Managing silage making to reduce losses

Losses of dry matter and metabolisable energy (ME) occur in silage making due to delayed harvest and also between field and feed trough due to fermentation and aerobic spoilage. Farmers should aim to exert greater control of silage making operations to improve timeliness of harvest and to minimise losses of nutrients. Concentrate input per unit of milk production is often higher than optimal which is more often a reflection of low silage quality than of wasteful overfeeding. A week's delayed harvest of grass is estimated to incur a net cost of 13 pence per cow per day of winter feeding. Mowing a dry crop and spreading it out to maximise rate of water loss during the wilting period can reduce losses in the field. Consolidation of crop in the silo to achieve a minimum fresh weight density of 700 kg/m^3 and dry matter (DM) density of 210 kg/m^3 will help to minimise losses during the storage period, paying particular attention to the outermost layer which should be covered with an oxygen barrier film. A feed-out progression rate of at least 1 metre per week in winter and 1.5 to 2 metres per week in summer, coupled with harvesting a clean crop with low yeast and mould counts will help to reduce losses during feed-out. Many bunker silos are too old, too small, have no safety rail and are over-filled. Safety issues should be considered at all stages of silage making. Appropriate steps should be taken wherever possible to minimise risk of injury.

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J M Wilkinson BSc PhD R Anim Sci, School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, Leics LE12 5RD

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The aim in grass silage making is to harvest a leafy crop and to conserve high-quality preserved material of high metabolisable energy (ME) value. Similarly, with maize and whole-crop wheat the aim is to harvest the crop at high ME before the stem and leaves become over mature due to plant senescence. But the conserved crop is reduced in both quantity and ME value by the time it enters the feed trough due to delayed harvest and/or losses of digestible material in the field and in the silo, How much of the initial crop yield is actually available to livestock? What are the financial penalties of losses in silage making and how can they be mitigated?

In this paper, losses of dry matter (DM) and ME at different stages of silage making are outlined together with estimates of the financial consequences of delaying first-cut grass silage making by a week. Ways of mitigating losses in the field and silo are described and potential effects of the ingestion of spoiled silage by the animal are discussed. Safety issues in silage making and feeding are also emphasised.

Losses at different stages of silage making

Dry matter losses post cutting occur due to respiration and leaching in the field, respiration, enzyme activity and fermentation in the silo, and aerobic deterioration due to growth of yeasts, aerobic bacteria and moulds following opening of the silo for feed-out. Plant components lost as carbon dioxide, water and soluble nitrogenous compounds are mainly cell contents comprising carbohydrates and proteins that are almost completely digestible by the animal and thus represent the most valuable part of the crop.

There is a huge range in losses during silage making, mainly reflecting weather conditions and variation in efficiency of filling and sealing the silo. Typical losses of DM and decrease in concentration of ME (predicted from the concentration of digestible organic matter in the DM) at different stages of silage making and feed-out are shown in *Table 1*. They relate to bunker silage made from crops of grass and forage maize. Field losses are typically higher for wilted grass than for direct-harvested maize. Losses due to top spoilage and aerobic deterioration during the feed-out period are higher for maize than grass silage.

Applying the losses in *Table 1* to 1000 kg of DM of grass or maize of similar ME concentration (11.5 MJ ME/kg DM) pre-harvest gives the quantities of crop DM and ME entering the silo, at feed-out and in the feed trough (*Table 2*). The losses in terms of both DM and ME are sequential and therefore cumulative. The ME concentration of the silage in the feed trough is

10.9 MJ/kg DM for grass and 11.1 MJ/kg DM for maize. In other words, typically silage may be expected to lose about 0.5 MJ ME/kg DM between field and feed trough. Total loss of ME yield between cutting and feeding is 24% for grass and 23% for maize.

By the time the crop is in the silo, virtually all the costs associated with its production have been incurred. Taking a cost for growing and harvesting of £18/tonne fresh weight (£99 per tonne DM) for grass at ensiling and £19/tonne fresh weight (£63/tonne DM) for maize at ensiling (Nix, 2014), the increases in cost per tonne due to losses between ensiling and feeding are shown in *Table 3*. The increases in cost reflect the typical losses of both DM and ME at different stages of the conservation process (*Table 1*). For comparison, the average cost of high-energy dairy compound (13.5 MJ ME/kg DM) in January 2015 was £240 per tonne fresh weight (DairyCo, 2015) or 2.02 p/MJ ME making a MJ of grass silage ME at the time of feeding slightly more than half, and a MJ of maize silage ME just over a third the cost of a MJ of ME of dairy cake.

Managing to reduce losses

The three teams in silage making and feeding are those involved in: cutting and harvesting; ensiling; and feeding. On some farms the different teams may be the same people but often a contractor does the harvesting and ensiling, and farm staff do the feeding. It is vital that farm staff are integrated into harvesting and ensiling as much as possible, with a senior member operating a silo packing tractor to control the speed of silo filling and ensure good crop consolidation.

Cutting and wilting grass crops

The big question is when to cut first-cut grass for silage? The answer is to cut as early as possible in as good weather as possible. Poor weather often delays cutting and prolongs field-wilting. Late arrival of the silage contractor may result in a short spell of good weather being missed, as happened to many farmers in the UK in the spring of 2014 and 2015. The decline in grass ME/kg DM with advancing crop maturity is greater once the crop has started to produce flowering stems from mid-May onwards than during the earlier vegetative (leafy) stage of growth. Thus there is more flexibility in deciding when to harvest an immature crop than there is with a more mature crop. Typically, grass D-value decreases at 0.5% units per day or 3.5% units per week during ear emergence (Keady et al, 2013). Regrowth is more rapid post-harvest after an earlier cut crop than after a later cut crop because the remaining stubble is still green and capable of photosynthesis, and moisture levels in the soil are relatively high. Thus the lower yield from an earlier cut crop can be mitigated by a higher yield at the second cut (Thomas et al, 1991).

The consequences of a delay of 1 week in cutting grass for first-cut silage in terms of yield and cost per MJ ME are shown in *Table 4*. The main effects of a week's delayed cutting are estimated to be 10% higher crop yield, lower concentration of ME per kg DM of 0.5 MJ/kg DM at cutting and 2% higher field losses due to slower wilting of the heavier crop. Assuming in-silo and feed-out losses remain similar to those of the earlier cut crop, the cost per MJ of ME at the point of feeding is 0.13 pence/MJ ME (10%) lower for the delayed cut than for the lighter earlier cut silage, assuming that costs are charged per hectare and not per tonne of crop harvested. Many farmers experience this situation due to delayed cutting following a period of poor weather between mid May and mid June.

The consequences to the animal of the week's delayed harvesting now have to be taken into account. The dairy cow responds to lower silage digestibility by decreasing daily silage DM intake. A week's delayed cutting is reflected in a reduction in silage DM intake of about 10%, equivalent to at least 1.5 litres of milk/day (Keady et al, 2013). Add to this the lower ME concentration and intake of ME is reduced to a greater extent than the reduction in

Table 1. Typical losses at different stages of silage making and feed-out

	Grass		Maize	
	Loss of DM (%)	Decrease in ME (MJ/kg DM)	Loss of DM (%)	Decrease in ME (MJ/kg DM)
In field[1]	5	0.15	2	0
Respiration and fermentation in silo	10	0	10	0
Top spoilage and aerobic deterioration	8	0.30	10	0.32
Weighted total loss of DM	21.3		20.6	

(based on Van Schooten and Phillipsen, 2012; Köhler et al, 2013) [1] = Mowing, raking, respiration, leaching, harvesting, DM = dry matter, ME = metabolisable energy

Table 2. Quantities of DM and ME at ensiling, at feed-out and in the feed trough, per tonne of crop in field

	Grass		Maize	
	DM	ME	DM	ME
	kg	GJ	kg	GJ
At cutting	1000	11.5	1000	11.5
At ensiling	950	10.8	980	11.3
At feed-out	855	9.71	882	10.1
In feed trough	787	8.70	794	8.90

DM = dry matter, ME = metabolisable energy

Table 3. Estimated cost per kg DM and per MJ ME of grass and maize silage at ensiling, at feed-out and in feed trough

	Grass		Maize	
	Pence/kg DM	Pence/MJ ME	Pence/kg DM	Pence/MJ ME
At ensiling	9.89	0.92	6.30	0.56
At feed-out	11.6	1.02	7.14	0.62
At feed trough	12.6	1.14	7.93	0.71

DM = dry matter, ME = metabolisable energy

Table 4. Effect of a delay of 1 week in grass silage making on yield, ME value and cost per MJ ME

	Earlier first-cut grass	Cutting delayed 1 week
Yield of DM (kg)	1000	1100
ME at cutting (MJ/kg DM)	11.5	11.0
Yield of ME (GJ/hectare)	11.5	12.0
ME at feeding (MJ/kg DM)	10.9	10.4
ME available to feed (GJ)	8.70	8.76
Cost of ME at feed trough (p/MJ)	1.14	1.01

ME = metabolisable energy

Table 5. Effect on the animal of delayed cutting of grass by 1 week

	Earlier cut	Cutting delayed 1 week
Silage DM intake (kg/cow/day)	11.0	9.9
Silage ME intake (MJ/day)	122	103
Cost of silage (p/MJ ME, *Table 4*)	1.14	1.01
Total cost of silage ME (p/day)	139	104
Saving of silage cost (p/day)		-35
Cost of extra compound feed (2 kg/cow/day @ 24 p/kg)		+48
Net additional cost (p/cow/day)		+13

DM = dry matter, ME = metabolisable energy

DM intake alone. This means that more concentrate is required to maintain milk yield. As concentrate intake is increased, silage intake is reduced whatever its quality. To maintain ME intake an additional 2 kg extra concentrate fresh weight is required per day costing 48 pence/cow per day. Although less silage is consumed and its unit cost is lower than that of the earlier cut material, there is a net additional cost of 13 pence/cow per day or £26 per cow over a 200-day winter period (*Table* 5). The break-even cost of concentrate is £175/tonne, so an alternative strategy might be to increase the level of concentrate with cheaper raw materials than dairy cake, such as wheat, barley and rapeseed meal. If level of concentrate is held constant and not increased to make up for the decrease in silage ME intake, the reduction in milk yield would be some 300 litres over a 200-day winter, worth £75 per cow at 25 pence/litre.

These calculations do not take into account the consequential animal health risks of the higher concentrate feeding level, including subclinical rumen acidosis and left displaced abomasa. There are also increased health risks associated with not increasing concentrate level such as ketosis, anoestrus and increased days to conception.

Mitigating the adverse effects of delayed harvesting

Planning ahead for first-cut grass silage involves knowing typical dates of ear emergence of the main grass species and varieties in the fields and then adjusting for seasonal effects. For example, a cold March delays heading date. A 2°C decrease in average soil temperature at 30 cm depth in March (e.g. from 8 to 6°C) is reflected in a week's delay in heading date (Wilkinson, 1984). Late application of fertiliser nitrogen should be avoided if possible because a 6-week period should elapse between the date of applying fertiliser to cutting for silage to reduce the risk of excess non-protein nitrogen (mainly nitrate) in the crop at harvest.

Later-heading varieties can be sown to increase the harvest window. Moving from early flowering to intermediate varieties of ryegrass can delay ear emergence by about 1 week, as can moving from intermediate to late-heading varieties. Sowing a mixture with different heading dates rather than a single early flowering variety can slow the overall rate of decline in D-value with advancing sward maturity. Fields can be grazed by sheep prior to being closed up for silage, but there is greater risk of poor silage fermentation due to contamination of the sward with undesirable bacteria from sheep manure.

Booking the contractor to arrive as early in the harvesting season as possible increases the probability of arrival closer to the planned date since there is less opportunity for delays to accumulate as the result of breakdowns and hold ups due to poor weather earlier in the season.

Owning a forage harvester and hiring temporary staff to help with silage making may be a feasible option. Increased popularity of forage wagons in recent years is evidence that some farmers, fed up with unreliable contractors, are taking matters into their own hands. The author knows of one farmer who has four forage harvesters, all with many years of service. Two are operational — one to do the harvesting and one to substitute in case of a breakdown. The other two harvesters are not operational, but are on the farm as ready sources of spares.

Mowing and wilting

Soil contamination should be avoided and fields should be rolled in advance of cutting, especially where the ground is uneven and where there are molehills. The micro-climate at the base of the swath and at the base of the stem of the maize plant is favourable to fungal growth so grass crops should be mown in dry weather to a minimum height of 50 mm above ground level, ensuring that spreading and rowing up rakes are set so that the tines do not touch the ground. Cutting wet grass with dew or rainwater on the surface of leaves (10% DM) should be avoided. Maize crops should be cut as early as possible to reduce the risk of mould and mycotoxin contamination, to a minimum stubble height of 150 mm above ground level.

Prolonged wilting in poor weather increases losses due to plant respiration and leaching. Digestibility (D-value) decreases during wilting by around 1 percentage unit per day in the field in average weather conditions and by as much as 2 units per day in poor weather (Wilkinson, 1981). The mown swath should occupy as much of the total ground area as possible to intercept the maximum possible amount of solar radiation for speedy water loss during the wilting period (Wright et al, 1997). Spread swaths are less affected by rain and mould growth is likely to be slower than in larger, denser, and narrower swaths. Conditioning can increase water retention in the swath following rainfall compared with unconditioned grass, especially in heavier swaths. Rowing up before rainfall can reduce the amount of rainwater retained by grass.

Packing and consolidating the silo

The bottleneck is the silo. Too often the high capacity of the forage harvester exceeds the weight of tractors on the silo with the result that silage density is too low, porosity is too high and aerobic stability during feed-out is reduced.

The general rule of thumb is that total packing tractor weight (kg) should be one quarter of the delivery rate to the silo (tonnes fresh weight per hour). Thus if the delivery rate is 50 tonnes per hour, the packing tractor weight should be 12.5 tonnes. Tractors typically weigh between 9 and 12 tonnes and, if delivery rate is 100 tonnes fresh weight per hour, total packing tractor weight should be 25 tonnes or at least two tractors on the silo rolling thin layers of crop to achieve adequate consolidation.

The recommended minimum fresh weight (bulk) density is 700 kg/m^3, minimum DM density is 210 kg DM/m^3 and maximum porosity is 0.4, i.e. 40% of air filled space (Wilkinson and Davies, 2012). To achieve these goals, DM at harvest should be less than 40%. If DM exceeds 40%, packing tractor weight must be increased substantially to achieve the target density and keep porosity below 0.4. The introduction of the tracked snow groomer 'PistenBully' (Nussbaum and Rubenschuh, 2012) for packing silage may have potential, but its weight (9.3 tonnes) and ground pressure (0.16 kg/cm^2) may be too low to achieve the target minimum density.

In-silo losses

Material in the peripheral areas of silos and bales, of lower density than the core, is prone to deterioration due to permeation of oxygen through standard polyethylene film covering and also due to damage to the film from wind, birds and animals. Consequently a layer of grey or black spoiled silage is often seen at the periphery of the silo or bale, with visible mould growth. The material may also show signs of overheating with dark brown colouration and a smell of tobacco. Dry matter density has a major impact on in-silo loss. Typically, the reduction in DM loss is 0.4% units per 10 kg increase in DM density (kg/m^3). Silage DM density and DM concentration interact to affect in-silo losses. In a farm-scale study with well-consolidated maize silage of 258 kg DM/m^3 average DM density (*Figure 1*), the lowest losses occurred in drier silage which had been packed to high density, most likely due to a combination of reduced respiration in the hours after filling and restricted fermentation. Density was on average 25% less in the uppermost 0.5 m than at lower depths (i.e. the core) of the silo. Density had less effect on loss at lower DM concentration than in higher DM silage because the range in DM density was much less in wetter than in drier silage.

Covering silos with standard 500-gauge polyethylene film (125 µm thickness) reduces losses by protecting the crop from the effects of wind and rain and also by reducing, but not preventing, oxygen permeation into the silo. Loss of organic matter (OM) is highest in the uppermost 0.5 m. Studies with farm-scale silos in the USA over a 4 year period revealed that loss of OM

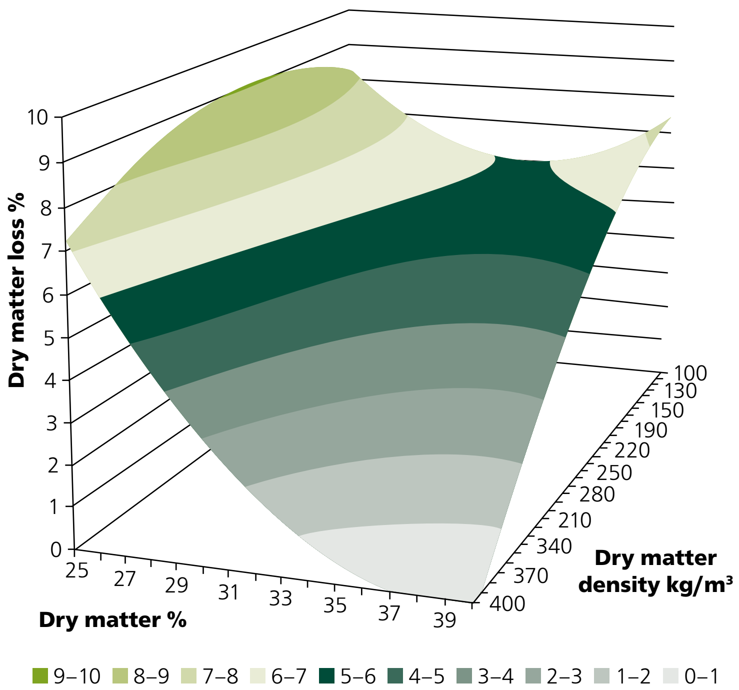

Figure 1. Maize silage density and in-silo loss (Griswold et al, 2010).

during the storage period was 47% in the top 0.5 m of uncovered silos, compared with only 11.5% for the same silage between 0.5 and 1 m depth. With covered silos loss was 20.3% in the top 0.5 metre and 4.5% between 0.5 and 1 m (Bolsen, 1997). Top spoiled silage would originally have been a much thicker layer. Shrinkage due to the decomposition of OM during the storage period produces a black, foul-smelling, slimy layer with a mud-like texture in the outermost layer. The decrease in height due to top shrinkage depends on the effectiveness of the covering system and can be up to 0.9 m in uncovered silos.

Top surface spoilage in bunker silos is most extensive nearest the walls where silage density is lowest. Spoiled silage judged to be unfit for use as animal feed (i.e. inedible) is normally discarded as waste material after the top surface is exposed prior to feed-out. However, spoiled silage can occasionally be given to livestock and the chances of including it in the diet are greatest when unloading takes place in the dark. The accidental inclusion of spoiled silage in the ration poses risks both to animal health and productivity.

There has been little research into the effects of exposure of silage to oxygen on its nutritional value to the animal. In an experiment with beef cattle fitted with ruminal cannulae, silage intake and digestibility were assessed when spoiled maize silage from the top 1 metre of an uncovered silo was mixed, at 25% of total silage DM, with unspoiled silage from the same original crop but stored in an 'AgBag' silo. Inclusion of spoiled silage in the ration appeared to destroy the integrity of the forage 'mat' in the rumen with detrimental effects on intake and digestibility (*Table 6*).

Research in Germany showed an average 57% reduction in DM intake of maize silages differing in DM, chop length and

Table 6. Effect of including spoiled maize silage in the diet of beef cattle

	100% normal silage	75% normal, 25% spoiled silage	P
Intake of dry matter (kg/day)	7.94	7.35	$p<0.05$
Digestibility of organic matter (%)	75.6	70.6	$p<0.05$
Digestibility of neutral detergent fibre (%)	63.2	56.0	$p<0.10$
Digestibility of acid detergent fibre (%)	56.1	46.2	$p<0.05$
Intake of digestible organic matter (kg/day)	6.00	5.18	$p<0.05$

(Whitlock et al, 2000)

Table 7. Mean composition and intake of maize silage after 0, 4 or 8 days' exposure to air

	Days exposure to air		
	0	4	8
DM (% of fresh weight)	36.0	37.1	39.5
pH	3.9	4.2	5.8
Lactic acid (% of DM)	5.8	4.9	0.8
Acetic acid (% of DM)	1.3	0.9	0.3
Ethanol (% of DM)	0.62	0.43	0.01
Yeasts (log10 cfu1/g)	4.6	7.2	7.3
Moulds (log10 cfu/g)	2.4	2.8	4.2
Aerobic mesophilic bacteria (log10 cfu/g)	4.7	5.7	6.7
Accumulated temperature (°C above ambient)	-0.6	8.4	28.7
DM intake (3 hour period, g)	646	626	280

(Gerlach et al, 2013) DM = dry matter, cfu = colony forming units

density and exposed to air for 8 days prior to being offered to goats in a preference trial (Gerlach et al, 2013). In this trial the temperature of the silages was stable for the first 48 hours' exposure to air. The mean composition and intakes of the silages exposed to air for 0, 4 and 8 days are in *Table 7*. Dry matter concentration, pH, and counts of yeasts, moulds and aerobic mesophilic bacteria increased during exposure to air while concentrations of fermentation products decreased, with the largest changes occurring between 4 and 8 days' exposure. Accumulated increase in silage temperature above ambient during exposure to air was the best predictor of intake.

The most common animal diseases associated with spoiled silage are mycotoxicosis and listeriosis. Mycotoxicosis is difficult to diagnose and there is a dearth of information on its prevalence. The risk of mycotoxin contamination appears to be much less in grass silage than in maize silages (Cogan et al, 2015). Signs of mycotoxicosis include decreased feed intake and fertility, reduced milk yield or growth rate and suppressed immune status with resulting increased incidence and severity of infectious diseases such as mastitis and diarrhoea. *Listeria monocytogenes* can develop in large numbers in wet mouldy silage, especially when oxygen ingress is significant due to physical damage to the silo covering film or bale stretch wrap. Outbreaks of listeriosis are often sporadic, especially in flocks of sheep given contaminated silage.

The introduction of oxygen barrier (OB) film was a step-change in technology that was potentially as large as the initial introduction of polyethylene film itself. OB film ('Silostop') reduces silage surface spoilage by restricting oxygen permeation and reducing the development of moulds and undesirable bacteria, including butyric acid bacterial spores in the peripheral areas of the silo or bale during the storage period.

The results of a meta-analysis of 51 comparisons (41 with bunker and clamp silos, 10 with baled silage) between standard polyethylene film and OB film are in *Table 8*. The OB film reduced losses from the outer layers of the silo during the storage period and increased the aerobic stability of maize silage. This means that less labour is needed to discard inedible material and the risk of accidentally including spoiled silage in the animals' diet is reduced. With bales, fewer layers of wrapping and less weight of film may be needed with OB stretch-wrap than with standard wrap and the process of wrapping bales may be speeded up.

Feed-out management

Aerobic instability of silage during feed-out can be a major issue, and can be a significant source of loss if large quantities of silage have to be discarded as being unfit for use as feed. Elevated silage temperature is a good indicator of aerobic spoilage and silage will often heat up after 3 to 5 days' exposure to air. If it takes 7 days to get across a silo face with a shear grab, silage exposed to air for that amount of time will have lost about 15% of the DM present at the start of the period of exposure. Rain landing on the exposed face can increase DM loss, as can covering the feed face temporarily during periods of very slow feed-out.

Baled silage, although generally higher in DM concentration and lower in DM density, typically has lower losses during storage and feed-out compared with bunker silage. The lower losses reflect immediate wrapping after baling, restricted fermentation and, provided the stretch-wrap is not broken during storage, less mould growth. Effective sealing with four layers of wrap, each layer overlapping by 50%, is crucial to prevent mould developing in the outer layers along with Listeria. Feed-out is normally within 24 hours of exposure of the bale surface to the atmosphere on removal of the wrap.

A survey of more than 100 dairy farms in Italy over 5 years revealed that although 42% of farms were successful in controlling maize silage aerobic deterioration in bunker silos in winter, only 10% were able to do so in summer (*Figure 2*). The extent of silo face moulding was related to speed of feed-out, also known as progression rate, which should be a minimum of 1 m/week in winter and 1.5 to 2 m/week in summer.

Yeasts are considered to be the primary agents involved in initiating heating and moulding during feed-out and a yeast count

Table 8. Losses, inedible silage and aerobic stability of silage in the top surface layer stored under standard or oxygen barrier (OB) films

		n[1]	Standard film	OB film	Sig.
Bunker and clamp silos[2]	Loss of DM or OM (%)	41	19.5	11.4	<0.001
	Inedible DM (%)	5	10.7	2.96	0.022
	Aerobic stability (h)	11[3]	75.3	134.5	0.001
Baled silage	Total loss of DM (%)	10	7.68	4.56	<0.001

(Wilkinson and Fenlon, 2013) [1] = number of comparisons, [2] = includes drive-over piles and laboratory silos, [3] = all comparisons with maize silage, DM = dry matter, OM = organic matter

of log 5 colony forming units (100 000) per gram of fresh silage is indicative of aerobic instability. Ensiling as clean a crop as possible and using an effective film covering can help to reduce the yeast count and improve aerobic stability. For example the use of OB film was reflected in a 59 hour (2.5 day) increase in aerobic stability of the top layer of maize silage (*Table 8*). Yeast growth is generally accompanied by moulding and a log 5 colony forming unit mould count is also indicative of high top surface DM losses. Acetic acid in silage is an effective inhibitor of yeast and mould growth, but its production is also associated with higher fermentation DM loss and reduced silage DM intake. Additives containing sulphite, sorbate or citrate salts, or inoculation with an additive containing *Lactobacillus buchneri*, which produces acetic acid from lactic acid, can help to reduce feed-out losses due to aerobic spoilage if the silo feed face is too wide to achieve the target feed-out progression rate.

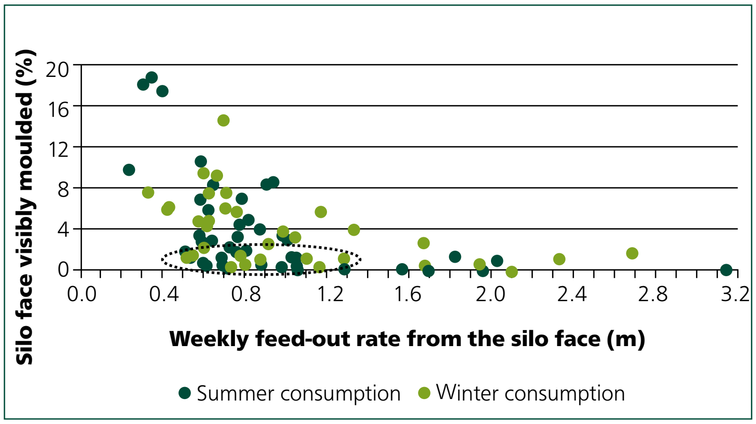

Figure 2. Rate of maize silage feed-out and silo face moulding. Silages in the dotted circle were well conserved due to other management practices such as good compaction, more than one layer of film or oxygen barrier film covering (Borreani and Tabacco, 2012) .

Silage and silo safety

The introduction of woven polypropylene netting, gravel bags and heavy polyethylene mats to cover bunker silos has removed the need for car tyres to protect the covering film from damage by wind, birds and vermin, with the added benefit of eliminating the risk of traumatic reticulitis from the accidental inclusion and ingestion with silage of pieces of wire from degraded tyres.

The risk of accidents to people during silage making and feed-out can be reduced by attention to safety at all times. For example, care should be undertaken when baling crops on hillsides to reduce the risk of bales rolling downhill. Trailers should not be driven down steep slopes when full of harvested crop. Too many bunker silos are too old, too small and are over filled with crop to the point that the risk of accidents during packing and unloading is increased. To reduce the risk of avalanche during feed-out the silo height should not exceed the reach of the unloading equipment. Care should be taken when working on top of bunker silos, especially those with no safety rail. During feed-out there is danger of falls from height on to concrete when pulling back the top covering film and protective netting and when removing car tyres. If possible, more than one person should work together on the silo, which should be well lit.

Almost all UK Health and Safety Executive prosecutions for safety offences result in convictions. The average fine in 2013/14 for agricultural offences was £40k (Health and Safety Executive, 2014). Employers are required to report specified work-related incidents under RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, 2013).

Conclusions

Timeliness and attention to detail is as important in silage making and feeding as it is in any other farm operation. The quality of silage determines the extent to which it is likely to meet the animal's nutrient requirements during the feed-out period and hence the level and cost of concentrate supplements. Managing to control every stage of silage making and feeding and recognising the need to observe correct safety procedures at all times will help to achieve the objective of successfully using this important home-produced feed resource. LS

Conflict of interest: none.

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KEY POINTS

- Losses can occur at each stage of silage making and feed-out. Farmers should aim to exert greater control over the entire silage making operation, including planning for an earlier start and managing equipment, staff and operations.
- Delayed harvest of first-cut grass crops results in reduced cost per unit of ME but also in depressed animal performance. Instead of accepting lower milk output per cow, the potential decrease in yield should be rectified by increased concentrate input.
- The critical control points in silage making to reduce losses are: i) stage of crop maturity at harvest; ii) degree of consolidation to achieve high DM density in the silo; iii) complete sealing with oxygen barrier film; and iv) rapid rate of removal of silage after the silo has been opened for feed-out.
- Silage safety issues should be recognised and appropriate steps taken where possible to minimise risk of injury to livestock and people during silage making and feed-out.

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