

Project number: 5916

Funding source: Teagasc and the seed industry

Date: September, 2013

Project dates: Jan 2009 – Dec 2012

Designing forage grass and clover with enhanced value for animal production, sustainability and profitability



Key external stakeholders:

Grassland farmers, seed industry, advisors, agricultural consultants and researchers.

Practical implications for stakeholders:

- Breeding offers a low cost and successful means to improve the productivity and profitability of grass/clover based swards.
- Seven new perennial ryegrass varieties and one new white clover variety with greater genetic merit and improved agronomic characteristics over existing varieties were commercialised and released.
- Nineteen new perennial ryegrass varieties bred by Teagasc displayed exceptional performance in the Teagasc breeder's trials and were submitted to the official Recommended/National List trials in Ireland, UK and other countries for independent evaluation and consideration for addition to the Recommended List of Grass and Clover Varieties in the respective countries.
- Research into breeding methodology to improve genetic gain per unit time and cost determined the optimum breeding system for improving perennial ryegrass for Irish farm systems.

Main results:

Eight new Teagasc-bred varieties were commercialised and released. The new perennial ryegrass varieties were: Genesis (early diploid), Solomon (intermediate diploid), Giant (intermediate tetraploid), Carraig (intermediate tetraploid), Majestic (late diploid), Glenveagh (late diploid) and Kintyre (late tetraploid). The new white clover variety was Iona (medium leaf size). Research into the optimum breeding methodology for perennial ryegrass indicated that the optimum breeding system would include a mixture of genotypic recurrent selection, phenotypic recurrent selection and marker-assisted selection.

Opportunity / Benefit:

This project offers farmers new improved perennial ryegrass and white clover varieties of greater genetic merit and improved agronomic characteristics that when sown may increase the productivity, profitability and sustainability of Irish farm systems. A commercial agreement between Teagasc and the seed industry ensures the production and availability of seed for farmers.

Collaborating Institutions:

DLF-Trifolium
Goldcrop Ltd.
University of Wisconsin-Madison
Department of Agriculture, Food and the Marine (DAFM), Ireland
Agri-Food and Biosciences Institute (AFBI) Northern Ireland

Teagasc project team: Patrick Conaghan (PI)
External collaborators: Prof. Michael Casler (University of Wisconsin-Madison)
Dr. Klaus Nielsen (DLF-Trifolium)
Dr. Trevor Gilliland and Dr. Brian Waters (AFBI)
John Claffey and Dermot Grogan (DAFM)

1. Project background:

Over 90% of the agricultural area in Ireland is devoted to grassland which provides the main feed for our ruminant livestock. While sward composition, especially for old pastures, is often complex, perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens*) are predominantly the most desirable grass and legume species for grazing and the key components of the most productive pastures. Almost all forage grass and legume seed sown in Ireland is perennial ryegrass and white clover, respectively. Consequently, any improvement in these species has large potential benefit to the Irish agricultural economy.

Forage breeding is a technology that harnesses the creative power of selection. It is powerful, precise and predictable. Forage grass and clover have been subjected to very little formal breeding. Genetic variation within and among populations is still extremely high, showing no signs of decreasing. Breeding offers a low cost means of improving the profitability and productivity of perennial ryegrass.

The objective of this project was to develop and use methods that effectively select for the best phenotypes leading to the breeding of improved varieties of perennial ryegrass and white clover for Irish farm systems. The main emphasis was on improving variety performance under grazing. The primary traits for improvement were seasonal yield distribution, nutritional value, ground cover, persistency and disease resistance. World-wide propagation and marketing rights on all new varieties were offered to a commercial company ensuring the availability of new varieties to Irish farmers. This project continues, with modifications, the successful commercial forage breeding programme established at Teagasc, Oak Park, Carlow in the 1960s.

2. Questions addressed by the project:

- Can forage breeding produce improved varieties of perennial ryegrass and white clover?
- What level of genetic improvement in perennial ryegrass and white clover can be achieved through breeding?
- What is the optimum breeding system for perennial ryegrass improvement?

3. The experimental studies:

The breeding programme was based on (i) phenotypic recurrent selection involving the phenotypic evaluation of individual plants, (ii) genotypic recurrent selection involving the phenotypic evaluation of the progeny of an individual under evaluation and (iii) the production of synthetic varieties constructed by intercrossing a number of selected genotypes. The main emphasis was on improving variety performance under grazing. The primary traits for improvement in perennial ryegrass were seasonal yield distribution, nutritional value, ground cover, persistency and disease resistance. The primary traits for improvement in white clover were annual and seasonal yield distribution of clover and grass plus clover, and clover persistency.

The best varieties were submitted to the official Recommended/National List trials in Ireland, UK and other countries for independent evaluation. World-wide propagation and marketing rights on all new varieties were offered to a commercial company ensuring the availability of new varieties to Irish farmers.

A simulation study and literature review was also conducted to investigate the optimum breeding system for the improvement of perennial ryegrass.

4. Main results:

Nineteen new perennial ryegrass varieties bred by Teagasc displayed exceptional performance in the Teagasc breeder's trials and were submitted to the official Recommended/National List trials in Ireland, UK and other countries for independent evaluation and consideration for addition to the Recommended List of Grass and Clover Varieties in the respective countries.

Seven new perennial ryegrass varieties and one new white clover variety were commercialised and released. The new perennial ryegrass varieties were: Genesis (early diploid), Solomon (intermediate diploid), Giant (intermediate tetraploid), Carraig (intermediate tetraploid), Majestic (late diploid), Glenveagh (late diploid), Kintyre (late tetraploid). The new white clover variety was Iona (medium leaf size). The varieties were shown to offer improved yield, quality and persistence characteristics for grass-based production systems. The new perennial ryegrass varieties had on average 2.0 percentage units higher annual yield and 10.5 percentage units higher spring yield at time of release than comparable varieties of similar ploidy and maturity group. Variety details are summarised in Table 1 with full variety results from the Ireland Recommended List available at www.agriculture.gov.ie and the Northern Ireland Recommended List at www.afbini.gov.uk

Table 1: New Teagasc-bred varieties

Variety	Key characteristics	Recommended List
Genesis	<ul style="list-style-type: none"> • Early diploid perennial ryegrass • Exceptionally high spring growth • Very high silage yields 	Ireland, Northern Ireland, England, Wales, Scotland and Germany
Solomon	<ul style="list-style-type: none"> • Intermediate diploid perennial ryegrass • Remarkably high spring grazing yields • Outstanding silage production 	Ireland, Northern Ireland, England, Wales and Scotland
Giant	<ul style="list-style-type: none"> • Intermediate tetraploid perennial ryegrass • Excellent spring growth • Outstanding sward density 	Ireland and Germany
Carraig	<ul style="list-style-type: none"> • Intermediate tetraploid perennial ryegrass • Outstanding spring yields • Very high autumn growth 	Ireland
Majestic	<ul style="list-style-type: none"> • Late diploid perennial ryegrass • Excellent autumn yields • High sward density 	Ireland
Glenveagh	<ul style="list-style-type: none"> • Late diploid perennial ryegrass • Excellent autumn growth • Remarkably high ground cover 	Ireland, Northern Ireland and Scotland
Kintyre	<ul style="list-style-type: none"> • Late tetraploid perennial ryegrass • Outstanding annual yields • Excellent digestibility 	Ireland, Northern Ireland and Scotland
Iona	<ul style="list-style-type: none"> • Medium leaf white clover • Excellent clover yields • Good grazing persistency 	Ireland, Northern Ireland, England, Wales and Scotland

Research into the optimum breeding methodology for perennial ryegrass indicated that the optimum breeding system depends on the traits to be improved, and the resources and skills available. Careful consideration should be given to the expression of the trait under the management regime imposed in the breeding programme and under real-world sward conditions in the target region. Three distinct breeding systems may be applied: (i) phenotypic recurrent selection based on the phenotypic value of individuals, (ii) genotypic recurrent selection based on the phenotypic value of the progeny of an individual under evaluation and (iii) marker-assisted selection based on molecular (DNA) marker scores. Genotypic recurrent selection will be a necessary part of the breeding system if forage yield is a trait for improvement and may be practiced using full-sib or half-sib families, each with their own advantages/disadvantages. Phenotypic recurrent selection in tandem (i.e., within-family selection) or in succession with genotypic recurrent selection should be used to improve traits that have a high correlation between measurements on spaced plants and those on sward plots. Genome-wide selection represents the most interesting and exciting potential application of marker assisted selection.

In conclusion, the Teagasc forage breeding programme continues to (i) improve the methodology for breeding and evaluating perennial ryegrass, and (ii) develop new improved varieties of perennial ryegrass and white clover with greater genetic merit and improved agronomic characteristics than existing commercial varieties.

5. Opportunity/Benefit:

This project highlights the benefit of perennial ryegrass and white clover breeding to grassland agriculture and the large improvements in forage productivity that may be achieved through breeding. This project offers farmers new improved perennial ryegrass and white clover varieties of greater genetic merit that when sown may increase the productivity, profitability and sustainability of Irish farm systems. A commercial agreement between Teagasc and the seed industry ensures the production and availability of seed for farmers. Research conducted offers improved breeding methodology and insight for perennial ryegrass improvement that may increase the rate and reduce the cost of the genetic gain in perennial ryegrass breeding programmes.

6. Dissemination:

This information has been widely disseminated to grassland farmers via discussion groups, open days, farm walks, popular press and Teagasc publications. It will continue to be disseminated through Teagasc advisors at discussion groups. Full variety results have also been published in the Recommended List of Grass and Clover Varieties for Ireland, Northern Ireland, Scotland, England and Wales.

Main publications:

Conaghan, P. and Casler, M.D. 2010. Opportunities using new technologies: Marker-assisted selection. In: Grasses for the Future. Perennial Ryegrasses: Current and Future Genetic Potential (ed. M. O'Donovan and D. Hennessy), Teagasc, Cork, Ireland, pages 69–97.

Conaghan, P. and Casler, M.D. 2011. A theoretical and practical analysis of the optimum breeding system for perennial ryegrass. Irish Journal of Agricultural and Food Research 50: 47–63.

Recommended List of Grass and Clover Varieties for Ireland (DAFM; www.agriculture.gov.ie) Northern Ireland (AFBI; www.afbini.gov.uk) and England and Wales (NIAB; www.bspb.co.uk)

Popular publications:

Irish Farmers Journal
Farming Independent
Today's Farm

7. Compiled by: Patrick Conaghan
