



## **The value of exotic germplasm to the NZ livestock industry**

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*Abstract:* A number of recent reports in New Zealand have stated that restricted access to new plant genetic material from overseas is a major risk to the future growth of the primary sector. This paper reviews one part of the overall problem by discussing the historical role of exotic forage germplasm in plant improvement in New Zealand, and quantifies the current contribution of recently imported plant material to exports from the pastoral sector.

In the past 30 years there has been a large increase in the number of improved cultivars.

There are now 115 forage cultivars of 26 species available to farmers, compared with 20 cultivars and 12 species in the early 1970s. 65 per cent of these contain exotic germplasm.

The current annual contribution of cultivars containing exotic forage germplasm to New Zealand pastoral exports of around \$14 billion is \$735 million. This represents an almost 6 fold increase over the figure of \$128 million in 1992, which is significantly faster than the 75% increase in pastoral exports in the same period.

A more important issue is the loss of future opportunities which will result from the continuation of restricted access to novel material from overseas. These include responses to climate change, biosecurity breaches and developments in biotechnology, food type and quality and endophyte.

A return to the well tried system of accredited institutions carrying out field evaluations under supervision is proposed.

### **Introduction**

A number of recent reports have expressed the view that new restrictions on the importation of overseas plant material are a major risk to the future growth of the primary sector (MAF 2002, Douglas 2003). These restrictions are the result of the Hazardous Substances and New Organisms (HSNO) Act and regulations administered by MAF and the Environmental Risk Management Authority (ERMA) since July 1998. More detail on the ongoing debate between proponents and opponents of the new restrictions is presented in New Zealand Geographic (2006).

The main factor in the continuing international competitiveness of the New Zealand livestock industry is the low cost of feed obtained from year round animal grazing of pastures in situ (Caradus & Clark 2001, Woodfield 2002). But this is under threat in the dairy sector as feed costs have risen by 90% in the last decade (J.R. Caradus pers. comm.).

Apart from the natural tussock grasslands of the South Island and the Central Volcanic Plateau, which are of relatively minor importance to the animal industries, all the plants used to feed New Zealand's livestock originally came from overseas. For the purpose of this investigation only examples of cultivars which utilise exotic germplasm obtained in the last 30-40 years under the import regimes prevailing from the 1960s have been used.

## **History**

Although Captain Cook brought both seeds and 2 sheep (they both died) in his visits from 1769 onwards, the early missionaries were responsible for the first organised introduction of seeds which were commonly used in their native lands. Marsden in 1814 and later other missionaries brought sheep, cattle and seeds. Six years later the first plough was operating at Kerikeri in Northland and it was there, on 20 July 1821, that the first grassland was sown in New Zealand by Rev John Butler. After that distribution was rapid and widespread and has been well described by Guthrie-Smith (1969) in his book “Tutira”. Major expansion of the grassland area occurred from 1870 onward with the clearance, particularly of North Island forest, and there was an extremely large increase in livestock carrying capacity all based on imported forage germplasm (Lancashire 1990).

From 1920 there was a period of intensification through the application of soil science, fertiliser technology and the selection and plant breeding of improved pasture species. Much of this early improvement work in the late 1920s on the major species, perennial ryegrass and white clover, was based on selections of the best ecotypes which had developed from the original sowings of imported seed in old pastures in Hawke’s Bay and North Canterbury. Many of these such as Huia white clover, Ruanui perennial ryegrass, Akaroa cocksfoot and later the Mangere ecotype, which led to Nui and Ellett perennial ryegrasses, were exported and used through the world. However the performance of these ecotypes was necessarily constrained by the local environment. It became necessary to bring genes in from overseas to introduce particular desired traits, such as better cool season or summer growth or tolerance of new insect pests or diseases into new cultivars. These procedures, together with the selection of a number of new ecotypes particularly in the perennial and Italian ryegrasses, have led to a large increase in the number of improved forage cultivars available to farmers over the past 30 years. There are now 115 forage cultivars, 65% of which contain exotic germplasm, covering 26 species on the market, compared with 20 cultivars and 12 species in the early 1970s.

## **Major individual species**

### White clover

The annual value of New Zealand’s most important forage legume, white clover, to the local economy has been estimated at between \$3 billion and \$4 billion (Caradus 1995, Lancashire 2003b). Germplasm from several Mediterranean countries for improved seasonal growth and drought tolerance, and Ladino types from the USA for higher yields, particularly in summer and disease and pest tolerance, has proved fundamental to the development of a dozen improved white clover cultivars for both national and international markets (Williams 1983, Caradus *et al.* 1995, Woodfield *et al.* 2001).

### Perennial ryegrass improvement 1960-80

Although hybrids with Italian ryegrass were used in the early years, the improvement of perennial ryegrass, the most commonly used grass in New Zealand, was largely based on the selection of ecotypes from older pastures until the mid 1980s. Examples were cultivars such as Nui released in 1975 and Ellett in 1982 derived from populations at Mangere, south Auckland, which rapidly replaced the older types Ruanui and Ariki.

### Perennial ryegrass endophyte

In the early 1980s, much of the perceived wisdom about perennial ryegrass improvement was thrown into disarray by the discovery of the crucial role played by the perennial ryegrass endophyte in the persistence and pest tolerance of the species (Easton *et al.* 2001). In fact Woodfield (1999) suggested that this was probably a factor in reducing genetic progress in improving ryegrass yield. A 20-year research programme to find a “safe” endophyte, which did not produce serious stock problems, discovered that the only “safe” endophytes were from overseas (Easton *et al.* 2001). The resulting novel endophyte AR 1 has now been inoculated into most commercially available perennial type ryegrasses, so that over 60% of proprietary cultivars now contain AR 1 (B. Belgrave pers. comm.).

### Perennial ryegrass improvement 1980-2000

Since the mid 1980s the breeding of perennial ryegrass and perennial ryegrass type hybrids has followed the pattern developed in white clover with much greater emphasis on the utilisation of overseas genetic material. As with white clover much of the useful exotic germplasm comes from Mediterranean regions like Spain and Italy which contributes both cool season and summer growth in newer cultivars. It is expected these trends will continue (G. Kerr pers. Comm., A.V. Stewart pers. comm.).

### Italian ryegrass

In general the same pattern of plant improvement is seen in the shorter lived Italian and Italian type hybrid ryegrasses with a mix of local ecotypes and imported germplasm. Recent releases of diploid types contain material from Italy and Japan, but in contrast there has been considerable success with ecotypes from the Waikato/Bay of Plenty in the past two decades (Easton *et al.* 1997).

### Red clover, lucerne and other legumes

Extensive use of overseas germplasm to improve cool season growth by the incorporation of Moroccan material; persistence and yield from Sweden and very prostrate types from Spain and Portugal have been essential elements in recent red clover improvement programmes (Stewart and Charlton 2003). Compared to other forage legumes lucerne is unusual to the extent that the first cultivar bred in New Zealand in the 1930s, Wairau, was derived from Marlborough, an introduction probably from Argentina, and other germplasm largely from North America, rather than from local ecotypes (Dunbier 1983). Subsequent improvement has depended entirely on imported germplasm (Stewart and Charlton 2003).

A range of other alternative legumes such as Lotus, birdsfoot trefoil, Alsike clover, strawberry clover, Serradella, sulla and Caucasian clover all contain recently imported overseas genetic material.

The advent of warmer temperatures and greater frequency of droughts, as a result of climate change, means that an extended range of legume species in particular will be required in the future. But successful growth of legumes is dependent on symbiosis with rhizobia. New and different strains will be required for the new legumes and these will have to go through the same restrictive processes in place for plant germplasm. Therefore field evaluation of the potential of a wide range of novel legume will be severely limited. (H. Pryor pers. comm.).

### Other grasses and species

Recent improvements in cocksfoot, tall fescue, prairie grass and phalaris have been dependent on the incorporation of overseas material from the Mediterranean, South America and the USA. The forage herbs chicory and plantain were first selected from

local ecotypes but recent developments have utilised material from Italy, Germany and Portugal (A.V. Stewart pers. comm., W. Rumball pers. comm.). Brassicas used in New Zealand are either direct imports of cultivars or selections from overseas material (Stewart & Charlton 2003). Overseas germplasm has played a key role in the improvement of poplars and willows for stock feed (Charlton 2003).

#### Value of exotic germplasm

A number of assumptions have been made in making this calculation. They are:

- \* The value of pastoral exports is around \$14 billion (MAF pers. comm.).
- \* Grazed pasture provides 90-95% of the feed requirements of New Zealand livestock (D.A. Clark pers. comm.).
- \* 65% of the returns from the pastoral sector are based on the perennial ryegrass/white clover combination (Woodfield 2002). However, recent increases in the use of short-lived and hybrid ryegrasses in the dairy sector and lamb finishing enterprises; the continuing use of cocksfoot, tall fescue and red clover particularly in drought years, and the rapid growth in the use of herbs and some brassicas would suggest that improved species underpin a higher figure of possibly 75%.
- \* An accurate figure for annual rates of pasture renewal is hard to find. Historically it was believed to be around 3% (Lancashire 1985). A recent survey by the Meat and Wool Economic Service's survey of beef and sheep farms gave a figure of 2% for 2001-2003 (Meat and Wool Board 2004). A conservative figure of 2.5% was used. In the last decade, today's pasture feed supply is partially the result of pasture renewal during that period and a annual renewal rate of 2.5% compounded for 10 years is 28%.
- \* After detailed discussions with breeders and examination of certified seed production statistics, it has been estimated that 25% of the seeds sown in the past 10 years contained exotic germplasm obtained relatively recently (in the past 30-40 years under the import regimes prevailing from the 1960s).

#### **Results**

75% of pastoral exports of \$14 billion underpinned by improved species = \$10.5 billion.

28% of pasture renewed in 10 years x \$10.5 billion = \$2.94 billion is the value of additions to New Zealand pastures in the past 10 years.

25% of seeds sown contained exotic germplasm x \$2.94 billion = \$735 million is their contribution to pastoral exports.

Given the number of fairly conservative assumptions i.e. pasture renewal rates of 2.5% per annum; 25% of seeds sown in the past 10 years contain exotic germplasm and figures produced by Meat New Zealand (2003) and dairy research (Bluett *et al.* 2003) showing the annual value of AR1 endophyte alone to the sector is \$63 million (the calculated figure was \$74 million) it appears that the figure of \$735 million is broadly correct. Other calculations assuming that the value of white clover to the export economy is \$4 billion also confirm this (Lancashire 2003b).

It is also important to note the dramatic increases in the use of exotic germplasm that have taken place in the last 10 years. If the same calculations are made for 1992 on the basis of the previous 10 years and assuming 10% of forage seeds contained exotic

germplasm, the annual contribution to New Zealand's export economy was \$128 million, 1/6 of the 2005 figure. This six-fold increase is significantly faster than the increase of 75% in pastoral exports over the same period.

### **Future challenges**

All New Zealand industries have to compete in a rapidly changing world caused by globalisation, freer trade, accelerating technological development and strongly driven market forces responding to fast changing socio-economic conditions. The world food industry is particularly competitive and subject to very rapid change (Lancashire 2003a). As over 85% of the products from the pastoral sector are in the food area and are largely exported, the industry will have to continue to change rapidly, particularly as Oram (2003) has pointed out that the rate of global change is likely to get even faster. The pastoral sector has already shown a remarkable capacity for change in the freer economic environment since the 1980s. But any restrictions such as those now in place on the importation of exotic forage germplasm or related organisms like endophyte, have the potential to stop some essential changes, or possibly of equal seriousness curtail the speed of response to new challenges.

#### Climate change

New Zealand has been getting warmer for over a century and predictions are that this will continue at the rate of 0.2 degrees per decade in the 21st century. In addition, it is expected that east coast dryland systems will become increasingly limited because of reduced rainfall and increased evapotranspiration rates (Salinger 2003). A number of authors have pointed out that it is essential to investigate a range of subtropical forage species under field conditions so we can adjust to the new conditions (Field & Forde 1990; Campbell *et al.* 1996). Unfortunately many of these species are not currently present in New Zealand and/or are not on the list of approved species. Already a request from a plant breeder to bring in a range of dryland legumes has been turned down. Therefore the pastoral sector cannot prepare for the inevitable effects of climate change on pasture composition.

#### Biosecurity

The arrival of unwelcome pests and diseases of pastures in New Zealand from overseas is unlikely to cease or even slow down, however effective our border biosecurity. Inevitably the centre of origin of a pest or disease is a good place to start the search for biological controls or resistant plants. Clearly the current restrictions are going to make it more difficult to respond in a timely and effective manner to what is often a serious emergency.

#### Endophyte

Because the novel endophytes are now well established in New Zealand it is permitted, although often time consuming, to bring in new endophytes under dispensation from MAF. (It should be pointed out that senior members of the endophyte research team consider that if the current restrictions on importation of exotic germplasm had been in place during the development of the research programme, it is unlikely that it would have been successful). Unfortunately new opportunities such as developing the endophyte technology in cereals with other strains from overseas, will almost certainly be a casualty of the regime.

#### Biotechnology

The biotechnology industry is one of the major government priorities for the future. It is expected that it will play a major role in maintaining the global competitiveness of

our forage based pastoral sector (Bryan 2001). The use of gene maps and marker assisted selection (MAS) to improve perennial ryegrass and white clover will be used to transfer novel traits from related species into elite forage cultivars via cross-hybridisation (Barrett *et al.* 2001). The problem here is that it may be difficult to import related species to carry out this work if the plant is not on the MAF list of acceptable species. Even if the work was approved to be carried out under containment, there is still the problem of the eventual necessity to evaluate the hybrid in the field. If this deterrent is added to the existing difficulty of getting genetically modified plants evaluated in the field, an environment is being created which is not conducive to establishing a successful biotechnology industry in New Zealand.

#### Food and animal health

Recent research has shown the potential for tannin containing plants to improve the health and productivity of grazing animals (Harris *et al.* 1998; Waghorn *et al.* 1998). Unfortunately many of these tannin containing plants such as birdsfoot trefoil, sainfoin, lotus and sulla have little winter growth and are difficult to grow and manage successfully on farms in New Zealand, although some are used widely overseas. If their undoubted potential is to be achieved in New Zealand further evaluation of exotic germplasm is essential.

Some of these plants also have the capacity to reduce some of the strong flavours in New Zealand meat products, and also to produce more protein and less milk fat than traditional ryegrass/white clover pastures (Harris *et al.* 1998). It is known that a wide range of dietary factors can affect flavours in meat and milk (W. Rumball pers. comm.). The underlying chemistry of these processes is often complex and not well understood, but it is clear that the search for novel food products from the pastoral sector will include the utilisation of a wide range of plants and/or genes not currently present in New Zealand.

#### **Conclusion**

It is important to recognise the relevance of a recent statement by the Director-General of MAF (Sherwin 2004). He said “None of these tasks assume that we will, or can, reach a point of zero risk. Rather they aim to find a point at which the consequences of incurring risk, and the costs of mitigating or avoiding it, are assessed and balanced”. In the case of forage germplasm, it appears that the costs of mitigating or avoiding risk now far outweigh the consequences of avoiding risk. Most researchers spoken to feel that the current highly regulated system poses more of a threat to New Zealand’s biosecurity than the system of accredited institutions it replaced (Lancashire 2003b). This system, in place for most of the second half of the 20<sup>th</sup> century, was largely based on permission being given by MAF to accredited organisations (usually involved in research) to evaluate exotic material in the field under prescribed quarantine conditions. This involved regular inspections by outside experts in entomology and plant pathology and regular monitoring by the operator of the trial. Issues such as the weed potential of the material were dealt with before the trial was established. No evidence of serious biosecurity breaches as a result of these forage evaluations has been found. A return to this system with appropriate modifications is long overdue. If this cannot be accommodated within the current constraints of the HSNO Act (particularly the New Organisms part) then the Act should be amended.

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