Agrifood Awareness AUSTRALIA Limited

Telephone: 02 6273 9535
Fax: 02 6273 3968
Email: info@afaa.com.au
Web site: http://www.afaa.com.au
Address: PO Box E10, Kingston, ACT, 2604
ABN: 49 103 817 296

Biotech Bulletin 19

Stocktake: GM Pastures

Welcome to Agrifood Awareness Australia Limited's (AFAA) latest *Biotech Bulletin*. This edition, entitled "Stocktake: GM pastures", features information on genetically modified (GM) pasture research underway in Australia and New Zealand.

The dairy industry recently captured headlines in Australia when it agreed, according to media reports, to reconsider its policy on the use of gene technology at the United Dairyfarmers of Victoria (UDV) annual conference. The resolution proposed from the floor was "That the UDV should reverse its current anti-GM policy and support choice of GM technology in the dairy industry". The resolution will be tabled at next year's annual conference, allowing members 12 months to consider whether they support this policy direction.

The UDV conference was addressed by Professor German Spangenberg, Research Director of the Victorian Government Department of Primary Industries plant genetics and genomic research program. During his presentation Prof Spangenberg predicted a 25 per cent increase in milk production if a high digestibility perennial ryegrass, developed using gene technology, is utilised in the future – translating into a $49 million benefit to the dairy industry.

This dairy industry development follows an announcement from the Victorian Government in April relating to the discovery of frost tolerance genes in Antarctic Hairgrass. This research may lead to the development of frost tolerant pastures and crops in the future. According to the Government media release, globally, five to 15 per cent of agricultural production is lost to frost each year.

The implications of such research however are much broader than the dairy industry. They extend to a number of industries including beef and lamb production and the turf industry. There is also the potential for human health benefits through dietary improvements and reduced incidences of hay fever.

As such, it is timely to gain a greater understanding of the gene technology research underway in the area of pasture improvement in Australia and New Zealand.

WHAT ARE PASTURES?

Pastures can be broadly defined as "grass or other vegetation eaten as food by grazing animals." A wide range of pasture species can be found across Australia. Types include native perennial grasses with some annual legume, for example sub-clover; annual grasses and legume based pastures; and sown exotic perennial grass pastures and annual or perennial legume.

In 2003, according to the Rural Industries Research and Development Corporation (RIRDC) the main pasture plants needed to satisfy domestic markets were ryegrass (2,300 tonnes), lucerne (2,500 tonnes), subterranean clover (2,300 tonnes), annual medics (1,800 tonnes), and tall fescue (400-500 tonnes). Australia does not import much pasture plant seed, but has significant export sales totalling almost $24 million for temperate legume and grass seeds and tropical and sub-tropical plants.

The quantity, quality and utilisation of pasture and feed grown on farm can greatly affect productivity and profitability and a number of initiatives targeting improvements in these areas have evolved over the past few years including a pasture species database and the Grain & Graze program which both aim to improve the productivity, profitability and sustainability of pastoralists and mixed livestock and cropping farmers.

Traditionally, pasture species composition and productivity has been enhanced through the use of fertilisers, grazing management and herbicides. More recently however, gene technology has been applied in laboratories globally to improve the performance of pastures.

For more information: www.rirdc.gov.au and www.grainandgraze.com.au

COMMERCIALLY-AVAILABLE GM ANIMAL FEED

In 2005, 90 million hectares of GM crops were grown in 21 countries around the world. Herbicide tolerance and insect resistance were the characteristics which dominate these soybean, corn, cotton and canola crops. While these modifications largely benefit broad-acre producers, these crops are all routinely and safely used as components of animal feed rations.

For more information: www.isaaa.org

The latest edition to this suite of crops is herbicide tolerant GM lucerne (known as alfalfa in the USA). The GM lucerne was approved for commercial use in the USA last year and seed became available as part of a limited domestic launch (50,000 to 75,000 acres or between 20,000 to 30,00 hectares) for growers in March. The benefits of GM lucerne are claimed to be fewer weeds resulting in better quality hay and better quality feed. The product was developed by Monsanto in conjunction with Forage Genetics, and will be grown across a limited area of the national lucerne crop, until import approvals have been granted in key export markets.

The first GM crop directly targeting animal health, a corn variety, has also received final regulatory approval in the USA. The GM corn contains higher levels of lysine than conventional corn. Lysine, an amino acid, is essential in the diets of animals as it is an important building block for proteins and muscle development. By incorporating lysine into the crop, synthetic lysine supplements will no longer be required and this is expected to reduce costs and improve efficiencies for producers.

The new crop will be planted on a limited area in 2007. Regulatory clearances in all key export markets are currently being sought. Until these clearances are achieved the grain will only be marketed to specific end-users in the USA. The high lysine corn will be produced under an identity preservation system. The corn has been developed by Renessen, a joint venture between Cargill Incorporated and Monsanto Company.

For more information: www.monsanto.com

PASTURE RESEARCH IN AUSTRALIA

In Australia, according to a report published by the Bureau of Rural Sciences (BRS), pasture research involving gene technology is focusing on superior pasture grasses with modified lignin biosynthesis, fructan metabolism and reduced pollen allergens.

The most advanced pasture research in Australia is a virus-resistant white clover project. The Victorian Department of Primary Industries (DPI) has been granted a licence by the Office of the Gene Technology Regulator (OGTR) to undertake the GM clover field trials in Victoria.

- GM VIRUS RESISTANT WHITE CLOVER

The GM clover is resistant to Alfalfa Mosaic Virus (AMV). Levels of AMV infection of white clover in pastoral populations have been observed to be substantial in many sites across Australia. Past estimates are that over 40 per cent of white clover plants were infected with AMV, and in some cases the level of infection exceeded 90 per cent.

The trials, licensed to occur from 2004 to 2007, aim to evaluate the GM white clover to assess its AMV resistance under field conditions and to produce GM white clover seed for future trials, subject to further approvals. DPI (Victoria) has evaluated the agronomic characteristics and resistance to AMV of the GM white clover over two years and will produce seed from a selection of GM white clover plants showing superior agronomic performance and AMV resistance. Naturally occurring resistance for clover yellow vein virus was found during the course of the project and it has been incorporated into these selections also.

According to the Risk Assessment and Risk Management Plan (RARMP), the OGTR concluded that the proposed release of the GM virus resistant white clover "does not pose significant risks to human health and safety or to the environment as a result of the genetic modification. The Regulator has imposed stringent licence conditions…to minimise potential exposure of humans and other organisms, and to limit the spread and persistence of the GMO and the introduced genes while more data is gathered on the behaviour and interactions of the GMO in the Australian environment."

The licence conditions include:

- surrounding the site by a livestock-proof fence and a rabbit-proof fence;
- destroying GM materials not required for subsequent research and any volunteer plants that may occur at the end of the trial;
- enclosing the GM plot with a bee-proof cage and ensuring the integrity of the cage is maintained during the flowering period of the GM white clover;
- securely transporting and storing any GM materials;
- cleaning any equipment used at the release site; and,
- preventing the white clover plants from the release, or their by-products, being used for animal feed or entering the human food chain.

The RARMP also indicates that research on the agronomic characteristics indicative of potential weediness of the GM white clover under Australian field conditions is required if the applicant applies for future larger scale releases of GM virus resistant white clover. More detailed information would be required to be collected on weediness of the GM white clover under Australian field conditions, including invasiveness, enhanced reproductive capacities, and limitation of white clover persistence by AMV outside of pastoral situations, such as roadsides, home gardens and natural environments.

For more information: www.ogtr.gov.au/ir/dir047.htm or German.Spangenberg@dpi.vic.gov.au

A study addressing the areas outlined above in relation to weediness and the GM clover is currently being undertaken by CSIRO researchers working in close communication with the OGTR. A steering committee was established to oversee the conduct of this project in its first phase and to become familiar with the regulatory environment. It comprised of farmer, community, Dairy Australia and CSIRO members. In phase two of the project there is close consultation between CSIRO and the OGTR with progress reports to industry, Dairy Australia and a commercial partner.

Any commercialisation of AMV-resistant GM clover is still a number of years away, with regulatory hurdles, seed multiplication and industry and consumer readiness all key factors in determining any future release.

For more information: Nives Milanovic, Dairy Australia, nmilanovic@dairyaustralia.com.au or Roger Barlow, rpabarlow@netwit.net.au

- FURTHER GM CLOVER RESEARCH

Bloat is caused by the formation of foam in a cow's stomach during grazing on pastures, and losses due to bloat cost Australia approximately $100 million annually. As a result, researchers investigated the potential of gene technology to help reduce this problem. Scientists found that small amounts of tannin, also found in tea and wine, helps to stop bloat. Scientists have isolated condensed tannin biosynthetic genes in white clover, which makes tannins in the seed coat and in the flowers. The aim of this research is to develop **bloat-safe** GM clover and lucerne.

For more information: German.Spangenberg@dpi.vic.gov.au or www.csiro.au

- RYEGRASS RESEARCH

Lignin is the part of the plant cell wall that gives it strength and rigidity. As a result, high lignin results in a stiffer and less palatable grass to livestock. Researchers are trying to alter lignin production and develop ryegrass with **higher digestibility**.

Researchers have also identified the genes involved in fructan metabolism, and are working to produce grasses with high fructan content for the dairy industry. Fructan is a naturally occurring sugar in pasture grasses and is an excellent energy source. Increasing fructan content and creating a **high-energy** ryegrass, will translate into an increase in live weight, milk production and possibly fertility.

Most of the hayfever-causing pollen in Australia is produced by ryegrass. Up to 25 per cent of people living in temperate climates are affected by hay fever and seasonal asthma. Ryegrass is used in turfs, lawns and pastures across the country. Australian scientists have identified the genes responsible for producing the protein in the pollen which causes the allergic reaction and have switched them off. The result is **low-allergy** ryegrass plants to reduce the incidence of hay fever.

Specific benefits in relation to the research mentioned above include:

- Overall, improving forage quality has the potential to provide a $320 million benefit to Australia's grazing industries if high quality grass is used to replace supplements currently used.

- High digestibility (that is, modified lignin content and composition) perennial ryegrass has the potential to increase milk production by 25 per cent.

- Perennial ryegrass with increased water-soluble carbohydrates may increase lamb production per hectare by 23 per cent.

- Hypoallergenic ryegrass has the potential to save Australia $86 million through reduced hay-fever and asthma incidences.

None of these projects have reached the field trial stage in Australia, although field trials of the low-allergen ryegrass are currently taking place in the USA. Upon completion of the USA study and an Australian study of gene flow using non-GM ryegrass, it is expected that a field trial application to the OGTR will be made in 2008 for a ryegrass with both increased herbage qualities (high fructan and low lignin content) and allergy-free characteristics.

For more information: www.molecularplantbreeding.com and German.Spangenberg@dpi.vic.gov.au

- OTHER RESEARCH

By looking to genes in other native and exotic plants, researchers are also hoping to develop pasture varieties which deal better with stresses and adapt to factors such as drought, low soil fertility, cold and frost and saline and acid soils.

For example, thirty million tons of phosphorous fertiliser is applied yearly around the world, and Australian farmers alone spend up to $600 million each year. Despite this application, up to 80 per cent of phosphorous is lost. It is estimated that a $10 billion phosphorous "bank" exists in Australian soils. Researchers are investigating the potential of developing a **phosphorous efficient** white clover to extract some of the nutrient already existing in the soil.

Thirty three million hectares of Australian farmland are currently affected by highly acidic soils, at a cost of one billion dollars annually. An even greater land area is at risk from this problem in the future. Production losses occur when acidity increases to the point where toxic elements in the soil, such as aluminium dissolve. Researchers have successfully introduced an aluminium tolerance gene into white clover. **Aluminium-tolerant** perennial pastures will allow more effective management of acid soils because their deep roots, instead of shallow-rooted annuals, will reduce acidification rates by reducing nutrient leaching.

For more information: www.molecularplantbreeding.com, German.Spangenberg@dpi.vic.gov.au or www.csiro.au

Research into the development of **AMV-tolerant** medic cultivars has also been conducted in the past, however it did not progress to field trial studies.

For more information: Ray Rose, University of Newcastle Ray.Rose@newcastle.edu.au

ACROSS THE TASMAN
AgResearch is New Zealand's largest Crown Research Institute (CRI), and its vision is to be " the world's foremost pastoral sector R&D organisation." Examples of GM pasture research being undertaken by AgResearch, including those undertaken in partnership with Australian researchers are:

- THE RYEGRASS EFFORT
Ryegrass with a **healthier lipid profile** is being investigated by researchers in New Zealand and Australia. Early results indicate these healthy lipids are incorporated in meat and milk which means that this could result in health promoting long chain omega-3 polyunsaturated fatty acids entering the human diet through meat and dairy products.

Improved forage quality through a generic flowering switch is the aim of research underway to control flowering in ryegrass. Researchers have "switched off" key flowering genes in ryegrass and the resulting GM plants show delayed flowering. Switching off flowering allows the plant to focus its energy on growing.

Research into modifying ryegrass endophytes to improve **insect resistance** and **animal health** is also underway at DPI (Victoria) and AgResearch. An endophyte is a fungus that lives inside the plant and is transmitted only through seed. It benefits the plant through several ways, for example by providing increased insect resistance. It can however also negatively impact animal health. Through the identification of genes responsible for insecticidal/bioactive compounds and, biologically active secondary metabolites, scientists hope to develop new endophytes which protect grass against insect pests but reduce toxic effects on animals.

- MORE CLOVER
Overcoming the genetic control of leaf size, researchers have located a clover gene which when switched off results in enlarged leaves. This has the potential to **improve clover yield**. In the past, breeding for larger leaved clover has been associated with thicker stolons (horizontal stems) with reduced branching and this results in fewer growing points and a reduction in persistence under grazing. A provisional patent has been filed and this work will soon be published. Further research on plant structure is also underway.

Research to **reduce bloat** in clover has also been undertaken in New Zealand.

For more information: Chris Jones, AgResearch Chris.Jones@agresearch.co.nz or
German.Spangenberg@dpi.vic.gov.au

THE RESEARCHERS AND THE FUNDING PARTNERS
This Bulletin provides a brief snapshot of some of the pasture research underway in Australia and New Zealand. More information can be gained from the organisations listed below.

AgResearch New Zealand
www.agresearch.co.nz

Agriseeds New Zealand
www.agriseeds.co.nz

Australian Centre for Plant Functional Genomics
www.acpfg.com.au

CSIRO Plant Industry
www.pi.csiro.au

Dairy Australia Limited
www.dairyaustralia.com.au

Department of Innovation, Industry and Regional Development, Victoria
www.diird.vic.gov.au

Department of Primary Industries, Victoria
www.dpi.vic.gov.au

Gardiner Dairy Foundation
www.gardinerfoundation.com.au/

Heritage Seeds
www.heritageseeds.com.au

Meat & Livestock Australia
www.mla.com.au

Molecular Plant Breeding Cooperative Research Centre
www.molecularplantbreeding.com

Victorian Bioinformatics Consortium
www.vicbioinformatics.com/home.shtml

Wrightson Seeds
www.wrightson.co.nz/

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We look forward to your feedback on this newsletter.

For further information, please contact the AFAA office on (02) 6273 9535 or via email – info@afaa.com.au

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