The Value of Grass

A guide to the nutritional composition of grazed and ensiled grass
Introduction:
Grass - and the ability to grow it successfully for a large part of the year - offers UK livestock farming the potential for significantly lower costs.

As grazing or silage, grass is the mainstay for the vast majority of forage-based systems. It is the cheapest source of ruminant feed and the most important factor in modern dairy, beef and sheep farming profitability.

To take full advantage of grass, however, livestock farmers need to maintain sward quality and productivity, and manage intakes through effective grazing and winter feeding strategies. It is also vital to have a good understanding of the nutritional qualities of grass. If the full feed value of grass is not known, there is every chance it will either be under-utilised or inaccurately supplemented – its full potential lost.

In this guide we aim to help livestock farmers gain a better understanding of the nutritional composition of grass. We provide simple definitions and highlight the importance of different components for maximum livestock performance. We also provide pointers on how to attain the best results.

Whilst effective as a stand-alone crop, grass is also commonly grown with companion species, so we include references where applicable to the nutritional contribution of white and red clover as well as a section on the increasingly popular perennial chicory for grazing.

Paul Billings
Agricultural Director, Germinal
Dry matter

Why is dry matter in grass important?

The dry matter (DM) content of forage (measured as a percentage) is the proportion of total components (fibres, proteins, ash, water soluble carbohydrates, lipids, etc) remaining after water has been removed.

Knowing the dry matter percentage of forage is important. The lower the dry matter content, the higher the freshweight of forage required to achieve a target nutrient intake, whether this is grazed grass or conserved forage.

Dry matter is also used as a term to measure yield. Recorded as kgDM/ha, this is used as a measure of sward carrying capacity (stocking rate) and is an essential element of effective grazing management. It is also used to measure silage crop yields.

The range of dry matter in grass

In terms of dry matter content, field and weather conditions will cause significant variation, and there are also inherent differences between diploid and tetraploid varieties. All other factors being equal, diploids have higher dry matter content (typically 18–26% DM) than tetraploids (15 – 20% DM), due to diploids having smaller cells and a lower cell wall to cell contents ratio. This means ruminants fed entirely on a tetraploid sward will need to consume as much as one-third more fresh grass per day to achieve the same nutritional intake as from a purely diploid sward.

Looking at dry matter yield, modern ryegrasses have been bred for maximum production. The best rated perennial ryegrass varieties on the Recommended List are now capable of grazing or conservation yields in excess of 11 tDM/ha whilst weed grasses (e.g. creeping bent or annual meadow grass) can yield as little as 2 tDM/ha. Production from ryegrasses over a season follows the classic growth curve, peaking at around 120 kgDM/ha/day in May/June and typically dipping to around one-third of peak levels by early autumn.

Making the most of dry matter

In grazing terms, the aim should be to present grazing that offers the ideal balance of fresh nutritious growth with the appropriate fibre content for optimal rumen passage. This balance is best achieved by using a grazing rotation of 18-25 days in peak season. Poor sward management will increase the proportion of dead and dying plant material, resulting in a significant decline in forage quality and intake potential.

When making silage, the aim should be to cut at 16–20% dry matter and ensile at 30 – 35% dry matter (for clamp silage) and 35 – 40% (baled). This will ensure a good fermentation and optimum intakes, and minimum risk of aerobic instability.

Comparative grass and clover growth curves

The higher the dry matter of grass, the lower the required intake to provide a given level of energy.

Fresh grass requirements at different DM contents

<table>
<thead>
<tr>
<th>Total ME supplied (MJ/cow/day)</th>
<th>Grass ME (MJ/kg DM)</th>
<th>Grass DM (%)</th>
<th>Fresh grass required (kg/cow/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>10</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>160</td>
<td>10</td>
<td>18</td>
<td>89</td>
</tr>
<tr>
<td>160</td>
<td>10</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>160</td>
<td>10</td>
<td>22</td>
<td>73</td>
</tr>
<tr>
<td>192</td>
<td>12</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>192</td>
<td>12</td>
<td>18</td>
<td>89</td>
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<tr>
<td>192</td>
<td>12</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>192</td>
<td>12</td>
<td>22</td>
<td>73</td>
</tr>
</tbody>
</table>
D-value and Metabolisable Energy (ME)

Why are the D-value and ME of grass important?

D-value is the measure of digestibility, or the proportion of the forage that can be digested by a ruminant. This digestible part of the forage is made up of crude protein, carbohydrates (including digestible fibres and sugars) and lipids (oils).

ME is the amount of energy that an animal can derive from the feed. It is measured in megajoules of energy per kilogram of forage dry matter (MJ/kg DM). ME is directly correlated with D-value because any feed has to be digestible in order for the energy to be available.

One percentage point of D-value equates to 0.16 MJ/kg DM of ME.

A proportion of ME is available as an energy source for rumen microbes. This is referred to as fermentable ME (FME) and is largely comprised of plant cell walls.

The range of D-value and ME in grass

D-value (and ME) is highest in the top ranking ryegrasses on the Recommended List, with figures for Grazing D-value and First Cut D-value available on all listed varieties. Leading varieties will be in the 75 – 80 D-value range, up to five percentage points higher than average varieties on the list and higher still than non-listed varieties. Weed grasses will be substantially lower in D-value than modern ryegrasses.

In all cases, D-value is highest in grass when the sward has fresh leafy growth and declines as the plants become more mature (stemmy). The decline in D-value is highest after ear emergence (heading). Grass cut for silage will typically lose 2 percentage points in D-value between cutting and feeding.

Making the most of D-value and ME

The higher the D-value and ME in forage, the better ruminant performance will be. In the UK, NIAB estimates that a single point increase in D-value (or 0.16 MJ/kg ME) equates to 0.26 litres of milk per dairy cow per day, 40g/day extra beef liveweight gain and 20g/day of extra lamb liveweight gain.

Similar work at Teagasc in Ireland and DARDNI put the increase in milk yield higher at 0.33 and 0.4 litres per cow per day respectively.

D-value and total annual dry matter yield in perennial ryegrasses

AberBite  AberGreen  AberMagic  AberWolf
AberChoice  AberClyde  AberDart
AberChoice  AberGreen  AberMagic  AberWolf
AberBite  AberClyde  AberDart
AberFarrell  AberGreen

Source: NIAB Recommended List 2014/2015

Grazing D-value and annual dry matter yield in perennial ryegrasses

Grass species Average D-value % Average ME (MJ/kg DM)
Perennial Ryegrass  73  11.7
Timothy  68  10.9
Smooth Meadow Grass  61  9.8
Red Fescue  61  9.8
Creeping Bent  58  9.3
Data from J. Frame, 1991

Typical nutrient content of farm feeds

<table>
<thead>
<tr>
<th>Feed Type</th>
<th>DM (%)</th>
<th>ME (MJ/kg DM)</th>
<th>Protein (% in DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazed leafy ryegrass</td>
<td>15-20</td>
<td>11.5</td>
<td>16-25</td>
</tr>
<tr>
<td>White clover</td>
<td>10-18</td>
<td>12.0</td>
<td>25-30</td>
</tr>
<tr>
<td>3 cut grass silage</td>
<td>16-28</td>
<td>10.5-11.5</td>
<td>12-18</td>
</tr>
<tr>
<td>Big bale silage</td>
<td>35</td>
<td>10.5-11.5</td>
<td>12.5-17.5</td>
</tr>
<tr>
<td>18% protein compound</td>
<td>86</td>
<td>10.3-12.0</td>
<td>20.9</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>88</td>
<td>12.9</td>
<td>47.0</td>
</tr>
<tr>
<td>Barley</td>
<td>86</td>
<td>13.2</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Pointers on D-value and ME

- Select the highest ranking varieties on the Recommended List
- Use a rotational (18 – 25 day) paddock grazing system with entry determined by the ‘Three Leaf System’ (see page 23)
- Consider soil nutrient availability and when applying fertiliser always apply in line with Fertiliser Manual RB209
- Cut for silage prior to stem thickening, or approximately one week before heading
- Manage to minimise diseases that will reduce D-value (e.g. crown rust, leaf spot)
- When necessary, top grazing swards to prevent heading

The Clover Effect

White and red clovers typically have D-values comparable to the highest ranking ryegrass varieties, with a greater proportion of the digestible material being in the form of crude protein (i.e. less carbohydrate).

The optimum white clover content in a grazing sward is an average of 30% over a grazing season.

When including red clover in a silage ley, it is important to use compatible ryegrass varieties to achieve the best overall D-value at cutting. As with ryegrass, D-value of red clover declines rapidly with increased crop maturity, with the target being to cut when no more than half the plants are in bud.
Water soluble carbohydrate

Why is water soluble carbohydrate (WSC) in grass important?

Water soluble carbohydrates are the soluble sugars that are quickly released from grass within the rumen. These sugars provide a readily available source of energy for the rumen microbes that are responsible for digesting forage. These sugars also provide the fuel for silage fermentation. The higher the sugar, the better the silage is preserved and the higher the feed value for the animal.

The range of WSC in grass

Higher WSC is a major differentiating factor in modern ryegrasses bred at IABERS Aberystwyth University over 30 years. Varieties higher in WSC than conventional varieties are now available as Aber High Sugar Grass. The Aber HSG range now includes intermediate and late heading diploid and tetraploid perennial ryegrasses and hybrid ryegrasses.

Relative differences in WSC are maintained between ryegrass varieties even though the content typically rises and falls over a season, with varying weather conditions and even over the period of a day. On a warm sunny summer day, WSC content can be as high as 35% of dry matter, whilst on a cool cloudy autumn day it can be as low as 10%, but at either end of the spectrum differences between varieties are maintained.

Making the most of WSC

A high WSC will generally mean forage composition is closer to the 2:1 WSC-to-crude protein ratio that animal models suggest is the target for optimum nitrogen use efficiency in the rumen. This means that more of the feed is converted into milk and meat, with less going to waste in urine (and methane). Under ideal growing conditions, modern Aber HSG ryegrasses will achieve the optimum ratio of 2:1 for WSC-to-protein.

The clover effect

White clover is generally lower in WSC and higher in protein, so it important to maintain the target of 30% white clover sward content over a grazing season for optimum performance.

Red clover is generally lower in WSC than ryegrass, so growing it in combination with Aber HSG varieties is beneficial for the silage fermentation process. Aiming for a minimum dry matter of 30% when ensiling red clover and ryegrass to increase the concentration of WSC in the forage.

The clover effect

- Select and sow grass and silage mixtures that are 100% Aber HSG to maximise WSC
- Avoid over-use of fertiliser by following RB209 guidelines
- Cut for silage late in the afternoon to maximise the WSC content
- Avoid making overly wet silage (below 28% DM) as this may result in sugar losses in the effluent and increases the effluent; wet silage also has increased need for sugars to create a good fermentation and stable silage
- WSC generally peaks 3 – 5 weeks after grazing or cutting
- Manage swards to avoid diseases that will reduce WSC (e.g. crown rust, leaf spot)

Average WSC over five years

<table>
<thead>
<tr>
<th>Month</th>
<th>Normal varieties</th>
<th>AberHSG varieties + 17.3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>230</td>
<td>280</td>
</tr>
<tr>
<td>May</td>
<td>220</td>
<td>250</td>
</tr>
<tr>
<td>June</td>
<td>210</td>
<td>240</td>
</tr>
<tr>
<td>Jul</td>
<td>200</td>
<td>230</td>
</tr>
<tr>
<td>Aug</td>
<td>190</td>
<td>220</td>
</tr>
<tr>
<td>Sept</td>
<td>180</td>
<td>210</td>
</tr>
<tr>
<td>Oct</td>
<td>170</td>
<td>200</td>
</tr>
<tr>
<td>Mean</td>
<td>200</td>
<td>230</td>
</tr>
</tbody>
</table>

Effect of DM at ensiling on WSC content of silage as a result of fermentation

<table>
<thead>
<tr>
<th>WSC g/kg DM</th>
<th>Homfermentative Inoculant</th>
<th>Untreated</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.3</td>
<td>22.3</td>
<td>20</td>
</tr>
<tr>
<td>24.3</td>
<td>24.3</td>
<td>20</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>35.8</td>
<td>35.8</td>
<td>30</td>
</tr>
</tbody>
</table>

Wetter silage ultimately uses up more sugar to achieve a stable fermentation, leaving less for the animal.
Cattle and sheep are inefficient at converting grass protein into milk and meat. When grazing conventional grass, livestock use only about 20% of protein from the herbage into milk and meat. When grazing conventional grass, process and often out of balance with the breakdown of protein. Grass cell walls consist of complex carbohydrates called cellulose, hemicellulose and lignin. Although these components are rapidly broken down when feed enters the rumen, when the diet lacks readily available energy, rumen microbes are able to use less of the nitrogen released from the feed. This results in a large proportion of the nitrogen being absorbed as ammonia and eventually excreted.

Research at IBEERS Aberystwyth University has shown that Aber HSG varieties have consistently higher levels of sugars than standard varieties, throughout any grass growing season. WSC levels up to 50% higher than controls have been recorded in some Aber HSG varieties. Results from trials are summarised later in this section.

Water soluble carbohydrates in grass are the sugars found inside the plant cells, rather than in the cell walls themselves. Unlike the carbohydrate in the cells walls, these sugars are a source of readily available energy soon after forage enters the rumen, fuelling the rumen microbes to process more of the grass protein. This protein can then be used in the production of milk and meat, rather than being excreted. This is why livestock perform better off forage with higher sugar levels.

Research to improve the quality of grass continues at IBEERS Aberystwyth University, with a focus on animal performance and increasing emphasis on the environmental benefits. In addition to WSC, other quality traits including improvement of the fibre and lipid components of grass, are now included in project objectives.

Reducing nitrogen excretion in ruminants

Enabling ruminants to convert more of the nitrogen in their feed into milk and meat improves production efficiency. It is also very positive for the environment in terms of reducing greenhouse gas emissions (ammonia and nitrous oxide) and urea (in urine). Feeding ryegrasses with higher WSC content leads to improved rumen efficiency (allowing increased protein synthesis) and evidence shows this results in reduced nitrogen losses.

Water soluble carbohydrate variation in Aber High Sugar Grasses (averaged between 2007 and 2009)

Ongoing Aber HSG research

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Extensive research over 30 years has shown how high water soluble carbohydrate content in Aber High Sugar Grass varieties improves performance and profitability in milk, beef and lamb production. Early research included:

- Grazing trials on commercial dairy and beef farms over two seasons
- Sheep studies at two research farms over three grazing seasons
- More recent research with improved varieties that combine the high WSC trait with good disease resistance and high yields includes:
  - Zero grazing studies to investigate the potential benefits of feeding Aber HSG to dairy and beef cattle on productivity and environmental impact
  - Studies to investigate the digestive mechanisms that allow ruminants to utilise Aber HSG varieties more efficiently than other recommended grass varieties
  - Field-scale grazing studies to investigate animal performance on Aber HSG awads
  - Studies on the reduction of methane emissions from ruminants grazing Aber HSG ryegrasses

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The development of Aber High Sugar Grasses

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High Sugar Grasses reduce methane emissions per lamb

Since proof of principle research established the value of a higher WSC content, a breeding programme has been on-going to develop Aber HSG ryegrasses. Following the first Recommended List variety AberDart HSG in 2000, new varieties have continued onto the Recommended List, with higher and higher levels of WSC and – as a result – continually improved performance potential.

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Water soluble carbohydrate variation in Aber High Sugar Grasses (averaged between 2007 and 2009)

Aber High Sugar Grass varieties are proven performers in terms of dry matter yield, D-value and ME yield, boosting not only production from forage but the environmental credentials for farming too. This has been recognised with a string of prestigious awards, beginning in 2003 when the first Aber High Sugar Grass, AberDart HSG, became the first (and still only) grass to win the NIAB Variety Cup. In subsequent years, the plant breeders behind this breakthrough technology have collected innovation and technology awards from RASE and the BGS, and with the Queen’s Anniversary Prize and the recent Times Higher Education Award they have received accolades beyond the agricultural industry.

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High Sugar Grasses reduce methane emissions per lamb

Sponsored by Defra through the Sustainable Livestock Production (SLP) LINK Programme in association with IBEERS Aberystwyth University, Germinal Holdings Limited, World Grassland Society (WGS), DairyCo, EBLEX, Hybu Cig Cymru (HCC), Livestock and Meat Commission of Northern Ireland (LM CNI) and Quality Meat Scotland (QMS).
Aber High Sugar Grass for milk production

Results of several studies conducted on commercial dairy farms and by IBERS at its dairy unit near Aberystwyth, show that grass protein is used more efficiently for milk production when extra energy is provided by feeding Aber HSG varieties.

Animals were fed either an experimental Aber HSG or a recommended control ryegrass variety. Both grazing and zero-grazing techniques were used in the assessments.

The main advantages of feeding Aber HSG varieties were found to be:

- Milk yield increased substantially
  In an early study that looked at Italian ryegrass across six commercial dairy farms, animals averaged 6% more milk per cow over the grazing season.
  - 6% more milk per cow over grazing season
  - Dry matter intakes up by 2kg/head per day
- The amount of feed nitrogen lost in urine is significantly reduced
  In three zero-grazing trials involving early, mid and late lactation animals, the amount of feed nitrogen lost in the urine was reduced by up to 24% from animals fed the Aber HSG variety. This has important implications for the environment in terms of nitrogen pollution.
  - 3% improvement in diet digestibility
  - 24% less feed nitrogen lost in urine

In recent zero grazing trials with perennial ryegrass, the average milk yield of animals fed Aber HSG increased by 2.3kg/day in early lactation and by 2.7kg/day in late lactation, without a detrimental effect on milk quality.

Dry matter intakes improved significantly
Zero grazing trials at IBERS completed in 2000 found that dry matter intakes rose by around 2kg/head per day. This is particularly important in low input farming systems where producers want animals to obtain as much of their nutrients as possible from grazed grass.

Diet digestibility increased
In the same trial, a 3% improvement in diet digestibility was recorded with Aber HSG. The dry matter digestibility of the Aber HSG variety was found to be consistently higher than the recommended control variety throughout spring, summer and autumn.

- Dry matter intakes increased by around 25%
- Improved palatability
- 20% higher daily liveweight gains
- Slaughter weights reached more quickly

Aber High Sugar Grass for beef production

Grazing trials and a companion zero-grazing study run by IBERS at Aberystwyth have shown that when extra energy is provided to beef cattle by feeding Aber HSG varieties, grass protein is used more efficiently and animal performance is enhanced.

Research involved beef steers offered either an Aber HSG variety or a recommended control ryegrass variety. No extra additional feed was given, and grass intakes and liveweight gains were monitored regularly.

- Dry matter intakes of animals fed Aber HSG increased by around 25%, compared with those fed the control variety.
- Greater intake was achieved because the Aber HSG variety was highly palatable. Additionally, Aber HSG was utilised more efficiently by rumen microbes and passed more quickly through the rumen.

- Higher forage intakes
- 20% higher liveweight gains

Aber High Sugar Grass for lamb production

In both upland and lowland situations, IBERS’ grazing trials have shown Aber HSG varieties to be superior in terms of animal performance, when compared with standard ryegrass swards.

- In the same study, the carrying capacity (stocking rate) of the Aber HSG sward was 20% higher than the standard ryegrass sward.
- Ad lib forage intake of grazing lambs was higher on the Aber HSG sward.

In recent trials with Welsh Halfbred ewes and lambs, the liveweight gain of lambs was 20% higher where animals were grazing the Aber HSG variety.

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Why is protein in grass important?

Protein is a large and expensive component of livestock rations, and reliance on imported sources (e.g. soya) leaves businesses vulnerable to price volatility and supply. Greater use of homegrown protein is therefore desirable.

Protein in grass is generally reported as total crude protein (CP), which is 6.25 times the nitrogen content. Typically around 80% of the crude protein in fresh grass is true protein. The remaining fraction is often referred to as non-protein nitrogen. Both types of nitrogen can be used by the animal but the true protein is used more efficiently for meat and milk production. A larger part of the non-protein nitrogen is used inefficiently and is excreted by the animal.

Crude protein can be split into effective rumen degradable protein (ERDP) and digestible undegradable protein (DUP). ERDP, which is by far the biggest part of fresh forage protein, can be broken down by rumen microbes and converted into microbial protein that is digested later. DUP passes through the rumen intact and can be broken down and digested in the small intestine.

Crude protein content can vary within single varieties and between varieties and is influenced by management factors such as nitrogen fertiliser applications and crop maturity.

The proportion of the crude protein that is available as true protein is lowest in the period after nitrogen fertiliser is applied, but rises as the grass grows and converts non-protein nitrogen into true protein.

In silage, the proportion of crude protein that is available as true protein is affected by the fermentation. A better fermentation results in more of the crude protein remaining as true protein.

Grazed grass provides the best source of true protein. Good ensiling practice will preserve more of the true protein in silage.

Animal research has shown that typically only about 20% of protein consumed by ruminants is used (to maintain the animal and produce meat or milk); the rest is lost in waste products. A better balance of protein and energy supply to the rumen will improve the proportion of protein that is used. Feeding forage (as grazed grass or silage) with a higher sugar (WSC) content has been shown to improve protein utilisation in ruminants.

Given the optimum balance of protein and energy sources, dietary crude protein concentrations can routinely be as low as 12 - 14% of dry matter without any detriment to livestock productivity (14% for milk production).

Aber HSG varieties are bred for improved protein-to-energy balance

Apply fertiliser in line with the Fertiliser Manual RB209, and 2 – 3 days after grazing or cutting

Avoid making overly wet silage (below 28% DM) as this may result in soluble protein losses in the effluent

Optimum protein concentrations occur 3 – 5 days after cutting or grazing
Fibre

Why is fibre important in grass?

Fibre is essential in the ruminant ration to provide the 'scratch factor' necessary to stimulate rumen function. There is an important balance to be achieved in all rations for optimum performance.

Fibre is measured as NDF (neutral detergent fibre), this being the insoluble fibre fraction (cellulose, hemicellulose, pectin and lignin) that remains after boiling in a neutral detergent solution.

Carbohydrates within NDF are not as readily accessible as those in the WSC component of ryegrasses. However, NDF content is important for predicting ruminant voluntary intake. The proportion of NDF that can be digested by ruminants is referred to as dNDF. This is a secondary source of slowly released carbohydrates that provides a useful source of fermentable energy for ruminants within the rumen and hind gut.

The range of fibre in grass

Grass fibre concentration can vary greatly during the growing season. It is at its highest (and the grass least digestible) when the sward is producing reproductive seed heads rather than vegetative leaves. Conversely, during the early spring when fresh growth is at its peak, fibre content is typically at its lowest (grass is most digestible).

Making the most of fibre in grass

The principle target with fibre is to maximise animal voluntary intake whilst ensuring sufficient rumen digestion time.

For grazing, the optimum NDF content of grass should be in the range of 30 – 40% of total dry matter, with dNDF around 20-30% of total dry matter, or roughly 60-75% of the total fibre content in a digestible form.

When grass fibre content falls below these optimum levels (e.g. early spring flush) supplementary feeding of fibre may be necessary to prevent grass passing through the rumen too rapidly.

When making silage, it is important to cut before grass becomes too mature (pre-heading) to avoid a significant reduction in digestibility.

The clover effect

The clover concentration of white and red clover is lower than that of ryegrass and can have the potential to increase voluntary intake.

The physical form of fibre in clovers typically breaks down in the rumen more quickly than the fibre in ryegrass.

Cutting grass after it has gone to head will increase the fibre content to the detriment of feed quality in silage.
**Lipids (Oil)**

**Why are lipids important in grass?**

Lipids in forage grasses contain a high proportion of polyunsaturated fatty acids (PUFA). These are the ‘good’ fatty acids, better known as Omega 3 and Omega 9, which have positive human health effects.

From an animal production perspective, increased PUFA supply has been shown to improve animal fertility and result in positive effects on meat quality (longer shelf life and a more desirable colour). There is also evidence of reduced methane emissions from ruminants consuming high PUFA diets, an effect that is positive for the environment.

**The range of lipids in grass**

Early data suggests total fatty acid content of grass varies from about 2.5 to 5% of forage dry matter, with the PUFA component making up 65 – 78% of the total lipid content.

**Making the most of lipids in grass**

Lipids have approximately twice the energy content of carbohydrates (WSC and fibre) and are an important source of energy for livestock. Ruminant diets are frequently supplemented with high lipid feeds as a means of increasing the energy content of the diet.

**Lipids (Oil)**

**Pointers on Lipids**

- Fresh grass provides a better PUFA profile than many dry feeds
- Forage-based systems have the potential to produce better quality human food due to the favourable PUFA profile in grass
- When silage making, rapid wilting will increase the level of lipids retained in the forage

**The CLOVER EFFECT**

- White clover lipid content is generally reported to be slightly lower than that of ryegrass, with a range of 2 – 4.4% of forage dry matter.
- Red clover is generally reported to be higher in polyunsaturated fats than ryegrass.

**Improving the lipid content and profile in grass is a new breeding objective at IBERS Aberystwyth University.**
Minerals and Vitamins

Why are minerals and vitamins important in grass?

Minerals include various elements like calcium, selenium and iron. These basic elements, like the more complex vitamins, have important roles in the health and performance of livestock. Understanding the mineral and vitamin content of grass is important in the context of any additional supplementation that may or may not be required.

The range of minerals and vitamins in grass

The mineral content of a sward will depend largely upon the mineral availability in the soil and the pH (see table). Mineral and vitamin content will not usually change in silage, though in very wet crops some losses may occur in effluent. Whilst many vitamins are synthesised by rumen microbes, some lipid soluble vitamins must be obtained from feed (vitamins A, D and E) and all vitamins provided by feeds can be a useful addition to the ruminant’s diet.

Making the most of minerals and vitamins in grass

Accurately managing a sward for minerals and vitamins content will require soil analysis for each paddock. Where any mineral is found to be deficient, provision of supplemental licks or mineral boluses can overcome most deficiencies.

When turning stock into lush pastures of rapidly growing grass, particularly in the spring, it is advisable to monitor them to further reduce the risk of staggers. Supplement rations with some lipid soluble vitamins must be obtained from feed (vitamins A, D and E) and all vitamins provided by feeds can be a useful addition to the ruminant’s diet.

Puna II Perennial Chicory

Perennial chicory has become a popular new grazing forage option on UK livestock farms since the introduction of new varieties bred in New Zealand.

Puna II is the leading perennial chicory variety, selected through a long term breeding programme for its nutritive value, productivity, palatability and persistency. Perennial chicory has proven anthelmintic properties and will reduce worm burdens in grazing livestock.

It is a broad-leaved perennial forage crop that can be grown in the UK as a pure stand or as a key part of mixed swards with clover, or grass and clover, for medium-long term rotational grazing (2-5 year persistency). Perennial chicory should not be confused with short-lived common chicory grown unsuccessfully previously.

Selection strategy in breeding Puna II has included tolerance to the fungal disease Sclerotinia, which causes plant death, and an erect growth habit to improve compatibility with ryegrass.

As a pure stand, Puna II typically yields up to 15tDM/ha in a season, with crude protein up to 25% and at a D-value of 70-80. It is deep rooting and hence very drought tolerant with high mineral content.
## Grazing management

In order to maximise the nutritional value of grass it is important to manage grazing effectively. This means ensuring the optimum balance between sward quality and quantity, thereby maximising intakes when the grass is in the best nutritional condition.

Regardless of whether livestock are set-stocked or rotationally grazed, the key is to assess pastures regularly (at least weekly) in order to establish when grass is at the right stage for grazing and when it is time to close an area to allow regrowth.

Methods to assess the condition of a sward for grazing include measuring sward height to establish the cover (kgDM/ha), with a calibrated sward stick or more simple aids, or using a rising plate meter. Guidelines on the optimum cover for grazing and closing up pastures are well-established (See tables).

### Using the Three-Leaf System

Whilst good and recommended practices, sward sticks and plate meters are primarily measurements of quantity whereas nutritional value is more related to quality. The established qualitative method of sward assessment is the Three-Leaf System.

This method is based on the understanding that a ryegrass tiller typically supports three green leaves.

As shown by the diagram, the typical ryegrass tiller structure includes the youngest green leaf (leaf 1) growing at the top; two further green leaves (leaf 2 and leaf 3) that are no longer growing; and a dead and decaying leaf (leaf 4).

### Using the Three-Leaf System

Assessments should be made at least weekly prior to grazing, with more frequent counts in the spring when grass is growing most rapidly and less often in late-autumn.

**Select a suitable ryegrass tiller**
- Identify ryegrass from the red stem base
- Only use vegetative tillers (avoid anything with seed heads)
- Use the main parent tiller (as opposed to a daughter tiller)

**Identify the remnant leaf**
- The youngest growing leaf when the grass was last grazed (near the base of the tiller, likely to have a blunt end)
- Assess the length of the remnant leaf in relation to the fresh un-grazed leaf above it
  - If the remnant is more than half the length of the first fresh leaf, count it as 0.5 – 1, but if not it should not be counted
  - If there is no remnant leaf, do not include this tiller in the assessment
- If there is more than one remnant leaf (because the sward was under-grazed previously) counting should start with the youngest remnant

**Count the fresh leaves**
- Start with the remnant leaf (as above)
- Each of the next full leaves count as 1.0
- The youngest (top) leaf may only be partly grown and should be assessed by its size relative to the previous leaf (this top leaf may not be immediately obvious but is often close to the previous leaf and can be revealed by opening the evident leaf by rolling it between thumb and forefinger)

**Count up to 10 tillers**
- Select up to 10 tillers randomly across the field
- Calculate an average to create an accurate assessment
- An evenly grazed area will have most of the tillers assessed within a half leaf stage of each other

### Table: Pre-graze (cm) Post-graze (cm) Interval guide (days)

<table>
<thead>
<tr>
<th>Class of stock</th>
<th>Grazing period</th>
<th>Rotational</th>
<th>Continuously</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Milking cows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turn Out - May</td>
<td>10-15</td>
<td>8-7</td>
</tr>
<tr>
<td></td>
<td>June - July</td>
<td>12-15</td>
<td>7-8</td>
</tr>
<tr>
<td></td>
<td>Aug - Sept</td>
<td>12-16</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td>Oct - Housing</td>
<td>12-15</td>
<td>6-7</td>
</tr>
</tbody>
</table>

**Beef cattle**

<table>
<thead>
<tr>
<th>Class of stock</th>
<th>Grazing period</th>
<th>Rotational/Aftermath</th>
<th>Continuously</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steer &amp; bull</strong></td>
<td>Turn Out - May</td>
<td>12-14</td>
<td>7-6</td>
</tr>
<tr>
<td></td>
<td>June - July</td>
<td>12-15</td>
<td>7-8</td>
</tr>
<tr>
<td></td>
<td>Aug - Nov</td>
<td>12-15</td>
<td>8-9</td>
</tr>
</tbody>
</table>

**Sheep**

<table>
<thead>
<tr>
<th>Class of stock</th>
<th>Grazing period</th>
<th>Rotational</th>
<th>Continuously</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ewes &amp; lambs</strong></td>
<td>Turn Out - April</td>
<td>8-10</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>May - Weaning</td>
<td>8-10</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td>Sept - Nov</td>
<td>8-10</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>July - Sept</td>
<td>10-12</td>
<td>5-7</td>
</tr>
</tbody>
</table>

**Structure of a ryegrass tiller**

- Blade of youngest leaf (1)
- Blade of leaf 2
- Blade of leaf 3
- Decaying leaf 4
- Sheath of leaf 2
- Growing point
- Roots
Making quality silage

This quick reference guide to silage making assumes that soils are free from compaction and have optimum nutrient status. It is a prompt to seek further information if required.

Mixture selection

Important considerations when selecting a grass mixture for silage making should include:

- Planned duration of the ley
- Number and timing of cuts in a season
- Silage only or dual purpose
- Quantity and quality
- Clover or no clover
- Is drought tolerance required

Addressing these points will help ensure that the type of mixture is fit for purpose. Mixtures for silage production will contain a number of ryegrass varieties (perennial, hybrid or Italian), with the possible addition of an alternative grass species, such as Timothy, white or red clover.

To ensure you have the best mixture for your purpose:

- Ensure all varieties are high ranking on the latest Recommended List
- Consider the relative merits of diploid and tetraploid varieties
  - Diploids are more persistent and create a denser sward, better suited to wetter conditions and where long term grazing is also required
  - Tetraploids have a more upright growth habit and can be faster establishing
- Ensure the heading date range within the mixture is as tight as possible (1 week optimum) and coincides with target cutting dates in order to maximise quality

Timing of harvest

When making silage, it is usually the case that as quantity increases, quality decreases. This is because the more mature (and higher yielding) crop will have lower nutritional value, for reasons explained earlier in this guide.

There is therefore an inevitable compromise, with decisions on when to cut best determined by the class of livestock to be fed and stock performance targets.

For maximum yield without significant compromise of quality, most crops are best cut approximately one week before heading.

Wilting

Wilting to achieve an optimum silage dry matter of 30–35% (clamp) and 35–40% (bale) should ideally be quick and short, so a maximum of 24 – 36 hours.

- Using a mower conditioner will increase the speed of wilting and reduce losses of sugar, protein and dry matter
- Leaf pores only remain open for two hours after cutting, when speed of moisture loss is five times greater than after pores close – so spread the crop quickly after cutting
- Spread the crop over 100% of the field area, again to increase the speed of wilting

Quality grass silage can be made in both clamps and bales, and both systems have their place on modern livestock farms. The choice depends on individual farm circumstances and a range of variables. Silage additives will not salvage poor quality forage, but when the right product is selected for the right purpose they may help make good silage even better.

Making good silage in clamps

- Ensure the forage harvester is blowing all chopped material into the trailer
- Set forage harvester chop length according to grass dry matter content
- Use a baler with a chopping function to produce denser bales with less oxygen trapped inside; chopping also releases sugars to assist a rapid fermentation
- Wrap bales as soon after baling as possible
- Use good quality wrap and an effective wrapper to apply at least six layers
- Move bales for stacking as soon after wrapping as possible
- Stack bales on a level surface free from sharp objects and at least 10m from a water course; bales are best stacked on their sides and no more than three high (or four if over 35% DM)
- Protect bales from bird and rodent damage

Making good silage in bales

- Create a box-shaped swath and use a baler (round or square) to form uniform bales with ‘square’ edges
- Use a baler with a chopping function to produce denser bales with less oxygen trapped inside; chopping also releases sugars to assist a rapid fermentation
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Understanding a silage analysis

Whether clamped or baled, conserved forage will often make up a large proportion of ruminant diets. It is important, therefore, to understand the nutritional value through a representative silage analysis.

### Obtaining a representative sample

**For clamps**
- Cored sample in a diagonal line across the top of the clamp
- At least four samples per clamp
- Mix samples well, seal in an airtight bag, and send for analysis without delay

**For bales**
- Three cored samples per bale, each taken from top to bottom
- Or, sample at feedout (when bales are mixed and chopped)
- Mix samples well, seal in an airtight bag, and send for analysis without delay

Your silage analysis will include values for all of the main nutritional components. Review these values against target levels and adjust feed supplementation accordingly. As highlighted below, different parameters are related to crop quality in the field, success of fermentation, or both. By understanding which parameter relates to which part of the process, steps can be taken to improve methods in future years.

### Analysis Abbreviation Units Range Target value **

<table>
<thead>
<tr>
<th>Dry matter (DM)</th>
<th>g/kg</th>
<th>150-500</th>
<th>280-350</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-value (D)</td>
<td>%</td>
<td>55-75</td>
<td>&gt;68</td>
</tr>
<tr>
<td>Metabolisable energy (ME)</td>
<td>MJ/kgDM</td>
<td>8.8-12.0</td>
<td>&gt;11</td>
</tr>
<tr>
<td>Neutral detergent fibre (NDF)</td>
<td>g/kgDM</td>
<td>500-650</td>
<td>500-550</td>
</tr>
<tr>
<td>Acid detergent fibre (ADF)</td>
<td>g/kgDM</td>
<td>230-350</td>
<td>300</td>
</tr>
<tr>
<td>Ash</td>
<td>g/kgDM</td>
<td>60-200</td>
<td>&lt;80</td>
</tr>
<tr>
<td>Crude protein (CP)</td>
<td>g/kgDM</td>
<td>100-200</td>
<td>150-175</td>
</tr>
<tr>
<td>pH</td>
<td>3.5-5.5</td>
<td>Depends on DM</td>
<td></td>
</tr>
<tr>
<td>Ammonia N (NH3N)</td>
<td>g/kg</td>
<td>20-300</td>
<td>&lt;80</td>
</tr>
<tr>
<td>Total fermentable acids (TFA)</td>
<td>g/kgDM</td>
<td>20-200</td>
<td>&lt;100 (depends on DM)</td>
</tr>
<tr>
<td>Volatile fatty acids (VFA)</td>
<td>g/kgDM</td>
<td>10-90</td>
<td>%TFA 25% (as low as possible)</td>
</tr>
<tr>
<td>Lactic acid*</td>
<td>g/kgDM</td>
<td>20-200</td>
<td>80-120</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>g/kgDM</td>
<td>20-80</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>g/kgDM</td>
<td>0-20</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Residual sugars</td>
<td>g/kgDM</td>
<td>0-150</td>
<td>100 (as high as possible)</td>
</tr>
</tbody>
</table>

*For well fermented silage lactic acid as the proportion as the total acids should be >75%.

**Different analytical companies use different units for expressing the values. This example shows g/kg DM to convert to % divide the value by 10.

### Indications of in-field crop quality

- D-value, ME, Crude Protein, ADF, NDF

### Indications of fermentation quality

- Lactic Acid, Acetic Acid, Butyric Acid, Ammonia N, VFAs

### Indications of both crop and fermentation quality

- Dry Matter, pH, WSC