Tall fescue in Australia and New Zealand

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Abstract  Tall fescue is widely naturalised in Australia and New Zealand. Its use in pastoral agriculture has developed with the availability of suitable cultivars. Naturalised tall fescue is infected with Acremonium endophyte and is known to be toxic. The significance of endophyte is briefly discussed. Tall fescue can be slow to establish after sowing, and palatability is sometimes inadequate. Greatly enhanced winter growth, through the use of Mediterranean germplasm, would extend use of the species into more summer-dry environments. Research supporting these and other objectives is reviewed. Current breeding programmes in Australia and New Zealand are described.

Keywords  tall fescue; pastoral agriculture; Acremonium endophyte

INTRODUCTION
Tall fescue (Festuca arundinacea Schreb.) is a widely adapted Eurasian grass species. Natural populations are found from north Africa to northern Europe, in sites varying from arid to very wet. Tall fescue prefers and responds to a high level of nitrogen (N) fertility, but is found on impoverished soils. The limits of its natural range are set by severe cold and by rainfall below 450 mm/year (Buckner 1985).

The Festuca genus is large and diverse. It has long been known that tall fescue is closely related to some Lolium species (Jenkin 1933), and recent nucleic acid matching work (Darbyshire & Warwick 1992) has placed it and meadow fescue (F. pratensis Huds.) closer to perennial ryegrass (L. perenne L.) than to other Festuca.

Most tall fescue is allohexaploid with 42 chromosomes. The three genomes are related, and diploid meiosis is imposed by a recessive gene (Jauhar 1975). Hybrids between Mediterranean and north European ecotypes are vigorous but may be sterile because of irregular meiosis (Lewis 1963; Jauhar 1975). Fertility is restored by chromosome doubling. Subspecies exist with 28, 56, and 70 chromosomes respectively (Borrill et al. 1971).

Tall fescue is now widely distributed outside its natural range, and is very successfully naturalised in Australia and New Zealand. It has long been known to be toxic (Cunningham 1948; Pulsford 1950; now known to be because of endophyte infection, see below), and in some circumstances is a redoubtable weed (Glassey & Reade 1986).

AGRICULTURAL USE
King included tall fescue in a species trial in Victoria in 1901 (Bennison 1992). Serious agricultural interest in tall fescue in Australia extends at least back into the 1930s with the introduction (1931) and study of accessions at Canberra and Armidale which led to the eventual
release of 'Demeter', 'Alta' and 'Kentucky 31' were imported for trial in 1941 and 1947 respectively (Oram 1990). Suitable cultivars enabled the expansion of the species, and in 1978 Cregan stated that 'Demeter' and 'Alta' were the most popular grasses on the northern tablelands of New South Wales. Likewise, in New Zealand, despite earlier trials with 'S170' (Allo & Southon 1967), use of tall fescue only expanded after the release of 'Grasslands Roa' (Anderson 1982), accompanied by a significant body of experimental data (e.g., Brock 1983). Australian and New Zealand experience parallels that in the United States, where use of tall fescue spread greatly after the release of 'Alta' and 'Kentucky 31' (Buckner 1985).

The area of tall fescue sown in New Zealand has developed as farmers have overcome their suspicion of the species' toxic reputation, have become aware of its value in difficult conditions, and have gained confidence in their ability to establish and manage it (Craw 1988; Martin & Moloney 1988).

In Australian conditions, summer-growing tall fescue is used in zones with 650-700 mm or more rainfall or on waterlogged soils in Victoria with 900 mm rainfall. It is considered particularly suited to the cooler areas of the northern tablelands and slopes of New South Wales where over half the annual rainfall falls during summer. Tall fescue can be more productive than phalaris or perennial ryegrass over this time (Lazenby & Lovett 1975) and provides nutritious feed to wool, prime lamb and steer fattening properties. However, it does not extend onto the temperate coast where perennial ryegrass is well adapted, or the subtropical coast where C4 grass competition is severe.

Winter-growing fescue can be used in areas with only 550 mm rainfall. Cregan (1978) expected it to expand the role of tall fescue in the southern tablelands of New South Wales, but its promise has not so far been fulfilled.

In New Zealand, the zone of potential use is not clearly defined, but tall fescue is seen as an option where summer moisture stress limits the persistence or yield of perennial ryegrass (Milne & Fraser 1990).

Tall fescue is resistant to or tolerant of several significant pasture (mainly ryegrass) pests. In New Zealand, it shows degrees of tolerance to grass grub (East et al. 1980; McCallum et al. 1990) and Argentine stem weevil (Prestidge et al. 1986) among others.

Establishment

Slow establishment is a limitation to use of tall fescue, particularly when it is compared with ryegrass. In Australia, Robinson & Whalley (1988) showed that sowing rate was reflected in the number of seedlings surviving beyond 3 months, but on their Northern Tablelands site it had no effect on weed suppression. Bellotti & Blair (1989a,b,c) showed that tall fescue seed germinated adequately after direct drilling into an existing sward, but not after aerial sowing. Subsequent seedling development, leading to a satisfactory tall fescue component in the botanical composition of the resultant sward, improved with herbicide control of the pre-existing vegetation. Charles et al. (1991a) achieved greater success on the Tablelands sowing in spring than in autumn, and in spring, direct drilling with an inverted T machine achieved better establishment than sowing after cultivation. Again, weed control was critical. Charles et al. (1991b) showed that temperature was likely to be the critical environmental factor in many establishment failures.

M. J. Hill (1985) showed that glyphosate application greatly enhanced the introduction of tall fescue into kikuyu grass swards.

In New Zealand, Brock (1973) showed that control of sowing depth was crucial, and Brock et al. (1982) identified lower rates of tillering and root elongation as components of the differences between perennial ryegrass and tall fescue establishment rates. Charlton et al. (1986) showed that germination of tall fescue was slowed more at a 10/5°C regime relative to 20°C than was that of the five other grass species studied.

Agronomy

In agriculture and as a volunteer weed, tall fescue is known as a plant which favours fertile soils. However, it is reputed to be tolerant of acid soils (Buckner 1985), moderately salt-tolerant (Myers 1990), and more tolerant than perennial ryegrass of raised soil aluminium levels (Edmeades et al. 1991).

In irrigated dairying areas of south-eastern Queensland, tall fescue has proven to be the temperate grass best able to compete with C₄ grasses, and to yield well (K. Lowe pers. comm.). In a recent trial, four cultivars of tall fescue averaged 107% of perennial ryegrass yield in the first year, and 133% in the second year. Tall fescue yield was 210% of ryegrass yield in the second summer.
Even without irrigation tall fescue persists, but with lower levels of production.

Other research on tall fescue agronomy has been into grazing management and seed production. Kerrisk & Thomson (1990) showed that tall fescue herbage production was optimised through spring by a 15-day rotation, whereas perennial ryegrass and phalaris performed best with a 30-day rotation. Research on seed production has been reviewed by Hare et al. (1990).

Limitations to use

The excellent trial results with tall fescue might have encouraged greater use of tall fescue than is the situation. Many farmers remain unaware of its potential (Belgrave et al. 1990), and some have had disappointing results. Establishment failures have been reported, and tall fescue is unable to compete in a grazed mixed sward with some other grasses (Percival & Duder 1983). Tall fescue failed to establish satisfactorily after oversowing at five of six dry hill sites (Barker et al. 1993). At the sixth site however, after a spring sowing, it established well and was the best performing grass in the trial. If establishment is not satisfactory, tall fescue does not usually “thicken up” in the sward, as does phalaris for example, and contribution to feed supply is negligible (B. D. Hill 1985).

Once established, tall fescue requires careful grazing management to prevent it becoming rank and losing quality. Early-heading cultivars require hard grazing in early–mid spring, when in many farm systems farmers are reluctant to “push their animals” hard. Classic work by Minson et al. (1964) showed that digestibility of leafy tall fescue compared well with that of other pasture grasses, but that the fall in quality approaching reproductive maturity was particularly early and severe for tall fescue.

Advantages in DM production are not always reflected in improved animal production. On dairy farmlets in Taranaki, a tall fescue-based pasture produced more DM than ryegrass in all seasons, and 18% annually (Thomson et al. 1988). However, this was not reflected in milk yield.

With tall fescue promoted as a plant which is tolerant of more difficult conditions than perennial ryegrass, some farmers have neglected the fertility requirements of the species, and stands have failed because the N status was too low.

The requirement to sow tall fescue as the only grass in a sward, the requirement for very good control of sowing technique and early grazing management, the need for more frequent grazing to maintain quality, and the difficulty of restoring the situation if control is lost, are all constraints on the grazing manager and disincentives to use of the species. Tall fescue is therefore in a similar situation to that of lucerne. Although it can be shown that a stand offers advantages in a system in many different situations, it is only where the species shows unequivocal advantages over alternatives that most farmers are interested. Ease of management and the relief of constraints are important objectives for research.

However, examples of successful use of tall fescue on farms continue to encourage more farmers to consider its place in their system. Widespread use on the New South Wales Northern Tablelands (Cregan 1978) and published success stories in trials (Hamilton et al. 1970; Goold & van der Elst 1980; Wright et al. 1985) and on farms (Craw 1988; Martin & Moloney 1988; Milne & Fraser 1990), are evidence that tall fescue has an important role in pastoral farming systems, which science should seek to extend, and which may become more critical should our climate become warmer and drier.

ENDOPHYTE IN TALL FESCUE

The toxicity syndromes of livestock grazing tall fescue pastures (Cunningham 1948; Pratt & Haynes 1950; Bush & Buckner 1973) are associated with the endophyte fungus, *Acremonium coenophialum* Morgan-Jones & Gams (Hoveland et al. 1980). Livestock grazing tall fescue may suffer lameness leading to gangrene in the hooves (“fescue foot”), or heat stress and associated poor summer performance (Bush & Buckner 1973). Most research has been conducted with cattle because of the large calf-rearing industry using tall fescue pastures in south-eastern United States, but other classes of livestock are also affected. Sheep grazing seed production stands of turf tall fescue in New Zealand have recently suffered severe cases of fescue foot.

It is generally accepted that the principal agents of tall fescue toxicity are the ergopeptine alkaloids, notably ergovaline (Garner et al. 1993). Loline alkaloids in infected tall fescue (Bush et al. 1993) have also received attention. The involvement of ergopeptine alkaloids produced by the endophyte fungus accounts for the earlier observations that symptoms were similar to ergotism. Ergovaline levels are 5 times or more higher in reproductive
heads than in vegetative tissue, and increase with N fertilisation (Garner et al. 1993). 'Kentucky 31' pasture grown in trials in New Zealand has ergovaline levels only about one half those measured in local naturalised “roadside” tall fescue (G. A. Lane pers. comm.), indicating the toxicity of the rough foliage associated with waste areas (often with high N status).

In New Zealand and Australia, fescue foot is of primary concern. Bullocks have died of heat stress after grazing wild tall fescue in Manawatu, not a region known for its high temperatures, but generally heat stress associated with grazing tall fescue in New Zealand is reported only in Northland (Kearns 1986).

Endophyte infection of seed declines when it is stored (Siegel et al. 1984), and observations of grazed tall fescue breeding trials (e.g., Anderson 1982) probably identified preferred plants which were endophyte-free. Indirectly therefore, and in ignorance of the significance of endophyte, cultivars bred outside the United States have been selected for freedom from endophyte. This has certainly been true in Australia and New Zealand, and there has been no tall fescue toxicity on cultivated, managed tall fescue pastures sown with certified seed.

Discovery of the toxicity-endophyte association led to a movement in the United States to establish “fungus-free fescue”. However, this soon proved to persist and grow less well than infected pasture, particularly under heat and drought stress (see West & Gwinn 1993 for a recent review). Among the factors involved are resistance to nematodes, pathogenic fungi and insects, more efficient water conservation, and ability to maintain turgor and recover turgor during and after water stress. Efficient use of mineral elements may also be enhanced by endophyte infection (Bacon 1993). Farmers had difficulty in maintaining endophyte-free tall fescue, and a plant which hitherto had had a reputation as easy-care pasture began to appear fragile. The new aphorism is that with endophyte you need to care for your animals, without it you need to care for your plants. Most farmers are more competent in caring for their animals.

Knowing the cause of tall fescue toxicity enables breeders to proceed with confidence. In the past it was necessary to test and retest material, and hope that no toxicosis would emerge. When breeding non-infected cultivars, endophyte should be eliminated from the breeding stock early in the programme. Infected plants may be advantaged under environmental stress, and survive selection screenings because of infection rather than genetic merit. Determination of endophyte infection is technically simple, but we have found more false negatives in our work at Palmerston North than with ryegrass. The position of the hyphae in the tissue, and the possibility that not all tillers in a plant are equally infected, mean that extra care is required (e.g., Welty & Azevedo 1993).

Alternatively, if the toxic properties of the fungus could be eliminated, the range, perennity, and production of tall fescue in Australia and New Zealand might be extended by the presence of a symbiotic endophyte. To exploit this possibility, breeders must be aware of interaction between plant genotype and endophyte strain, and the effects of environment on it, and seek to maintain some diversity in the symbiotic system (Hill 1993).

**BREEDING OBJECTIVES**

The pastoral industries require cultivars which extend the potential of tall fescue and overcome the constraints which currently limit or complicate its use. Some conditions call for a plant which will establish and survive in very difficult conditions. Elsewhere, cultivars are required which deliver forage at crucial times of the year and which contribute to greater production per hectare and per animal. The following objectives are perceived as important and achievable.

**Forage quality**

While tall fescue has good nutritive value as determined by any of the classic parameters, breeders have sought to improve its value as a forage. Further, although animal production measured in trials is generally excellent, results have sometimes been disappointing, given the apparent value of the forage.

The classic parameters of quality such as digestibility, and protein and soluble carbohydrate content, have been studied in many open-pollinated pasture grasses. Tall fescue has been shown to have significant variation in all traits studied, and to respond to selection. In a recent example among many, Bughrara et al. (1991) predicted rapid gains for digestibility of autumn herbage.

Palatability has been assessed as animals' choice, either in situ (Petersen et al. 1958; Anderson 1982) or with cut samples fed to animals in stalls (Gillet et al. 1983). There is considerable variation,
although before 1980 this was often confounded with the presence or absence of endophyte. Buckner et al. (1967) and Berg et al. (1979) observed a close association between palatability, digestibility, and chemical constituents of tall fescue and hybrids with *Lolium*. However, Carlson et al. (1973) found that the cultivar ‘Kenwell’, selected for palatability, supported less liveweight gain per hectare or per animal than ‘Kentucky 31’. Buckner et al. (1979) also reported that succulence, measured as % water content, and indicated by absence of leaf rolling, was related to forage quality.

Silica content of leaves has been related to indigestible components and suggested as an inverse indicator of quality (Buckner et al. 1967).

Another indicator of palatability is leaf softness, as felt manually (Gillet 1975). This trait is repeatable between observers and has been related to palatability in choice tests. Gillet (1975) reported that the loss of palatability as leaf matured was delayed 7–10 days in selected material. A more objective approach used with ryegrass is the measurement of leaf shear strength (Easton 1989). Leaf softness was selected empirically, to see if livestock might prefer softer leaves. Leaf strength was tried because the rate of leaf breakdown limits the passage of feed through the rumen, and therefore feed intake.

Since digestibility and palatability both decline as tall fescue matures, Gillet (1975) sought to extend the period between the onset of stem elongation, with its attendant surge in DM availability, and ear emergence. Delaying the stages of reproductive development but not the onset of rapid growth, would extend the period of relatively good quality forage, and afford the grazing manager more flexibility in grazing or harvesting.

A totally different approach to palatability, but not quality as such, is the study of volatile components which might affect forage flavour. Boland et al. (1976) showed variation between tall fescue genotypes for organic acid composition. Scehovic & Jadas-Hecart (1989) associated the lower palatability of tall fescue relative to ryegrass and ryegrass-fescue hybrids with higher levels of phenolic acids and terpenes, and lower levels of soluble phenols. Tava et al. (1993) found differences between tall fescue varieties in their content of volatile alcohols, aldehydes, and esters.

Mineral element levels in tall fescue are sometimes suboptimal. Anderson et al. (1982) found that the hypomagnesaemia ratio, K/(Ca + Mg), was wider in Roa tall fescue than in Ariki long-rotation hybrid ryegrass. Sleper et al. (1977a) showed heritable variation for the ratio and for the elements separately. They predicted rapid response to selection. The correlation between years for the ratio was better than those for the elements individually. Nguyen & Sleper (1981) found significant additive genetic variance for mineral levels but found that the narrow sense heritability of the ratio was lower than those of the elements individually. Thomson et al. (1988) suggested sodium levels as a limiting factor in tall fescue quality, and McQuinn et al. (1991) showed significant variation in selenium levels.

The approaches described seek to address perceived shortcomings of tall fescue as a forage. High-quality forage grasses do not support the same per animal performance as concentrates, or even that achieved with better quality legumes. The classic parameters of quality do not account for these results. Animal nutritionists are currently seeking to develop criteria to “synchronise” the energy and N supply to the ruminant (Beever 1993).

**Seedling vigour**

Tall fescue establishes more slowly than some other grasses, notably perennial ryegrass. Brock (1973) found that seedling number, tillers and leaves per seedling, and shoot dry weight, 56 days after sowing in April, and available DM the following September, of Roa (then designated G4710) and S170 were all about half the levels of ryegrass.

Badoux (1977) achieved better heritability of seedling weight than of tiller number for tall fescue grown in a glasshouse (19°C). Badoux did not comment, but tiller number can be recorded for many more seedlings in a given time than seedling weight. The presence of a coleoptile tiller on seedlings grown in a glasshouse at 20–25°C was closely correlated with plant weight and tiller number at later stages (Lewis & Garcia 1979), and tall fescue populations varied in the frequency of this trait. Seed weight has been suggested by several authors as a likely indicator of seedling vigour, but Lewis & Garcia found it had a very ephemeral effect.

Faulkner et al. (1982) selected over one generation for speed of germination, leaf length and root length at 7 days, and days to production of the second leaf, of seedlings grown hydroponically at 13°C for one cycle; and over two generations for the same traits, and the presence of the coleoptile tiller, of seedlings grown in soil in a glasshouse at 8–15°C. All traits responded significantly to
selection except speed of germination in the hydroponic experiment. Tall fescue seedlings have long leaves and roots, so selection for these traits is unlikely to be helpful. Speed of morphogenesis is limiting. The authors suggested selecting for early achievement after sowing of any readily recorded stage in seedling development.

Faulkner et al. (1982) also noted that seed origin affected seedling development, and needed to be controlled if seed lots were compared for seedling vigour.

The programme at AgResearch Grasslands, Palmerston North, involves selection in the field for rate of establishment. Half-sib families are sown in replicated rows, and are assessed for a series of observations such as numbers emerged at different times, tiller number, leaf number, and eventually some indicator of DM production. These data and later observations serve to evaluate and select families. Individual plants are selected from the best families on the basis of disease resistance and other traits. In the earlier stages of the programme, rate of germination in petri dishes was assessed. This was repeatable, and correlated with field observations. However, the necessary data can be obtained from a carefully sown field trial, and field evaluation is essential.

Response to selection appeared very promising (Easton & Pennell 1994). The advanced lines were certainly more vigorous at establishment than the original breeding material, and appeared to be greatly superior to all controls. However, field multiplication of the elite lines has required a re-evaluation. During the breeding programme, plants were isolated and seed matured and harvested in a well-ventilated glasshouse. This environment was warmer and probably drier than ambient conditions near Palmerston North in December. Subsequent experiments have shown (Easton & Pennell 1994) that seed matured and harvested in the glasshouse, even if its seed weight is a little inferior, will germinate and establish more quickly than seed of the same genetic material harvested in the field. Glasshouse conditions enhance the vigour of seed harvested, possibly associated with a lower level of seed dormancy (Simpson 1990), and mask potential genetic differences in adaptation to field-harvesting conditions.

**Cool-season growth**

Tall fescue occurs naturally over a wide range of latitude, so the species exhibits a range of seasonal growth patterns.

Kemp (1985) showed a strong relation between winter growth and flowering date in tall fescue and three other grass species. He proposed selection for early flowering to improve winter growth. Watson & McLean (1991) found low but workable heritabilities for early flowering (heritabilities were higher when selecting for late flowering). However, quality falls as flowering approaches (Minson et al. 1964). Early-flowering plants are difficult to manage in many farm systems, and the grazing manager is afforded more flexibility if the period between onset of rapid growth in winter–early spring and heading is extended (Gillet 1975). The relationship noted by Kemp (1985) is not absolute, and independent selection for early growth without advancing heading date is possible. Mid-season heading ryegrass cultivars with good early-season growth have recently been bred in Britain and in New Zealand.

Mediterranean types of tall fescue with strong winter growth, sometimes associated with summer dormancy, offer a different model (Robson 1967, 1968). The cultivar ‘Melik’ derived from an Israeli source was released by the Western Australian Department of Agriculture in 1971, but has never established itself in Australian farming.

Neal-Smith & Wright (1969) studied the growth of a range of accessions as spaced plants and swards at Canberra and Armidale. As spaced plants, many of the Mediterranean accessions showed very good cool-season growth. However, in sward conditions, with competition for moisture, their superiority was not evident. The authors concluded that the material would show its maximum yield potential where water is not limiting in the cool season. A clear advantage of the better Mediterranean accessions was their very good persistence under moisture stress. Schiller & Lazenby (1975) also showed the superiority of Mediterranean populations in winter, particularly in the second year. Survival was good, even with very low winter temperatures. Hill et al. (1985) showed that two Mediterranean cultivars established more slowly than a temperate control, producing more tillers but a much lower weight per tiller.

Mediterranean tall fescue would suit the Mediterranean areas of Western Australia and also the low summer rainfall areas of Victoria, where no summer production is expected. ‘Melik’, while being superior in winter growth, has lower annual yield than ‘Demeter’ in regions of some summer growth (e.g., Clark et al. 1993). The challenge is to develop a fescue of Mediterranean winter growth
characteristics allied with enough late spring/summer production to give a high annual yield.

**Yield and persistence**

As for other perennial, open-pollinated pasture grasses, quantitative traits such as yield in tall fescue are governed largely by additive genes. Frakes & Matheson (1973) and Sleper et al. (1977b) found that general combining ability effects were predominant and that heritability estimates for yield and its components were high. However, experience with perennial forage grasses indicates that breeding for forage yield does not achieve the success predicted by such data. The interactions with environmental variations resulting from site, season, and management tend to make genetic gains in yield elusive, although Nguyen et al. (1980) found that entry effects were more important than interactions.

Nevertheless, the best cultivars are consistently better than others so that progress can be made. ‘AU Triumph’ has proved a very successful cultivar in a wide range of environments (Clark et al. 1993), and in New Zealand and Australia will be the yield standard plant breeders must seek to meet. Other cultivars such as ‘Grasslands Roa’ in New Zealand and ‘Demeter’ in Australia maintain their place through superior forage quality or local adaptation, allied with yield that matches ‘AU Triumph’ most of the time.

Persistence of tall fescue in New Zealand is usually a function of fertility and grazing management. In Australia, drought tolerance may be a factor and could be enhanced by the development of adapted Mediterranean cultivars. Silsbury (1961) found that persistence of Mediterranean accessions of perennial ryegrass at Adelaide was related to summer dormancy and that dormancy could be broken by provision of moisture. However, Morgan (1964) found that dormancy in Mediterranean tall fescue was controlled by high temperatures and long days.

A number of measurable traits have been suggested to predict tall fescue persistence. Recent suggestions include thicker (stronger) roots enabling penetration of dense soil (Torbert et al. 1990), rhizome production (Bouton et al. 1992), and different techniques to predict drought tolerance (White et al. 1992). Leaf rolling scores and tiller and plant survival were judged the most promising. As turf breeders, White and associates were not troubled by any negative correlations between leaf rolling and palatability. Johnson (1993) tried carbon isotope discrimination as a predictor of water use efficiency in two accessions of tall fescue. The accessions differed in their mean value, and within accessions, low isotope discrimination did predict low internal CO₂ and high water use efficiency.

Selection methods developed for other species, such as tolerance to soil aluminium, should succeed for tall fescue if they are judged worthwhile. However, isolated screening for traits shown to be individually correlated with field performance is likely to be disappointing, if it is not integrated into a field-based programme where material is observed for extended periods in the target environments. The experience of lucerne breeding in the United States is interesting in this regard (Ipson 1991).

Good seed yield is essential to the success of a cultivar. Some cultivars have failed because of poor seed yield (e.g., Gillet 1975), and an increasingly competitive industry requires better performing plant material. Tall fescue seed production has increased through improved management (Hare et al. 1990), but it falls well short of that of ryegrass, an alternative crop for the seed grower. The difference in mean yields between the two species in New Zealand is much greater than the difference in yield achieved by leading growers. Tall fescue appears to require better control of seed stand management and heavier soils than ryegrass. Should plant breeders work within the systems achieved by the most professional growers, or in the systems used by the majority?

**Disease and pest resistance**

Breeding ‘Grasslands Roa’ involved selection for freedom from crown rust (*Puccinia coronata*), and when released, Roa was declared to have a high level of resistance (Anderson 1982). However, significant levels of crown and stem rust have recently been observed when Roa is allowed to grow tall (usually for seed production) and seed growers now protect crops with fungicide. Likewise, a stem rust (*P. graminis* ssp *graminicola*) has been recorded in the Willamette Valley in Oregon, where it had not been reported as a serious disease before (Welty & Mellbye 1989). The disease status of intensively grown tall fescue is not stable, and to maintain the health of pastures plant breeders need to give ongoing attention to disease resistance.

Disease damage on herbage grasses can affect yield, persistence, palatability, and nutritive value. Resistance interacts with management, frequently
grazed pastures being less exposed to attack from leaf pathogens than pastures allowed to grow rank. However, managing a pasture to avoid disease development is yet another constraint which plant breeders should seek to relieve.

Other disease organisms reported to damage tall fescue are *Drechslera* (Smith et al. 1986), *Xanthomonas* (Samson et al. 1989), and nematodes (Hoveland et al. 1975). Severity depends on environmental factors, including local farm practice. The real significance of disease organisms present in pastures needs to be assessed.

**BREEDING PROGRAMMES**

**Methods**

The standard methods of breeding open-pollinated perennial grasses are appropriate to tall fescue. However, tall fescue and other pasture grasses are moving from the status of an essentially natural organism, barely domesticated, to a crop plant integrated into a well-managed system. Therefore, the earlier approaches to plant breeding, satisfactory for eliminating the poorest performing section of original populations, are no longer adequate. Significant improvement on the already respectable cultivars in place requires greater control of breeding experiments and regular focusing of objectives.

Further, the pasture plant breeder is exhorted to take note of and exploit new technologies. These have only recently been deployed for the intensively worked field crops, with huge resources involved and thousands of years of domestication behind them. Some of this technology is premature in species for which we have limited knowledge of the quantitative or qualitative genetics. The potential of new breeding technology for tall fescue has been reviewed (Kasperbauer 1990).

There remain large resources of untapped genetic variation in collections of tall fescue (de Araujo et al. 1983; Burner et al. 1988; van Santen & Collins 1991 for recent examples), and most tall fescue breeding pools in the world have probably been through very few generations of selection. The intriguing potential of hybridisation with *Lolium* still attracts, with new methods available (Scott & White 1988).

**Australian programme**

The study of introduced germplasm to improve Australian tall fescue pastures dates at least from 1931, with the material from which ‘Demeter’ was developed. Mediterranean material was studied in the 1960s (Neal-Smith & Wright 1969), leading to the development of ‘Melik’, released by Western Australian Department of Agriculture but never commercialised.

A recently initiated Australian programme based at the PVI, Hamilton, Victoria, and at New South Wales Agriculture, Glen Innes, aims to develop improved Mediterranean (summer-dormant) cultivars for dry zones of southern Australia, and summer-active cultivars for the summer rainfall climates of northern New South Wales. Enhanced seedling vigour will be an objective in both situations.

‘Melik’ tall fescue has been nearly 300% more productive than ‘Demeter’ at Hamilton over the autumn and winter, and is much less affected by rust than ‘Demeter’ and ‘AU Triumph’, but it is not very productive in the spring and summer. Improved spring growth is necessary for a cultivar to be competitive, but ‘Melik’ is a valuable starting point for renewed work. Plants from ‘Melik’ were selected at Hamilton for crown size, productivity, and leaf size, and progeny are being evaluated at Hamilton and Balmoral.

Introduced germplasm, held at CSIRO or recently acquired, is evaluated at Hamilton and Glen Innes. Currently, 434 accessions are under study. Drill rows (1 m), if sufficient seed is held, or spaced plants are grazed and observed over 2 years for annual and seasonal productivity, persistence, habit, and susceptibility to rust. Very good accessions may be multiplied and released as an interim measure while the breeding programme continues. Plants from the more useful accessions will be isolated to constitute summer-active and Mediterranean breeding pools.

**New Zealand programme**

Tall fescue breeding at AgResearch, Palmerston North, dates from the 1950s. The development of ‘Grasslands Roa’ used classical spaced plant nursery techniques. The current primary aim is to improve establishment vigour, while maintaining Roa’s very good palatability (reflected in livestock performance). The programme involves multi-site evaluation of half-sib families in rows under grazing, usually in 3-year cycles. Plots are maintained beyond 3 years to check persistence, but selection decisions are made within the 3 years. Year-round growth is scored, with an emphasis on summer production.
The next 3–5 years will determine whether there is extra variation for establishment vigour, hitherto masked by use of the isolation glasshouses which enhance seedling vigour (see above).

Little breeding has been done for improved seed production or forage quality. Data on components of seed yield are interesting, but the operational aspects of collecting such data on a large breeding pool need to be refined. Experience with palatability and leaf softness has been positive, and developments in ruminant nutrition may soon identify clearer objectives. We expect to do more on seed yield and palatability in the future.

We expect endophyte research to affect tall fescue breeding within the next 5 years. The possibility of extending the use of the species in New Zealand through managed use of the endophyte is exciting.

In 1986, a large forage collection expedition was mounted to south-western Europe, and 60 accessions of tall fescue were collected. These, with other accessions furnished by germplasm centres in Europe, were evaluated in a trial at Palmerston North. The most promising material was identified, and progeny from them now forms a new breeding pool. Generally, the material is inferior to available cultivars. It is seen as a resource for broadening the base of our programme and requires ongoing work to raise it to an acceptable standard.

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