The role of genetic resources in developing improved pastures in semi-arid and subhumid northern Australia

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Abstract

The role of introduced pasture species in the drier areas of northern Australia, and the need for genetic resource support, are reviewed. Introduced legumes are the key to improving animal production from the less fertile duplex soils, whereas introduced grasses have been of greater importance on the more fertile and heavier-textured soils. There is increasing recognition of the need for legumes adapted to clay soils. All of the successful legume and grass cultivars are of exotic species. The development of useful cultivars and the role of the Australian Tropical Forages Genetic Resource Centre are discussed, using the recently released pasture legume *Desmanthus virgatus* as an example.

Introduction

Most development of improved pastures in the drier semi-arid and subhumid areas of northern Australia has occurred since 1950. The underlying concept has been that the large benefits achieved by pasture improvement in southern Australia could be repeated in the north. This was to be achieved through a combination of improved species, alleviation of nutrient deficiencies and better management.

Substantial adoption of pasture improvement technology by the grazing industry has occurred, although the high early expectations have not been met fully. By 1996, some 5 M ha have been sown to improved pastures. Most of this involved sowing of grasses into fertile soils which had been cleared of native trees. However, approximately 1 M ha of lighter-textured soils have been sown to legumes, mainly *Stylosanthes* spp. Clements (1996) estimated that sown and naturalised pastures and forage crops will occupy some 14 M ha in northern Australia by the year 2010.

This paper outlines the past and potential role of the Australian Tropical Forages Genetic Resource Centre (ATFGRC) and its precursor (the Plant Introduction group of the CSIRO Division of Tropical Crops and Pastures) in the development of improved pastures in subhumid and semi-arid regions of northern Australia, using *Desmanthus virgatus* as an example. These areas receive an average annual rainfall of 500–900 mm in the subtropics and 500–1200 mm in the tropics. Most soils in the region are either heavy-textured, usually fertile clay soils or less fertile duplex soils with a light-textured A horizon.

Duplex soils

The main native pasture types are the speargrass (*Heteropogon contortus*) and mid-grass (*Aristida-Bothriochloa* spp.) grasslands covering some 25 and 33 M ha, respectively. These pastures support some 4.5 M cattle and 2 M sheep. The soils are usually low in total and available N with available P levels of 3 ppm (very deficient) to 15 ppm (adequate). Areas of duplex soils formerly under brigalow (*Acacia harpophylla*) have higher soil fertility.

Sown grasses

Establishment of grasses and grass-legume mixtures is mainly by sowing into cultivated seedbeds. The main sown grasses have been buffel grass (*Cenchrus ciliaris*) cvv. Biloela, Gayndah and American, rhodes grass (*Chloris*

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gayana) cvv. Pioneer and Katambora, sabi grass (*Urochloa mosambicensis*) cv. Nixon and green panic (*Panicum maximum* var. *trichoglume*) cv. Petrie. Other less widely used cultivars include some buffel grass cultivars (Nunbank, Tarewinnabar, Lawes and Boorara), gamba grass (*Andropogon gayanus*) cv. Kent, digit grasses (*Digitaria eriantha*) cv. Premier and (*Digitaria milanjiana*) cvv. Jarra and Strickland, Indian couch (*Bothriochloa pertusa*) cvv. Dawson and Medway (and Bowen and Yeppoon-Keppel types), and forest blue grass (*Bothriochloa bladhii*) cv. Swann. Current Australian seed production of all tropical grasses is of the order of 1300–2100 t/yr (Smith 1996).

Sown legumes

The most widely sown legumes are shrubby stylo (*Stylosanthes scabra*) cv. Seca and Caribbean stylo (*S. hamata*) cv. Verano. Other legumes sown in these soils are roundleaf cassia (*Chamaecrista rotundifolia*) cv. Wynn, siratro (*Macroptilium atropurpureum*) cv. Siratro, centurion centro (*Centrosema pascuorum*) cv. Cavalcade and finestem stylo (*Stylosanthes hippocampoides*) cv. Oxley. Commercial use of *Aeschynomene falcata* cv. Bargoo is limited by seed supply. Sometimes, some superphosphate may be applied to pastures sown to these legumes, often only at sowing.

New cultivars include Amiga Caribbean stylo, Siran shrubby stylo, Bundey centurion centro and Aztec atro. Accessions of *Aeschynomene brasiliana*, *Chamaecrista rotundifolia*, "Stylosanthes seabrana"[1] and *Centrosema brasilianum* are currently on pre-release with the Queensland and the Northern Territory Herbage Plant Liaison Committees. Current Australian seed production of these legumes is of the order of 250 t/yr (Smith 1996).

Most legumes have been established through low-cost oversowing into native pastures. They have had a substantial impact on animal production. Liveweight gain per head has been increased typically by some 30–40 kg/yr in good stylo pastures compared with grass-only pastures, and calving percentages have usually been raised (Coates 1995). Carrying capacity can sometimes be increased, although careful management is needed to ensure that the desirable species are maintained.

[1]Endorsed for release by QHPLC in 1996.

Future needs

Research programs are addressing deficiencies in and potential threats to current cultivars. A major objective is to protect stylo from the threat of anthracnose (*Colletotrichum gloeosporioides*) by breeding resistant lines. Other legume genera are being evaluated to see if they can provide alternatives to stylo (H.G. Bishop, personal communication). There is a need for better adapted legumes in southern Queensland and perhaps for a perennial stylo that has less tendency to dominate than Seca. Such a cultivar could make it easier to maintain a good legume:grass balance with reduced potential for soil acidification.

Testing of grasses requiring higher fertility, such as buffel grass, has given way to providing grasses for more specific purposes, *e.g.* tolerance of heavy grazing, or for colonising degraded areas. Although naturalised *Bothriochloa pertusa* is proving useful as a persistent grass on degraded areas, there could be opportunities for a similarly grazing-tolerant but more productive species. A wide range of grasses is currently being tested for this role.

Heavy-textured soils

Over 15 M ha of heavy-textured soils in Queensland and northern New South Wales receive adequate rain for cropping or improved pastures. Approximately half of this area was once dominated by brigalow. These areas usually have high total N levels, unless these have been reduced by sustained cropping, and adequate P levels. The decline in N levels in cropped soils and the resultant fall in wheat protein and yield has highlighted the potential for legume-based ley pastures.

Pastures on clay soils are grown on over 3 M ha and, in general, give higher yields, better quality feed and higher liveweight gain than pastures on duplex soils. Where grasses were sown into cultivation, particularly following clearing of brigalow, pastures were initially very productive. However, productivity has declined with time as a consequence of lowered levels of available N, although total N can remain high. This has led to lower pasture yields, lower animal production and, in some cases, replacement of productive grasses by less productive species. Application of fertiliser N can compensate for this "run-down" (Jones *et al.* 1995), but is unlikely to be economic. The grazing industry continues to have a high level of interest in legumes as a source of N for both leys and permanent pastures.

Sown grasses

Sown grasses are essential for most pasture improvement on clay soils, particularly in the brigalow communities, where there were virtually no grasses present before clearing. Sown grasses are also needed for a pasture phase after cropping. The requirement for "higher fertility" grasses is adequately met by the current cultivars of rhodes grass, buffel grass, bambatsi panic (*Panicum coloratum*), purple pigeon grass (*Setaria incrassata*), green panic and the perennial *Sorghum* hybrid cv. Silk, the latter being used in leys. Grasses with better adaptation to lower fertility levels, such as Hatch and Bisset creeping bluegrass (*Bothriochloa insculpta*) and Floren bluegrass (*Dichanthium aristatum*), are available. We consider further work aimed at developing new grass cultivars to be low in priority. The one exception would be cultivar selection within Queensland blue grass (*Dichanthium sericeum*), a native grass also adapted to lower fertility levels.

Sown legumes

In southern Queensland and northern New South Wales, lucerne- and medic-based pastures can provide quality feed and enhance soil N (Lloyd *et al.* 1991). However, lucerne has a limited life span of up to 4 years, depending on rainfall patterns and grazing systems, and medics, being annuals, are very dependent on cool season rainfall. These species are even less suited to lower latitudes of the subtropics, where cool season rainfall is lower and even less reliable.

Despite substantial research input in the 1960s and 1970s, there is still a limited range of tropical legumes that are widely used in ley or permanent pastures on clay soils. The annuals *Lablab purpureus* and cowpea (*Vigna unguiculata*) have an annual Australian seed production of 600 and 300 t, respectively (Smith 1996). *Leucaena leucocephala* is well suited to some central Queensland areas with deep fertile soils. It can produce high liveweight gains but requires intensive management. Thus, it is most unlikely to be sown in "low-input" pasture systems.

With the recent revival of interest in ley legumes and concern over reducing fertility, a wide range of tropical legumes from ATFGRC has been evaluated on clay soils in Queensland (Conway *et al.* 1988; Clem and Hall 1994; Rees *et al.* 1995). A number of promising legumes for perennial pastures have been identified, particularly *Desmanthus virgatus*, which is described in more detail in the next section. *Indigofera schimperi* has been very persistent and productive at a range of sites. It is eaten if grazed regularly over the growing season, but is somewhat unpalatable if grazed only towards the end of the growing season. The native *Glycine latifolia* has shown considerable promise on a basalt-derived soil at Pittsworth (Rees *et al.* 1995), but has been less promising at some other sites. "Stylosanthes seabrana" is showing considerable promise and should be commercially available in 1997.

Promising annuals or short-term perennials for use in ley pastures have been identifed, mainly butterfly pea (*Clitoria ternatea*) cv. Milgarra, and accessions of *Vigna*, *Macroptilium*, and *Macrotyloma* — and possibly *Desmanthus*. These are now being evaluated more widely in "on-farm" sowings supported by industry funding.

Desmanthus virgatus

Variation and cultivar development

The genus *Desmanthus* is endemic to the Americas and the Caribbean islands, although *D. virgatus* has become naturalised in many areas of the tropics and subtropics (Burt 1993). There are 18–24 species in the genus, depending on the classification accepted. Five species other than *D. virgatus* have shown little promise in Queensland, although these have been represented by only 1 or 2 accessions. In contrast, some 50 out of 300 accessions of *D. virgatus* held by ATFGRC have been grown.

D. virgatus shows wide variation in flowering time and growth habit — from almost prostrate, to erect shrubs over 2 m tall. Many of the accessions introduced into Australia were grouped by Burt (1993), who found little consistency between site of collection and growth form. Consequently, he concluded that the geographic locations could not be used to select "representative types".

The first purposeful introduction of desmanthus into Australia (CPI 16672) was in 1952, although the genus was recorded in Queensland as early as 1912. The first published reports of field evaluation were by Conway *et al.* (1988) and Clem and Hall (1994), who evaluated 16 and 4 accessions, respectively, in 1978 and 1979. During the 1980s, more accessions of desmanthus were sown at a range of sites (Gardiner and Burt 1995), but comparison of the results is difficult because the range of accessions sown differed at different sites.

A more co-ordinated evaluation commenced in 1988, when 40 *Desmanthus* accessions were sown at 12 sites over a wide latitudinal range in Queensland (Cook *et al.* 1993), with additional sowings in later years. Accessions were usually more successful on clay soils, although some, particularly CPI 37538, showed promise on lighter soils. Three cultivars were released in 1991.

Cultivar Marc is a free-seeding cultivar with small leaves and rarely grows to more than 50 cm in height. Cultivar Bayamo is taller, growing up to 150 cm. Although typically flowering in mid-season, it requires a much longer period of good soil moisture to seed than does cv. Marc. Cultivar Uman is decumbent and spreading, and is described as late-flowering. However, in inland southern Queensland, it often flowers in early spring on old stems not killed by winter frosting. Cultivar Marc originates from Argentina, Bayamo from Cuba and Uman from Mexico. Commercially, the 3 cultivars are mixed in equal proportions and sold as "Jaribu". The mixture was used, in the absence of precise information, to provide a broader genetic base to accommodate differences in soil, climate and management.

CPI 78382 is an early flowering line, very similar to cv. Marc, which showed considerable early promise. As a result, it was sown widely in small plot evaluation studies (*e.g.* Rees *et al.* 1995) and even in simple grazing trials (Burrows and Porter 1993). Although it was not subsequently released, the data from this accession are still relevant because of its similarity to cv. Marc.

Jaribu became available commercially in the 1994–95 summer and, by the end of the 1995–96 summer, some 10 t of seed had been sold. Feedback from commercial sowings will provide more information about areas to which the 3 cultivars are best suited and will help to identify characters to be sought in further cultivars.

Supporting research

Before the 3 cultivars were selected, a range of *Rhizobium* strains had been screened in sand-culture experiments. The initially recommended strain was CB1397, but this strain failed and strain CB3126 is now used commercially.

However, little was known about the ability of *D. virgatus* to form effective nodules with native strains. This is particularly important as inoculated seed is usually sown at depths of < 2 cm into dry surface soil with subsoil moisture. Given the frequent hot, dry periods in areas to which desmanthus is suited, it is likely that applied rhizobia will often die, so ability to nodulate from native rhizobia is very desirable. Recent research (G. Bahnisch, N.J. Brandon and R.A. Date, personal communication) indicates that uninoculated desmanthus will form effective nodules on most clay soils but there are some soils where this may not occur. The presence of native *Neptunia gracilis* may indicate the presence of effective rhizobia. Monitoring of commercial sowings could indicate the areas where nodulation is a problem. However, such a failure may not be apparent in the first or second year after sowing, as plants may remain green and productive through uptake of N released by cultivation.

When the cultivars were released, it was assumed that the clay soils where desmanthus would be sown would have adequate nutrient status. However, recent research has shown responses to P, S and Mo in pot trials and a field response to S and Mo at one site (P. Spies, R.A. Date and N.J. Brandon, personal communication). The possibility of nutrient deficiencies in commercial sowings should be recognised.

When the cultivars were released, little was known about their reaction to different grazing pressures or about their long-term persistence. Research now suggests that, although Marc types may not survive as long as the more robust Bayamo types, they can persist through recruitment of new plants from seed set under grazing. Reserves of over 10 000 seeds/m^2 of cv. Marc and CPI 78382 have been measured in desmanthus swards (authors, unpublished data). However, lower levels of 150–450 seeds/m^2 were measured below poorer stands of CPI 78382 growing with a very vigorous companion grass (Burrows and Porter 1993). Later-flowering types such as Bayamo have seeded very poorly under grazing in the recent drier years, so their longer-term persistence is questionable. This need for a seed reserve for long-term persistence could affect both future cultivar selection and grazing management recommendations.

These experiences with the nodulation, nutrition and persistence of desmanthus illustrate the need for strategic research to accompany the release of any "new" legume that has not been used previously.

Future research needed on D. virgatus

It is important that, if problems with nodulation, nutrition, disease and poor persistence arise with the current suite of pasture cultivars, we have the genetic resources for developing further cultivars which are adapted to the new situation. For example, there may be a need for accessions that nodulate more promiscuously or have greater disease resistance.

From experience to date, there are 2 attributes that we could look for in new cultivars. The first would be greater frost resistance, which may be present in recent introductions from Paraguay (Hacker and Pengelly 1996). The second is for lines such as TQ90 and CPI 40071 that are more productive than cv. Marc but which set more seed in pastures than cv. Bayamo. If the need arises, passport information suggests that some accessions may have tolerance to saline conditions (B.C. Pengelly, personal communication). A final caution is that, in the quest for persistence, there is a need to avoid cultivars which may have an unnecessary risk of weed potential.

Previous and future role of the ATFGRC

Most of the grass cultivars and all the legume cultivars and accessions on pre-release for the duplex soils in the drier areas of northern Australia have been introduced through the ATFGRC — as have most of the grasses and legumes used on clay soils (Hacker 1997). The ATFGRC has provided all the desmanthus accessions tested prior to the release of cv. Jaribu and has carried out the glasshouse and field testing of rhizobia for desmanthus and other legumes. It has provided the genetic material used to develop disease-resistant cultivars of siratro and stylo. It will remain the key source of new cultivars — whether used as direct introductions or in breeding new lines with specific properties.

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