

The role of native grasses and legumes for land revegetation in central and eastern Australia with particular reference to low rainfall areas

C.M. WATERS¹, D.S. LOCH² AND
P.W. JOHNSTON³

¹Rangelands Research Unit, New South Wales
Agriculture, Trangie, NSW, Australia

²Queensland Department of Primary Industries,
Gympie, and

³Charleville, Queensland, Australia

Abstract

There is increasing interest in using native grasses and legumes in revegetation programs directed at pastoral, amenity and mining use. However, few native grasses and essentially no native legumes are available commercially. The developing Native Seed Industry is based largely on the use of locally harvested seed from wild stands, a situation likely to continue at least in the short to medium term, although improved cultivars being developed in a number of domestication programs are now reaching the early stage of commercialisation. The major factor limiting further expansion in the area sown to native grasses in Australia is the current fragmented state of the industry which is characterised by fickle demand for the often low and irregular supplies of seed of variable quality. Until stronger, more reliable markets develop, native species will continue to play a minor role in revegetation programs.

Introduction

Revegetation of agricultural lands, mine sites and amenity areas for environmental or productivity reasons has become increasingly important to the majority of Australians. Land users wanting to revegetate areas for these purposes have two options: either to rest an area from use to allow

natural re-vegetation or to reseed these areas. Resting areas from grazing, for example, can be effective (Hodgkinson 1992); however, rate of recovery depends on the amount of seed in the soil. When soil seedbanks are depleted, reseeding can hasten the recovery process.

Some native grass species are currently being utilised by the pastoral, amenity and mining industries, with most of this seed harvested from wild stands. The greatest limitation to the expansion of this use of native species is the current fragmentation of the industry, which is characterised by fickle demand for the often low and irregular seed supplies of variable quality. Six cultivars of 3 native grass species and 1 native legume have been granted Australian Plant Breeders Rights (PBR), but limited quantities of seed are available commercially.

However, in low rainfall environments (<600 mm annual rainfall), the general failure of exotic species to persist has re-focused attention towards the use of low-input native species which have ecological and adaptive advantages (Wilson 1996).

In this paper, we consider the benefits of native grass and legume species, discuss their evaluation and development, and describe those which are commercially available.

Advantages of using native species

Australia's native grasses and legumes have evolved mainly on soils of low fertility, with climatic conditions characterised by highly variable and generally low annual rainfall. Since they have evolved under these often harsh climatic and edaphic conditions, Australian native grasses and legumes are better adapted than most exotic species, which tend to have evolved under more benign environments.

Apart from these adaptive advantages, native species have been recognised for their low requirements compared with exotic species in

Correspondence: Ms C.M. Waters, Rangelands Research Unit, NSW Agriculture, PMB 19, Trangie, NSW 2823, Australia

terms of nutrients and establishment costs (Wilson 1996). More recently, the ecological benefits of using native species have been recognised increasingly by the Australian public. Native herbaceous species contribute to maintaining ecological integrity and biodiversity and provide suitable habitats for indigenous flora and fauna. Combined with this emphasis on the re-establishment and/or maintenance of natural diversity has been an acknowledgement that the use of exotic species provides a potential threat of introducing weeds (Humphries *et al.* 1991). Potential threats in environmentally sensitive areas are posed by widely used species such as buffel grass (*Cenchrus ciliaris*), currently being used in revegetation programs in rangeland areas of central Australia. Here, they tend to dominate the vegetation, in some cases resulting in the loss of the native grass population (Reu 1995a). On mined land undergoing rehabilitation, rill erosion can continue between the grass tussocks to the detriment of landscape stability.

The failure of most introduced species to persist under the variable climatic conditions in arid Australia has recently stimulated interest in the use of native species in revegetation programs. In Queensland alone, almost 500 accessions of exotic species have been evaluated for the arid region (Johnston 1990), but few were identified as "useful", especially in terms of their ability to withstand dry periods. This has provided an incentive for government agencies to examine the potential use of native species in low rainfall areas.

Disadvantages of using native species

Past emphasis on the evaluation of exotic species for revegetation programs has been based largely on their value for livestock production and ease of seed production. While native species may provide forage sustainably, generally they produce lower fodder quality and yields than exotics (Wilson 1996). The use of natives in revegetation programs has therefore focussed on agricultural land of lower productivity or on non-agricultural land (*e.g.* roadsides, mine sites).

Native grasses and legumes also generally have poor establishment rates and slow initial growth rates. While the latter is an adaptation that assists in long-term survival, the reasons for low establishment rates are not always clear. Moreover,

broad guidelines for successful establishment of native species are generally not practicable; the range of environmental conditions in which they are being used, the purposes for which they are being employed, and the type of species often require techniques tailored to meet site-specific requirements (Silcock and Scholz 1996).

These latter problems highlight the need to study appropriate management and establishment technologies as well as ecological aspects when developing new varieties of native species. Rather than expecting natives to be used with existing technologies developed for exotic species, we should anticipate that alternative technologies may be required. For example, the hygroscopically passive awns found in *Chloris* and *Microlaena* spp. orient the falling seeds, helping them to become embedded in the soil surface in a position advantageous to establishment, but pose seed processing and handling problems (Loch and Clark 1996). In such cases, new technologies that improve handling without detriment to establishment need to be developed to facilitate their commercial use.

Another example of the need to adapt technology to suit plant characteristics is the technique for harvesting seed. Many native grass species produce difficult-to-handle "chaffy" seeds. The development and adoption of brush harvesters has facilitated the harvesting of chaffy-seeded grasses and allows several passes to be made, picking up ripening seed each time with only minor damage to the plant (Loch *et al.* 1996).

The evaluation and selection of native grass and legume species for use in revegetation programs is a recent phenomenon in Australia (only within the last 12 years) and has focussed almost exclusively on grasses. Six native grass cultivars and 1 native legume have been registered under PBR. These include cultivars of *Danthonia richardsonii* and *D. linkii*, *Microlaena stipoides* and *Glycine latifolia*. Advanced selections of *Astrelba lappacea* and *A. pectinata* (Waters and Munnich 1995) have been made with commercial release expected in the near future. Details of the selection process in each of these cultivars have been described by Waters and Johnston (1996) and Lodge (1996).

Currently, a major constraint to broad-scale use of native grass and legume species in Australia is the lack of commercial quantities of appropriately priced, quality seed. This is in contrast to the situation in the USA where

approximately 100 native species are now available commercially in the state of Utah alone (R.B. Hacker, personal communication).

Natural stands (of grasses) are harvested currently for use in regional revegetation programs being undertaken throughout eastern Australia, for town beautification, green corridors, habitat maintenance, or agricultural land reclamation purposes. For these purposes, the harvesting and sowing of mixed seed from native stands may result in a more robust and biologically stable stand than a monospecific pasture (Silcock and Johnston 1993).

The Native Pasture Seed Industry, however, is still in its infancy, and is characterised by fickle demand for the often low and irregular seed supplies of variable quality (Loch *et al.* 1996; Waters and Noad 1996). Seed production cannot continue without markets, and markets will not continue without seed to sustain them. Until this nexus is broken, and a stronger, more reliable market developed, native species will continue to play only a minor role in revegetation programs.

Development and use of native species

The potential for developing varieties of native species is considerable. In Australia, there are more than 750 native grass species in about 180 different genera (Lodge and Groves 1990).

As new cultivars are developed, more species will be available for use, but there could be some loss in genetic diversity (as compared with natural populations). With sexually-reproducing species, it is unlikely that this will be a serious problem, as there is likely to be extensive genetic variation within the cultivar. This is not the case, however, with obligate apomicts (such as *Heteropogon contortus*).

Simple, inexpensive sowing and establishment techniques need to be developed for these species (Wilson 1996). Selected cultivars should be targeted for particular roles and agronomic merit (*e.g.* green leaf production) and evaluated against other species (native or exotic) that are being used for similar purposes. Native cultivars should not be released just because they are of native origin, but because they have merit in their own right (Garden *et al.* 1996).

Roles played by native species

The more important native grass species which have been evaluated for use in revegetation programs are listed in Table 1. Three native legume species should also be noted, these being *Glycine latifolia*, *Psoralea patens* (Skerman 1957) and *Rhynchosia minima*. Only the first of these would be rated highly for commercialisation and, although *G. latifolia* cv. Capella has been awarded PBR protection, its formal release is still uncertain.

Pastoral use

Selected grasses. Native grasses contribute substantially towards pasture production. In some temperate areas, native grasses contribute up to 60% or more of the pasture (Lodge and Groves 1990; Munnich *et al.* 1991), providing benefits such as summer and drought fodder, persistence and adaptation to low fertility soils (Leigh 1990; Garden *et al.* 1996). In semi-arid (Harrington *et al.* 1984) and tropical rangelands, native herbaceous species comprise the entire diet of grazing livestock. Most of the development of native grass species for sowing has been recent and has been concerned primarily with their development for use in the pastoral industry.

Danthonia spp. are palatable, cool season, perennial grasses which produce green forage high in crude protein (Lodge 1993). Two cultivars have been developed for use in temperate areas of eastern Australia. *D. richardsonii* (cv. Taranna) is adapted to a range of soil types whereas *D. linkii* (cv. Bunderra) prefers finer textured soils (Table 1). These were the first native grass varieties to be released, and only recently have they been sown by graziers in southern New South Wales.

Microlaena stipoides (cv. Wakefield) is a more recent release for the northern tablelands of NSW (Table 1). In this area, *M. stipoides* forms a valuable component of native pastures (Jones and Whalley 1994). It is tolerant of both shade and grazing.

Astrebla lappacea and *A. pectinata* (Mitchell grasses) are warm season perennials (Table 1). *Astrebla* spp. are the basis for the most productive and stable native grasslands of eastern Australia (Orr and Holmes 1984). Decline of Mitchell grass pasture has resulted from increases in areas being cropped, inappropriate

Table 1. Native species evaluated for use in revegetation programs (adapted from Loch and Clark 1996).

Species	Use ²	Problems	Comments
<i>Astrebula elymoides</i> ^{M1}	Forage	High percentage of trash harvested (inflorescence stalks brittle & break off with spikelets)	Widespread on heavy Mitchell grass plains; establishes more readily than <i>A. pectinata</i>
<i>Astrebula lappacea</i> ^H	Forage	Long, often multiple seed heads can become lodged; very persistent	Widespread on heavy Mitchell grass plains in the subtropics
<i>Astrebula pectinata</i> ^H	Forage	Seeds ripen over a prolonged period	Widespread on heavy Mitchell grass plains in more arid areas
<i>Astrebula squarrosa</i> ^M	Forage	Handling difficult (awns & bristles very prickly); high percentage of trash harvested	Widespread on heavy Mitchell grass plains in tropical areas; tolerates heavy grazing
<i>Bothriochloa bladhi</i> ^M	Forage	Handling difficult (seeds cling together)	Widespread on loam & clay soils
<i>Bothriochloa decipiens</i> ^M		Handling difficult (seeds cling together)	Widespread on less fertile loam & clay soils
<i>Bothriochloa macra</i> ^M	Amenity, forage	Handling difficult (seeds cling together)	Widespread on loams & clay soils in SE Australia
<i>Chloris truncata</i> ^M	Forage	Harvestable stands isolated & patchy; low drought tolerance	Adapted to a wide range of soils in semi-arid areas; colonises denuded land
<i>Cymbopogon ambiguus</i> ^M	Erosion control	Seed hand harvested; little known about establishment characteristics	Prefers wetter areas
<i>Cymbopogon refractus</i> ^M	Amenity	Low seed yields; difficult to clean	Promising roadside species in SE Queensland
<i>Danthonia caespitosa</i> ^H	Forage	Needs winter/spring rain	Widespread in temperate Australia, from clay soils to light sandy loams; recruits readily
<i>Danthonia linkii</i> ^H	Forage	Weed control; seed harvesting & processing	Widespread in temperate Australia
<i>Danthonia richardsonii</i> ^H	Forage, amenity	Weed control; seed harvesting & processing	Widespread in temperate Australia
<i>Dichanthium sericeum</i> ^H	Forage, amenity	Handling difficult (seeds cling together)	Widespread dominant species on alkaline clay soils
<i>Digitaria brownii</i> ^M	Forage	Post-harvest dormancy; seedlings very moisture-sensitive	Variable species widespread on sands, loams & hard red earths
<i>Diplachne fusca</i> ^M	Rehabilitation	Will persist only while conditions remain favourable	Salt-tolerant; occurs naturally on clay pans; establishes well on hard-setting clay soils
<i>Elymus scaber</i> ^M		Low seed fill in apomictic forms	Widespread in southern Australia
<i>Enneapogon avenaceus</i> ^M	Forage	Rapid shedding of ripe seed; seed fill usually low	Good pioneer species adapted to coarse-textured soils
<i>Eragrostis setifolia</i> ^M	Forage	Very small seeds; quality usually low	Widespread in arid areas, especially on heavier soils
<i>Eulalia aurea</i> ^M	Rehabilitation	Low seed fill; seed retention poor; seedling survival poor	Widespread dominant species on sandy-clay soils
<i>Heteropogon contortus</i> ^H	Forage	Handling difficult (seeds sharp & cling together)	Widespread dominant species on well-drained loams & clay soils
<i>Microalaena stipoides</i> ^H	Turf, amenity, forage	Broadacre establishment; weed control; seed harvesting and processing	Widespread shade-tolerant species for acid soils in cooler areas
<i>Monachather paradoxa</i> ^M	Forage	Difficult to locate harvestable stands (isolated patches)	Common on red earths & sandy soils in mulga country
<i>Panicum decompositum</i> ^M	Forage	Strong post-harvest dormancy	Rarely forms dominant stands; good rehabilitation species
<i>Plectrachne, Triodia</i> spp. ^M		Low seed fill; low seed yields; plants easily damaged by wheeled traffic	Useful for mine rehabilitation in arid N & NW Australia
<i>Sporobolus caroli</i> ^M		Very low laboratory germination	Good field establishment on heavy soils; useful early coloniser for mined land
<i>Sporobolus virginicus</i> ^M		Low seed fill	Dominant on saline tidal flats
<i>Themeda triandra</i> ^H	Amenity	Low numbers of seeds per kg	Widespread on well-drained sandy to clay soils
<i>Thyridolepis mitchelliana</i> ^M	Forage	Difficult to locate harvestable sized stands; readily grazed	Common on red earths and sandy soils in mulga country
<i>Zygochloa paradoxa</i> ^M	Rehabilitation (erosion control)	Seed hand harvested; little known about establishment characteristics	Unpalatable; highly tolerant of grazing; exists in large dense stands

¹Current priority ratings for commercialisation: H = high, M = medium.²Purpose for which species has mainly been evaluated.

grazing management and flooding. Cultivars of these species with a high leaf percentage have been developed for use in reseeding pastoral areas and rundown cropping paddocks in north-eastern NSW and central-western Queensland (Waters and Munnich 1995).

The LIGULE project (Low Input Grasses Useful in Limiting Environments) aims to develop and release a range of agriculturally useful perennial native grasses for the 500–700 mm rainfall zone in the Murray-Darling Basin (Johnston *et al.* 1995). In this region, large areas have been cleared extensively and summer-growing native plants have been replaced by exotic temperate perennial grasses which fail to persist. As a result, these areas are becoming dominated by annual plants, leading to an increase in ground water recharge, dryland salinity and soil erosion. From an original collection of 33 native grass species, 12 have been selected for further evaluation of their ability to reduce ground water recharge.

A number of other species have also been evaluated for use in the pastoral industry, some of which have undergone selection within populations. No commercial release of these species is planned, though commercial quantities of wild-collected seed are available for some of them (*e.g.* *Dichanthium sericeum*). The major ones are described below.

Twenty-two native grass species were identified for use on red soils in the semi-arid areas of eastern Australia (Torpy *et al.* 1994). In these areas, the desirable perennial component of the pasture has been reduced (Harrington *et al.* 1984), and in some cases, unpalatable woody shrub populations dominate the landscape. Few adapted exotic pasture species are available for reseeding purposes. Three perennial native species, *Danthonia caespitosa*, *Digitaria brownii* and *Dichanthium sericeum* (Table 1), were selected because seed could be harvested with relative ease and they proved to establish successfully in the field.

In the arid rangelands of central Australia, 12 native grass species were evaluated for their suitability in rehabilitation programs on different soil types (Reu 1995b). Selection criteria included palatability, drought tolerance, provision of ground cover in dry periods and quick growth responses following rainfall. Four species were identified as promising: *Astrelba pectinata*,

Bothriochloa ewartiana, *Diplachne fusca* and *Enneapogon avenaceus* (Table 1).

Two species, *Thyridolepis mitchelliana* and *Monachather paradoxa* (Table 1), native to the mulga lands of south-western Queensland, were identified by Johnston (1990) as suitable for reseeding these areas. Some selection between ecotypes within species has been undertaken. Selection criteria included height of inflorescence, seed yield, and high amounts of leaf production.

Selected legumes. The only native forage legume close to commercial release is *Glycine latifolia* cv. Capella, which has been described for Australian PBR (Jones 1994). This is a mainly subtropical species which is drought-tolerant and frost-resistant and is adapted to clay soils (Rees *et al.* 1993). Capella is persistent under grazing, and spreads by rooting down of the stolons or by seed.

Amenity use

In both urban and semi-rural areas, there is public demand for seed of native species to re-establish natural biodiversity and to reduce maintenance and for the ability of native grasses to "soften" the appearance of the landscape. Two such native grass cultivars have been developed — *D. richardsonii* cv. Hume and *M. stipoides* cv. Shannon. A second selection of *M. stipoides* (cv. Griffin) has been released as a turf variety, and cultivars of *Themeda triandra* and *Bothriochloa macra* (Lodge 1996) are expected to follow in late 1996 (Table 1).

Mine site rehabilitation

Last year in central Queensland, the mining industry used 875 kg of native shrub and tree seed, but only about 50 kg of native grass seed (Roe 1996). This industry is expected to continue to rely on the use of native tree and shrub species, which appear to have fewer seed collection and germination problems than some of the native grasses. As native grass species are not able to provide the rapid early ground cover required by this industry, exotic species are used initially as an understorey before introducing natives later on. A strip of established exotic grasses is killed with herbicide and seed of native species broadcast into the treated strips in the

hope that they will spread. Further bands may be sown at later dates. The use of native grass species is necessary, not only to enhance the species diversity of the site, but also because some exotic species tend to grow rank and fail to persist in the absence of grazing. Generally, exotic grass species also tend not to persist in the long term due to the low soil fertility and soil structural problems associated with mine site areas (P.A. Roe, personal communication).

In the past, the use of native species in the revegetation of mine sites has been driven largely by legislative requirements and, more recently, by public expectation. However, the Mining Industry is now funding its own studies of native ecosystem management (with 4 major projects in eastern Australia), as well as undertaking local seed harvesting and processing.

This involvement in the evaluation of native species has become an economic necessity as revegetation programs represent approximately 5% of the total mining costs. With an expected annual expansion of 5000 ha of disturbed land, future demand for native species from the Mining Industry is likely to increase. However, these areas are dwarfed by the extensive areas of Australia's rangelands that have experienced a reduced abundance of perennial grasses through the effects of grazing (Harrington *et al.* 1979).

Genetic resources for native species of grasses and legumes

Almost all projects aimed at developing cultivars or gaining an understanding of genetic variation in native grasses and legumes have relied on collections made from the wild for the purpose. Conservation of the genetic resource has been almost entirely *in situ*. In the past, valuable collections have not been conserved *ex situ*; an example is a genetic study of *Heteropogon contortus* (Tothill and Hacker 1976). This study was based on a collection covering the entire Australian geographic range of the species, but was not conserved for future study or development. There is an urgent need for *ex situ* conservation of collections of native grasses and legumes currently under study, as a basis for further development. The Australian Tropical Forages Genetic Resource Centre (in Brisbane) has offered to provide this service.

Conclusions

Native grass and legume species currently play only a minor role in revegetation programs directed at pastoral, amenity and mining use in Australia. Most of this is seed harvested from wild stands, a situation likely to continue at least in the short to medium term, although improved cultivars being developed in a number of domestication programs are now reaching the early stage of commercialisation.

The major factor limiting further expansion in the area sown to native grasses in Australia is the current fragmented state of the industry, which is characterised by fickle demand for the often low and irregular seed supplies of variable quality. Until a stronger, more reliable market develops, native species will continue to play only a minor role in revegetation programs despite their advantages.

References

- GARDEN, D., JONES, C., FRIEND, D., MITCHELL, M. and FAIRBROTHER, P. (1996) Regional research on native grass-based pastures. *New Zealand Journal of Agricultural Research*, **39** (4), 471–486.
- HARRINGTON, G.N., OXLEY, R.E. and TONGWAY, D.J. (1979) The effects of European settlement and domestic livestock on the biological system in poplar box (*Eucalyptus populnea*) lands. *Australian Rangeland Journal*, **1**, 271–279.
- HARRINGTON, G.N., FREIDEL, M.H., HODGKINSON, K. and NOBLE, K.C. (1984) Vegetation ecology and management. In: Harrington, G.N., Wilson, A.D. and Young, M.D. (eds) *Management of Australia's Rangelands*. pp. 41–61. (CSIRO: Australia).
- HODGKINSON, K.C. (1992) Elements of grazing strategies for perennial grass management in rangelands. In: Chapman, G.P. (ed.) *Desertified Grasslands: Their Biology and Management*. pp. 77–94. (Academic Press: London).
- HUMPHRIES, S.E., GROVES, R.H. and MITCHELL, D.S. (1991) Plant invasions of Australian ecosystems: a status review and management directions. *Kowari*, **2**, 1–127.
- JOHNSTON, P.W. (1990) Producing native seed for mulga lands. In: Dowling, P.M. and Garden, D.L. (eds) *Native Grass Workshop Proceedings, Dubbo, 16–17 October, 1990*. p. 161. (Australian Wool Corporation: Melbourne).
- JOHNSTON, W.H., MITCHELL, M., CLIFTON, C., WATERHOUSE, D. and KOEN, T. (1995) The LIGULE project — an outline. *Proceedings of the Second Australasian Perennial Grass Workshop, Launceston, Tasmania, 17–19 October, 1995*. pp. 259–263.
- JONES, C.E. and WHALLEY, R.D.B. (1994) Responses of different selections of *Microlaena* to sward density and cutting frequency. *Proceedings of the First ATRI Turf Research Conference*. pp. 117–119.
- JONES, D. (1994) GLYCINE. *Glycine latifolia* 'Capella' Application No. 93/272. *Plant Varieties Journal*, **7**, 26–27.
- LEIGH, J.H. (1990) Pastoral value and production from native pastures. In: Dowling, P.M. and Garden, D.L. (eds) *Native Grass Workshop Proceedings, Dubbo, 16–17 October, 1990*. pp. 25–46. (Australian Wool Corporation: Melbourne).

- LOCH, D. and CLARK, M. (1996) Production, harvesting and processing of native grass and herbaceous legume seed: the reality and the challenge. In: Waters, C.M. and Noad, W.J. (eds) *Proceedings of the Native Grass and Legume Seed Industry Workshop, Roma, 26–27 March, 1996*. pp. 29–50.
- LOCH, D.S., JOHNSTON, P.W., JENSEN, T.A. and HARVEY, G.L. (1996) Harvesting, processing and marketing Australian native grass seeds. *New Zealand Journal of Agricultural Research*, **34**, 591–599.
- LODGE, G.M. (1993) The domestication of the native grasses *Danthonia richardsonii* Cashmore and *Danthonia linkii* Kunth for agricultural use. I. Selecting for inflorescence seed yield. *Australian Journal of Agricultural Research*, **44**, 55–77.
- LODGE, G.M. (1996) Temperate native Australian grass improvement by selection. *New Zealand Journal of Agricultural Research*, **39** (4), 487–498.
- LODGE, G.M. and GROVES, R.H. (1990) The domestication and agronomy of native grasses. In: Dowling, P.M. and Garden, D.L. (eds) *Native Grass Workshop Proceedings, Dubbo, 16–17 October, 1990*. pp. 73–84. (Australian Wool Corporation: Melbourne).
- MUNNICH, D.J., SIMPSON, P.C. and NICOLS, H.I. (1991) A survey of native grasses in the Goulburn district and the factors influencing their abundance. *Rangeland Journal*, **5**, 118–129.
- ORR, D.M. and HOLMES, W.E. (1984) Mitchell grasslands. In: Harrington, G.N., Wilson, A.D. and Young, M.D. (eds) *Management of Australia's Rangelands*. pp. 241–254. (CSIRO: Australia).
- REES, M.C., JONES, R.M., BROWN, A.H.D. and COOTE, J.N. (1993) *Glycine latifolia* — a potentially useful native legume for clay soils in tropical and subtropical Australia. *Proceedings of the XVII International Grassland Congress, Rockhampton, 1993*. pp. 2134–2135.
- REU, S. (1995a) The performance of selected native grass species when used for rangeland rehabilitation in central Australia. *Northern Territory Department of Lands, Planning and Environment Resource Management Division, Technical Memorandum No. TM 95/4*.
- REU, S. (1995b) Assessment and use of native grasses for rehabilitation in central Australia. *Australian Rangeland Society Range Management Newsletter No. 95/3*. pp. 1–5.
- ROE, P.A. (1996) Native grasses for the mining industry. In: Waters, C.M. and Noad, W.J. (eds) *Proceedings of the Native Grass and Legume Seed Industry Workshop, Roma, 26–27 March, 1996*. pp. 91–94.
- SILCOCK, R.G. and JOHNSTON, P.W. (1993) Establishing new pastures in difficult tropical environments — do we expect too much? *Tropical Grasslands*, **27**, 349–358.
- SILCOCK, R.G. and SCHOLZ, G. (1996) Establishment and management of native grass stands for seed production and forage. In: Waters, C.M. and Noad, W.J. (eds) *Proceedings of the Native Grass and Legume Seed Industry Workshop, Roma, 26–27 March, 1996*. pp. 51–67.
- SKERMAN, P.J. (1957) Bullamon lucerne (*Psoralea eriantha* Benth.) — a plant worth watching. *Journal of the Australian Institute of Agricultural Science*, **23**, 337–339.
- TORPY, C.M., TOOLE, I. and HALBISCH, W. (1994) Selection and evaluation of native grasses suitable for the semi-arid rangelands and marginal croplands. *Final Report to the Wool Research and Development Corporation*.
- TOTHILL, J.C. and HACKER, J.B. (1976) Polyploidy, flowering phenology and climatic adaptation in *Heteropogon contortus* (Gramineae). *Australian Journal of Ecology*, **1**, 213–222.
- WATERS, C.M. and MUNNICH, D. (1995) The domestication of Mitchell grass (*Astrelba*) for use in the semi-arid rangelands of eastern Australia. *Proceedings of the 10th Annual Conference of NSW Grassland Society, Armidale*.
- WATERS, C.M. and JOHNSTON, P.W. (1996) A review of native grass and legume selection and evaluation programs. In: Waters, C.M. and Noad, W.J. (eds) *Proceedings of the Native Grass and Legume Seed Industry Workshop, Roma, 26–27 March, 1996*. pp. 18–28.
- WATERS, C.M. and NOAD, W.J. (eds) (1996) *Proceedings of the Native Grass and Legume Seed Industry Workshop, Roma, 26–27 March, 1996*.
- WILSON, A.D. (1996) Native and low input grasses for pastoral and marginal cropping land. *New Zealand Journal of Agricultural Research*, **39** (4), 465–469.