The potential for domestication and seed propagation of native New Zealand grasses for turf

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ABSTRACT

Although native grasses are now used widely in landscaping and gardens these are all vegetatively propagated and no native species are available as seed in anything more than a few grams. Yet each year in New Zealand more than 5000 tonne of grass seed is sown of species originating elsewhere. Few countries in the world have such an overwhelming imbalance of introduced species versus natives.

This raises the question as to why don't we use seed of native grass species? Surely some of our native grass species have potential to be harvested and used outside gardens. If we could domesticate seed of even one species for revegetation, turf or pasture use it could be a breakthrough.

This paper discusses the issues and difficulties involved in domesticating our native grass species as well as progress towards that goal.

INTRODUCTION

All our commercial turf (and pasture) grass species used in New Zealand are introduced from overseas, predominantly from Europe (browntop, chewings fescue and perennial ryegrass), although we do have a few species from Africa (kikuyu) and Asia (*Cynodon*). We sow no native grasses in New Zealand for pasture or turf, although we do use small amounts of native herbs *Cotula*, starweed (*Plantago* spp.) and others in bowling greens. By and large this is typical of the New Zealand economy, which is based almost entirely on exotic flora and fauna.

The seed propagated turf and pasture industry amounts to more than 5000 tonne of seed sown in New Zealand each year of exotic grasses with no contribution at all from native grasses. Yet the landscape and garden industry has been able to incorporate a significant proportion of natives into their industry.

Working from this basis it would be good to redress this serious imbalance by developing some native species where possible; indeed as New Zealanders we probably have some responsibility to do this.

BIODIVERSITY AND TURF

The concept of biodiversity and turf almost seems incompatible. Turf is judged on its uniformity, never on its biodiversity. Who wants a weedy lawn?

Yet we must move beyond this paradox and provide the urban turf world with biodiversity. This can be achieved at a number of levels.

Firstly, much turf in urban areas is not uniform and supports a considerable number of species. This would be true of much roadside turf with a range of exotic species, both sown and weedy. However, native species are probably rare in much of this turf, at least in Christchurch.

We could expand the range of species sown particularly of New Zealand native grasses as outlined in this paper.

The cultivars sown should incorporate as diverse a source of germplasm as possible, either in exotic or native species. Indeed in our turf breeding program, the only remaining one in New Zealand, we are hybridising between Mediterranean germplasm and finer European

[1] Editor's note: now merged as part of PGG Wrightson.

or North American turf types to both increase performance during winter and incorporate genetic diversity into cultivars (Stewart & Aberdeen 1997). Imported cultivars are frequently poorly adapted and are likely to be less diverse than such hybrids.

The biodiversity of turf also extends to fungal endophytes contained in the grass as these may seriously affect the biodiversity at other trophic levels such as the insect and bird fauna which are often reduced when endophyte is present (Clay & Shardl 2002; Bultman et al. 2003). Many of our exotic turf grasses such as ryegrass and fescues contain fungal endophytes. At least two native species are known to contain endophyte. However, endophyte is not present in the species outlined in this paper despite checking for them (Davis & Guy 2001; Rolston et al. 2002).

DOMESTICATION

For a species to be domesticated for turf or ground cover, it must not only function suitably in this role, it must also be able to be readily propagated. The propagation method must also provide the function at reasonable prices. For this reason seed propagation is highly desirable, although reasonably priced vegetative propagation would be acceptable. The ability to be domesticated is not a random process but dependant upon many characteristics of a species (Heiser 1988).

Australian research has resulted in selected cultivars (and considerable publicity) on two of their native grasses *Danthonia richardsonii* (Wallaby Grass) and *Microlaena stipoides* (a grass shared with New Zealand). However, the commercial propagation of these selections has effectively been a failure as seed is too expensive at more than AU$100/kg and is not readily available. We can learn from this that seed production can be an enormous barrier to commercialisation and not a trivial point to consider after breeding a suitable cultivar.

NEW ZEALAND’S NATIVE GRASS FLORA

The species of the New Zealand grasses are now reasonably well known with the recent publication of the grass flora (Edgar & Connor 2000), although the taxa may well be subject to further refinements and reclassifications as information becomes available.

We have 188 native grass species of which 157 are endemic to New Zealand. However, many of these species have restricted distributions or are now rare, with more than 48% of the endemic species listed in the threatened plants list (Hitchmough 2002). The restricted distribution of so many is understandable considering that much of New Zealand was once forested. This restricted grasses to forest floors and margins, or to areas unsuitable for forest such as wetlands, coastal sand-dunes, cliffs, high altitude areas, dry areas and mineral soils. The result of this effect is that there are not many widely distributed grass species of open lowland habitats.

CHOICE OF SPECIES TO DOMESTICATE

The most obvious choice of species to domesticate are those already occurring in turf areas around New Zealand. These include *Agrostis muscosa* in cotula bowling greens, *Microlaena stipoides* in shaded areas, and *Rytidosperma* (syn. *Danthonia*) in dryland areas.

In choosing a species to domesticate we would prefer species of open habitats adapted to lowland climates on ‘normal’ soils. This automatically rejects many species restricted to forest floors, wetlands and alpine areas.

We could also consider relatives of those introduced species we already use as these may be easier to produce commercial seed and domesticate. These would include our native *Agrostis, Deschampsia, Elymus, Festuca, Poa* and *Zoysia* species.

We could also look at species noted as having some turf, weed or pasture potential by botanical observers. These would include the *Elymus* species (Connor 1950; Scott et al. 1996) or the prolific weedy grass *Poa imbecilla* (Edgar & Connor 2000) and others (Meurk 2001).

We could also remove many of the species that would be unsuitable in turf because they are large tussocks, such as the *Chionochloa* and *Cortaderia* species.

We could also remove those species with seed that would be extremely difficult to handle such as those with long awns, effectively preventing handling with normal farm and seed processing machinery (Fig. 1 & 2).

After applying these criteria to the grass flora we are left with less than 20 species to consider. Some of the most interesting are discussed further.

POTENTIAL SPECIES TO CONSIDER

1. *Agrostis* species

New Zealand has many native species of *Agrostis*, most of which are small mountain species with little prospect of further development for turf. However, the endemic *Agrostis muscosa* or pincushion grass is present as a weed in many bowling greens where it forms clumps of extremely fine turf (Fig. 3). The species is much finer than the introduced *Agrostis* species but the flowerhead is extremely short and confined to the leaf canopy making traditional harvesting impossible.

Our other native *Agrostis* species could be investigated for turf potential.

It may be worth attempting hybridisation of native *Agrostis* species with the valuable introduced species. However, it is not known whether this is possible.

2. *Deschampsia cespitosa*

This species is a cosmopolitan one that has been developed for commercial turf use, predominantly for swampy soils in the northern hemisphere. Its seed production ability appears to be adequate for commercialisation.

Our New Zealand form of this species is now considered quite rare (Mark & Dickenson 2001) and even threatened by grazing and disturbance. A further threat is simply genetic contamination by introduced types from Europe (Fig. 4), not only in turf but also from material used for landscaping in gardens.

Our New Zealand form of this species needs not just in situ conservation but would benefit from ex situ preservation in genebanks, as would many other native grass species. The Margot Forde Genebank at Palmerston North is designated as a national repository for both exotic and native grasses but as yet its value in conservation of the native grass flora has not been utilised.

We do not know whether our New Zealand forms of *Deschampsia cespitosa* are of potential turf interest until they have been collected and compared with the overseas types in turf. Research should concentrate on collecting germplasm and assessing its characteristics alongside overseas bred cultivars.

Other *Deschampsia* species may also be worth investigating for turf potential.

3. *Elymus* species

New Zealand has a number of endemic *Elymus* species or wheatgrasses. Most have a seed with an awn up to 50 mm long making it effectively impossible to harvest commercially with existing equipment. However, one species has awnless seeds, this is *Elymus multiflorus* native to New Zealand and eastern Australia (Fig. 5). It will produce seed readily and a suitable seed production system has been developed for this. It flowers quite late compared to our introduced grasses and appears not to have a vernalisation requirement.

However, it will not form a dense turf, rather an open pasture, which will limit it to rough ground cover rather than fine turf.

This species may well respond to breeding for fineness and turf forming ability. To this end there exists the potential for crossing with other native long-awned hexaploid *Elymus* (Connor 1950, 1994) to develop a wider range of types.

4. *Festuca* species

New Zealand has a number of endemic *Festuca* species, many of which are tussocks and of little interest for turf. However, some finer leaved ones are more closely related to the successful introduced *Festuca rubra* (Lloyd et al. in prep.).

One of these is *Festuca coxii*, endemic to the Chatham Islands, and a species widely promoted around New Zealand as a native blue fescue for landscaping (Metcalf 1998). Unfortunately, although appearing vigorous the plant sold is almost always a European diploid *Festuca* — even those on display in many botanic gardens and institutes.

Festuca coxii is easily distinguished as the only fine *Festuca* with long awns, usually 6–13 mm long (Stewart 2003a,b). *Festuca coxii* is less vigorous than the European impostor (Fig. 6), slower growing, not flowering until the second or third year and never prolifically. Generally it is too slow growing to be of interest for turf.

Of more interest is the coastal fescue *Festuca multinodis* (Fig. 7). It is an octoploid stoloniferous species related to *Festuca rubra* although probably not close enough to cross, but this has yet to be determined.

It is a prolific seeder, at least in established plants, and suitable seed production methods should be similar to that used for *Festuca rubra*. Breeding work is likely to be required to develop suitable turf types.

5. *Microlaena stipoides* — meadow rice grass[2]
Microlaena stipoides is indigenous to Malesia, Australia, and New Zealand. In New Zealand, *Microlaena stipoides* is widely present in turf, particularly in the North Island, where it forms an excellent light coloured turf, often in shaded dry areas. Its performance as a turf species is excellent making it an obvious choice to domesticate.

Cultivars of *Microlaena* have been bred in Australia but commercial seed production systems have not been successful, resulting in very limited and extremely high priced seed. Prospects for commercial seed production of *Microlaena* are quite difficult as the seed has an awn up to 10 mm long making handling difficult with traditional machinery (Fig. 2). Furthermore, flowering is prolonged, lacking the synchrony of domesticated species and seed shatters quite freely. Future research needs to concentrate on perfecting commercial propagation methods for seed or for vegetative spread.

6. *Poa* species
New Zealand has a number of endemic fine leaved *Poa* species worthy of investigation for turf purposes. *Poa colensoi* or blue tussock (Fig. 8) is a widespread fine leaved species noted as one of the few of the native grasses of our tussock grasslands which increases in frequency under grazing and disturbance (Scott et al. 1996).

This species does not appear to form a turf but otherwise it will flower and produce moderate yields of seed in the second year. Further breeding work hybridising this to the closely related rhizomatous species *Poa hesperia* may be worthwhile as well as developing suitable seed production systems.

Poa imbecilla is a very fine leaf perennial, often of shaded habitats, which will flower and produce seed very prolifically (Fig. 9). It is noted by Edgar & Connor (2000) as one of our few native grass weeds. It flowers very early in the season of its first year and seed could readily be produced, except that it would be very difficult to control the weedy exotic *Poa annua* in seed production situations. Further research on this species should concentrate on seed production systems.

7. *Rytidosperma* (syn. *Danthonia*) species
Rytidosperma species occur on many of our driest and least fertile sites. Many of the species will form turf in dry regions (Harris 1972). The main turf species were previously identified to be in the *Danthonia semiannularis* group, now *Rytidosperma unarede* and others. Most are endemic to New Zealand but confusion can occur as some may be early Australian introductions.

Flowering in these species is prolonged, with the seed being light, hairy and difficult to handle, as well as shattering readily (Fig. 10). In addition, observations on plants collected show that seed can suffer from smut (*Ustilago* spp.). However, *Rytidosperma* seed was commercially harvested from natural stands in the 1940s (Hilgendorf 1940). Any research on these

[2] Editor's note: the suitability of *Microlaena stipoides* as a turfgrass species is discussed in more detail by Philip Smith in these proceedings.

species should concentrate on commercial seed production systems.

8. *Zoysia* species

Zoysia is a genus of some 10 species. Two are major turf species, *Z. japonica* and *Z. matrella*, grown in Asia and the USA. It is known that within this genus most species have the same chromosome number and will hybridise quite readily (Yaneshita et al. 1997).

New Zealand has two endemic species, *Zoysia pauciflora*, which occurs on sand dunes in the north of New Zealand, and *Zoysia minima* occurring throughout New Zealand on sandy areas (Fig. 11). Both will form turf but are very slow growing.

Overseas *Zoysia japonica* is propagated vegetatively and by seed. *Zoysia minima* has very short seedheads within the canopy, only 20 mm long with 1–2 seeds per head making commercial seed production effectively impossible.

There are no studies on these species but it is likely that our New Zealand species may have a turf role as suggested by Cooper & Cambie (1991) or could be crossed with *Z. japonica* or *Z. matrella* to develop suitable slow growing turf types for warmer areas.

ISSUES WITH NATIVE TURF GRASSES

Many of our native grass species are often slow growing and may have difficulty competing with the introduced exotic vegetation, particularly at establishment. Maintaining their presence in a biodiverse landscape is likely to be more complex than just sowing seed of the species; it is likely to involve some degree of management to ensure their continued contribution.

As New Zealand is a signatory to the Convention on Biological Diversity, appropriate action must be taken to protect the rights of indigenous people before any plant with traditional uses is commercialised or subject to intellectual property rights.

COST OF SEED

It is likely that native species will be more expensive than our current species as seed yields are likely to be lower and plants may not always produce seed in the first year like many of our exotic species. Clearly, extremely high costs like that of *Microlaena* in Australia at AU$100/kg or more, are unacceptable but reasonable premium prices may not necessarily be a barrier.

Quantities of seed are likely to be limited, as markets have not been developed. This may create unreliability of supply.

CONCLUSION

The New Zealand grass flora contains a few species for which it would be worth researching for potential domestication as turf or ground cover species. For some species plant breeding to develop finer turf forming types will be necessary while for others emphasis should be solely on developing suitable commercial seed production systems. Unfortunately, this work is unlikely to be commercially viable for the few skilled teams capable of achieving results, particularly as it is likely to take years to develop the suitable germplasm or seed production systems. It may however, be worth pursuing by amateur breeders provided attention is paid to seed production.

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Fig. 1 Long awn (35–75 mm) of *Elymus solandri*.

Fig. 2 Difficult to process awns (8–10 mm) of *Microlaena stipoides*.

Fig. 3 The fine growth habit of *Agrostis muscosa*.

Fig. 4 *Deschampsia cespitosa* of UK origin.

Fig. 5 *Elymus multiflorus*.

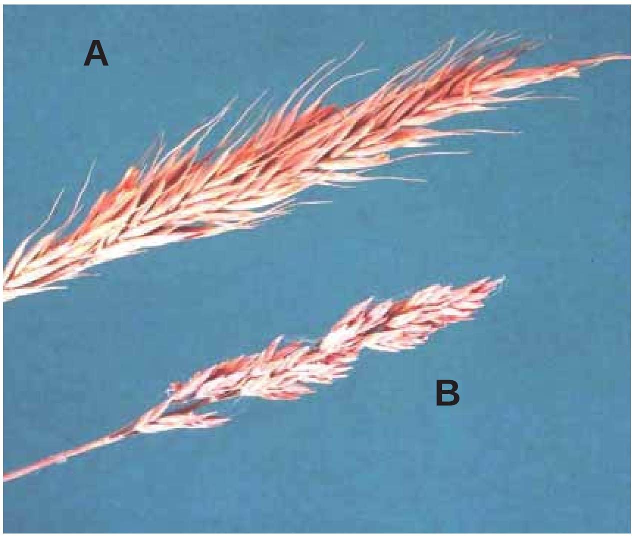

Fig. 6 The long awns (6–13 mm) of the New Zealand endemic species *Festuca coxii* (**A**), and the shorter awns (usually less has 5 mm and mostly less than 1 mm) of an exotic, European *Festuca* for which it is often confused (**B**).

Fig. 7 *Festuca multinodis*.

Fig. 8 *Poa colensoi.*

Fig. 9 *Poa imbecilla*.

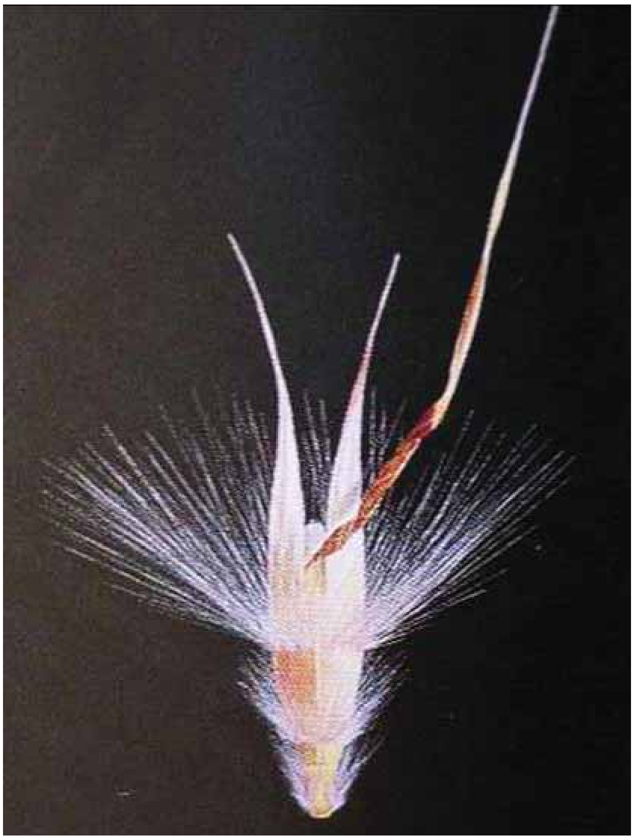

Fig. 10 The light, hairy seed of *Rytidosperma biannulare*. (From Edgar & Connor 2000, Plate 11C).

Fig. 11 *Zoysia minima* growing in sand dunes.