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A review of perennial ryegrass variety evaluation in Ireland

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Official National List (NL) testing of perennial ryegrasses commenced in Ireland at the start of the 1970s with Northern Ireland (NI) having one site as part of the UK NL testing network, and the Republic of Ireland (ROI) using 5 sites. The different testing strategies adopted to achieve sufficient precision for regional Recommended Listing in ROI from a multi-site system and from a single-site system in NI were considered, including the test protocols, use of sequential sowings, timeframes and 'merit scores'. The precision with which varieties can be discriminated for yield potential was shown to decline at lower trial plot yields. Furthermore, reducing the number of data sets used for decision making was shown to increase the 'breeder's risk' of having an improved variety incorrectly rejected but not the 'tester's risk' of erroneously recommending a variety that was not a clear improvement, because statistical analysis expanded confidence limits. These variety lists initially assessed only yield and persistency, giving a progressive improvement in recommended varieties and despite high genotype-x-environment interaction effects was most clearly evident in spring productivity improvements. The lists have been highly influential in both jurisdictions as almost all agricultural grass seed sales were recommended in ROI or NI, but the overuse of late maturing varieties in the ROI market and declining reseeding levels across Ireland indicated the current limits of this influence. This, and increasing requirements from Irish farmers for improvement in the nutritive value of varieties to support greater dependence on grass for animal production, has led to increased testing for digestibility and other quality parameters. While there is valid scientific evidence that shows that improvements in perennial ryegrass varieties has increased milk and meat production, more detailed information is required to satisfy the specific needs of local farmers. Consequently, a research initiative has been instigated to develop an index that will incorporate all

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the yield, persistence and quality performances of each recommended variety into a ranking score for a specific herd management system. This guidance should simplify recommendations and better quantify variety improvements in financial terms. It is envisaged that this will encourage an increase in the renewal of Irish pastures, promote selection of varieties based on enterprise-specific value and will continue to enhance the profitability and sustainability of grass-dependent Irish farming as has been achieved since recommended lists were first introduced in Ireland.

Keywords: Ireland; perennial ryegrass; value for cultivation; variety evaluation

Introduction

Perennial ryegrass (*Lolium perenne* L.) is a widely used forage species in temperate regions of the world and particularly in Western Europe, where there is a valuable market for new varieties. There has been considerable breeding effort to create improved grasses of this species for Europe. Given the wide climatic range of growing conditions across the European market, selection criteria in grass breeding programmes need to be focussed on specific ecozones if breeding advances are to be achieved. The use of dormancy zones, based on Lucerne adaptation, has been found to be a useful means of classifying such regions (Long and Gilliland 2010). Ireland is within Zone 6, a maritime region that includes Britain and the coastal regions of north west France and Spain. There is ample evidence that ryegrass breeding programmes focused on this agri-environmental zone have achieved notable success in the past (Van Wijk and Reheul 1991; Wilkins and Humphreys 2003).

The climatic conditions in Ireland support a predominately grassland-dependent agribusiness. Grassland covers approximately 85% of the arable area of the island of Ireland and is by far the most important agricultural land use. The total grassland area in the island comprises 3.4 Mha in the Republic of Ireland (ROI) and 0.8 Mha in Northern Ireland (NI). A measure of the financial importance of grassland to these economies is that annual farm gate output from the ruminant sector was worth ca. €4 billion to ROI (CSO 2009) and ca. €0.7 billion to NI (DARD 2010). A breakdown of these headline figures to separate enterprise sectors shows annual outputs in ROI of €1.5 billion, €1.1 billion and €0.2 billion for beef, dairy and sheep, respectively. For NI the corresponding values were € 0.3 billion, € 0.35 billion and €0.05 billion (DARD 2010).

Given the dominant and valuable role of grassland-based production in Irish agriculture, improvement in grass varieties has the potential to make a major contribution to the economies of both ROI and NI. There are two government funded grass breeding programmes on the island of Ireland; at Teagasc, Oakpark, Co. Carlow in ROI and at the Agri-Food and Biosciences Institute (AFBI), Loughgall, Co. Armagh, NI. There are also a number of government funded institutes and private organisations providing research and development, tertiary education, demonstration and extension services to the ruminant sector. Both jurisdictions also have specialist facilities for variety evaluation and publish, annually, national and regional Recommended Lists (RL) of perennial ryegrass varieties. These play a vital role in support of the ruminant industry by identifying and promoting the use of new varieties with improved performance characteristics. Unlike cereals, assessment of variety value by farmers is virtually impossible, partly because most swards are sown as mixtures, but also because the end product is meat, milk or wool and many factors, other than the grass varieties used, can affect animal performance and mask the true contribution of the sward. This means that these specialist testing facilities are vital to the identification of new elite material and to ensuring that Irish farming businesses reap the benefits. The procedures and impacts of these grass variety evaluation programmes in Ireland are presented.

The history of grass variety evaluation in Ireland

Perennial ryegrass variety evaluation first started in NI in 1955 as an advisory function to local farmers. A formal variety testing programme did not commence until 1969 at Crossnacreevy, Co. Down, after the UK Plant Varieties and Seeds Act, 1965, made "Value for Cultivation and Use" (VCU) testing of agricultural species a statutory obligation. The AFBI facility at Crossnacreevy was one of the initial test centres in the UK National List (NL) for evaluation of perennial ryegrass varieties (Weddell, Gilliland and McVittie 1997), and trials are undertaken on behalf of the Department of Agriculture and Rural Development (DARD), NI. The best performing varieties in the UK NL trials undergo additional evaluation at the Crossnacreevy site to provide further data used for the NI RL. The first DARD RL was published in 1972 (Stewart and Camlin 1972); the list of perennial ryegrass varieties comprised 8 early, 6 intermediate and 8 late maturing varieties. These included varieties such as Gremie, Premo, Cropper, Abersytwyth S24, RvP Hay-Pasture, Barlenna, Perma, Melle and Aberystwyth S23, which would become market leaders.

In 1973, Ireland and the UK joined the EU, and statutory variety testing became a requirement under EU legislation (currently Council Directive 2002/53/EC; NI: S.I. 2001 No. 3510; ROI: S.I. No. 525/2002). Each member state was obliged to set up, on the basis of official growing trials, a NL of agricultural varieties for marketing within the state. Information from the NLs of the member states is collated to form the EU Common Catalogue of varieties. The Common Catalogue implemented the 'common market' concept by making it legally permissible to sell anywhere across the EU a variety that has been included on the NL of any member state. While this conformed to the ethos of the EU, surpassing the minimum requirements in one member state give no evidence of agronomic potential in another part of the EU where the climate is significantly different. For this reason, registration schemes and the RL trials of individual member states have largely remained the driving force for variety use within their territories.

The first VCU trials in ROI were established in 1973 at 5 locations and the first RL was published in 1976. This included 10 early, 4 intermediate and 9 late maturing varieties, including the varieties mentioned above, plus a number of Irish bred varieties, such as Oakpark and Fingal, that would later become market leaders. Varieties bred at Oak Park and Loughgall have continued to account for a significant proportion of the RL varieties; almost half of the recommended perennial ryegrass varieties on the current ROI and NI are from Irish breeders, about 20% from mainland UK, and the remainder from various EU breeders such as the Netherlands, Germany, Denmark and France. This is a significant shift from 15 years ago when these lists would have been dominated by varieties from Continental Europe.

Requirements for registration

To achieve NL status a candidate variety must show that it is "Distinct, Uniform and Stable" (DUS) and has VCU. The DUS test is concerned with intellectual property rights and, in essence, ensures that when a breeder produces a superior variety it is protected from plagiarism. The DUS tests of perennial ryegrass varieties submitted to the UK testing authority are carried out by AFBI at Crossnacreevy and, as this centre is an 'Entrusted Centre' of the EU Community Plant Varieties Office for ryegrass DUS testing, the centre also normally tests submissions to ROI testing authority, through bilateral agreement. Unless a variety is proven to be distinct from all other varieties in common knowledge, plus uniform and stable in its essential morphological characteristics, it cannot be marketed, regardless of its VCU performance. This ensures that breeders of existing elite varieties are protected and can earn a fair remuneration that can fund further breeding.

The VCU test involves assessment of agronomic value. In compliance with EU directives, member states are required to demonstrate that a new variety is a 'clear improvement' before it can be listed. Interpretation of 'clear improvement' differs from species to species and between testing authorities. The minimum requirement for inclusion on a NL is 2 years of field testing, but for long-term species, such as perennial ryegrass, assessment of value usually requires at least 2 sowings and 2 to 3 harvest years following a summer/autumn sowing. Recommended List testing is regionally based and is not under statutory or EU regulation and so test periods, procedures and entry standards vary greatly between member states. In some cases RL tests are integral to NL testing schemes, as is the case in ROI, where ryegrass NL and RL testing are carried out simultaneously. This allows RL trials to be designed to assess the specific agronomic requirements for the climatic conditions of the particular region. Typically they are run over a longer period and at more sites than required for National Listing. It is these more specific local performance data that affect farmers' choice and breeders strategies in developing varieties for a regional market, though market size can also greatly influence breeders priorities (Long and Gilliland 2010).

Ryegrass testing procedures in Ireland

As the jurisdictions of ROI and NI are able to interpret the EU regulation to best suit their environmental conditions and farming practices, there are both similarities and differences between the two schemes. In ROI, applications to DAFF (Department of Agriculture, Fisheries and Food) for inclusion in combined NL/RL trials are invited from breeders and their agents in the year prior to sowing. The UK NL system provides the preliminary screen of new perennial ryegrass varieties for the RL testing programme in NI, and so submissions are initially made to the coordinating offices of the Food and Environment Research Agency (FERA) of the Department for Environment, Food and Rural Affairs, in Cambridge, England (www.fera.defra.gov.uk/).

The DAFF, having relatively more climatic diversity to take account of, has a multi-site system, similar to that used in the UK NL system. Initially (the 1970s) this involved sites at Backweston, Co. Kildare, Ballyhaise, Co. Cavan, Clonakilty, Co. Cork, Athenry, Co. Galway, and Oak

Park, Carlow. The Oak Park site was discontinued during the 1980s, and the Cork site was moved to Ballinacurra in 1996, and then to Fermoy in 2003. In 2000 the Ballyhaise site was replaced by a site at Raphoe, Co. Donegal and a fifth location was established at Piltown, Co. Kilkenny (Table 1). Candidate varieties are included in trials sown in 2 successive years and this produces a joint NL/RL recommendation 4 years after the variety was submitted for testing.

The DARD RL, produced by AFBI, serves a much less diverse ecozone than the DAFF programme and so utilizes a single site at Crossnacreevy, Co. Down (Table 1), but implements a sequential sowing system and a phased level of recommendation (Table 2). Varieties initially enter through the UK NL network, which yields a multi-site informed listing decision 4 years after submission. The three additional RL sowings (only at Crossnacreevy) provide a sufficient sample of growing seasons to take account of variations in growing conditions, and allow confident and reliable recommendations. Since the early 1980s the plots from these additional RL sowings have been grazed by suckler cows in the first year to directly assess the response of the varieties to grazing pressure. The first provisional recommendation for NI is produced 1 year after the UK NL decision, followed by an upgrading through an ascending order of recommendation classes termed 'Plain Type' and then 'Bold Type'. If the variety is sufficiently high performing it is upgraded to the highest 'Bold Type' classification, almost 8 years after the initial submission.

Both DAFF and AFBI establish variety trials by broadcasting seed, as this is common practice on farms. DAFF sow 11.4 m^2 plots at seed rates of 30 kg/ha for diploids and 40 kg/ha for tetraploids and apply 350 kg/ha N annually under their General Purpose cutting protocol. All plots are sprayed with appropriate broad-leaved herbicides during the establishment year, and, where possible, annual meadow grass is also controlled. The plots used in NI are 7.5 m^2 and seeding rates are 25 and 37 kg/ha for diploid and tetraploid varieties, respectively. Fertilizer N is applied annually at 360 kg/ha for simulated grazing management trials and 375 kg/ha for conservation management trials (FERA 2010). Applications of P, K and S are as indicated by annual soil analysis to meet growth requirements but to avoid contamination of waterways, as indicated by Tunney, Foy and Carton (1998). These fertilizer rates are intended to simulate intensive grassland use. For example, a cow with N consumption of 547 g/day will excrete 70% (383 g/day), and at a stocking rate of 4 cows per hectare on a 24-day grazing cycle creates a total annual deposition potential of around 295 kg/ha. The rest of the N applied in these trials is to represent typical inorganic fertilizer use on intensive farms.

Herbage is harvested using a Haldrup plot harvester at cutting heights of between 5 and 8 cm for 'simulated grazing', 'general

Table 1. Site details of Cultivar Evaluation Trials for perennial ryegrass in Ireland 2010

Site	Geographic coordinates	Altitude (m)	Soil type	Organic matter (g/kg)	pH
Athenry	53°18′N 8°45′W	35	Peaty loam	79	7.1
Backweston	53°22′N 6°30′W	50	Clay loam	63	7.2
Crossnacreevy	54°32′N 5°52′W	90	Medium loam	65	6.5
Fermoy	52°08′N 8°17′W	53	Medium loam	59	5.8
Piltown	52°21′N 7°20′W	15	Clay loam	49	5.5
Raphoe	54°52′N 7°36′W	65	Medium loam	62	5.6

Table 2. Summary[†] of Recommended List testing schedules undertaken by AFBI in Northern Ireland and DAFF in Republic of Ireland

Agency	Harvest year							
	0	1	2	3	4	5	6	7
AFBI								
	Sow I NL	(H1 C)	H2 SG	H3 C				
		Sow II NL	(H1 C)	H2 SG	H3 C			
			Sow III RL	Graze	H2 SG	H3 C		
				Sow IV RL	Graze	H2 SG	H3 C	
					Sow V RL	Graze	H2 SG	H3 C
					NL	RL (Prov)	RL (plain)	RL (bold)
DAFF								
	Sow I NL/RL	H1 GP	H2 GP					
		Sow II NL/RL	H1 GP	H2 GP	NL/RL (Subject to seed availability)			

[†]Key:

Sow I-V	Trial sowing series
NL	National List
RL	Recommended List
Hn	Harvest year (n =1…7)
C	Conservation management (5 cuts)
SG	Simulated grazing (frequent cutting) management
GP	General purpose management (6 cuts, 2 silage + 4)
Graze	Grazed with cattle
(H1 C)	Not used for DARD RL

AFBI Recommendation Classes:

RL(prov)	Provisional Recommendation
RL(plain)	Plain Type Recommendation
RL(bold)	Bold Type Recommendation

purpose' and 'conservation' managements. Total plot yield is recorded and a subsample (300 to 400 g, depending on management system) is oven-dried at 80 °C for 16 h to determine dry matter (DM) yield (FERA 2010; DAFF 2010). Ground cover score, on a 0 to 9 scale, is recorded by visual assessment at the end of each year, and heading date is recorded for single plants sown separately.

Changes in evaluation priorities

After World War II most available varieties, such as Irish Commercial, were low yielding, early heading, and lacking in persistency (Camlin 1997). The main effort of grass breeders from then until the 1980s was, therefore, to improve the yield and persistency. Evaluation procedures reflected this with the emphasis on yield, particularly under conservation management (i.e., 4 to 5 cuts per annum). Rapid progress was made in total yield and ground cover/persistency until the 1980s when the introduction of milk production quotas altered farmers' requirements. From then on a wider seasonal distribution of yield (i.e., more growth in spring and autumn), and improved digestibility became more important.

Values for spring growth were included on the DAFF RL for the first time in 1995, followed by autumn growth in 1999 when DAFF protocols were changed to a 6-cut 'general purpose' management; a spring cut was taken in early April followed by 2 silage cuts, and 3 cuts over late summer/autumn. Similarly for the NI RL, although there had always been a simulated grazing management that produced spring yields, it was not until 2001 that a full seasonal yield pattern of varieties was published.

Since 2003, all harvested samples from one location in ROI, Backweston, have been analysed by Near Infrared Spectroscopy (NIRS). This technology potentially offers a rapid and cost-effective means of measuring different nutritional value indicators such as water soluble carbohydrate, crude protein, digestibility, fatty acids and their precursors, and has the potential to help focus future breeding improvement on enhancing animal performance at grass, rather than simply increasing the amount of grass produced. This, however, brings both the advantage of specific nutritional assessment of varieties, but also a potential burden on breeders, if too many diverse requirements are demanded of new varieties. Initially, priorities are focused on improving dry matter digestibility and water soluble carbohydrate concentration. To this end DAFF have included these traits in the RLs since 2009.

Trial precision

Results of the variety trials are assessed by analysis of variance, using the Agrobase software package in the case of DAFF, or through a fitted-constant procedure (AFBI). Results are collated from all harvest years (and sites, DAFF), and candidate varieties are compared to commercial control varieties of the appropriate ploidy level.

The coefficient of variation and mean yield from all DAFF trials from 2007 to 2009 (all cuts from all sites) are presented in Figure 1. The data show that precision declines as plot DM yield falls below 2 t/ha. Even when the yield was higher there was a wide range in the precision among trials of similar productivity, such that only 41% of the scatter is explained by the fitted curve. This clearly demonstrates the difficulty in establishing the rank of grass genotypes due to large genotype × environment (G×E) interaction for productivity (Talbot 1984; Jafari, Connolly and Walsh 2003). This was further confirmed, in the case of the DAFF perennial ryegrass variety trials, by Conaghan *et al*. (2008) who determined the nature and relative magnitude of G×E interactions from 6 sites harvested over the period 2000 to 2004. The effects of microclimate, fertility, year of sowing, year of harvest

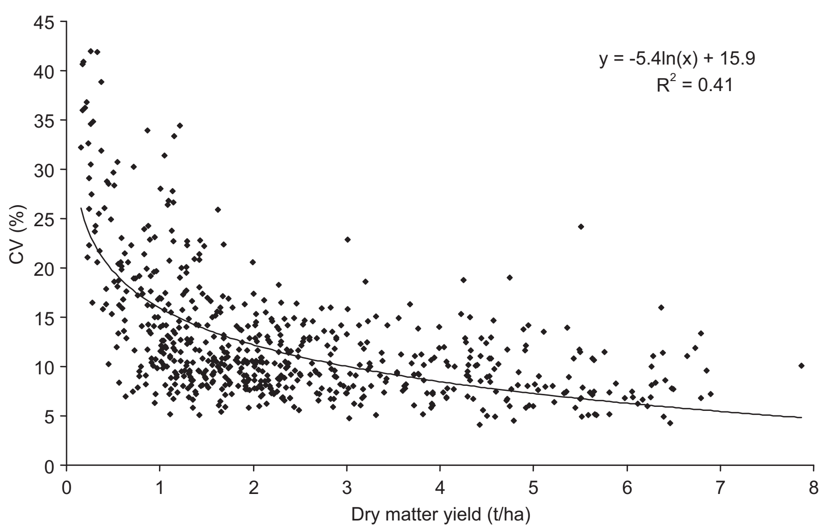


Figure 1. Relationship between dry matter yield (x) and coefficient of variation (y), for 629 perennial ryegrass harvests in DAFF trials (data from 2007 to 2009; all cuts, all sites).

and plot management (including cutting protocol) are all regarded as significant factors determining relative performance of grass varieties in evaluation trials. Figure 1 also shows how the precision of the trials declines with lower yield, which require more replication and/or sites to retain the same degree of precision in variety comparisons.

In ROI a 'merit score' is assigned where various traits are given relative weightings (for example spring growth is given a greater weighting than mid-season or autumn yield). An equivalent merit system is used in the UK and NI. Any candidate with a superior performance compared to a group of control varieties will achieve a positive VCU 'merit score' and will be included in the next RL, provided sufficient seed will be made available to farmers.

The current DAFF and DARD trial arrangement of multiple locations or multiple sowings, respectively, is designed to achieve the necessary level of precision outlined by Talbot (1984). As these testing schemes apply a merit threshold that is dependent on trial precision, reduced precision due to fewer trials increases the 'breeder's risk', not the 'tester's risk'. The principles of this are explained in Figure 2 in which the relationship between the measured performance response and the pass/fail merit score is shown. In this example a merit score of +2 represents a 'Clear Improvement' sufficient to award a listing (pass) and -2 represents a 'Clear Weakness' that would normally result in a refusal to list (fail). Varieties falling between +2 and -2 would normally also fail unless additional evidence is available to show an improvement in characteristics that would sufficiently improve

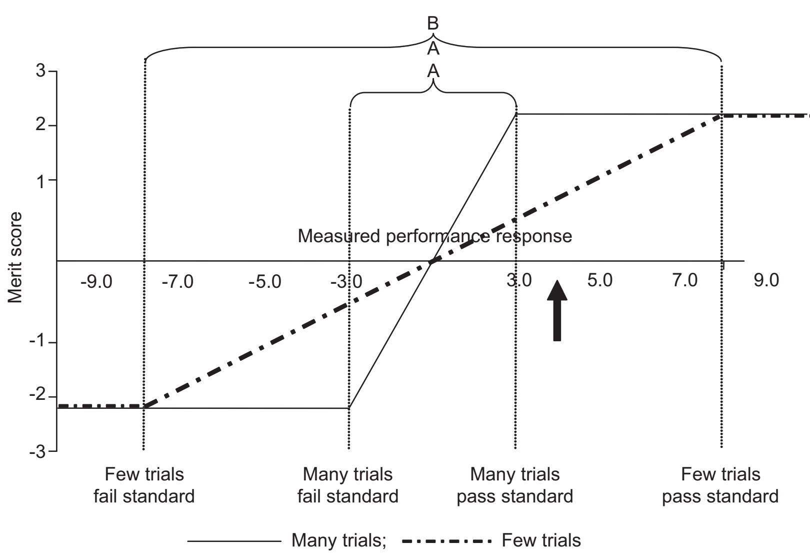


Figure 2. Consequence of reduced precision on pass/fail decisions in perennial ryegrass evaluation trials (A=Width of confidence limits with many trials; B=Width of confidence limits with few trials). The black arrow highlights case where a variety with measured response of '4.0' fails to reach the +2 pass standard when 'few trials' are involved but passes in a testing scheme with 'many trials'.

the overall agronomic value of the variety to compensate for a merit score of less than +2. Typical characters would be pathogen or pest resistance, enhanced climatic tolerance or increased nutritive value.

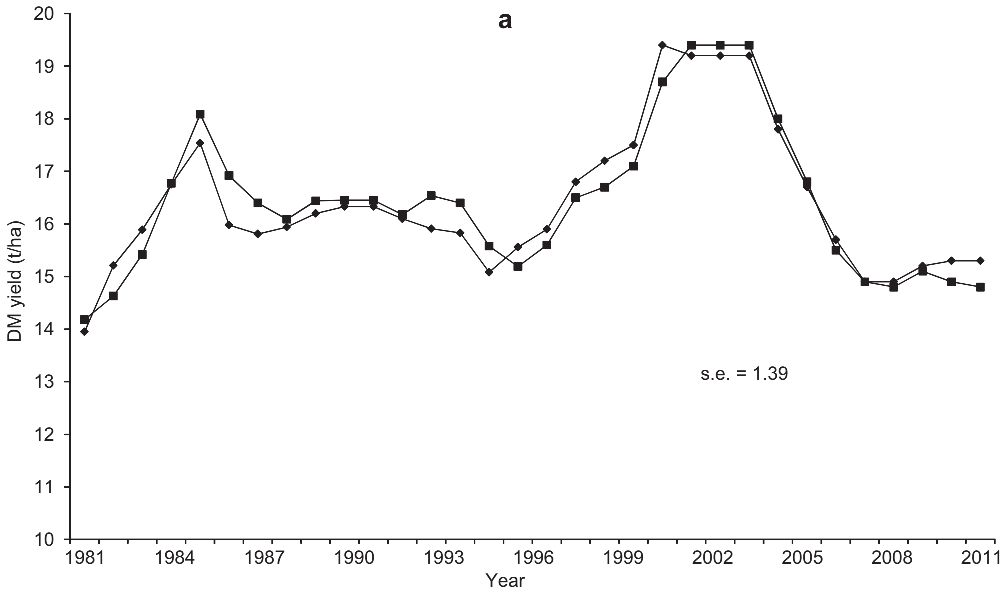
As shown in Figure 2, when there are many trials, and confidence limits are narrow, the slope of the graph is steep, but when there are few trials, and confidence limits are wide, the slope is gradual. This means that to achieve the +2 score with few trials requires a measured response of 9.0 (e.g., t/ha DM), but only 3.0 (e.g., t/ha DM) when there are many trials. The black arrow in Figure 2 indicates that a variety with a measured response of 4.0 fails to reach the +2 standard when 'few trials' are involved but is passed by a testing scheme with 'many trials'. The same pattern applies for a clear weakness, so giving fewer clear failures (<-2). So the breeder's risk of having an improved variety refused increases, but the tester's risk of recommending a variety that is not an improvement remains unchanged.

In specific terms, Talbot (1984) showed that, for the NL testing system in the UK, results from conservation management had a higher variance than those from simulated grazing. In calculating the resulting increase in LSD (10%), due to the reduced precision because of fewer trials, he showed that a perennial ryegrass variety with a true yield of 105% relative to the pass standard had a 1/25 chance of failing to achieve the NL pass standard if a 6-trial series was used, but a 1/10 chance of failing with 3 trials. This means that without sufficient precision, provided by an appropriate number of trial results, varieties with clear improvements may be falsely rejected. These valuable varieties would then be lost to Irish agriculture and an incorrect rejection of a breeder's achievements would have occurred.

Genetic gain and rate of introduction of new varieties

The presence of G×E interactions, e.g., involving annual climatic fluctuations, can mask the detection of progressive genetic gain that has been achieved over time. Examples of this are given in Figure 3. The annual control yields from RL in ROI (Figure 3a) appear to show an early rapid rise in yield, 1976 to 1984, followed by a period of decline to 1993. The subsequent rapid rise to 2002 appears to have been followed by another acute decline to 2010. A similar fluctuation pattern is also evident at the NI site (Figure 3b). Much of this fluctuation is due to climate, changes to cutting management and sites, and fertilizer regime. For example, in recent years compliance with the Nitrates Regulations (S.I. 610 of 2010) has resulted in reduced applied N in DAFF trials and brought second harvest-year yield down to an average of 14 to 15 t/ha DM. In addition, the DM yield across sites, in the same year, ranged from 18 t/ha (Fermoy) to 12.0 t/ha (Donegal) (Figure 4). Even when there have been no management or site changes and the control varieties are constant over time, background G×E variability in yield is still substantial.

Despite this, several workers have been able to make statistically valid estimates of genetic gain in perennial ryegrass. Current estimates for the increase in total DM yield due to the recommendation of improved varieties are of the order of 0.5% per annum (Chaves *et al*. 2009; Smit, Metzger and Ewart 2008; Gilliland and Gensollen 2010). This compares well with the generally accepted genetic gain of 1 to 1.5% per annum for cereals (Peltonen-Sainio and Karjalainen 1991; Silvey 1986; Öfversten, Jauhiainen and Kangas 2004). Furthermore, there have also



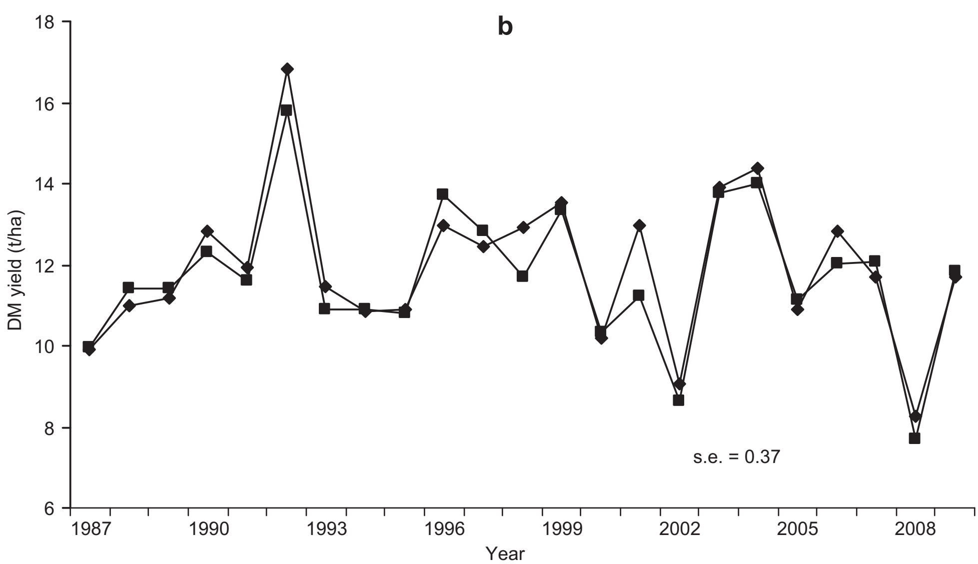


Figure 3. Average annual values for total dry matter (DM) yield of intermediate (—◆—) and late (—■—) perennial ryegrass control varieties used in Recommended List trials: a) DAFF 1976 to 2010, b) AFBI 1987 to 2009.

been improvements in grass nutritive value, be that digestibility, reduced secondary heading, increased water soluble carbohydrate concentration, or greater spring and autumn distribution of yield. Analysis of data on spring yield from DAFF trials shows improved spring yield performance, when the performance of the control varieties is compared, between 2005 and 2010 (Figure 5).

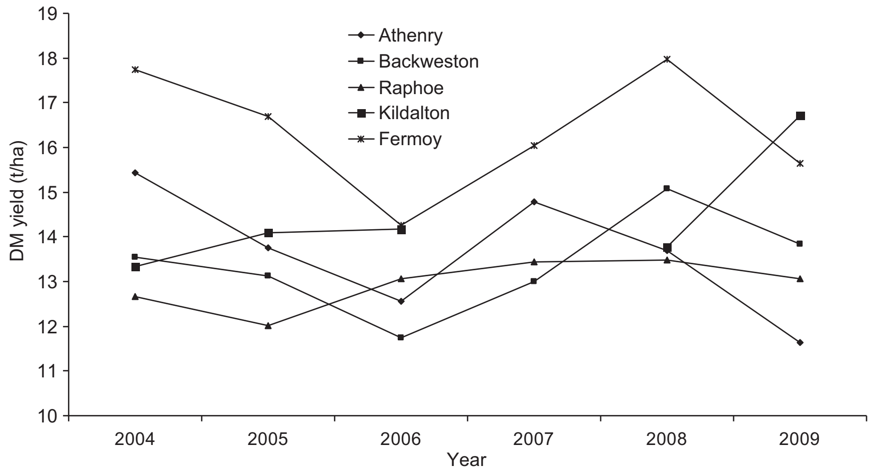


Figure 4. Average total dry matter (DM) yield at individual DAFF sites. Data comprises year-2 average yields from late maturing perennial ryegrass varieties (data from 2007 trial in Kildalton were not used).

Market impact of Irish recommended lists

Almost all varieties marketed to farmers in Ireland are on either the DAFF or DARD RL, and half the varieties are present on both lists. Gilliland, Johnston and Connolly (2007) showed, in a survey of the Northern Irish seed market, that variety choice was made primarily

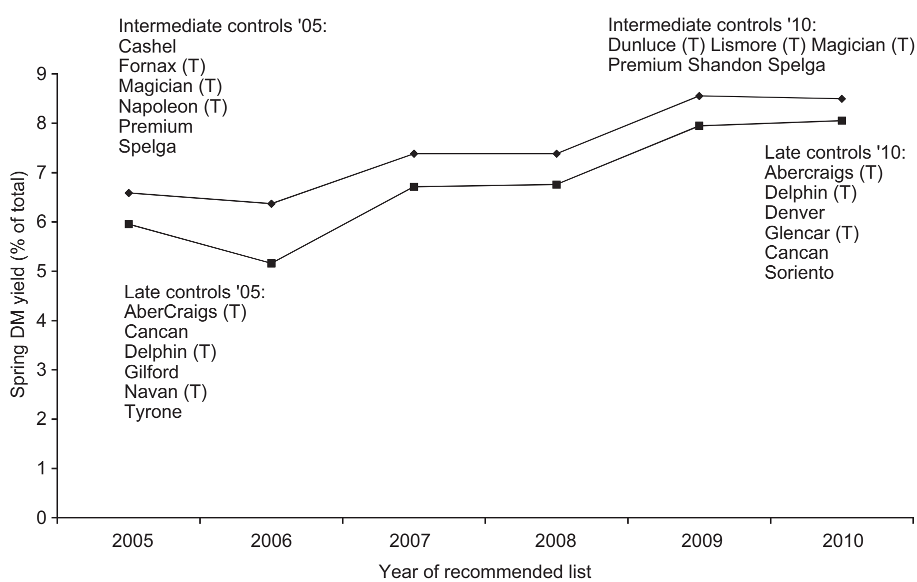


Figure 5. Spring dry matter (DM) yield of Intermediate and Late control varieties as a percentage of total annual DM yield, from DAFF trials for the period 2005 to 2010. Names, (T) = triploid, of the control varieties for 2005 and 2010 are shown.

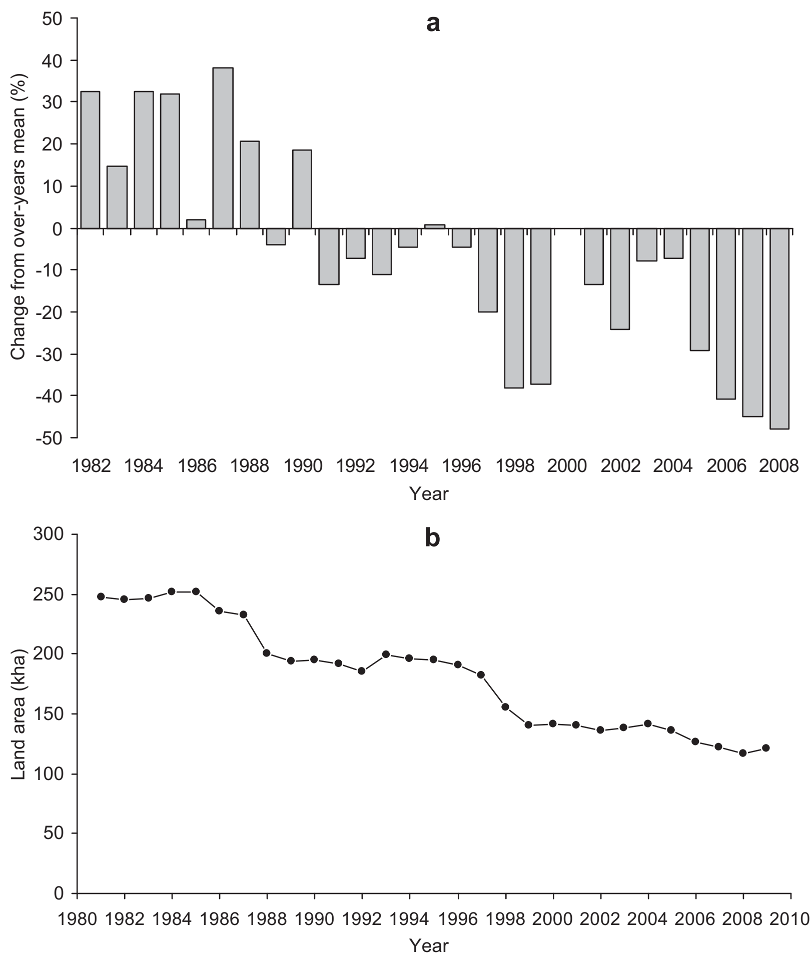


Figure 6. Change in reseeding activity in Northern Ireland: annual percentage change in a) volume of herbage seed sales and b) area of grassland under 5 years old (5-year rolling average).

on agronomic value, with the top varieties on the RL being used predominantly, and that only minor amounts of untested varieties were used. Culleton, Cullen and McCarthy (1992) provided similar evidence for ROI. These lists are, therefore, widely used. While this is undoubtedly an impressive success story, there are still significant issues of concern.

The key issue is the reduction in grassland reseeding activity in Ireland in recent decades. This is clearly demonstrated by the annual seed survey for NI, compiled at Crossnacreevy, which shows a substantial decline in reseeding since the 1980s (Figure 6a). This is also clearly reflected in the decline in the area of grassland under 5 years old in NI (Figure 6b), though the annual fluctuations appear smaller as these data are effectively five year rolling averages, whereas Figure 6a contains annual data.

Based on the certified seed import and usage statistics from DAFF (Figure 7),

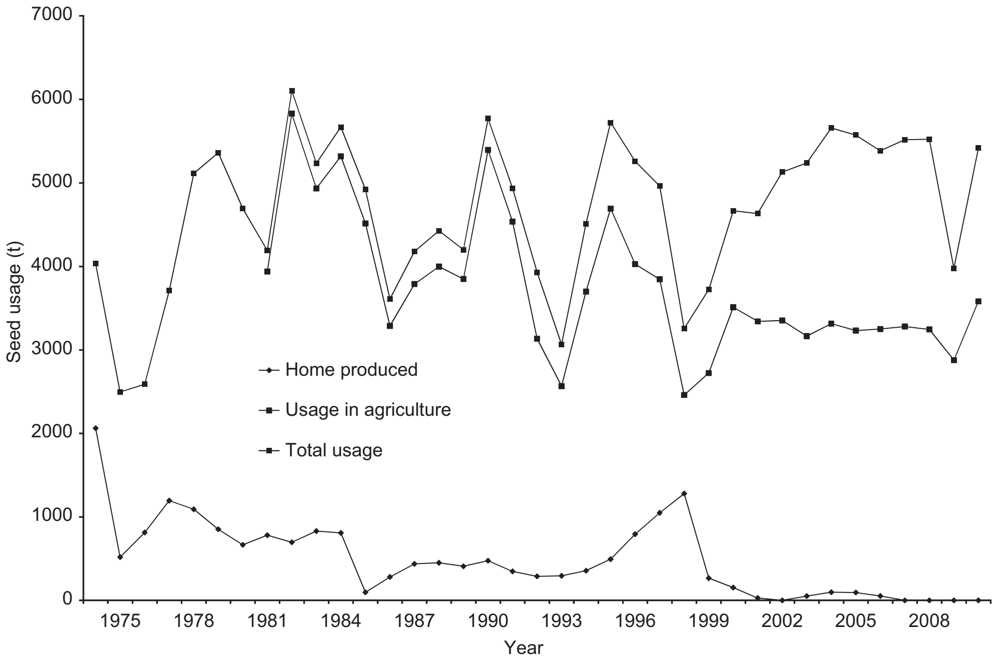


Figure 7. Republic of Ireland: annual certified grass and clover seed usage.

the level of grassland reseeding has also fallen in ROI since EU entry, and is now at approximately 2.4% of the total area devoted to pasture, hay and silage. Perennial ryegrass accounts for 95% of grass seed usage, and there is no longer any native production of seed (Culleton *et al*. 1992). In the last 10 years overall imports of grass seed to ROI increased to over 5,000 t, due mainly to a doubling of amenity grass seed imports. In the same period, however, agricultural varieties showed a continuing decline, falling below 3,000 t for the first time since the 1980s. Total seed demand in Ireland is less than 1% of total world production, and about 2.5% of EU production (ISF 2006). This common Irish profile shows a declining usage, which is partly driven by the removal of Government subsidies for reseeding as well as a consequence of declining farm incomes in the past two decades.

Changes in the proportion of the different maturity and ploidy groups used by farmers in Ireland are shown in Figure 8. The use of tetraploid varieties has risen steadily since 1981; from <20% in ROI to ca. 40% (Figure 8a) and from <10% in NI to ca. 30% (Figure 8b). Although the use of early maturing perennial ryegrasses was greater in NI than the ROI in 1981, the pattern of decline in this category is similar and it has now largely disappeared from commercial use in both markets. This has been attributed to a reduction in the price of later maturing varieties due to increased seed yield and an awareness, on farm, of problems with stemmy regrowth from the early maturing varieties (Gilliland *et al*. 2007). This decline has been replaced in NI by intermediate (heading date from 15 to 31 May) and late maturing (after 1 June) varieties in broadly similar amounts. In contrast, the

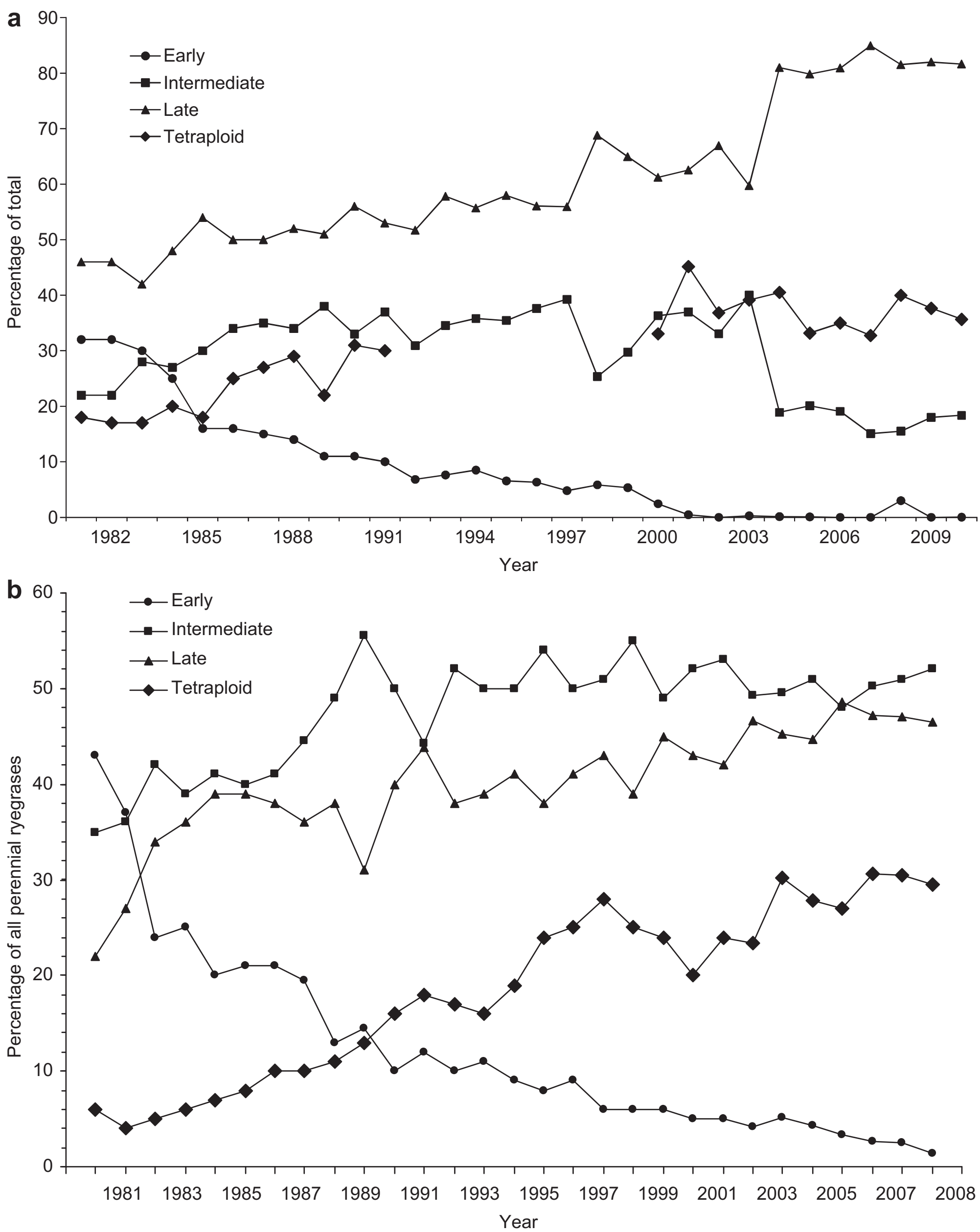


Figure 8. The proportion of total perennial ryegrass used annually represented by different maturity and ploidy types for: a) Republic of Ireland (ploidy details from 1992 to 1999 not available), b) Northern Ireland.

ROI market for late maturing perennial ryegrass varieties was the largest category in 1981, and has come to dominate the market, particularly in the past 10 years. This was not always the case as results from a survey in the mid 1960s showed that late maturing varieties accounted for 2% of the ROI market rising to 18% by 1975 (Connolly 1975). It currently comprises 80% of the seed sown (DAFF 2010). Later-heading varieties are regarded as more suitable for mid-season grazing management, and are more persistent under intensive grazing (Gately 1984, Gowen *et al.* 2003). This carries through to such an extent that if a variety is categorized as an intermediate, then its market share is massively depressed. This is despite the fact that the 'Early', 'Intermediate' and 'Late' categories are not truly different types. As shown in Figure 9, this is an artificial classification based on whether a variety heads before or after a reference variety. The only purpose of this demarcation is to separate varieties into similar heading-date range groups so that they can be easily managed in official evaluation trials. It is, therefore, an artificial segregation on a continuum such that a variety close to a delineating value may be only a few hours different in heading date from another variety in a different maturity class.

The declining reseeding activity and market resistance to certain varieties based purely on their maturity classification are two issues that must be addressed by the testing authorities if grassland agriculture in Ireland is to fully benefit from current perennial ryegrass breeding programmes.

Future developments and conclusions

By the early 2000s, a demand for varieties more suited to high-output intensive-grazing systems became evident in Ireland. An increasing number of early spring-

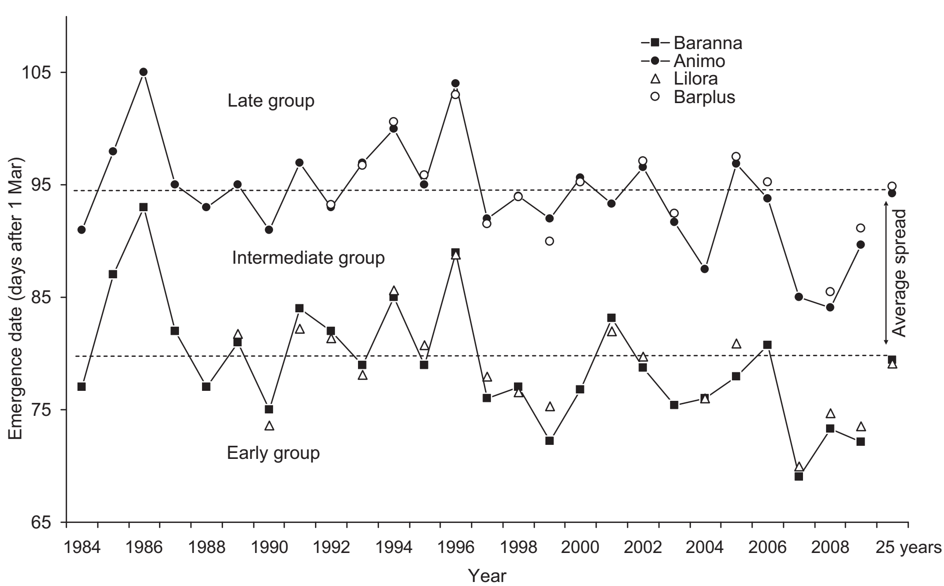


Figure 9. Annual flux in ear emergence date for the perennial ryegrass varieties used by DAFF to delineate the early, intermediate and late groups (the 25 year average is shown as the final data point).

calving herds of cows of high genetic merit has led to increased demand for early spring production of highly digestible grass, with less emphasis on silage production. Evidence of re-ranking of variety performance, under frequent cutting (simulated grazing) compared to conservation management protocols and to protocols involving animal-grazing, has been widely reported (Reed 1994, Smit *et al*. 2005, O'Donovan and Delaby 2005). Consequently, DAFF, DARD and Teagasc established a four 4-year study in 2007 to compare various cutting and animal-grazing protocols. The objective is to develop a means of bringing all the attributes of grass varieties into a unified assessment of animal value, and to develop an index or merit ranking for each recommended variety that can be tailored to a specified herd management.

To date, the authorities in ROI and NI have successfully promoted adoption of perennial ryegrasses with improved yield and persistence and are now publishing results on nutritive value, mainly in terms of digestibility. The annual turnover in varieties on the RLs has provided a progressive improvement in the capability of Ireland's managed grasslands. This has been largely because the size and design of the testing programmes have given sufficient precision to reliably identify the few elite genotypes from among the many candidate varieties that are tested. As input costs to the ruminant sector have risen, so the value of home grown herbage to the farm business has increased and as a consequence, farmers are seeking grasses that supply a greater proportion of the total nutritional requirements throughout the growing season. The introduction in 2010 of a frequent cutting (i.e., simulated grazing) protocol to ROI trials will help identify such material.

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