Amenity Grass Breeding at IBERS

Turfgrass breeding has been going on in Aberystwyth since the early 1970s and has benefited from the basic and strategic grass genetics research experience at IGER that stretches back to the 1930s. A perennial ryegrass breeding programme was initiated in 1987, funded by British Seed Houses Ltd, to exploit specific aspects of this research. Fine-leaved fescue and bent grass breeding programmes were re-launched in 1997.

Turf Benefits

Turfgrass is an important if unobtrusive part of our lives with functional (erosion control; reduction of glare, noise, heat build up and air pollutants; stabilising dust and soil), recreational (sport and leisure) and aesthetic/psychological benefits. It should remain integral to modern day living. But what makes a good turf and what are the recent developments in turfgrass breeding at IGER?

The annual Ian Rush tournament held at the University of Wales Aberystwyth sports fields at Blaendolau

A top class sports stadium - Sunderland F.C.'s Stadium of Light

The croquet lawn at Plas Gogerddan

Aberystwyth Golf Club

Why Grass

The grass family is one of the largest and most successful flowering plant families on earth consisting of around 10 000 species. Grasses are adapted to most habitats from tropical rainforest, through arid desert to temperate prairies and steppe. Their success is largely due to farming - annual cereals and mainly perennial grasses used as forage for farm animals - without which most of the world's major grassland areas would rapidly return to scrub or even woodland through the processes of competition and succession towards a climax community.

Only a handful of grass species are used for turf in the UK and these are the very same species used for forage production. This is not surprising seeing that they are highly adapted to a cutting regime - be it by grazing animals or by mowing - by virtue of their growing points being protected close to ground level and sheathed by green leaves. Continuous cutting or grazing in fact encourages the development of a dense turf by inducing new shoot (tiller) growth. Some grass species also develop rhizomes or stolons which further aids turf formation.

'Grasses' by J.C.E.Hubbard,
the definitive publication on grass species

Which Speciec?

Perennial ryegrass (*Lolium perenne*) is the most commonly used species for turf in the UK. Its advantages are that it is quick to establish, withstands heavy wear and traffic and the newest varieties also produce very acceptable lawns even when mown as low as 8mm. It responds well to fertiliser applications and ousts other species from the sward. It develops solely by tiller production so does not spread where it is not wanted.

For a finer textured turf, red fescues (*Festuca rubra*) are used in conjunction with browntop bent (*Agrostis capillaris*) in a 5:1 to 10:1 ratio by seed weight. This mixture mimics the cohabitation found in natural acid grassland communities. Although fine in texture and tolerant of very close mowing this turf is not particularly wear tolerant. The fescues are especially tolerant of low fertility and, because of their inrolled leaves, are drought tolerant. Three sub species of red fescue are commonly used; Chewings fescue, like ryegrass does not spread but Slender and Strong Creeping Red fescues produce underground rhizomes to expand into uncolonised areas.

Related to the red fescues, sheeps and hard fescues (*F. ovina* and *F. longifolia*) are also used. Although not producing as dense a sward, they are even better adapted to low maintenance situations where fertility and moisture levels are low.

Smooth-stalked meadow grass (*Poa pratensis*) is extensively used in North America and increasingly in the UK in mixtures with ryegrass. It is slower to establish, intolerant of wet conditions and current varieties are susceptible to rust diseases which, as well as looking unattractive, reduce turf quality.

Although a tenacious weed, mention should also be made of annual meadow grass (*Poa annua*) which often represents a substantial percentage of many turf areas especially where the mowing height is low (5mm or less). It is an incredibly successful species and is often the first coloniser of bare soil. It is commonly found in highly worn and poached areas where there is a degree of soil compaction. It seeds continuously throughout the year and creates a persistent seed bank in the soil. Despite these attributes its disadvantages are many - it has a poor yellowish colour, it is shallow rooting making it intolerant of dry conditions, it produces flowering heads which influence aesthetics and playing quality on greens, it is susceptible to disease and also produces a soggy spongy playing surface in the wet.

Which varieties?

The species above all naturally create a turf surface. But selecting the appropriate species is not the final step in deciding what kind of turf the landscaper and groundsman needs. If you were going to choose a rose for your garden, you wouldn't want just any Rose, you would go through the catalogues and choose the variety that most met your requirements in terms of flower colour, plant habit, mildew and black spot resistance and so on. The same applies for turf, there are large genetic differences between individuals or populations within a species in the expression of primary turf characteristics. The main turf characteristics are: shoot density, wear tolerance, leaf fineness, persistence, tolerance of close mowing, slow vertical growth, colour and disease resistance.

Finished varieties undergo statutory testing to achieve National listing. This establishes that a new variety; is Distinct from other varieties of the same species, is Uniform within the variety, and is genetically stable across generations. National Listing ensures that a variety can be legally sold in the UK (and Europe).

Further independent testing is carried out for the turf recommended lists at the Sports Turf Research Institute, Bingley West Yorkshire. This is to establish a turf variety's suitability for a specific purpose, for example winter sports pitches, close mown greens and lawns and summer sports. http://www.stri.co.uk/

Natural variation

Plant breeders use the natural environment to select plants with the appropriate characteristics. Habitats such as woodlands, sand dunes, isolated hilltops, heavily grazed or trampled areas or even natural grasslands used for sport have been exposed to environmental selection pressures favouring genetically suitable material. Much of this naturally occurring variation is maintained in IGER's genebank held by our Genetic Resources Unit which breeders throughout the world can access.

Through controlled hybridisation and selection of plants possessing the appropriate character components, performance can be further improved and characteristics combined. For example, consider the huge progress in turf performance that has been made since the mud baths of winter games pitches in the 60s and 70s.

Left: Grass plants established individually to allow identification and selection of elite genotypes

Right: Controlled hybridisation of two individual grass plants. Wrapping the stems in cotton wool protects them from damage. Placing the inflores-cences in a bag prevents contamination by other pollen.

Left: The bag is shaken each day to help pollen dispersal, and after allowing the seed to mature the cross can be harvested, thus allowing the seed to be sown and another cycle of evaluation and selection to take place

Stress tolerance

One of the major goals of the plant breeder is to produce varieties that are adapted to specific environments so that they not only perform well under optimum conditions but also tolerate sub-optimal stresses of one kind or another.

Extreme examples are the breeding of the metal tolerant browntop bent, 'Parys Mountain' (Copper) and 'Goginan' (Lead and Zinc) or the salt tolerant slender creeping red fescue, 'Merlin'. These varieties were selected under the specific edaphic stresses, which, by natural selection, quickly evolved tolerant strains for use in land reclamation projects.

Parys Mountain copper mine, Ynys Mon, North Wales

Screening for drought tolerance

There is still much within species variation to be identified and used but it should also be possible to acquire traits from other species; Tall and Meadow Fescues are particularly good sources of drought tolerance and winter hardiness and can be hybridised with ryegrass. By continually back-crossing the hybrids to the ryegrass parent and at the same time testing the progeny for tolerance to drought or cold it is possible to obtain ryegrass plants with the genes for drought tolerance

Sometimes a degree of serendipity is useful as was the case in the discovery of a naturally occurring mutant gene in meadow fescue which caused plants to stay green for longer. This gene has been introgressed into turf-type ryegrasses through several generations of conventional back-crossing to produce varieties which stay greener during drought and in the winter months when grass growth slows down and, normally, the proportion of yellowing leaves is increased.

Senescing grass leaves taken from a population

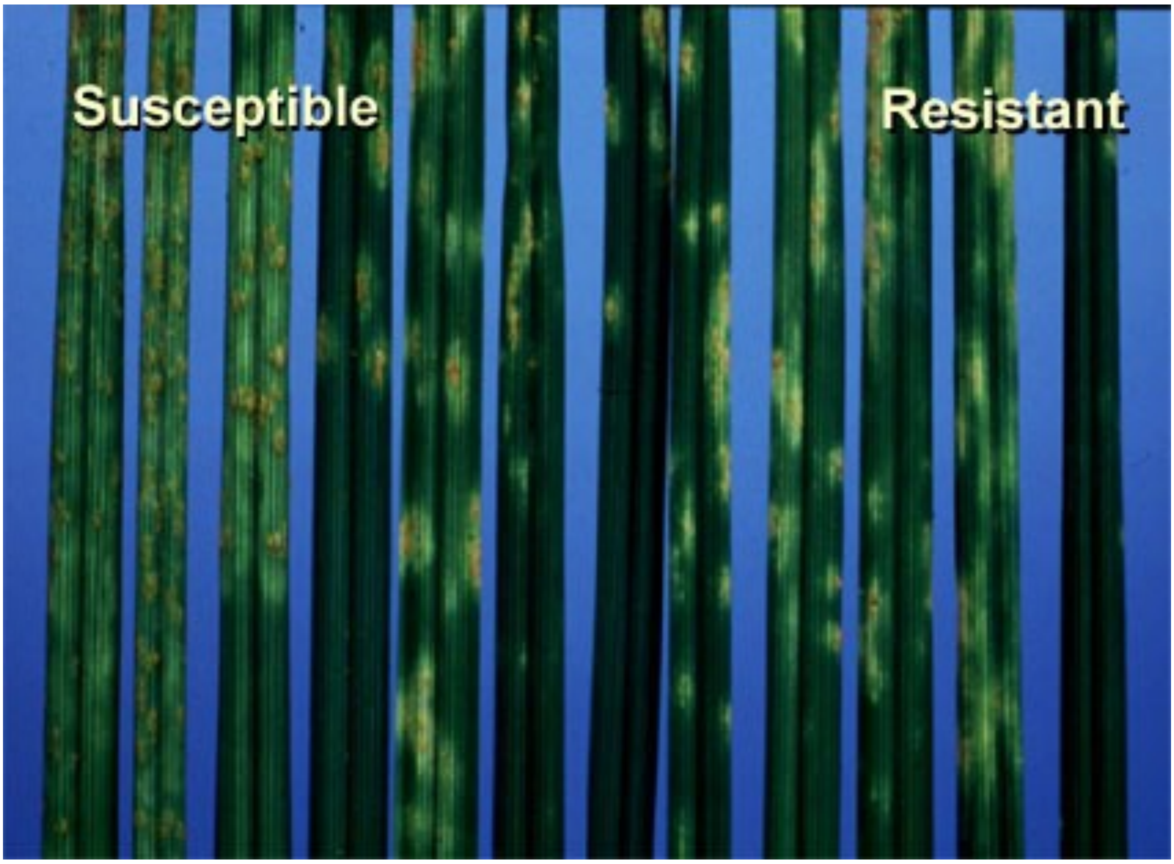
Right: *Turf plots of 'stay-green' and 'normal' ryegrass varieties*

Left: *Objective turf-grass colour measurement*

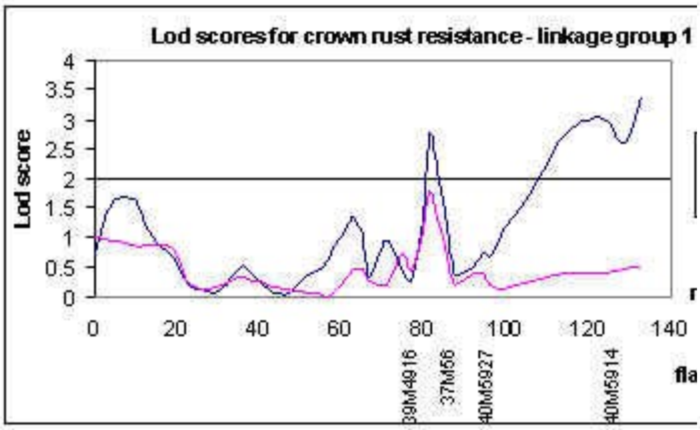
Breeding Technology

Breeding and selection programmes can often be rather complex but breeders are beginning to use new molecular biology techniques to unravel the genes responsible for particular traits thus enabling them to potentially streamline their selection procedures. In particular we have been investigating the genetic control of crown rust (*Puccinia coronata*) resistance in ryegrass. This is an important leaf spot disease in forage and turf ryegrass throughout the temperate world.

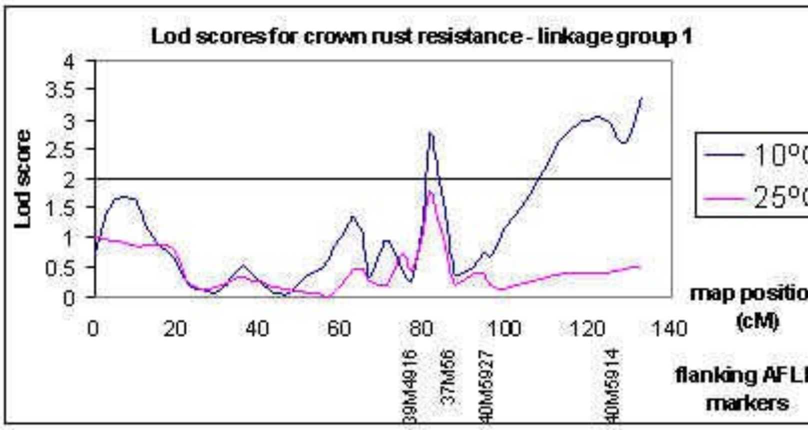
Responses of ryegrass leaves to artificial crown rust inoculation



We have been able to identify regions of the ryegrass genome mapped with DNA markers (mainly AFLPs and RFLPs and isoenzymes) which contain resistance genes (Thorogood et al, 1999). The following graphs show four separate genetic linkage groups for which crown rust resistance genes have been identified. A high LOD (log of the difference) score indicates the possibility of a gene or cluster of genes being associated with that region of the genome. Five such regions are indicated in the graphs. The presence of molecular markers in these same regions enable the possibility to select at the genotypic, rather than the phenotypic level, for rust resistance. By co-selecting markers from different regions we are able to ensure that several resistance genes, maybe with different modes of action, are incorporated into our breeding populations, for more durable resistance. Unfortunately, all of the resistance genes so far identified in our mapping population, although functional at 10ºC do not appear to work at 25ºC.



Linkage Group 1



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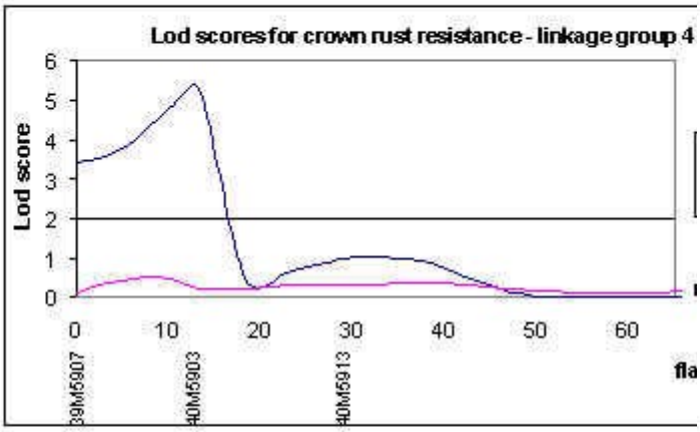

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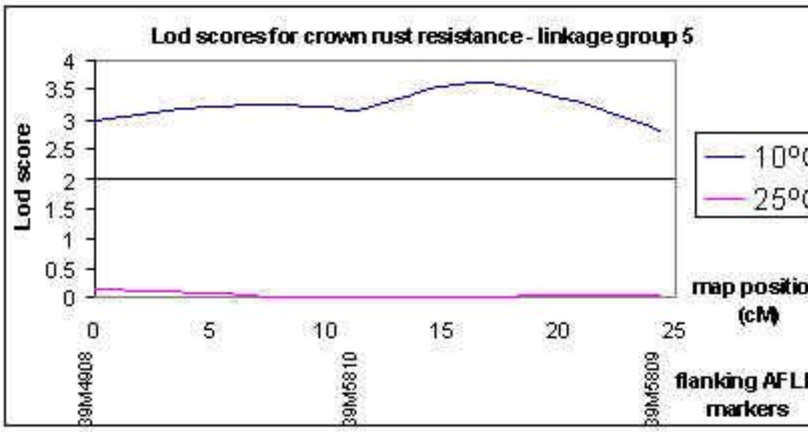
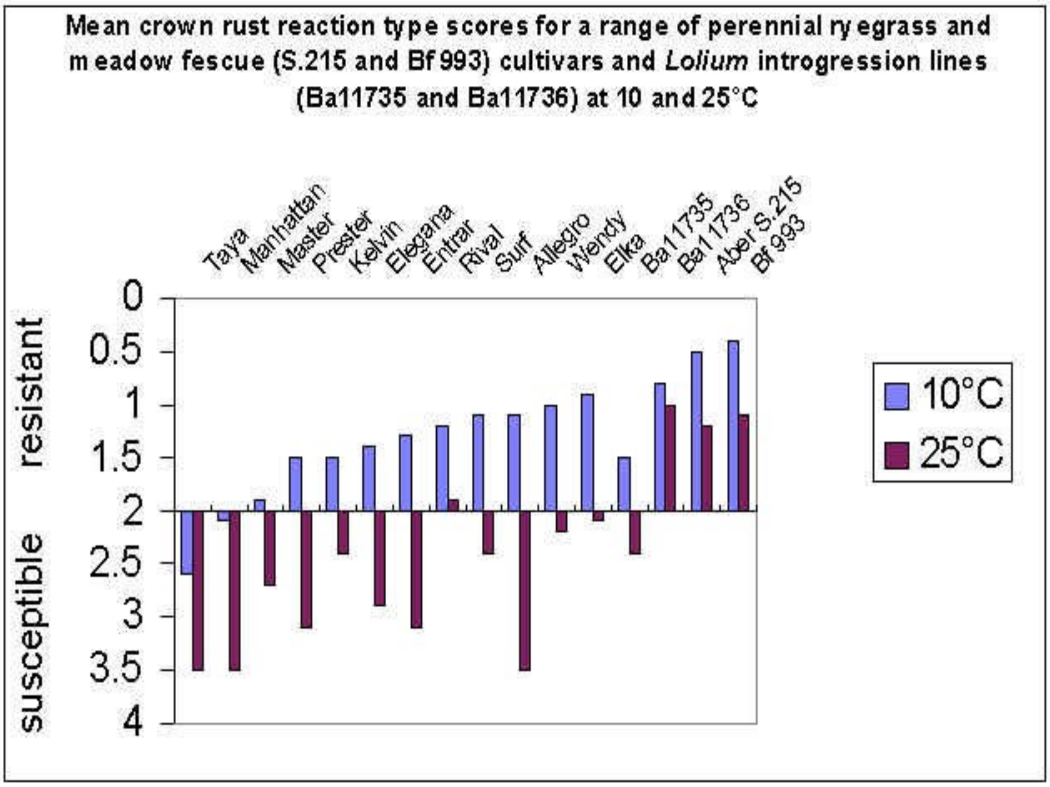


Linkage Group 5

Other sources of rust resistance have been identified in meadow fescue (Festuca pratensis) which, unlike much resistance so far characterised in ryegrass is insensitive to temperature being equally effective at preventing sporulation at 25ºC as at 10ºC. Meadow fescue resistance has successfully been transferred into turf ryegrass germplasm (Adomako et al, 1997, Roderick et al, 1999).



'New' species?

Looking through most grass seed catalogues it becomes clear that the choice of species for turf is limited to about six or seven. So what of all the other grass species of our heaths and downlands that are adapted to the particular stresses associated with turf? The potential is probably large and ‘new’ species are tentatively being added to the market place. For example, Tufted hair-grass *(Deschampsia caespitosa*), which is not a natural turf forming species but will produce a turf when cut regularly, is adapted to shade but as a consequence of this adaptation has rapid vertical growth and Crested hair-grass (*Koeleria cristata*) is tolerant of poor soils. These species are by no means perfect but breeding and selection effort could improve them.

The success of the grass family is indisputable, the range of different types both natural and artificially developed by plant breeders is immense. With informed decisions, turf should continue to be used to enhance our landscaped and sporting environments.