Knowledge Transfer Network

Biosciences

Technology Strategy Board

Driving Innovation

How the agriculture and food industry profits from innovation

New forage varieties for the sustainable intensification of livestock agriculture

BSH

PRIFYSGOL ABERYSTWYTH UNIVERSITY

IBERS Institute of Biological, Environmental and Rural Sciences

New forage varieties for the sustainable intensification of livestock agriculture

One of the key challenges facing UK agriculture is to improve food production and security, whilst reducing the environmental impact of the sector. New varieties of grass and clover with improved yields and water-soluble carbohydrate levels are being developed to meet these challenges by increasing meat and milk production, whilst reducing greenhouse gas emissions from livestock farming.

The challenges of food security, climate change and reducing the environmental impact of agriculture require the application of modern genomic and informatic tools in approaches to precision plant breeding. They also require effective public-private partnerships to ensure that the pipeline of basic, strategic and applied research is effective in supplying improvements to farmers and other stakeholders.

Plant breeding programmes undertaken at the Institute of Biological, Environmental and Rural Sciences, Aberystwyth University (IBERS) have been directed at reducing emissions to water and air and adapting grasslands to increased water stress as well as producing successful varieties that add to the economic viability of livestock enterprises. These 'high sugar grasses' (HSG) have been shown to reduce emissions of greenhouse gases (GHG) as well as increasing meat and milk production, and are being approved by Recommended Lists (RL) for their combination of good disease resistance, good grazing D-value and high yield.

Grass breeding for optimised animal nutrition

When grazing ordinary grass, livestock convert only about 20% of protein from the herbage – most of the rest is excreted in faeces and urine. This is not only financially costly, but also detrimental to the environment.

A major reason for these losses is the imbalance between readily available energy and protein within the grass. When the diet lacks easily available energy in the form of sugars, the rumen microbes gain more of their energy by degrading proteins. This means that more ammonia is produced, increasing nitrogenous excretions and reducing nitrogen allocation to meat and milk.

Grass cell walls consist of the complex carbohydrates, cellulose, hemicelluloses and lignin. Although these components can be broken down to release energy, this takes time and the carbohydrates are therefore not readily available when grass protein is broken down in the rumen. Water-soluble carbohydrates (WSC) in grass are the sugars found inside the plant cells, rather than in the cell walls themselves. They become a source of readily available energy soon after forage enters the rumen, allowing rumen microbes to process more grass protein.

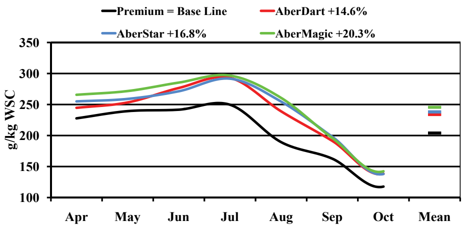
At IBERS, programmes for breeding grasses with elevated WSC and grazing D-Value started in the 1970's.

HSG varieties, with high levels of WSC, can significantly improve the utilisation of protein in grass by enabling a more efficient conversion of grass proteins by rumen microbes into milk and meat proteins, thus improving production efficiency.

Research at IBERS has shown that Aber HSG varieties have consistently higher levels of sugars (overall 20 - 30% higher) than standard varieties throughout the grazing season (see figure 1). Aber HSG also have a significantly better grazing D-Value (index of concentration of digestible energy in the herbage) than the mean of the 2010/11 NIAB RL, with an average of 73.4 compared to 71.4, thus a gain of 2.0 units. It should be noted that differences among varieties in D-Value can vary throughout the year and are larger in the summer.

Aber HSG varieties are highly palatable, resulting in greater dry matter (DM) intake by livestock, which is particularly important in low input farming systems where producers want animals to obtain as much of their nutrients as possible from grazed grass, reducing the need for feed supplements.

Figure 1. Water Soluble Carbohydrate Variation in High Sugar Grasses (averaged between 2007 and 2009)



Economic Impact

Extensive trials undertaken at commercial farms and Aberystwyth University IBERS farms have demonstrated that Aber HSG varieties improve performance and profitability of milk, beef and lamb production. Key profitability highlights are summarised below.

Milk production:

- Up to 6% more milk per cow over grazing season
- Dry matter intakes up by 2 kg/head per day
- 3% improvement in diet digestibility

Beef production:

- Dry matter intakes increased by around 25%
- Higher forage intakes
- 18 - 35% higher daily live-weight gains
- Slaughter weights reached more quickly

Lamb production:

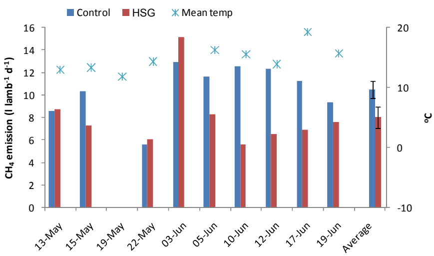
- Higher forage intakes
- 10 - 15% higher daily live-weight gains
- 20% higher carrying capacity of Aber HSG sward

Reducing the environmental impact of agriculture

Farming and land use are responsible for about 7% of total UK GHG emissions[1]. Aber HSG varieties have been shown to help reduce emissions from UK livestock.

Methane (CH_4): Livestock account for approximately 37% of all emissions of methane, which although less persistent in the atmosphere than carbon dioxide, has 20-25 times its global warming potential[2]. Studies undertaken by IBERS demonstrated that Aber HSG reduce methane emissions per unit of production. Figure 2 allows a direct comparison of methane emitted over a period of 5 weeks per lamb fed with either a control grass or a HSG variety: on average, a lamb fed with the HSG variety released 20% less CH_4 than a lamb fed with the control variety.

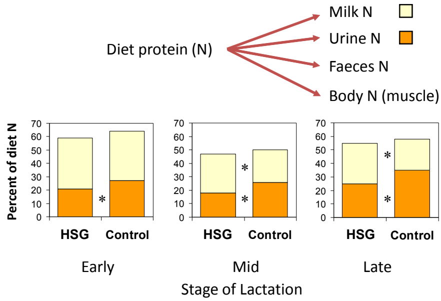
Figure 2. High Sugar Grass variety reduces methane emissions from lamb farming



Nitrous oxide (N_2O): Livestock account for approximately 85% ammonia emissions. Break down products include nitrous oxide, which is approximately 250-310 times more effective as a GHG than CO_2, making the reduction of these emissions a key issue for agriculture[3]. Enabling livestock to convert more of the nitrogen in their feed into meat and milk improves production efficiency. It is also very positive for the environment in terms of reducing GHG emissions (ammonia and nitrous oxide), urea (in urine) and nitrates (in manure). Feeding grasses with higher WSC content leads to improved rumen efficiency (allowing increased microbial protein synthesis) and evidence suggests that this results in reduced nitrogen losses.

In three zero-grazing trials involving early, mid and late lactation animals undertaken at IBERS, the amount of feed nitrogen (N) lost in the urine was reduced by up to 24% from animals fed the Aber HSG variety (see figure 3). This has important implications for the environment in terms of nitrogen pollution.

Figure 3. N partitioning



Integrated Supply Chains

Alongside the use of modern tools and approaches, a greater focus on the whole value chain will be important in placing plant breeding and allied research on a better footing for the future.

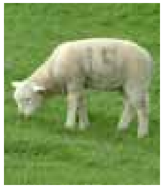
- Aber HSG and its advantages to famers and the environment become lost in an undifferentiated supply chain.
- Product differentiation to enable consumer recognition of goods with lower GHG emissions – “Little Green Tractor”?
- Rewarding producers for choice of variety and management practices leading to reduced environmental impact:
  - Public sector procurement policies, e.g. to help meet UK GHG emission targets in 2050.
  - Integrated private sector value chains.

Conclusion

Breeding programmes in forage grasses and legumes have provided significant yield and trait benefits for livestock agriculture in the UK. One key economic impact to UK farmers is highlighted below.

Example of economic value to dairy farmers:

Aber HSG are available commercially, and approximately 6,000 MT has been sown in the UK since 2005, covering an area of 425,000 acres (175,000 Ha). To calculate the increase in milk yield over the life of ley per acre, we will assume that the average stocking rate is one cow per acre, the length of ley is 5 years, and the difference in D-value is 2 points. Trials have shown that the increase per unit of D-value per day is between 0.28 – 0.4 litre per day (l/d).



Extra milk per acre over one year

1cow/acre x 0.28 – 0.4 l/d x 2 D x 200 grazing days = **112 – 160 l**

Extra milk over the life of ley

112 – 160 l x 5 years = **560 – 800 litres**

Economic value to UK dairy farmers over 5 years

If we assume that all HSG were sown on dairy farms, and the farm milk value is £0.23 per litre, the economic value to dairy farmers is:

560 – 800 l x 425,000 acres = 238 – 340 million litres extra milk

238 – 340 l x £0.23 = **£54.7 – £78.2 million**

Aber HSG in practice

Managing 200 high yielding Holstein Friesian cows on a rotational paddock system at Walford College in Shropshire, farm manager Adrian Joynt set out to demonstrate the impact of varying grass varieties by sowing different mixtures in his four main grazing paddocks.

It became immediately apparent that cows favoured a paddock sown exclusively with an Aber High Sugar Grass mixture with white clover.

"The cows appeared to have a greater appetite for the Aber HSG ley, but more significant was the impact on the bulk tank. The response shortly after cows had grazed this paddock was a 1.5 litres/cow/day increase in yields. This happened every time the cows grazed the paddock."

---

[1] http://defrafarmingandfoodscience.csl.gov.uk/

[2] Bourne, D., Maitima, J., Motsamai, B., Blake, R., Nicholson, C. & Sundstøl, F. 2005. Livestock and the Environment. In E. Owen, A. Kitalyi, N. Jayasuriya & T. Smith, eds. Livestock and wealth creation. Improving the husbandry of animals kept by resource-poor people in developing countries, pp. 191-213. Natural Resources International Limited, Aylesford, Kent ME20 6SN, UK. (www.nrinternational.co.uk). Published by Nottingham University Press, Nottingham, UK. 601 pp. (www.nup.com)

[3] R. Jam & P Fane, Climate Change and UK Agriculture – Implications for Land Management. 2006. RICS

Knowledge Transfer Network

Biosciences

Biosciences Knowledge Transfer Network

Serving the Agriculture, Food and Industrial Bioscience Sectors

Contact British Seed Houses:

Paul Billings
Director
British Seed Houses Ltd.
Portview Road
Avonmouth
Bristol, BS11 9JH

email: paul@bshavon.co.uk
tel: 01179 823691
mob: 07713 878064

web: www.britishseedhouses.com

Contact Institute of Biological, Environmental & Rural Sciences:

Prof. Michael Abberton
Institute of Biological, Environmental & Rural Sciences
Aberystwyth University
Gogerddan
Aberystwyth
Ceredigion, SY23 3EB

email: mla@aber.ac.uk
tel: 01970 823180

web: www.aber.ac.uk/en/ibers

Contact Biosciences KTN:

Dr Aurélie Bovi
Knowledge Transfer Manager
Plant Sector
Biosciences KTN

email: aurelie.bovi@biosciencektn.com
mob: 07702713805

web: https://ktn.innovateuk.org/web/biosciencesktn

Technology Strategy Board
Driving Innovation

Biosciences KTN is Sponsored by the Technology Strategy Board, the Scottish Government, European Regional Development Funds, Defra, BBSRC and NERC.