Quality Grass Silage for Dairy and Beef Production Systems

A Best Practice Guide




eagasc
Agriculture and Food Development Authority

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Introduction

Most livestock farmers in Ireland operate a grazing system based on maximising grazed grass in the diet. Across dairy and beef systems, the benefit of maximising grazed grass as a proportion of the total diet is very clear. However, seasonal patterns of grass growth means that there is practically no growth in winter, limited growth in early spring and early winter, with peak growth in May and June. Grass supply is in surplus during this peak growth and consequently grass silage is made to match supply and demand, maintain grass quality and provide winter feed when grass growth is at its lowest.

Grass silage thus accounts for 20-25% of total annual feed per cow on well-run dairy farms, and up to 30% of total feed on beef farms depending on the production systems in place. Over 85% of farms in Ireland make silage each year, and the estimated cost of harvesting over 1 million ha of grass silage exceeds €500 million annually. Clearly this is a significant cost component of our ruminant production systems.

At the field level, the single biggest factor contributing to the cost of producing silage is the yield of the crop. The primary challenge for farmers is to maximise silage yield while at the same time achieving target silage quality for production system on the farm. There is a balancing act in silage production, between maximising yield and maintaining feed quality (DMD). During the milk quota area, many spring calving dairy farms moved to a low DMD/high bulk first cut silage system, which suited low stocking rates, early dry-off and long winter dry periods. This strategy may need to be adjusted for the post-quota era to account for increased spring/autumn feed demand and shorter dry period durations. Based on surveys of silage analysis results over recent seasons, it is clear that silage quality on beef farms also needs to be addressed. Mean silage quality on beef farms sits at 66 DMD, which is adequate for dry suckler cows in good body condition but is a low grade feed for growing and finishing cattle.

Soil P & K concentrations as well as pH (lime requirement) have been depleted in recent years. This is reflected in sub-optimal grass growth and consequently light yields at target harvest dates. The consequence of this is later cutting dates to maximise yields which results in poorer quality silage. It is imperative that soil fertility is optimised and the correct fertiliser regime is applied to allow farmers to achieve target silage quality. Understanding optimal time of harvest, the role of additives, and the benefits of reseeding silage areas are also important.

As a stand alone feed silage is expensive to produce. But looking at silage as part of an integrated grassland management system, grazed grass + grass silage are competitive feeds and over 2.5 timed cheaper than concentrate feeds. The objective of this publication is to provide farmers, students and advisers with a template for cost-effective production of good yields of grass silage, at the optimum feed quality for farm system.

Dry matter yield- effect on silage cost

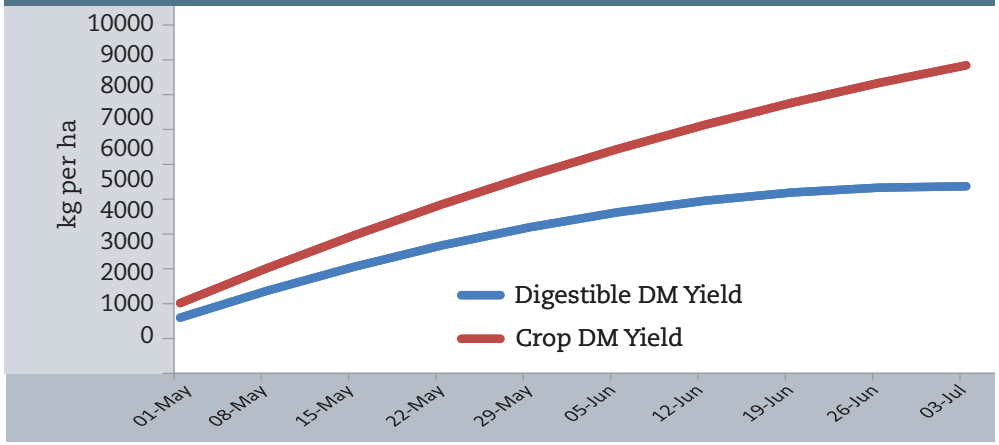
First cut grass DM yield (t/ha)	3.0	4.0	5.0	6.0	7.0
Cost € per tDM silage	240	182	147	124	107
Relative cost per t DM grown	1.63	1.24	1.00	0.84	0.73

Grass silage costs approximately 2.0 to 2.5 times grazed grass per tonne of DM fed. Most of the additional cost is incurred through harvesting and fixed charges, plus feed-out costs.

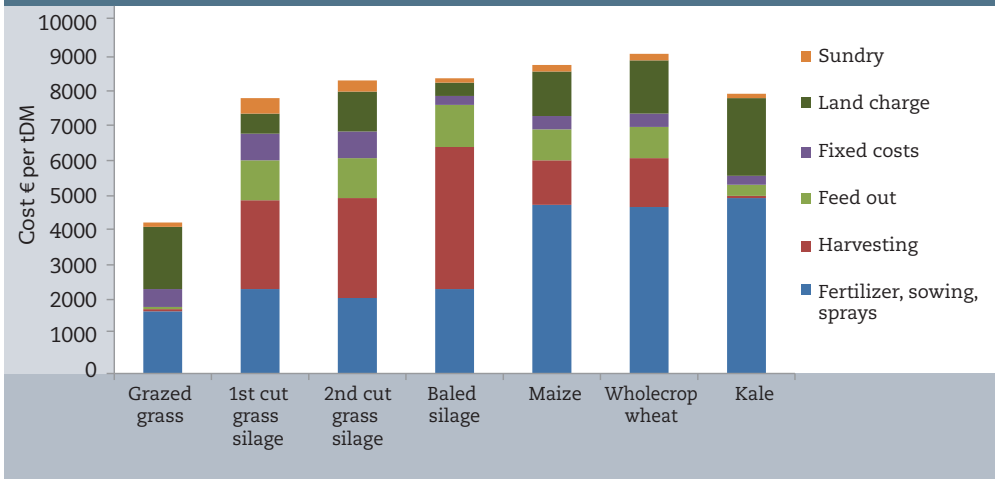
Dry matter yield is the most important factor affecting cost per tonne of silage fed. First cut silage tends to be less expensive than subsequent cuts. The relative cost of baled silage depends on DM yield -lighter crops make bales a more viable option. On a feed cost per ha basis, well-managed grass-plus-silage systems compare favourably with alternative forage options.

The capacity to maximize DM yield per cut is limited by effect of stage of growth on grass quality. Delaying harvest to 'bulk up' crops will increase DM yield. However digestibility declines sharply after grass heading date such that total yield of digestible feed in the crop does not increase further - removal of the crop is necessary to promote new growth. It is important therefore to factor in effects on annual DM yield per ha (grazing plus all silage crops) when planning silage cuts, rather than solely focussing on yield per individual harvest.

Digestible yield is limited by changes to grass quality post heading



Cost breakdown per tonne utilisable DM for different feed crop options



Silage quality -what difference does it make?

Beef Cattle– Weight gain

Silage Quality				
DMD %	75	70	65	60
Harvest date	*20 May*	*2 Jun*	*15 Jun*	*28 Jun*
Silage tDM per ha	4.6	6.0	7.0	7.7
Intake (kg/day)	9.0	8.3	7.6	7.0
Liveweight gain (kg/day)	0.83	0.66	0.49	0.31

Over a number of studies at Teagasc Grange, leafy silage with higher dry matter digestibility (DMD) resulted in resulted in better feed intakes and liveweight gains for finishing cattle. The benefits include shorter days to finish (lower total silage DM required), lower daily concentrate intakes to achieve target daily gains, and lower fixed costs (slurry, labour, overheads etc.) Similar benefits are incurred with higher DMD silage fed to weanling cattle. Dry suckler cows in good BCS require lower DMD (66-68) silage.

Dairy Cattle– Milk yield

Concentrates (kg/cow/day)				
Silage DMD	0	4	8	12
79	23.6	29.1	32.8	32.0
75		27.1	29.3	28.8
69		24.7	27.3	30.1

For milking cows, the benefits of higher DMD silage are improved forage intake, more milk solids and milk from forage, better rumen health and lower concentrate feeding levels. Cows fed high quality silage (75+ DMD) require 3-4kg less concentrate to achieve similar milk solids output than cows fed average quality (69 DMD) silage. Dairy heifers fed >70 DMD silage have improved daily gains during their first winter. Silage DMD for dry cows depends on BCS at drying off and duration of dry period.

Planning your grass silage strategy

Benefits of Good Silage Planning

1. Reduced concentrate feeding
2. Improved milk solids yield
3. Improved cow condition at calving
4. Better herd fertility
5. Replacement heifers at target weight
6. Improved daily gain
7. Shorter finishing period
8. Higher annual grass yield

A good management plan will deliver on the 3 main objectives for quality silage:

- Good yield for 1st cut silage with high annual grass tonnage per hectare
- A clean, well-preserved feed with good palatability
- The appropriate nutritional quality (DMD)

The objectives of high dry matter yield & good preservation remain consistent across farming systems. Optimum DMD will vary depending on the type of stock being fed, e.g. freshly calved dairy cows versus dry suckler cows.

The main factor affecting DMD is crop maturity at harvesting. Assuming good early season management, ryegrass swards and correct soil fertility, target cutting date should be dictated by the type of silage required.

Most farms carry more than one class of stock over the winter, so more than one type of silage may be required. This should be factored into the silage plan.

Where high DMD silage is part of your plan, talk to your contractor early about planned cutting from 15th to 25th May

Planning your grass silage strategy

Step 1 Define the highest quality silage type required on the farm first

Step 2 Estimate the quantity of this silage quality needed

Step 3 Calculate area of first (and subsequent) cuts required to produce this silage

Step 4 Mark this area on the farm map and set the target cutting date(s)

Step 5 Manage the remaining area to produce silage of standard quality

Guideline Silage Dry Matter Intake (kg DM/day)	
Suckler cows	
-Dry	8-9
-Calved	10-12
Dairy Cows	
-Dry	10-12
-Milking*	12-14
Weanlings	4.5-6
Cattle (18-20 months)	7-9

Target Silage DMD for Different Classes of Stock

75+	74	72	70	68	66
					
Fresh Autumn-Calving dairy cows	Spring-calving cows in milk Finishing cattle	Dairy young stock Growing cattle	Dry dairy cowpoor BCS Suckler cow in milk	Dry dairy cow good BCS	Dry Suckler cows

*For dairy herds, target a further 400-600kg DM per cow of good quality silage to supplement the milking herd during spring and autumn grazing if necessary.

Adjust this target depending on stocking rate, land type etc.

Example Silage Plan- Dairy Herd

Details
Stock
• 108 spring-calving dairy cows
• 26 weanling dairy heifers
• 2 breeding bulls
Land Available
• 44 dairy grazing ha
• 12 ha out-farm for silage/heifers

Action Plan		
Step		
1.	• Good quality silage-72-74 DMD for milking herd and weanling heifers	
2.	• 108 cows @ 400kg DM = 43.5t DM • 26 heifers * 150 days@ 5.5kg DM = 21.5t DM	**65t DM of 74 DMD silage**
3.	Require 14 ha @ 4.5t DM for high quality silage • Close outside block {12ha) plus 12ha milking block for silage • Bale 7ha of closed milking block area on May 20th {35t quality silage) • Target 130 bales from grass surpluses Jun-Aug {30t quality silage)	
4.	• Standard silage- 68 DMD adequate for dry cows in good condition, stock bulls	
5.	• 110 (dry cows plus bulls) * 125 days* 11kg DM = 151 t DM	**151t DM of 68 DMD silage**
6.	• 17ha {12 ha outside block plus 5ha) cut in early June at 7.5t DM = 127t DM • Close 7ha of external block for 2nd cut silage in late July= 35t DM	

Example Silage Plan- Suckler Herd

Details
Stock
• 40 suckler cows
• 40 weanling calves
• 20 finishing steers
Land Available
• 37 hectares grassland

Action Plan		
Step		
1.	• Good quality silage- 74 DMD for finishing steers	
2.	• 20 steers * 120 days * 8kg DM = 20t DM	**20t DM of 74 DMD silage**
3.	Require 4.5 ha @ 4.5t DM for high quality silage • Close 4.5 ha for baling in mid-May	
4.	• Standard quality silage- 68 DMD • Restrict feeding to dry suckler cows • Ad-lib silage plus meals to weanlings	
5.	• 40 dry cows * 125 days * 8.5kg DM = 43t DM • 40 weanlings * 125 days * 6kg DM = 30t DM	**78t DM of 70 DMD silage**
6.	• 13ha cut in early June at 6.0t DM = 78t DM	

Fig 1. Clean leaf at base

Fig 2. Dead material at base

Should I graze silage ground in spring?

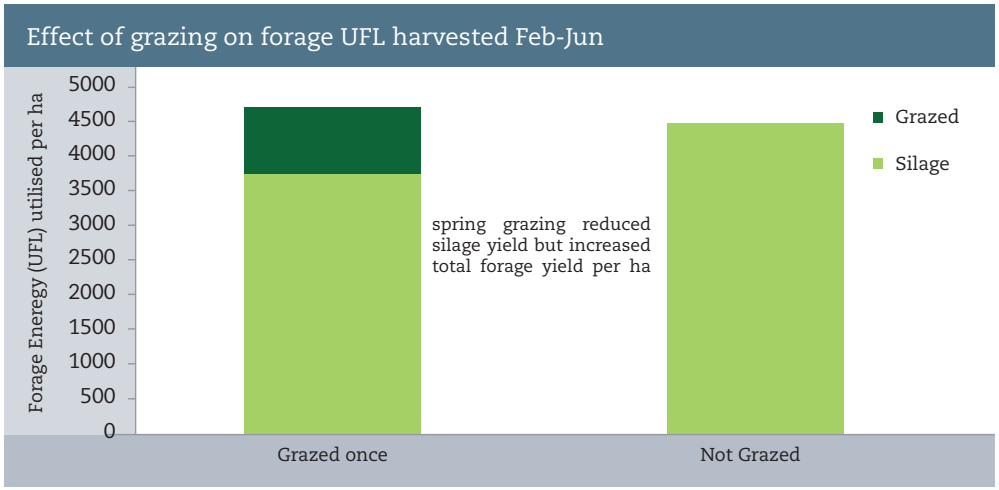
- If milking herd can walk to silage ground- always graze in Feb/March before closing
- A clean, green base in March is essential for high quality silage in May (Fig 1)
- Graze to <4cm residual in Feb/Mar before applying fertilizer for silage
- Can also be achieved by tight grazing with young stock in late autumn
- Swards with yellow/dead material at base (Fig 2) in spring must be grazed off
- Silage DMD will be 6-8 points lower if this material is not removed before closing
- Graze all re-seeded silage ground at least twice before cutting to promote tillering

Graze some of the grazing ground first, before grazing the silage ground. This is to ensure that there is grass available for grazing in early April.

Aim to have silage fields grazed off by mid-late March where good yields of high DMD silage are needed.

Be flexible in which areas are closed for first cut silage each year. Silage areas also used for grazing should have good roadways and water supply to facilitate early/late season grazing management

How will spring grazing affect forage yield?



- Grazing once in spring (mid-March) reduces 1st cut silage yield by 0.5 to 1.2t DM per ha
- Earlier grazing/closing (mid-late March) and later cutting (late May to early June) reduce relative loss in 1st cut yield
- Intermediate heading swards grazed in spring have lower relative losses for May harvesting
- Late heading swards grazed in spring can be harvested 6-8 days later while retaining crop quality (DMD)
- Grazing spring grass before closing can improve total forage (grass plus silage) DM utilised per ha
- Total silage demand also decreases as spring grass displaces silage from the spring diet
- Grazing silage ground twice in spring significantly reduces 1st cut silage yield. However, it but may be necessary to graze a small percentage of area at the start of the second rotation if grass recovery is slower than normal.

Fertilizer for First Cut Silage

- Apply fertiliser and/or slurry evenly and as early as feasible
- Slurry should only be spread on bare stubble or very short grass
- 20% of the value of fertiliser spread on silage ground in Jan/Feb is retained for the silage
- Don't overestimate the quality of slurry. Good cattle slurry will have a DM of 7%, watery slurry could be as low as 3-4%
- A slurry hydrometer can be used to assess the DM% of slurry, helping to predict the nutrient content more accurately
- Trailing shoe increases N availability by 3 units
- Where cattle slurry is applied, delay the top-up fertiliser applications for 1 week
- In very deficient ground use 15 units of sulphur per acre for silage ground but avoid high application rates as it will tie up trace elements
- In wetter soil conditions fertiliser N can be split 50:50 for example 50% in late March I early April and the remainder 2 weeks later to reduce the risk of N losses
- Old swards will need 25% less N than that outlined in the tables (p12 and p20)
- A crop of grass silage will remove approximately 4kg P and 25kg K /tonne of grass DM

High Potassium (K) silage increases risk of milk fever and related health problems in dairy herds. Target <2.0% K in silage fed for 2-3 weeks pre-calving. Where problems exist, reserve 150-200kg DM per cow of clean silage cut from areas with low K index/low slurry application
(See p30)

A useful guide for fertilizer N is that grass crop uses up 2.5kg N (2 units) per day on average.

Apply fertilizer approximately 50 days before planned cutting date.

However, the crop may still be harvested sooner depending on nitrate and sugar levels.

Therefore if conditions are otherwise suitable, it is advisable to test the grass crop rather than delaying cutting based solely on the '2-unit' rule.

Fertilizer for First Cut Silage

Soil Index	1	2	3	4
P Required kg/ha	40	30	20	0
K Required kg/ha	175	155	125	0
N Required kg/ha	125			
Sulphur Required kg/ha	12-14 (10% of N applied)			

Assumes a target 5.5t DM per ha first cut crop- reduce N:P:K by 25:4:25 kg per ha on older swards with low growth potential.

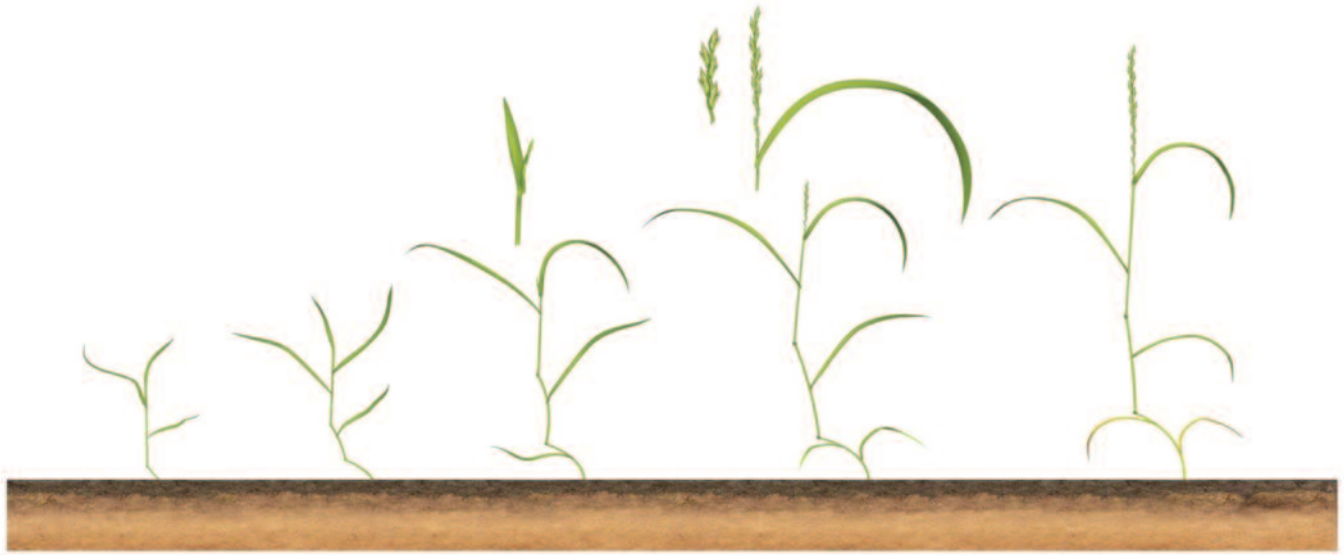
Reduce N requirement to 100kg/ha if field was grazed not cut last year.

Treat P and K requirements separately- many silage fields are have high K index but are low in P.

Guideline values for organic fertilizers- spring application				
kg per tonne	Cattle Slurry 7% DM	Cattle Slurry 3% DM	Pig Slurry	Farmyard Manure
N	0.7 (21)*	0.6 (17)	2.1 (66)	1.4
P	0.6 (17)	0.3 (10)	0.8 (25)	1.2
K	3.3 (105)	1. 7 (52)	2.2 (70)	6

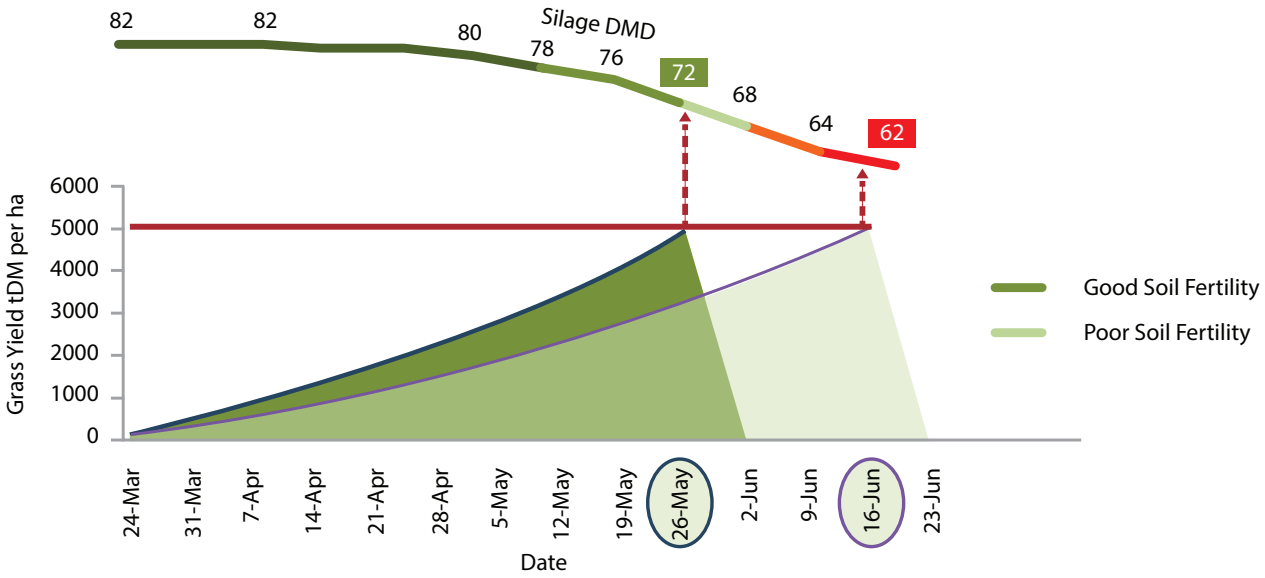
*values in parentheses show total slurry NPK value per hectare where approx. 33m^3 per ha (3000 gallons/acre) is applied.

How does grass growth stage at cutting affect silage quality?



Silage DMD	**76+%**	**74-76%**	**71-73%**	**68-70%**	**<67%**
Suitable For	Fresh calved dairy cows in winter milk Buffer feeding milking cows early spring/late autumn Finishing cattle		Dry cows requiring BCS gain-2.75 at dry off Dairy weanling/ In-calf heifers Growing Cattle	Dry dairy cows requiring little or no BCS gain Dry suckler cows requiring BCS gain	Poor quality feed Dry dairy cows - meal feeding required to gain BCS Dry Suckler cows requiring no BCS gain

Soil Fertility - Effects Silage on Yield and Quality



Silage yield and quality are often considered to be incompatible but this should not be the case.

If the parameters for high DM yield are in place (good soil fertility, fertilizer N, reseeded swards) then silage DMD becomes a management decision (target cutting date) rather than a compromise.

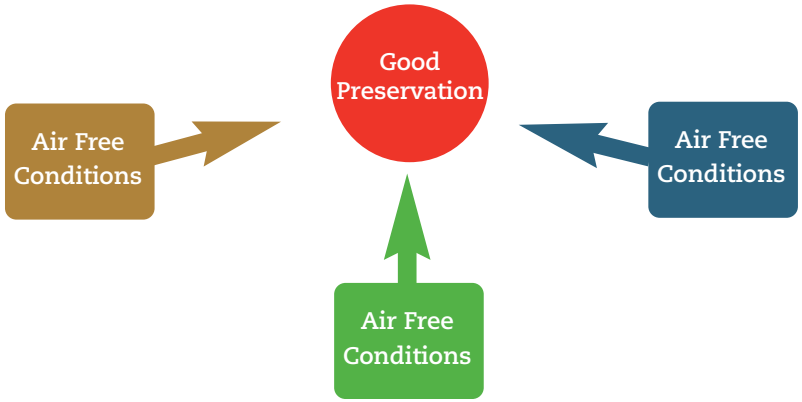
- High yield for 1st cut silage reduces cost per tonne in the pit
- However silage quality (DMD) falls rapidly after grass heading date (0.5 units per day)
- For high DMD mow as seed heads begin to emerge, for standard DMD mow S-6 days later
- Good soil fertility= target yield 5 t DM reached by May 26th= good quality silage (72 DMD)
- Poor soil fertility = target yield 5 t DM reached by June 16th= poor quality silage (62 DMD)
- Swards on high fertility soils have earlier recovery and 3 weeks more growth for second cut

Achieving Good Silage Preservation

Refractometer- to test sugars

Grass Sugars are converted to acid during the anaerobic fermentation process. This acid preserves feed value of the crop in the sealed pit. The target sugar content to ensure good fermentation is 3% or higher. This can be tested using a refractometer.

Optimum conditions for high sugars are ryegrass swards, dry sunny weather, cool nights and mowing in the afternoon when levels have built up. Very leafy grass has lower sugars. Wilting will help to increase DM content.



Fill and pit quickly, seal immediately

Anaerobic conditions are essential for initial fermentation and to prevent subsequent spoilage. Fill the silo quickly and roll well to exclude air. Chop length of 1.0 to 1.2cm promotes good compaction. Cover with 2x0.125 mm polythene sheets. Use vertical sheets along silo walls. Check for 3-4 days to ensure seal remains intact as the pit settles. Prevent bird damage.

Test Strips- to test nitrate (NO_3) content

Buffering capacity measures the resistance to a drop in pH. Crops with high buffering capacity may have a poor initial fermentation.

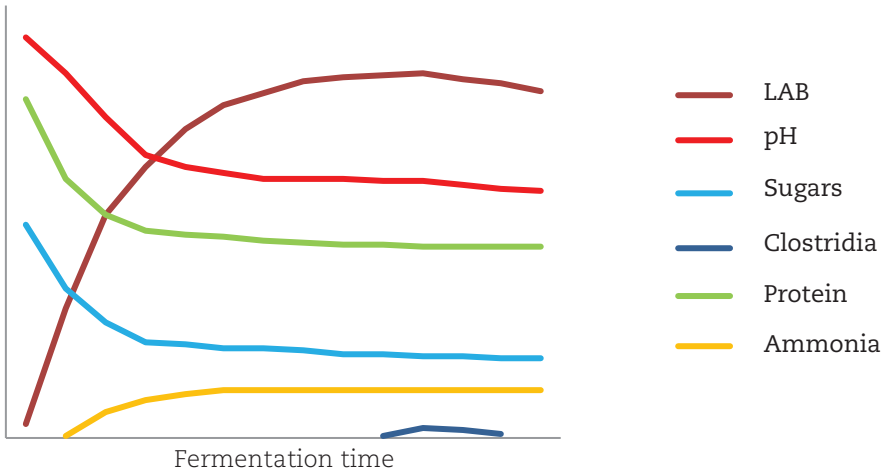
High nitrate in grass increases buffering capacity. This can be checked using nitrate test strips.

However, nitrates are of secondary importance to sugar levels. Grass will ensile correctly with up to 800ppm nitrate provided sugars are adequate.

Wilting the crop to >28% DM helps to overcome effects of high nitrate.

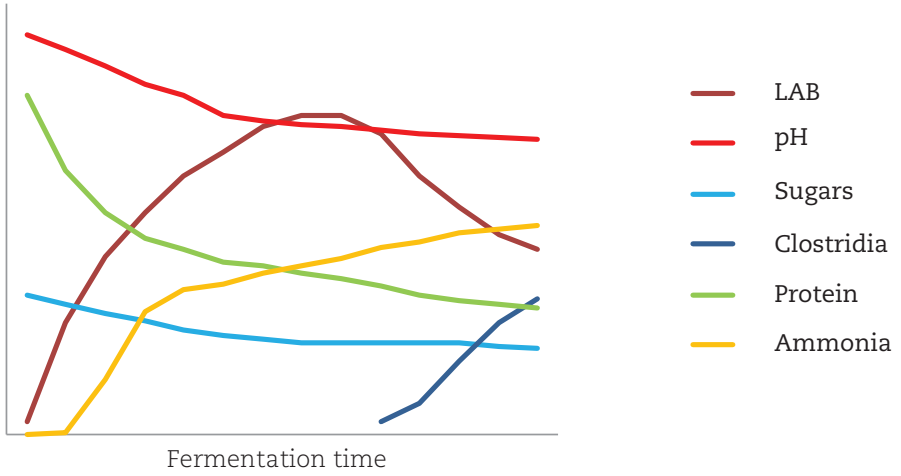
Silage Fermentation Process

A. Good Fermentation



Fermentation begins after oxygen in the pit is depleted during the initial aerobic ensilage phase. Under good conditions, lactic acid bacteria (LAB), which are present on the grass, multiply rapidly and convert available sugars to lactic acid. This causes pH to decline quickly- the optimum end point depends on silage dry matter. Some nutrient losses and protein degradation to ammonia occur during this phase, however once target pH is reached, a clean forage with good intake potential is the result. The nutrient value of this silage is preserved until re-exposure to air at feed-out.

B. Poor Fermentation



In contrast, a poor silage fermentation occurs where one or more of the necessary conditions (high sugars, low buffering capacity, air-free conditions) is not met. In the example shown, low initial available sugars restricts the growth of LAB, causing an insufficient drop in pH. This allows clostridia bacteria, also present on the crop but increased with soil contamination, to begin a secondary fermentation . Ammonia levels rise as protein is broken down. Clostridia bacteria convert residual sugars, lactic acid and protein to butyric acid, which results in a dark, foul-smelling silage with low feed value and poor intake characteristics.

Dry Matter%	18-20	20-24	24-26	26-30	30+
Target silage pH	3.8	4.0-4.1	4.2	4.3-4.4	4.8

To Use an Additive or Not?

Risk factors for poor ensilability

1) High Leaf content
2) Short N application Interval
3) Lack of sunshine

Test grass sugars & nitrate

High quality silage can often be made without additives

No one additive is ideal in all circumstances

Make an informed decision based on current conditions

Sugars <2%

Additive Required

Sugars 2-3%

(Plus Elevated Nitrate >600ppm)

Wilting not an option

Wilt to above 28% DM

Sugars >3%

No Additive Required

Additive Type	Mode of Action	When to use
Molasses	Increase fermentable sugars	Low grass sugars, poor weather. Direct supply of available sugar
Acid	Accelerates drop in pH	Low sugars, poor weather
Absorbent	Retain effluent, increase sugars	Wet conditions. 50-100kg of pulp or hulls per tonne fresh silage
Inoculants	Increase favourable lactic acid bacteria (LAB) population	High DMD targeted. Requires good conditions & high available sugars. LAB population not limiting in many situations

Molasses Rate per tonne fresh grass

Grass Sugar %	0-1	1-2	2-3
Litres/tonne	20	15	10

How do wilting duration and swath treatment affect DM?

Wilting Hours			
DM% of crop	0	24	48
6 metres per row	17	19	23
3 metres per row	17	23	31
Tedded Out	17	30	50

The change to grass dry matter content due to wilting is affected by duration of wilt and mechanical treatment of the swath. Dry matter of grass cut into large rows will change little in a 48 hour period. Tedded swaths wilted for >24 hours may become excessively dry. Pit silage DM over 33% will not improve animal performance and may have poor aerobic stability at feed -out

Cutting silage in difficult weather conditions

- Delay mowing until it is very likely the harvest can be completed once commenced.
- Check sugar content and apply additive if necessary
- Reduce soil contamination- multiple field access points, keep concrete apron clean of soil
- Part fill trailers, work downhill on steep slopes, low ground pressure tyres {<1.0 bar pressure)
- Postpone harvesting the very steepest or wettest areas to a later bale cut if necessary
- Be prepared to handle high effluent outflow from wet crops

Tips for Making Round Quality Bale Silage

- Mow when dew has evaporated and wilt to a target of 30 to 35% DM
- The aim is for dense, well-shaped bales with over 220kg DM per bale. Baler choppers increase DM per bale by 10-15%
- Use a slow tractor speed to produce well-packed bales. Adjust the baler density setting to a high/maximum position
- Avoid rough handling of unwrapped bales as this can cause them to lose shape. A bale lifter is preferable to a spike fortran sport
- Use a recommended plastic wrap sourced from a reputable supplier
- At least 4 layers of plastic are required for adequate preservation. Under good management conditions the benefits of 6 layers is small
- If bales are to be stored for a prolonged period (9 months+) then 6 layers is advised
- Ideally transport bales to final storage area before wrapping. Damage to wrap during transport is a significant source of DM loss
- Bales made from low DM or very leafy grass will lose shape when stacked, increasing spoilage losses. Store on ground level instead
- Check for damage and repair plastic on a regular basis
- Aim to have bales consumed within 2 days at feed-out. Do not feed mouldy bales or parts of bales to livestock

Research at Teagasc Grange has shown the most effective pattern for prevention of bird damage is an 'eye' - circle with dot at the centre-using white paint. Netting should also be used if possible

Fertilizer for Second Cut Silage

Soil Index	1	2	3	4
P Required kg/ha	30	20	10	0
K Required kg/ha	70	50	35	
N Required kg/ha	100			

Reduce N:P:K by 25:4:25 kg per ha on older swards with low growth potential

Treat P and K requirements separately– many silage fields are have high K index but are low in P

Guideline values for organic fertilizers– summer application				
Kg per tonne	Cattle Slurry 7% DM	Cattle Slurry 3% DM	Pig Slurry	Farmyard Manure
N	0.23 (5)	0.19 (4.5)	0.7 (15)	0.63
P	0.6 (13)	0.3 (7)	0.8 (17)	1.2
K	3.3 (72)	1.7 (37)	2.2 (48)	6

Reduce N:P:K by 25:4:25 kg per ha on older swards with low growth potential

Treat P and K requirements separately– many silage fields are have high K index but are low in P

Reseed to Improve Silage Yield and Quality

Productive silage ground must have perennial ryegrass swards. Old permanent pasture is less responsive to fertilizer nutrients for first cut crops, leading to delayed harvest and poor DMD. Lower sugar content also make preservation more difficult.

The decision to reseed should be based on potential economic return, sward composition and performance. A rule of thumb is silage ground should be reseeded every 8-10 years (5-6 years for multiple cut systems). Many farms do not reach this target, especially if silage ground is rented or on external blocks. A whole-farm reseeding plan should be put in place which include silage areas.

	Perennial Ryegrass	Old Pasture	Benefit
DMD	High >74	Low <70	Improved Animal Performance
Sugars	High 3%	Low 1.2%	Better Preservation
N response	High 30:1	Low 14:1	Higher DM yield potential
Spring growth	Good	Poor	Earlier cutting and/or grazing

Guidelines for selecting ryegrass varieties for silage		
	Reason	**Guidelines**
Yield & spring growth	Excellent spring growth and first cut yield essential	Select high silage yield as the main trait
Heading Date	Intermediates tend to have higher first cut silage yield but DMD may decline earlier	Limit the range of heading date to 5-6 days. Use later-heading varieties on heavier soils.
Tetraploids v Diploid	High DMD and DMI , but swards tend to be more open	Include at 40% of seed mixture on dry land. Limit use on wetter soils.
Hybrid ryegrasses	Can have excellent yield for early first cut, however grass quality may be poor for mid-season grazing	Best suited to multiple cut systems. Do not use in mixed silage and grazing ground, especially for milking herds.

Checklist for Successful Reseeding

- ✓ Identify paddocks for reseeding based on performance (tonnes DM per year) and ryegrass content
- ✓ Test soil pH, P and K status and put a plan in place. Reseeds will not perform if soil fertility issues are not addressed. Retest in 1 year
- ✓ Land drainage problems should also be addressed before reseeding is carried out
- ✓ Timing– reseed in early autumn to allow time for post-emergence spraying and grazing twice before winter closing
- ✓ Spray off the old sward and perennial weeds with a glyphosphate spray
- ✓ Begin cultivation 7-10 days after spraying. Graze or cut low to remove trash beforehand
- ✓ Cultivation method depends on field-to-field conditions. Ploughing, on-pass, direct drill etc. all work well if carried out correctly
- ✓ Firm fine seed bed and roll after sowing
- ✓ Apply lime, P and K based soil test results
- ✓ Apply 40kg N per ha when reseeding to promote grass establishment and growth
- ✓ Use a post-emergence spray at 6 weeks post sowing to kill off weeds at the seedling stage
- ✓ Monitor and control pests (slugs, frit fly, leatherjackets) in the new ley
- ✓ Grazing at least twice before cutting silage to promote tillering (this is a critical step that is missed on many farms)

See Teagasc Moorepark *'Pocket Manual for Reseeding'* for more detail on these steps

Soil P and K Fertility Index – Key to Yield and Quality

1	2	3	4
Severe restriction on growth Reseeds do not perform Silage yield and quality poor	Nutrients limiting grass growth Annual DM yield reduced Need to delay cutting-lower DMD	Optimum Index Good silage yield and DMD Ensure fertilizer replaces off-take	P & K not limiting growth Reserve of nutrients in soil Monitor and apply P&K when index falls to 3

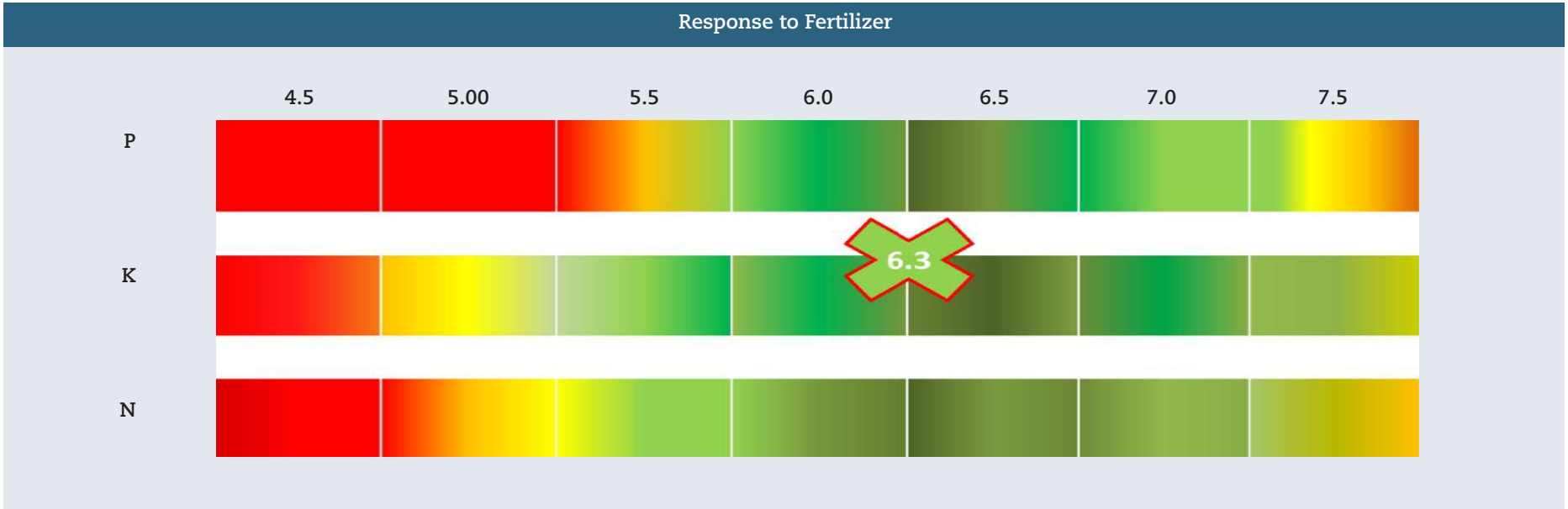
Soil Fertility Index

- Low soil P & K levels reduce yield and quality of silage
- Poor N fertilizer response on low index soils
- Optimum is Index 3 for both P and K
- Regular soil tests are very important
- Build a fertilizer plan field-by-field based on test results

Sulphur

- Important for protein formation in grass
- Light, sandy soils are more prone to deficits
- Apply 20kg/ha to silage ground
- Ratio 10:1 to N

Soil pH Analysis – The First Step to Quality Silage



Liming silage ground for best yields and quality

Optimum soil pH is 6.3

Poor response to P fertilizer at low pH

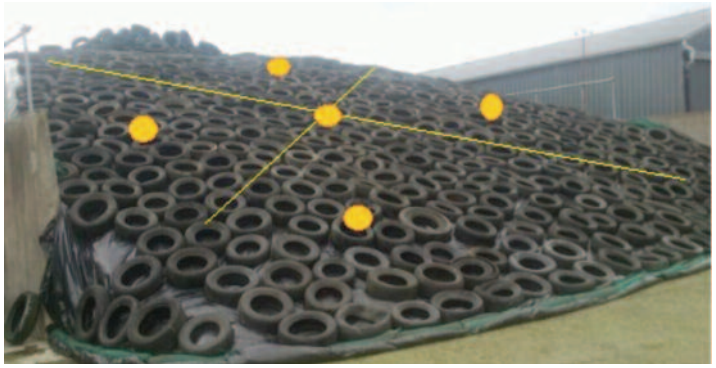
Response to N & K also reduced at low pH

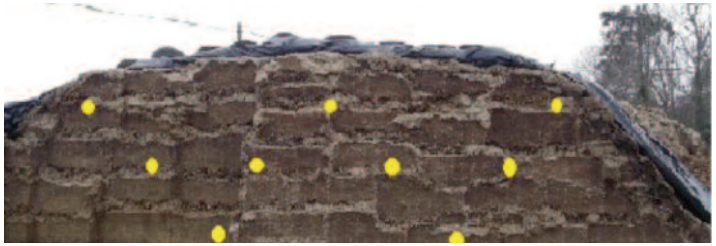
Excess lime can reduce P response

Apply lime based on soil test results

Do not cut silage for 4-6 months after liming– may affect preservation

Silage Sampling and Analysis



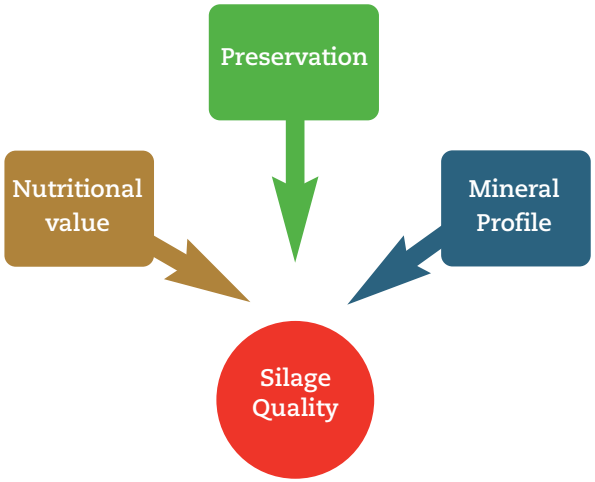


Taking a representative silage sample

- Poor sampling technique is one of the main causes of unreliable silage analysis results.
- Wait 5-6 weeks after ensiling to take the samples
- Ideally use a long core sampler to sample 3-5 points from well spaced points on or between diagonals on the pit surface as per diagram. Core to within 0.5m of the pit floor
- Alternatively sample an open pit by taking 9 grab samples in a 'W' pattern across the pit face. Where high performance diets are being fed (e.g. finishing cattle, fresh milking cows) it is advisable to repeat sample at 4- week intervals if using this method
- Discard the top 100mm of each core before mixing into a composite sample. The final sample should weigh approximately 500g.
- Exclude air, seal well and post immediately. Avoid posting samples late in the week.

A standard silage sample from 500-tonne pit represents about 0.0001% of fresh material available– ensure that a standard procedure is followed to generate representative samples

Interpreting Silage Analysis



Silage quality is a function of 3 main aspects

- **Nutritional value** - Measures include dry matter, energy and protein content, digestibility and fibre fractions, oil, ash, intake potential
- **Preservation**- Assesses efficacy of the fermentation process. Measures include pH, ammonia, lactic acid, volatile fatty acids
- **Mineral profile**- Measures macro minerals, anion-cation balance, trace mineral content, plus antagonists.

Summary Value Ranges for Silage Analysis Parameters

	Low	Hgh	Quality is best when
DM%	13-17	40-55	Medium
pH	3 .4-3.7	4 .5-5 .5	Medium to Low
Ammonia-N (%N)	4-7	15-25	Low
Lactic acid (%DM)	0.5-5	9-12	High
Lactic acid (as% of acids)	10-25	70-90	High
Acetic acid (%DM)	1 .0	4-6	Low
Propionic acid (%DM)	0.1	1-2	Low
Butyric acid (%DM)	0.1	1-4	Very Low
Volatile fatty acids (VFA) %DM	<2	5-8	Low
Sugars (%DM)	<2	5-12	Medium/low depending on DM
Potential Acid Load (PAL) mEq/kgDM	450-700	1000-1200	Low to medium
Rumen Stability Value	220-260	350-450	Medium (260 to 300)
DMD(%)	55-65	76-80	High to moderate
D-value (%)	50-60	67-74	High to moderate
Metabolizable energy (ME) MJ/kg DM	8-9	11-12	High to moderate
Fermentable ME (FME) MJ/kg DM	5-6	7.5-9 .0	High to moderate
FME/ME	0.5	0.75 -0.85	High
UFL (unit/kg DM)	0.7-0.8	0.90-0 .95	High to moderate
UFV (unit/kg DM)	0.6-0.7	0.89-0.96	High
NDF (% DM)	42-47	55-65	Moderate to pw
ADF (% DM)	29-32	35-40	Low
Oil (%DM)	1-2	5-8	Moderate
Ash(% DM)	5-6	12-15	Low to moderate
Crude protein (% DM)	7-9	15+	Moderate to high
Protein PDIE (g/kg DM)	57-60	76-90	High
Protein PDIN (g/kg DM)	65-72	82-100	Moderate to high
FIM intake (g/kg livewt $.^{075}$)	70-80	105-120	High

Silage Analysis– Key Measures of Nutritional Value Explained

Parameter	Why it's important	What the analysis says
Dry Matter	Important determinant of intake and preservation values. Most silage analysis parameters are expressed on a DM basis.	Range 15-45%. Optimum for intake is 28-32%. Low values can result in low pH, poor intake. Reduced aerobic stability at very high values
Dry Matter Digestibility (DMD)	The key measure of quality. Determines intake and energy values per kg DM. Low if cutting is delayed beyond heading date, and/or dead material present in base of sward. D value is a similar measure used in some analyses.	Values of 74+ suitable for high performance animals. DMD below 66 is sub-maintenance feed for most classes of stock. Silage at 68-70 DMD adequate for dry cows requiring little body condition gain . To convert D value: DMD = (D Value – 7.32)/0.84.
Net Energy (UFL/UFV or Metabolizable Energy (ME)	Directly linked to DMD value. Increased energy values boost animal performance and reduce cost of supplementation	Predicted from DMD and fibre fractions. Top quality silage can be >0.90 UFL, but values close to 0.70 are more common. Value drops quite quickly for each day delay in cutting after grass heading date.
Neutral Detergent Fibre (NDF)	A measure of forage fibre, NDF affects the intake potential and 'fill-effect' of silage. Strongly influenced by growth stage at cutting.	Lower is better for high intake and performance. Typical value is 50- 55% for stemmy June silage. Highest quality requires NDF <44%.
Crude Protein (CP)	Measures Nitrogen as an indicator of true protein content. Gives no information on the quality of protein. Typical values range 9-15%.	Usually higher in leafy/higher DMD silage, but this can vary. High CP in silage tends to be rapidly degradable, leading to poor utilisation if diet energy is lacking. CP <10% may impede rumen microbial growth.
Feed Protein (PDIN and PDIE)	PDI measures the true feed protein value to the animal based on available energy (PDIE) and Nitrogen (PDIN) content.	Quality silage will have high PDIE (>75g/kg) due to better energy content, with a good balance of PDIN (3-5 units higher). Low PDI values indicate that extra protein supplementation is essential.
FiM Intake Value (g DMI /kg $W0^{0.75}$) (Dairy cows)	Dry matter intake potential is a major limiting factor for performance. FiM is un-supplemented silage intake potential, expressed per kg metabolic liveweight	High DM, DMD, and good preservation contribute to better FiM intake values. Silage DMI on 0-3kg concentrate can be estimated by dividing FiM value by 8 (for Hol/Fr cows) or 9 (for Jersey/Crossbred cows)
Ash	High ash indicates soil contamination, may affect trace mineral absorption. Feed quality per kg DM reduced.	Carry out mineral analysis if ash is >8% - adjust supplementation . Take steps to reduce soil contamination in cutting in wet conditions.

Silage Analysis– Key Measures of Preservation Explained

Parameter	Why it's important	What the analysis says
pH	A primary indicator of preservation quality and fermentation efficiency, pH measures acidity of the final silage product. Very acidic (low pH) silage has poor feed intake and rumen stability. High pH in wet silage indicates poor preservation- ammonia is usually high in this case leading to poor intakes	Target pH depends on DM content of the ensiled crop. A pH of 3.8 to 4.2 indicates good preservation at <28% DM. Dry/wilted crops (>28% DM) can be well preserved at pH up to 4.5. Wet silage with pH values of > 4.2 are generally poorly preserved. Where silage pH is <3.6, adjust diets to ensure correct rumen pH
Lactic Acid	High lactic acid content results in clean, sweet smelling silage with good stability and intake characteristics. Low values result in foul smelling material with poor feed quality.	Average value is 7.5% of DM. Lactic acid at 8-10% of DM, and >75% of total acids, means excellent preservation. Dry silage can be well-preserved at 1-2% of DM lower. Values below 5% mean poor quality.
Volatile fatty acids (VFAs)	Acetic, butyric and propionic acid. These are unfavourable end-products of silage fermentation.	Lower figures are better. Total VFAs (as % of DM) should be less than 2% and lower than total lactic acid content
Potential Acid Load (PAL)	Measures the risk of acidosis. PAL estimates rumen acid load when silage is fed, comprising i) the acid present in the silage and ii) acid produced when the silage is fermented in the rumen.	Values below 900 indicate moderate to low risk of acidosis. Silage at PAL 900-1100 fed as the sole feed should not cause issues but caution advised if using high concentrate feeds– replace starch with digestible fibre. Silage at PAL >1100 may require rumen buffers
Rumen stability value (RSV)	RSV is calculated from acid content and silage NDF. It estimates the potential effect of the silage on rumen pH.	Low RSV (<200) indicates risk of rumen acidosis– may need to adjust starch levels and add buffers. Silage RSV increases with higher NDF, however too much fibre reduced intake overall. Target 220-300 RSV
Ammonia	Ammonia (NH_3) results from protein breakdown during preservation, reducing feed quality and palatability. High nitrate in grass at ensiling contributes to elevated ammonia.	Values of less than 8-10% show good fermentation with little protein breakdown. Silage ammonia levels above 15% indicate poor preservation and will likely result in feed refusals

Grass Silage Mineral Analysis

Macro Mineral	Mean[1] (SD) % DM	Comments
Calcium	0.54 (0.110)	Average value 0.54% of DM. tends to increase with sward maturity
Phosphorus	0.25 (0.423)	Silage P content associated with soil P status and P fertilizer strategy. Forage P 0.30% to 0.35% optimal
Potassium	1.81 (0.531)	Essential for good DM yield, but high forage K (>2.4%) is a major risk for milk fever. Highest with early cutting, leafy grass and heavy cattle slurry applications. Reserve some low K silage for feeding to late gestation cows. Direct K toxicity is extremely unlikely under natural conditions
Chloride	0.98 (0.322)	Silage Cl content is associated with use of K fertilizer (potassium chloride). Excess Cl is not usually an issue
Magnesium	0.16 (0.0324)	Important for milk fever prevention in dairy cows. Supplement diet based on forage Mg content
Sulphur	0.15 (0.0305)	Optimum S content of dairy and beef diets is 0.2%. Apply fertilizer S at 1:10 ratio to N
Sodium	0.29 (0.193)	Low Na forages (<0.24%) may have reduce feed intakes. Apply Na fertilizer in spring, supplement diets with salt based on animal requirements

[1] *Based on 320 silage samples from Teagasc client farms 2011-12*

Typical mineral requirements (as % total DM intake) for different classes of stock						
	Ca	P	K	Mg	S	Na
Milking Cows	0.65 - 0.75	0.35 - 0.42	-	0.22 to 0.28	0.20	0.22 - 0.30
Dry cows	0.45 – 0.50	0.30	<1.9	0.40	0.20	0.18
Weanling Cattle	0.55	0.35-0.40	-	0.18	0.20	0.20
Finishing Cattle	0.55	0.32	-	0.18	0.20	0.20

Grass Silage Mineral Analysis

Silage Cation Anion Balance (CAB)

Silage cation anion balance (CAB value) describes the mineral balance between the major cations (Na and K) and anions (Cl and S) in the silage. Lower (negative) CAB in the pre-calving diet promotes mild metabolic acidosis, which aids in the prevention of milk fever through its effects on Ca mobilization from bone. Equations describing CAB values factor in the mineral content of silage and the relative atomic mass of each element:

CAB (meq/kg) = [(Na/0.23) + (K/0.39)] - [(Cl/0.355) + (S/0.16)]

Example: A silage with 0.28% Na, 1.99% K, 0.95% Cl, and 0.15% S has a calculated CAB of [(0.28/0.23) + (1.99/0.39)] - [(0.96/0.355) + (0.15/0.16)] = 267meq/kg

Grass silages with CAB <180meq/kg reduce milk fever risk, while CAB >350meq/kg is associated with significant increases in milk fever incidence. Forage K levels in grass silage are usually the main driver of high CAB values. Anionic salts can be fed to reduce CAB, however these tend to be unpalatable and may cause issue with low feed intake. The most appropriate strategy is often to remove high K silage from late gestation diets, or dilute cation content by feeding 2-3kg DM of haylage/straw from 2-3 weeks pre-calving.

Silage Mineral Content	'Low milk fever risk'	'High milk fever risk'
Na %	0.17	0.22
K %	1.78	2.83
Cl %	0.90	0.96
S %	0.16	0.16
CAB meq/kg	134	450

Micro (Trace) Minerals	Mean ppm (SD)
Selenium (Se)	0.073 (0.0432)
Manganese (Mn)	102 (60.2)
Copper (Cu)	6.16 (1.822)
Cobalt (Co)	0.15 (0.153)
Zinc (Zn)	51 (262.3)
Iron (Fe)	261 (319.1)
Aluminium (Al)	149 (145.4)
Molybdenum (Mo)	1.59 (1.182)

Silage micro mineral content varies with soil type. Soil contamination at harvest can result in high Iron (>500ppm) and Aluminium (>700ppm), reducing availability of micro minerals (e.g. Cu, Zn and Se). High Mo (3.5 ppm) also reduces Cu availability. Effects may be exacerbated after sulphur and lime applications. Analyze silage CAB and micro-mineral profiles where animal performance and metabolic health issues have occurred previously.

Managing silage losses in the pit and at feeding

Grass DM loss –field to barrier	High 35%	Avg. 25%	Low 15%
Cost per tonne silage DM fed	€155	€135	€120

High pit face losses

- Poorly sealed edges
- Pit face too wide
- Loose pit face- air
- Heating– high pH
- Physical losses
- Mould

Low pit face losses

- Sealed at edges
- Narrow pit 3-4 days across
- Shear-grab cut face
- Clean stable silage

Reducing DM losses at harvest and feed-out is often overlooked as a potential means of improving silage value. High losses add significantly to the cost per tonne of silage fed, and increase requirement for purchased feed. The main sources are poor aerobic stability (poor fermentation), failure to seal pits fully, excessive pit face exposure to air and waste at the feed barrier. Silage moulds can be dangerous to cattle, adding to losses. To control losses:

1) Fill pit quickly, exclude air and seal fully

2) Don't over-wilt. Very dry silage may heat in air

3) Minimize pit face time exposure to air

4) Manage losses at barrier– feed silage 3 times weekly at a minimum. Remove silage refusals regularly.

5) Pit silage losses can be high in warm weather. If possible, use high DMD bales when summer buffer feeding is required

Think Safety at Silage Time!

Attention to Farm Safety is essential at silage making. There is considerable high risk activity, often under time pressure, so safety control is needed to prevent serious or fatal accidents.

Safety at silage making requires a lot of organisation and co-operation between contractors and farmers. Every workplace has a duty to produce a Safety Statement or safety plan. For workplaces with three or less employees (97% of farms) completion of a Risk Assessment document is accepted as an alternative to preparing a Safety Statement.

- The majority of fatal accidents now occur when a person gets struck or crushed by a farm vehicle in or around a farmyard. Older farmer and children are particularly at risk. Control access to high risk areas
- Children should be well supervised at all times during silage making. The farmyard should be a 'no go area' for children without supervision. No exceptions.
- Yards should be free of obstructions to allow the free flow of equipment. Good visibility is necessary at access points to public roadways. Warning signs and bollards should be used on road verges.
- As industrial loaders put enormous pressure on silage pit walls especially when grass is wet. Walls should be checked in advance for soundness and drainage pipes need to used when grass is wet. Fit sighting rails to walls.
- Blockages and breakdowns lead to high injury risk. Turn off the PTO and stop the engine before attempting to unblock a machine.
- As toxic gases are produced during silage making time, there should always be good air circulation. Never go under the polythene sheet.

Further information of Farm Health and Safety is available at the following Web sites:
http://www.hsa.ie/eng/Your_Industry/Agriculture_Forestry/
http://www.teagasc.ie/health_safety/

Monthly Checklist for Silage Management

Month	Task	Decisions
January	• Plan your silage strategy (p6 & p7) • Manage pit face and feed barrier to reduce DM losses (p32) • Soil Test silage area (p24 & 25)	
February	• Graze silage ground on milking block (P10) • Slurry areas requiring P & K (p12 & 13)	
March	• Fertilizer NPK plus S (p12 & 13) • Roll fields	
April	• Close silage ground (p11) • Talk to contractor about early silage cut if required (p6)	
May	• Monitor grass growth stage (p14) • Check sugars plus nitrates in grass crop (p16-18) • Silage safety plan (p33)	
June	• Manage silage effluent • Lime post silage cut (p25) • Fertilizer NPK for 2nd cut (p21) • Bale surplus grass paddocks (p20)	

Monthly Checklist for Silage Management

Month	Task	Decisions
July	• Check silage covers for bird damage (p16) • Bale surplus grass paddocks (p20) • Second silage cut (p16-19)	
August	• Reseed to improve sward quality (p22 and 23) • Final surplus grass bales harvested (p20)	
September	• Soil test silage area (p25 and 25) • Complete an outline fodder budget (p35)	
October	• Silage sampling & quality analysis (p26-29) • Silage mineral analysis (p30 & 31)	
November	• Formulate winter diets using test results • Review silage quality results – note potential changes to management for next season (p6 and 7)	
December	• Manage pit face and feed barrier to minimize losses (p32) • Monitor animal performance (daily weight gain/ milk yield) and review diet formulations • Repeat silage quality analysis for high-performance systems e.g. winter milk/ finishing cattle (p26 & 27)	

Silage Budgeting Worksheet

Section 1. What forage is needed on the farm?

Animal Type	A Number	B Months	C Pit silage* tonnes per head/month	A x B x C Total tonnes required
Dairy cow			1.6	
Suckler cows			1.4	
0-1 weanlings			0.7	
1-2 year old			1.3	
2+ years old			1.4	
Total pit silage needed*(at 22% DM)			X	
or				
Total bales needed (tonnes multiplied by 1.1)			Y	

Section 2. What forage is available on the farm?

Farms with pit silage and bale silage	A	Pit silage in yard	
	B	Pit silage to be cut (acres * 7t/ac)	
	C	Total pit silage (A + B)	
	D	Bales in yard	
	E	Silage tonnes in bales (multiply bales by 0.9)	
	F	Total silage (C + E) stocks	
Farms with bale silage only	A	Bales in Yard	
	B	Bales to be cut	
	C	Total Bales (A + B) stocks	

Pit silage: (Length x Breadth x Height metres) /1.35 = tonnes equivalent

Calculate Silage Budget Balance	Pit and bales (F—X)	Bales only (C—Y)
Silage Balance		
% Deficit (Balance divided by X or Y)		

Act early if deficits are likely. Plan ahead– a range of measures may be needed. Secure at least 60% of silage requirement before looking at other options. Reduce demand from low value stock. Selling 12 cull cows early saves 100 tonnes of silage (110 bales). Sell store cattle and/or put finishers on high grain diets. 2-3kg straw plus meals can bridge shortfalls, so too soya hulls and other high fibre products. Purchase alternatives on a per unit energy plus protein basis. Always check that the final diet is balanced for energy, protein, fibre and minerals. Consult Teagasc advisory for feed budget analysis and the relative value of feeds. Copies of this worksheet are available at www.teagasc.ie/advisory

Case studies– Quality Silage for Dairy and Beef Systems

Trevor Minion, Wicklow

I run a spring-calving suckler to finish system, a dairy calf to beef system, plus some tillage, on a mainly dry farm outside Wicklow town. Steers are finished at 24 months old (370 -380kg carcass weight) with heifers at 23 months (348kg carcass weight). Along with high quality silage I feed 5-6 kg of concentrate during the finishing period. The target is to average lkg per day liveweight gain in the finishing period, and 0.6kg gain per day for weanlings in winter on very little meal fed.

Good quality silage is essential for reducing meal costs over the expensive winter period. I aim for silage at 72 DMD or higher on a consistent basis. I harvest early as possible, generally around the last week of May to ensure maximum leaf content in the sward and to avoid stemmy material.

Silage ground is grazed with yearlings in early spring to remove any dead material from the base of the sward. Silage fields are closed in early April and fertilizer applied based on recent soil test results. Reseeding plays a big role in maximising grass growth and quality for silage and grazing.

Silage area is managed as part of the farm reseeding programme to ensure high content of perennial ryegrass and to control weeds and docks.

Silage quality results (2015 average)							
Harvest	DM%	pH	NH3	Cr Protein	DMD	UFL	UFV
28th May	24.8	3.9	7.6	11.7	73	0.82	0.78

Denis and Christy Nulty, Rathkenny, Co. Meath

We operate a block autumn-calving herd on the home farm and a spring calving herd on a separate unit 2 miles away. Last year combined milk sales were 6820kg per cow @ 487kg milk solids per cow. About 30% of annual milk is sold during the winter period. All heifers are reared on the farm.

First cut silage is taken from land outside the milking platform. This ground is grazed bare by heifers in November, with any remaining covers grazed off before the end of February. Fertilizer N and slurry are applied by 15th March to set up for a target cutting date of 10th to 15th May. Around 100 units/acre N in total is applied. We use 18:6:12 to top up slurry P&K, based on soil test results.

For high DMD first cut, we mow grass at high leaf content well before heading date. It is usually wilted for 24 hours. No additive is used unless conditions are poor. First cut silage is used for the winter milking diet, for buffer feeding when grass is scarce, and for weanling heifers in their first winter. High DMD gives a significant saving on meal, and we are less reliant on alternative forages.

While first cut yield is generally lighter, the sward has a long interval to second cut which improves yield and quality. This silage is fed to dry and late lactation cows. We feed a high fibre silage with low K content for 2 weeks before calving to control milk fever. The average reseeding interval for silage ground here is 8-10 years.

Silage quality results (2015 average)							
Harvest	DM%	pH	NH3	Cr Protein	DMD	UFL	UFV
14h May	26.7	3.8	6.1	12.5	82	36.9	0.86

Quality Grass Silage for Dairy and Beef Production Systems

A Best Practice Guide

Teagasc
Agriculture and Food Development Authority