were the first to adopt the technology, but as the advantages of flexibility and labour were realised, many larger operations are now using round bale silage for some or all of their forage needs.

Eastern Canadian conditions are somewhat different to Western Europe, with drier silage-making conditions and different crops.

Typically, silage crops are wilted for less than 24 hours and ensiled at between 30 and 50% dry matter (DM). Major forage crops are timothy and lucerne, with red clover replacing lucerne as the dominant legume in wetter regions, prone to freeze-thaw cycles in winter.

Perennial ryegrass does not survive Canadian winters, but some annual ryegrasses are grown in rotations. Maize silage is also an important forage crop. In spite of these differences, round bale technology, imported form Europe has become widespread. By and large, the same management decisions apply, with some crucial differences.

Baled silage has a restricted fermentation

The physical nature of baled silage is very different to that of precision-chopped silage. The absence of chopping reduces physical damage to the stems and leaves which slows and restricts fermentation. If round bale silages are compared with precision chopped silages of the same DM, fermentation is always less.

The pH declines more slowly and is ultimately higher, there are less organic acids and more residual sugars remain in baled silage. Unlike precision chopped silage, where the fermentation has a definite end-point, fermentation in baled silage tends to be ongoing and continues throughout the storage period.

Canadian research has confirmed that intake and performance of baled silage, with restricted fermentations, is generally as good as, or better than precision chopped silage of similar DM content (See Table 1).

Some evidence suggests that protein quality may not be as good in round bale silage as compared with precision chopped silage. Protein quality is preserved by a combination of low pH and rapid wilting. Thus, effective wilting in the field is needed to offset the negative effects of a slow decline in pH in round bale silage.

Optimum dry matter

Optimum dry matter for baled silage in eastern Canada is between 30 and 40%. This is higher than the average for British and Irish round bale silage. Wilting conditions in eastern Canada frequently allow for rapid drying up to about 30 or 40% within 24 hours. Round bale silage wetter than 30% is prone to freezing in Canadian winters, which makes it very difficult to cope with at feeding. Although Canadian wilting conditions will often allow for higher DM content, baled silage

Table 1: Relative composition and animal performance from round bale and precision chopped silage in eastern Canada (eight comparisons)[1] .	Precision-chopped silage (DM range 30 to 40%)	Round bale silage (DM range 30 to 40%)	Round bale silage (DM range 40 to 50%)
pH	4.4	4.8	5.1
Fermentation acids(% DM)	130	75	41
Ammonia (% N)	11	13	10
Non-protein N (% N)	55	55	58
DM intake (% LW)	2.1	2.4	2.5
LW gain (kg/d)	0.8	1.0	0.9
Feed/gain ratio	9.2	8.4	10.7

[1] Adapted from: Beaulieu et al 1993, Charmley et al. 1999; Nicholson et al. 1991;1992; Ouellet et al. 2000.

drier than 40% is prone to spoilage, particularly before the temperature drops in winter-time.

Furthermore, round bales only became popular in Canada after the advent of silage wrap and hard-core balers. These two mechanical advances have played a major role in improving aerobic stability of higher DM baled silages. Voluntary intake of round bale silage improves as the DM increased up to 50% (Table 1), and can be 20% greater than precision chopped silage ensiled at 30% DM. However, in eight Canadian studies with growing cattle, animal performance was greatest for round bale silage in the 30 to 40% DM range (Table 1).

Is a restricted fermentation a benefit?

Generally, higher voluntary intake and better animal performance from drier round bales, versus wetter bales or precision chopped silage, have been attributed to the restricted fermentation. However, evidence has also shown that protein degradation can be more extensive in round bales with restricted fermentation. Our research has shown that cattle respond better to supplemental protein, when fed baled silage rather than precision chopped silage. On balance, higher intakes usually compensate for any possible negative effects of a restricted fermentation.

Is DM intake improved?

Most of our research has found that cattle eat more round bales than precision chopped silage. However, part of this response is actually attributed to more wastage of long, unchopped silage. Even under controlled research conditions, this can be a problem, and is certainly a factor on many farms. Nevertheless, some of the intake response is real and translates into higher animal performance. We suggest that farmers should expect to use about 10 to 20% more forage when feeding baled silage compared with precision chopped silage. This will usually contribute to improved performance, but often with lower feed use efficiency.

Ensiling legumes

Lucerne (alfalfa) is widely grown in eastern Canada either in pure stands, or in mixtures with timothy or other grasses. Lucerne, as with all legumes, is more difficult to ensile than grasses. The crop is lower in soluble carbohydrates than grass and has a higher protein concentration which contributes to increased buffering capacity (Table 2).

A good example of the difficulty encountered when ensiling legumes was tested in a study comparing lucerne silage with annual ryegrass silage (Table 2). Although both silages were similar in DM at ensiling and underwent similar fermentations, liveweight gain was less for cattle fed lucerne silage. This was attributed to poor preservation and utilisation of the protein in lucerne. This study was conducted with precision-chopped silage, as there are no direct comparisons of grass and legume baled silages.

A similar "protein" problem could be expected in round bale silages, and might actually be worse, given the slower fermentation. However, in the summary of research trials in Table 1, over half the comparisons were made with legume or legume-dominated swards (either lucerne or red clover). It seems safe to assume that protein in baled legume silages can be well preserved, at least under conditions of rapid wilting.

Our research would suggest that lucerne can be successfully ensiled in round bales, provided the DM is in the 30-40% range.

Below 30% DM - poor fermentation:

- higher non-protein N and ammonia N levels.
- Handling problems - irregular bales, freezing.

Above 40% DM - excessive aerobic spoilage:

- Crop becomes brittle.
- Loss of leaf reduces feeding value.
- Bale density is reduced, increasing the amount of air in the bale.
- Prickly stems puncture the silage wrap.

To maximise dryer legume silage quality, the crop should be harvested before it gets too mature (mid-bloom growth stage). Crop conditioning at mowing will increase drying rate and the crop can be baled at 40% without an excessive field period.

In Canadian conditions, this means less than 24 hours. In wetter conditions, the risk of damage from rain is always greater in a conditioned crop.

If wet weather is unavoidable, and baling below 30% DM looks likely, use of a good silage inoculant may help with fermentation. Wetter bales should be fed out first, since the fermentation in round bales is slow and on-going, as opposed to rapid and short-lived in precision-chopped silage. Thus, the sooner it is fed the less chance there is a bad fermentation to develop. Finally, over-wilting should be avoided.

Concluding points:

1. Legumes (lucerne and red clover in eastern Canada) can make good round bale silage.
2. Baling at between 30 and 40% restricts fermentation, but aerobic spoilage is still controlled.
3. Voluntary Intake is up to 20% higher for round bale silage.
4. Performance is excellent - around 1kg/day in growing cattle.
5. However feed conversion is often less - need to budget for more feed with this system.

Table 2. Composition of ryegrass and lucerne precision chopped silages grown in eastern Canada[1].

	Annual ryegrass	Lucerne	Relative composition lucerne/ryegrass
Dry matter (%)	30	30	1.00
Crude protein (% DM)	20	23	1.15
Non-protein N (% N)	37	50	1.35
Ammonia N (% N)	17	22	1.29
Acid detergent fibre (% DM)	30	31	1.00
Neutral detergent fibre (% DM)	48	39	0.81
Total acids (% DM)	5.1	4.9	0.96
Lactic acid (% total acids)	64	65	1.00
Acetic acid (% total acids)	26	27	1.00
Butyric acid (% total acids)	3.1	7.8	2.50
pH	4.9	5.5	1.12

[1] *Adapted from Charmley 2002.*

Wrapping alternative forage crops

There is growing interest amongst farmers in the use of alternative forages to complement grass silage in the feeding of ruminant livestock.

Kaleage

Kaleage is a very palatable high protein forage, often consumed in preference to other feeds. This should lead to higher feed intakes and better stock performance. Kale is relatively easy to grow and unlike maize, its cultivation is possible throughout most of Britain and Ireland.

Fresh yields of up to 10-12 tonnes/acre at between 18-20% DM and 15-18% protein means there are real potential savings in purchased feed costs.

Wrapping recommendations

The crop is usually harvested during August/September. Although kale can be relatively high in sugar content, an effective additive is needed because the buffering capacity of this crop is at least twice that of grass.

Bales should be wrapped as soon as possible after baling. Because of the heavier weight of each bale (i.e. 750-850kg) six layers of a quality film should be applied with a 50% overlap.

Bales should not be stacked as this will increase the risk of effluent loss and may result in bales splitting. As with all wrapped silage bales, they should be checked regularly through the winter for rodent damage and patched if necessary.

Haylage

Haylage has increased in popularity as a high value feed, especially for horses. Conditions need to be dry and the grass crop wilted to achieve 55-60% dry matter (DM). Haylage has the benefits of: improved feed value over hay, better retention of nutrients and less waste. It is also a sweet smelling, highly palatable feed - no effluent is released. And it is a dust-free product.

Wrapping recommendations

Haylage is made up of very high DM material, but its success is reliant on the exclusion of air. Therefore, it is recommended to put a minimum of six layers at 50% overlap on each bale, using a quality silage film.

The bales should be handled with great care, carefully netted and frequently checked for signs of rodent damage.

Higher dry matter bales can be stacked three high. This saves space and bales are less exposed to damage from small animals and birds.

Whole crop

Whole crop is a flexible alternative forage and is potentially higher yielding than grass. It is suitable for both autumn and spring grown cereals of almost any species. Triticale, rye or oats will all make good forage but wheat tends to be the most popular.

Oats offer an alternative in wetter areas of the country where fungal problems could hamper a wheat crop. Barley is slightly less suitable. This is because the tough grain coat formed once the crop exceeds 36% DM is relatively resistant to chemical breakdown in the rumen and this limits digestibility.

Wrapping recommendations

Whole crop for baling should be cut when the leaf is changing colour and the grain is at the cheesy ripe stage. This will typically be approximately five weeks before the normal combining date.

The DM of the crop should be 36-46%, but better results are achieved at 39-41% DM. For improved fermentation, a biological silage inoculant may be applied at two litres per tonne fresh weight.

Cutting at higher DMs may result in aerobic stability problems such as mould growth, and the harder seed coat may reduce digestibility. As whole crop is usually stemmy and high in DM, six layers of a quality film with 50% overlap should be applied to the bales. Bales can be stacked up to three layers high.

Ammonia treated straw

The ammonia treatment of straw will convert straw of very low feeding value into forage with a feeding value equivalent to moderate hay. It has several benefits. It is a cheap alternative forage. Digestibility is increased on average by 10-15 units of D-Value (DMD) and crude protein is increased by 3-4%.

Intake and palatability are improved over untreated straw. After the treatment process is complete (2-4 weeks) the straw is completely

preserved and sterilised - even if the wrap is torn and air gets in, no moulding should occur.

Wrapping recommendations

Bales of straw are wrapped immediately after baling and a representative number should be weighed to ensure the correct amount of ammonia is injected.

Aqueous or anhydrous ammonia is easily injected into the bale through a hole in the wrap, which is then sealed with a patch. Four layers of film should be applied to ensure that the ammonia is well sealed in the bale.

Black rather than lighter coloured film is recommended as this absorbs heat, warms up the bale and speeds up the reaction to the ammonia treatment, especially in colder climates.

Individually wrapped bales should be left on the treatment site for a minimum period of one week before moving. Bales can then be stacked up to three layers high.

Planning for quality and cost effective silage

Brendan Barnes

By Brendan Barnes, agri-consultant with 20 years experience as an agronomic adviser on grassland and nutrient management.

This article identifies current best practice particularly in the area of nutrient management and integrated grass management systems.

Grass silage is the primary winter forage on many farms in Ireland and elsewhere. Matching silage quality and quantity to each farm and enterprise in a cost effective and environmentally correct manner is the key to long term profit and sustainability.

Farmers producing grass silage to support high production and growth rates in livestock require a comprehensive plan to consistently achieve high yields of quality silage with minimal waste and with controlled costs. Flexible systems of production allow farmers respond to the effects of unpredictable weather.

The critical importance of an adequate supply of silage to feed livestock throughout the winter, and of possessing a reserve of silage to buffer animals through other times, has been starkly illustrated in previous fodder shortages.

Determining the silage requirements of a farm is an essential part of annual feed budgeting, and providing the requirements necessitates the allocation of sufficient land, removal of grazing animals in time and timely application of sufficient fertiliser.

In addition, adequate drainage, avoidance of soil compaction and maintenance of ryegrass-dominant swards greatly help provide consistently better grass yields, digestibility and ensilability.

Silage systems for different enterprises

Achieving a correct balance between yield and quality is the challenge that faces all farmers. This is determined by the farm enterprise, soil type, stocking rate and the expected length of the wintering period. In each situation, economic considerations play a key role.

Spring calving

The reliance on very high DMD (dry matter digestibility) silage is not as critical in creamery herds as in autumn calving herds, if the trend is towards compact calving close to grazing grass. The emphasis is on sufficient silage as maintenance feed during the dry period, while providing high quality silage for freshly calved cows in spring and late lactation.

Winter/liquid milk

Top quality silage is a critical in winter milk production where maximum performance is required. While maize silage has increased in importance as a complementary winter-feed, grass silage will continue to be important.

Cattle

Where conditions allow, beef farmers allow stock on silage fields prior to closing, with grazing normally completed in Ireland by mid-April. A higher percentage of total silage is conserved as baled silage on cattle farms than on dairy farms. Silage quality targets on cattle farms depend on:

- Type of animal and performance required.
- Cost and feeding value of alternative feeds.

Baled silage

It is the main system of winter fodder on the majority of small-sized farms. Although larger farms usually produce precision-chop silage as a first cut, they also bale surplus grass from paddocks, so as to maintain grass quality for grazing animals.

Surplus grass needs to be taken out as it arises. This ensures that the area cut is returned into the grazing cycle for the next rotation. Delaying removal means that the ground will not have recovered for the next grazing cycle.

Nitrogen (N) for silage

If too little N is applied, yield will suffer. If excess is applied it will make the crop more difficult to ensile, through the increased risk of lodging and a combination of reduced sugar levels and increased buffering capacity.

Total nitrogen for first cut silage should be between 110 to 140kg N/ha (90 to 110 units per acre). The higher rates of N can be used on recent reseeds and in a two cut regime, while the lower rate is more suited to old permanent pasture.

Nitrogen should be applied eight weeks before the expected cutting date, so as to ensure at least six weeks of active uptake before harvesting. N fertiliser needs to be adjusted to take account of organic N in slurry - variable and difficult to estimate accurately. Assume 10 to 15kgs of N are available for every 5,000 litre/ha of undiluted cattle slurry applied in the February/March period. Slurry applied under Irish conditions pre-Christmas contributes very little N to a first cut silage crop.

If early grazing, assume that one-third of the N applied will be available to the silage crop and reduce the specific N for silage accordingly. Example: if you apply 57kg/ha for early grazing you should reduce N for silage by 19kg/ha.

Research to date has shown no clear benefit to splitting N applications for first cuts. However, where the silage fields are not being grazed in spring, apply about one third of the silage N in January or February and the remainder in March. Many farmers feel they benefit by applying 35 to 50kg/ha of N in Jan/Feb - they will be in a position to take advantage of any early growth for possible grazing.

The rate of N recommended for second cuts is 75 to 100kg N/ha (60 to 80 units N/acre). A second cut should be treated as a crop in its own right and requires Phosphate (P) and Potash (K) as well as N. This can be applied either in the form of slurry or a compound fertiliser.

Potassium in particular is an important nutrient for second cuts, as much of the available K in the soil will have been utilised by the first cut. Urea is generally not a suitable nitrogen source for second cut silage, as the risk of volatilisation losses can increase on bare swards in warm dry conditions.

Phosphorus and Potassium (P & K)

Good soil fertility is the foundation for good yields of quality silage. Regular soil sampling should be followed each year. The objective is to maintain silage fields at index three for P and K. Where early grazing on silage fields is not required, or full production is not attainable, the target is P index two.

The P and K removal levels in silage are high compared to a grazing scenario where up to 80% of the nutrients are returned by the grazing stock. In a continuous silage situation, adequate P and K must be returned or yields will suffer. Silage fields are often on outfarms or, on heavier soil type's not suitable for early grazing, and it may not be feasible to apply slurry every year.

There is evidence to show that potassium levels on Irish silage fields have declined. In the last five years, potassium usage has declined by 30% and over 60% of silage fields that are cut twice are now classed as low or deficient in K.

Potash recommendations are based on the K levels in the soil and the quantity of slurry spread on the silage fields. Both these factors are also taken into account when giving P recommendations, as well as stocking rate, type of enterprise, level of concentrate feeding and the requirement for early grass.

Lime

A good soil lime status is also required with a target soil pH of 6.3. Care should be taken when applying lime. If it adheres to the crop, good preservation will be very difficult to achieve. Lime should only be applied to short grass before March or after the silage harvesting season is completed. Urea is not a suitable nitrogen source on grassland in the season after liming.

Sulphur for silage

Correct sulphur (S) fertilisation can have major benefits for the yield and quality of a silage crop and, in particular, for second cuts. Like N, it needs to be applied every year on sulphur deficient soils. The most responsive soils are sandy, free draining soils with low organic matter content. Responses of 30% extra grass has been obtained by applying sulphur on responsive sites. Grass quality is also improved, as more of the nitrogen is converted to plant protein when the plant has an adequate supply of sulphur. Utilisation of grass intake is also improved.

Soil analysis is not an accurate predictor of S deficiency. Herbage analysis is the most accurate method of predicting a likely response. The plant sulphur level should be greater than 0.2% in DM and the NS ratio less than 15:1. Knowledge of soil type and local responses are good indicators of a likely response.

Over the years, many farmers have shown a response to sulphur on their own farm by applying a nitrogen fertiliser on part of a field and treating an adjoining area with an equivalent nitrogen fertiliser containing sulphur.

Dramatic responses have sometimes been observed on second cut silage and on grazing fields from May onwards. Generally, good responses are not observed on first cut silage except on some sandy soil types. If a good response is obtained on second cuts, it may be worthwhile using a fertiliser with S for first cuts.

Usage of traditional fertilisers like Sulphate of Ammonia has declined, as they tended to scorch the grass under dry conditions and were also more difficult fertilisers to spread. The rates of sulphur recommended are 20kg S/ha for each cut and 20kg S/ha applied on grazing fields over the course of the year.

Optimising silage feeding value

By Dr. Tom Butler, Farm Business Advisers Ltd., Fermoy, Ireland.

The feeding value of silage is determined by the nutritive value (energy and protein density) per unit of dry matter (DM), and the voluntary animal intake. It is of little benefit to the farmer to have silage of excellent chemical composition, but highly unattractive to the animal. In establishing silage feeding value, intake is a more important determinant than any chemical factor.

Silage nutritive value

The nutritive value of a clamp of silage is determined by:

(i) DM content:

Silage of 27% dry matter is potentially worth 50% more than silage of 18% dry matter.

(ii) Energy density:

The energy density of silage dry matter is influenced by the digestibility of the herbage ensiled, and the efficiency of preservation. The typical average values found in silage analysis are:

DMD %	ME (MJ/kg DM)
68–76	9.7–10.9

(iii) Protein content:

Satisfactory protein values are in the region of 14% to 17%. Excessively high crude proteins are composed largely of non-protein nitrogen. These are of little nutritive value, and make good preservation more difficult to achieve.

(iv) Mineral composition:

The major minerals of importance in silage are calcium, phosphorus, magnesium, sodium and potassium. Where there is proper maintenance of soil fertility, there is not wide fluctuation in the quantities of major minerals present in silage. Of the trace minerals, there are generally inadequate amounts of copper, selenium and iodine to meet animal requirements.

Table 1:Effect of dry matter intake on composition of diet supplying 240 MJ of ME and 3500g of crude protein

Diet DM	DAILY DM INTAKE (kg)		
Composition	18.0	20.0	22.0
ME (MJ/kg)	13.3	12.0	10.9
Crude Protein %	19.4	17.5	15.9

Importance of feed intake

Whether feeding a lactating dairy cow, finishing a bullock or growing a weanling, it is essential to supply the animal with a daily dietary intake that contains all the nutrients for the desired level of performance. Well preserved, palatable, silage that has high intake characteristics will generally give better performance, particularly when measured over a prolonged period of feeding. As total dry matter intake increases, the required dietary concentration of nutrients decreases. This is illustrated in Table 1 showing different dry matter intakes in lactating dairy cow diets.

Relative feeding value

It is essential that the farmer makes every effort to optimise the silage making procedure.

This involves all of the steps from start of growth to animal consumption:

(i) Use good ryegrass pasture.
(ii) Ensure proper soil nutrient balance.
(iii) Cut at correct stage of growth to achieve the best balance of yield, digestibility and protein content.
(iv) Ensure good preservation by wilting or additive use.
(v) Avoid clamp wastage during storage, or at feeding time.

Whilst good quality grass silage is the basis of profitable dairy and beef cattle winter feeding, it no longer has the big cost advantage that prevailed historically.

Quality by-products such as Brewers Grains, Beet Pulp, Citrus Pulp and Molasses are quite competitive with silage on an energy basis. Apart from by-products, home grown cereals are no longer highly expensive relative to silage, with harvest cereals costing about €90 per tonne.

Baled silage

The making of baled silage has developed mainly on smaller farms, but is now gaining more widespread popularity. The major criticism of baled silage has been its higher cost relative to clamp silage. The cost can be reduced significantly by greater attention to bale making, and herbage dry matter. There is 72% more dry matter in a bale of 650kg at 32% dry matter compared with a bale of 550kg at 22% dry matter. Well-packed, chopped bales can be made to weights of at least 650kg at high dry matter, thus reducing the cost per unit of dry matter.

Baled silage has distinct advantages to offer on all farms:

(i) Surplus grass can be harvested into high quality silage, rather than be wasted as excessively mature grazing or topping.
(ii) Bales can be conveniently fed during brief periods of grass scarcity e.g. drought, wet weather. This is difficult to do with clamp silage.
(iii) When good quality grass of high dry matter content is used, high animal intakes are achieved.
(iv) Expensive silage clamps are not required.
(v) There is no effluent wastage.

Apart from improved efficiency of bale making, the other change that is required at farm level is greater attention to the quality of the material being ensiled. Since all bales carry the same cost of mowing, baling and wrapping, it is extremely wasteful to have herbage of very low nutrient content. Unfortunately, a large proportion of Irish baled silage is made of excessively mature, poor quality forage.

Predicting silage intake

Extensive research work has taken place at the Agricultural Research Institute of Northern Ireland (ARINI), Hillsborough. As a result of these studies, it is possible to accurately predict the intake and feeding value of silage for dairy cows, beef cattle and sheep. In collaboration with ARINI, a number of forage laboratories in Britain and Ireland are now using Near Infrared Reflectance Spectroscopy (NIRS) to predict silage intake and composition.

This new analytical technology has resulted in greater emphasis on silage quality. It also enables the advisor and farmer to determine the quantities and types of supplementary feeds required for the different categories of livestock being fed.

Assessing feed stocks

Extract from Dept of Agriculture & Rural Development (DARDNI) publication on Winter Feeding. publication on Winter Feeding.

http://www.dardni.gov.uk/publications/pubs0041.htm

- Assess the forage necessary to carry stock through the winter and the amount of forage available on the farm - see Table 1.
- Have the silage analysed to determine its feed value and adjust intakes for different dry matters.
- The quantity of silage eaten will depend on concentrate feeding level and silage intake potential.

Risks with feeding poor quality forage

Feeding poor quality forage can result in health problems such as listeriosis. *Listeria* is a type of bacteria that can grow in poorly fermented silage. It is naturally present in the soil and multiplies quickly in silage where air is present. This can occur if the silage wrap is torn or where soil contamination is present. Listeriosis in cattle and sheep causes inflammation of the brain tissue (often characterised by animals going around in circles) and can also cause abortion and death. Farmers must make every effort to avoid feeding mouldy or poorly fermented silage. Sheep are the most susceptible, followed by pregnant cattle. Some preventative measures to avoid listeriosis are as follows:

- Maintain an anaerobic environment by ensuring good compaction and sealing.
- Keep a clean environment and discard spoiled bales.
- Do not feed mouldy silage and remove refused silage every two days to avoid accumulations of spoiled material.

Listeria is also thought to be responsible for eye problems. In severe cases, sight may be lost for a short time, but these cases respond well to early

Ewes too can appreciate the quality of this forage.

Table 1: Monthly feed requirement for various classes of stock			
	Silage (tonnes/month)	Small hay strawbales/month	Hay/straw 1.3m round bale
DAIRY COWS			
-milking	1.5	17.0	1.25
-dry	1.0	10.0	0.75
SUCKLER COWS			
-dry spring calving	1.0	10.0	0.75
-autumn calving	1.2	14.0	1.0
OTHER CATTLE			
-350kg+	1.0	10.0	0.75
-250-350kg	0.8	8.0	0.6
-200-250kg	0.7	7.0	0.5
-calves	0.3	4.0	0.3
EWES	0.15	2.0	0.15

Table 2: Quantity of forage in large bales				
Forage	Large round bales	Equivalent number of small rectangular bales per large bale.	Large square bales (2.5x0.9x1.2m) weight (kg)	Equivalent number of small rectangular bales per large bale
Silage -unchopped	450 - 500	-	770	-
Silage - chopped	600 - 700	-	-	-
Wheat straw unchopped	220	15	250	17
Wheat straw chopped	230	15	-	-
Hay	275	14	400	20

Table 3: The minimum forage requirements for dairy cows , suckler cows and store cattle		
	Minimum fresh Silage (kg/day)	Minimum hay/straw (kg/day)
Dairy cow (giving 30 litres/day)	23 (4.1t)	5.5 (1t)
Suckler cow (600kg dry cow)	11 (2t)	2.5 (0.5t)
Store cattle (300-400kg)	9 (1.6t)	2 (0.4t)

treatment. Some outbreaks may affect up to 50% of animals. Livestock fed big bale silage through round feeders are more likely to contract eye infections through contact with infected particles on the long chop silage. Wet weather and poor ground conditions, leading to soil contamination and poor quality forage, can also cause problems such as fungal and bacterial abortion and occasionally botulism (especially if poultry litter has been spread on fields).

Where silage is of poor quality, supplementary feeds will be necessary to meet performance targets. In some cases, performance targets may need to be reduced.

Production costs

There is a perception that the baled silage conservation system is expensive relative to clamp silage. However this opinion is inaccurate if all costs are considered. Estimates of the comparative costs of big bale and conventional clamp silage over three cuts have been carried out at Greenmount College and the Agricultural Research Institute of Northern Ireland (Table 4b). The results show little difference in the cost of producing grass silage (Stg£/tonne dry matter) using either a clamp silo or big bales. Bale weight can have a major bearing on the cost of production. Research has also shown that although a higher cost per bale is incurred for chopped bales, fewer bales are produced and costs are reduced.

The importance of dry matter (DM) levels and the impact it has on bale numbers is clearly demonstrated by research work by Teagasc at Grange, Co. Meath, Ireland.

The costs of feeding baled or clamp silage will vary between farms. Each system has its merits and farmers can decide for themselves which system is the most suitable for their circumstances.

Table 4a. Est. Bale production per hectare

Grass Dry Matter % at baling

(25 tonne/ha crop @ 18% DM)

	Number of bales per hectare		
Bale weight (kgs)	18	25	35
400	-	-	32
500	-	36	25
600	41	30	21
700	35	35	18
800	31	22	-
900	27	-	-

Source: Teagasc, Grange

Table 4b. Comparative costs of big bale and conventional grass silage

	Conventional silage	Big bale silage
Cash cost		
(Stg£/tonne DM)	52	51
Full economic cost		
(Stg£/tonne DM)	84	85

Source: Department of Agriculture and Rural Development (N. Ireland)

Wrapper sets it up

For all balewrappers follow the manufacturer's recommendations and be particularly aware of the following points:

- Ensure that the machine has been well maintained, paying particular attention to the pre-stretch unit (PSU). A poorly maintained PSU may lead to inconsistent stretching of the film and possible tearing.
- Regularly clean the surface of the prestretch unit rollers with a proprietary hand cleaner to prevent the build-up of tackifier.
- Adjust the PSU to align the middle of the roll of film to the centre of the bale.
- Check that the gearing is set to give a prestretch of 70%. Film will narrow on the bale to approximately 80% of its original width. As a rule of thumb 750mm wide should narrow to no less than 600mm.
- To check that the PSU is set correctly put two marks on the roll of film 10cm apart. When the film is stretched on to the bale the distance between these marks should be 17cm apart - indicating 70% stretch.
- Check the correct size of sprocket is fitted to the wrapper turntable according to the width of film used and the number of layers applied (consult manual).
- Put the roll of film onto the pre-stretch unit and ensure that the outside (tackier) side of the film is applied against the bale.
- Please consult your machine operator's manual on how to thread film through the pre-stretch unit.

Round bales

- It is important to read the manufacturer's recommendations on the use of film before wrapping operations commence.
- Use a quality stretch film which stretches evenly, has high impact strength, good tear resistance, consistent UV protection, a high initial tack and a good long term seal.
- Use 750mm wide film, as it is quicker to wrap and effluent seepage from wet bales is also substantially reduced.
- The film should be handled with care to avoid damage and always transported inside its packaging.
- Rolls should be stored under cover on their ends, in their original packaging. Avoid direct sunlight and extremes of temperature and keep the film dry.
- Immediately before use, the rolls should be kept in a warm place (20-30°C) for up to 48 hours to optimise tack performance.
- Wrap the bales as soon as possible after baling, preferably within two hours and ideally at the stack, to reduce the risk of handling damage to the film.

Calculating your film requirements

1500m X 750mm film No. of bales to be wrapped	Four layers of film (2+2) No. @ 32-33 bales/roll	Six layers of film (2+2+2) No. @ 21-22 bales/roll
50	2	3
100	3	5
200	6	9
500	15	22
1000	30	44

- When baling in the field, film should be kept protected in its box until needed.
- Very warm conditions causes "necking down" and film should be checked more regularly (see machine set-up).
- Do not wrap bales in the rain as this may impair the tack.
- Ensure the bale is completely covered with four layers of film. Less than four layers may result in mouldy silage.

How many revolutions to apply four layers?

To ensure the bale is completely covered with four layers of film (2+2) using a 50% overlap, use the following formula:

- WRAP UNTIL THE BALE IS COVERED (BLACK) ADD A FURTHER REVOLUTION AND THEN APPLY THE SAME TOTAL NUMBER OF REVOLUTIONS AGAIN

For 750mm film, seven revolutions, plus one and then a further eight revolutions, making 16 in total.

NB. The above examples are for guidance only as the total number of revolutions needed will vary according to bale size and shape.

How many revolutions to apply six layers?

For increased protection, particularly when wrapping higher dry matter material, for extended storage life , when the bale is likely to be exposed to strong winds or strong sunlight, apply six layers of film instead of four. To ensure the bale is completely covered with six layers of film (2+2+2) using a 50% overlap, use the following formula:

- WRAP UNTIL THE BALE IS COVERED (BLACK). ADD A FURTHER REVOLUTION AND THEN APPLY TWICE THE TOTAL NUMBER OF REVOLUTIONS AGAIN.

For 750mm film, seven revolutions plus one = eight and a further 16 revolutions making 24 in total. *NB. The above examples are for guidance only as the total number of revolutions needed will vary according to bale size.*

- STRETCH FILM IS STABILISED AGAINST UV DEGRADADATION FOR 12 MONTHS. WRAPPED BALES SHOULD BE STORED FOR ONE SEASON ONLY AND NO MORE THAN 12 MONTHS FROM THE DATE OF APPLICATION OF THE FILM TO THE BALE

Square bales

Follow the basic guidelines for making round bales as outlined above. High density square bales need to be made at approximately 25-30% DM. It is recommended that 1500m x 750mm size quality film be used to give the desired overlap and coverage of the bale. Six layers of film should always be applied to the bales. This can be calculated in the same way as for round bales.

Mini round balers

Mini round balers and wrappers have been introduced to the market, mainly to make haylage for feeding to horses. Weighing approximately 30-40kg, at 65% dry matter, these mini bales can easily be moved by hand and are normally quickly eaten up, resulting in less wastage.

Mini bales can vary in dimensions but the most popular at present are 570mm (22in) in diameter with a barrel length of 630 mm (25in). Wrapping with six layers of a 250mm wide film is recommended which, when applied with a 50% overlap at 35% stretch, yields approximately 30 bales per 1800m roll. To calculate the total number of revolutions required to apply six layers: wrap until the bale is covered. Add a further revolution and then apply twice the total number revolutions again (e.g., for 250mm film: 10 revolutions plus 1=11 and then a further 22 revolutions making 33 in total).

NB. The above example is for guidance only as the total number of revolutions needed will vary according to bale size and shape.

Contributors

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Diagnostic Guide for Balewrapping

1. Identify brand, record batch and roll number on film core. Take a film sample for analysis by supplier.
2. Check bale and film application (ie. target is a minimum of four layers and 50% film overlap).
3. Check storage application (ie. stacked no higher than three bales, vermin, small animal and bird damage).
4. Check balewrapper (pre-stretch unit rollers, build up of tack, correct setting, and 70% pre-stretch)
5. Check bale density and forage quality.

Problem identified	Tick	Possible causes	Recommendations
Aquaplaning		Build up of tack on PSU rollers/film fault (PSU = pre-stretch unit)	Clean rollers with white spirit only. Check PSU setting.
Film over-stretching		Incorrect PSU setting (not 50% overlap on bale). Excessive turntable speeds. High tack-avoid wrapping during very hot weather conditions.	Check PSU-clean, replace roller or repair unit. Operate bale wrapper as per manufacturers instructions.
Bales splitting		Insufficient film/PSU overstretching / handling or other damage/die lines/heavy bales.	Check PSU/handling equipment. Check for four layers of film. Repair physical damage.
Holes/windows		Bird, stubble or physical damage. Also caused by impurities in film.	Patch bales and protect stacks with netting. Repair or replace damaged drop mat/fall damper.
Film breaking		Tack build up on PSU (exacerbated by hot weather)/incorrect stretch adjustment/ edge damage to roll/incorrect core alignment.	Check PSU and for film abnormalities. Return film to stockist if product is outside specification.
Low/excess tack Die/port lines, Spiral tearing, nibs/gels		Film fault/storage problem(too cold/ too hot-direct sunlight). These problems are associated with manufacturing and raw materials used and may cause film breakage.	Check storage, adjust as appropriate and contact stockist if necessary.
Damaged rolls and film cores		Damage on farm or in transit.(careless handling/damp storage/core alignment/ collapsed or telescoped cores).	Do not use unsatisfactory film and return it to your stockist. Check cause and return film to your local stockist.
Mouldy silage		Insufficient film cover and poor overlap/ vermin damage/holes in film/high dry matter forage/soil contamination/balewrapping delay etc.	Check film and consider silage analysis. Investigate original forage quality and harvesting conditions. Check whether mower/ baler pick up settings (too low).
Bird, small animal and vermin damage		Holes appear on top of bales/grease marks along walls indicating rats/ undergrowth not kept clear of stack/no netting or cover on bales.	Patch or re-wrap affected bales and use silage netting raised above stack by tyres. Exercise proper rodent control.
Poor bale shape		Misshapen-causing stress on film and splits (do not stack more than one high if low dry matter and bales are heavy, e.g. Kaleage)	Check stack. Isolate bad bales if possible. Re-wrap bales if required.
Effluent leakage		Bales not properly overlapped/film damage/insufficient tack/low dry matter forage/bales stacked too high.	If possible re-wrap or repair bales. Do not stack bales.
Rotten bales but wrap OK		Often due to low sugar/low dry matter forage or due to high nitrates, soil or slurry contamination etc.	Analyse silage. Liaise with forage adviser. Check weather conditions for harvesting dates.

For high DM forage a chopper baler with a wide pick up is recommended to minimise problems with mouldy silage and uneven swathes. Machinery models/brands, the condition of the PSU /drop mat, operator skills, weather conditions and forage quality will all impact on bale/ silage quality.
For Kaleage, heavy wet bales, high dry matter or misshapen bales six layers of a quality film are always recommended.
When cleaning the PSU, petrol or diesel should never be used as it exacerbates the problem particularly if rubber rollers are used.

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