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Pasture under adverse conditions - Handling what you have:

Harvesting and sowing native grasses

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Summary: Increasingly Australians are interested in using native grasses because of both declines in productivity and persistence of exotic based pastures, and a recognition of the ecological and economic advantages of using native grasses. These benefits are greatest in low rainfall areas or in areas where land values are also low. With increased interest in using native grasses there is a need to develop approriate harvesting and sowing systems. Whilst the advent of non destructive harvesting technologies such as the brush harvester has removed the problems associated with native species producing seed periodically over long periods, seed sources are often low yielding and of variable quality. Since commercialisation of a few broadly adapted species has been achieved recently, this industry relies heavily on seed harvested from natural stands. Significant advances in both seed yields and quality could be gained from development of management plans for natural stands specifically for seed production using relatively low inputs. With such management, relatively pure seed samples may be obtained, making cleaning and processing largely unnecessary and thus reducing the cost of seed. There is no prescriptive advice for sowing native grasses. Since interest in native grasses has only recently gained momentum, little technical information is currently available. As native grasses are being used not only for a number of different purposes (pastoral, revegetation, amenity and ornamental) but also over a range of environments, techniques will vary not only between but also within species. Principles for pasture establishment should, however, be simple and of low cost in order to retain the low input advantages of using native grasses. This paper deals with the current seed harvesting techniques and outlines the ways in which native grasses are currently being successfully established.

Interest in the use of native perennial grasses is increasing rapidly (Waters and Noad 1996; Loch *et al.* 1996; Dowling and Garden 1990). This interest is no longer confined to the pastoral industry as other industries begin to recognise the wide variety of roles these plants can play (turf, amenity and ornamental purposes) (Loch *et al.* 1996). Traditionally, most scientists and farmers viewed native grasses as low productivity 'weeds' that needed to be replaced by the 'new' improved pasture species from overseas. The cumulative effects of settlement and agriculture over the last 200 years has been to extensively modify the dominance and distribution patterns of many of our most useful grass species some of which remain only as small remnants. For example, kangaroo grass (*Themeda triandra*), barbwire grass (*Cymbo-pogon refractus*) and fine leaf tussock grass (*Poa sieberana*) were once dominant across eastern Australia (Garden & Dowling 1996; Whalley *et al.* 1978) and *Astrebla* spp once covered large areas in NW NSW and western Queensland (Partridge, 1996; Orr, 1975). We now realise the substantial contribution of native grasses towards pasture production. In some temperate areas they contribute up to 60% or more of the pasture (Munnich *et al.* 1991; Lodge and Groves 1990). Some native grass-es have been demonstrated to have comparable for-age quality to that of exotic species (Eddy and Garden 1996a; Jones and Murphy 1995; Simpson 1992; Archer and Robinson 1988) and thus producers are now beginning to re-think the roles of native grasses. There are three major reasons for this recent upsurge of interest in using native grasses.

Failure of exotic grass species to persist

In particular, in low rainfall areas graziers have been finding that introduced grasses sown as pastures are often not only short lived but also lack persistence. In Queenslands alone, almost 500 exotic species have been evaluated for use in semi-arid regions (Johnston 1990), but few have been identified as "useful", especially in terms of their ability to withstand dry periods. As Australia's native grasses have evolved in an environment that is characterised by low soil fertility and a highly variable, low annual rainfall, they are well adapted to persist in our landscape.

Low input value

Rising water tables and associated salinisation, increasing acidification of agricultural land, continuing soil erosion, reduced water quality, loss of biodiversity and weed invasion, are symptoms of ecosystem collapse. Whether caused by inappropriate management of vegetation or widespread clearing, these areas have become low in value and require reduced inputs and maintenance if rehabilitation is to be implemented. Native species have low requirements in terms of nutrients and establishment costs compared with exotics native species (Wilson 1996; Lodge 1993). These characteristics have provided an incentive for government agencies to examine the potential of native species in low rainfall areas (Waters and Johnston 1996).

Low prices for rural commodities including wool and beef and steadily increasing production costs is galvanising support for these 'low input' grazing systems. Based on native perennial pastures bolstered by introduced legumes and modest inputs of fertilisers, these systems have been shown to increase profitability by reducing costs whilst maintaining relatively high levels of production (Simpson and Langford, 1996).

Ecological considerations

Environmental groups have also increased demand for native grass seed. Rehabilitation of mine sites and roadsides is increasingly open to environmental scrutiny. It is now less acceptable to 'rehabilitate' a site simply by using a mix of introduced pasture species. The faster growing exotic species are effective in providing good initial erosion control independent of season and an aesthetically pleasing screen, however such works tend to either deteriorate over time or require high maintenance inputs (Roe, 1996).

The use of exotic species in rehabilitation programs will always provide a potential threat of introducing weeds (Humphries *et al.* 1991). Examples of exotic species that have been introduced for "useful" purposes are bitou bush (*Chrysanthemoides monilifera*) which was original-ly used for sand dune stabilisation in coastal areas, Johnston grass (*Sorghum halepense*) which was brought in as fodder with the first fleet and common prickly pear (*Opuntina stricta*) which came also with the first fleet to begin a cochineal industry. Such species are now considered major weed problems.

The ecological benefits of using native species are now widely acknowledged. Locally adapted ecotypes, in particular, have a role in maintaining ecological integrity and biodiversity (Greening Australia 1995) and in providing suitable habitats for indigenous flora and fauna, especially threatened species (Foreman, 1995).

Harvesting seed of native grasses

As the name implies native grasses are wild types that are biologically at odds with man's efforts to domesticate them. Their inflorescences (seed heads) and seed structures are far better adapted to natural processes of seed dispersal such as wind, water and animals than to man made seed harvesters. One such adaptation is to produce seed progressively along the inflorescence. As the seed ripens it falls to the ground widening the interval in which seed has to germinate. Seed head height and size varies not only between species but can also vary throughout the growing season for any one species. Even when seed contains a viable embryo, immature seeds can be low in energy reserves and when harvested often fail to produce a healthy seedling. The result is only small proportions of mature seed can be harvested at any one time. If sufficient rain falls, (or crops are irrigated), seed set and ripening will be protracted although some seasons seed ripening may be reduced to a two week period (Loch and Clark 1996). This highlights the importance of a good understanding of the set of climatic conditions under which viable seed is set.

Native grass seeds often have hairy structures, a callus or long awns which make seed light, fluffy and difficult to handle. These appendages may play a role in helping to locate the seed in a more suitable micro climate and thus aid germination (Silcock 1973). Hygroscopic awns are capable of burying seed of spear grass (*Stipa spp.*) and kangaroo grass (*Themeda triandra*) whilst the hairy lemma's of wallaby grass (*Danthonia spp.*) is thought to allow for dispersion by wind and to control water uptake by the seed. Whilst these structures and the fashion in which seed is produced often make conventional harvesting and processing methods inappropriate they are adaptations that have aided in survival of these grasses there is a need therefore for understanding the purposes of various appendages and implications of their removal.

Because native grasses cannot be subjected to normal seed processing methods we need to adapt current technologies to meet the requirements of native grass species. One such technological adaptation has been the development and use of the brush harvester. This is a non destructive harvesting technique that allows for multiple harvests of any one stand of grass and therefore overcomes some of the difficulties of seed removal, resulting in increased yields of viable seed.

Most current Australian models of the brush harvester are based on the American Woodward Flail-Vac Stripper brush harvester, developed by Aaron Beisel in 1981 (Beisel 1983). The success of this machine in the USA led to investigations into its adaptation for Australian species (Jensen *et al.* 1993). These harvesters use a cylindrical brush that rotates upwards in a metal shroud against the direction of travel to dislodge ripe seed (Figure 1). The viscous drag of the rotating brush creates a flow of air that

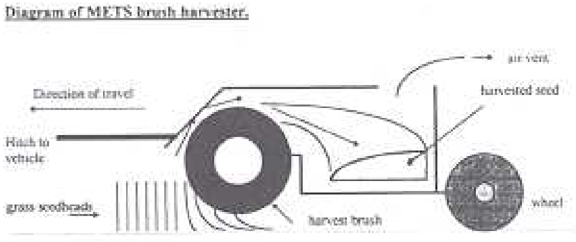

Figure 1. Schematic diagram of the basic brush harvester design (Jensen *et al.* 1993 - after Dewald and Beisel 1983).

carries the ripe seed away from the harvest area, depositing it behind the brush in a suitable bin. Several different types of the machine operating on this principal have been developed commercially. Harvesting efficiency of brush harvesters depends on several factors. Scholz (1995) reported single pass efficiencies of between 10 to 70% depending on species, machine settings, prevailing weather conditions, plant density, type of season, degree of ripening and effects of wind. Harvesting in two directions or against the wind can increase seed yields. Various designs of brush harvesters have since been developed and are currently harvesting seed in the Northern Territory (Loch and Clark 1996), Queensland (T. A. Jensen & A. Dobson *pers. comm.*), New South Wales (P. Kelly and J. Ryan *pers. comm.*) and South Australia (R. Myers *pers. comm.*). Seed yields and efficiency of the brush harvester are given in Tables 1 and 2, respectively.

Beater harvesters, originally developed to harvest buffel grass (*Cenchrus ciliaris*) have been used to harvest a wide range of species including *Heteropogon*, *Themeda*, and *Danthonia* (Loch and Clark 1996). Whilst they are useful for collecting seed of more upright species with tough inflores-cences they are not as efficient as the brush harvesters as most of the seed tends to be knocked to the ground.

Table 1. Harvest yields using brush harvester.

Species	Total weight (kg)	Harvested area (ha)	Seed yield (kg/ha)
Urochloa piligra	3.4	0.8	4.25
Bothriochloa macra	5.5	2.0	2.85
Chloris truncata	6.3	2.8	2.40
Dichanthium sericeum	5.0	3.8	1.30
Microlaena stipoides	153.9	14.0	10.90
Paspalidium jubiflorum	35.0	5.6	6.20
Themeda triandra	10.4	2.7	3.70
Total	219.4	31.4	

Table 2. Mean florets per inflorescence before and after a single pass with the brush harvester.

Species	Before	After	% stripped
Bothriochloa macra	25	18	28
Dichanthium sericeum	19	12	37
Microlaena stipoides	11	3	73
Themeda triandra	12	5	58

Figure 2. Hand held native grass seed harvester (Source: Jensen *et al.* 1996).

Conventional headers have been used to harvest mitchell grass (*Astrebla spp.*) for many years, with an estimated 10 tonnes a year is harvested in Queensland (Loch *et al.* 1996). This species tends to have a high degree of seed retention and therefore allows high proportions of seed to be harvested in this manner. Other species such as *Danthonia* are not suited to direct heading but can be windrowed a few days prior to picking and threshing the dry crop through a header (*G.* West *pers.comm.*). The general application of conventional headers to native grasses is however limited.

Handheld harvesters (Figure 2) have also been developed in a bid to mechanise the collection of seed from small areas (Jensen *et al.* 1996). These machines utilise the brush harvester technology where a brush rotating upwards sits on the end of a hand-held brushcutter and have been successful in harvesting seed from many native grasses (E. McGahan *pers. comm.*).

Innovation and development of new harvesting technologies is continuing. In 1995 and 1996 several prizes in farmer constructed machinery categories at Orange National Field Days have been given to new native grass seed harvester designs which use suction ("Bushranger" - T. Wilson and J. Betts *pers. comm.*) and suction with beater ("Scorpion" - Barney's Reef Landcare Group) as their primary harvesting principle. Field evaluation of these designs is currently under way.

As we are now able to successfully use different harvesting methods for native grass seed, a remaining constraint is the ability to locate suitable grass stands for harvesting. Whilst the domestication of native grass species and subsequent commercial seed production will ultimately result in greater quantities of seed being available, only a few native grass species have been domesticated to date (Lodge 1993). Since the domestication process is slow it is likely seed from only a limited number of species of these broadly adapted ecotypes will be available.

It is likely that most of the native grass seed available in the future will be sourced from natural stands of grasses and will be harvested purely on a opportunistic basis. Inconsistent management, competition with grazing enterprises and natural seasonal variations can cause considerable variation in seed production and quality from natural stands. Annual grasses and broadleaf weeds reduce perennial plant numbers and vigour often making areas of paddocks uneconomical to harvest and the set up of harvesting machines difficult. Even low levels of weed seed contamination may increase the moisture level of the sample, reduce the value of the seed (*eg.* noxious weeds) make it unpleasant to handle (*eg.* thistles) and increase seed cleaning costs for an uncertain result.

A number of seed harvesting programs have commenced where large quantities of seed of different species is being collected over large areas (Northern Territory, M. Clark; South Australia, R. Myers *pers. comm.*) or seed has been collected from natural stands and sown under irrigation to bulk up seed supplies (R.D.B. Whalley *pers. comm.*,Torpy *et al.* 1994). As the potential value of native grass seed is being realised, land managers (including Rural Lands Protection Boards and mine managers) are becoming interested in setting aside areas for seed production, either to provide a seed source for the rest of their property or as an extra source of income. Whilst the potential of such stands will be determined by the season, even low levels of management may improve seed yield and quality if applied strategically. Management options may include: fertiliser application, slashing, crash grazing, burning and herbicide application. Theroretically, native grasses, whilst persisting in soils of poor fertility should be responsive to moderate levels of superphosphate fertiliser to increase seed head production (Silcock and Sholz 1996).

Seed quality

The quality of seed harvested from natural native grass stands varies enormously. Sellers of native grass seed need to be able to communicate to the potential buyer the main quality parameters (M Farrar *pers. comm.*). Issues of consumer protection legislation are also important as the NSW Fair Trading Practices Act does not permit a seller to make false or misleading claims about his products.

Testing of cultivated species takes place in seed testing laboratories according to established species specific (usually internationally recognised, ISTA) testing procedures. Quality is defined mainly in terms of germination percentage and pure seed percent and arguably to a lesser extent genetic purity, weed seed number, presence of fungi, bacteria or insects, seed size and perhaps seedling vigour. Germination and percent purity are not useful measures of seed quality harvested from natural stands due to the large variation in seed size between species, the relatively high levels of empty florets and chaff that can be difficult to remove and the protracted seed dormancy expressed by some species. Quality is beter expressed in terms of how many seeds of what species are present in each kilogram of seed material, provenance, germination percentage of the main species and the presence of seed of noxious or prohibited species. Standard testing proceedures for native species are being developed. There is also some debate as to whether in a seed sample, "contamination" from another useful grass species (*eg.* Queensland bluegrass seed in a mitchell grass sample) is disadvantageous when using the seed for certain purposes (*eg.* pasture). Thus in some cases purity may not be an isssue with the sale of native grass.

Conventional seed cleaning techniques do not work with many native grass seeds because they do not flow freely and tend to clump together. Weed contamination and the presence of straw and chaff compound the problem. Six new approaches to cleaning native grass seed are described by Loch and Clark (1996). The most promising is that of aerodynamic conditioning which uses a flow of air to accelerate seeds to given velocity and separates them in a momentum discrimination chamber. Empty and full florets of a number of native species (*Elymus scaber, Chloris ventricosa, Paspalidium* spp., *Themeda triandra* and *Microlaena stipoides*) have been successfully segregated at DLWC, Cowra, but more work is required to improve species range and throughput.

By better management of natural stands to reduce weed seed contamination and by refining the brush harvesting techniques it is possible that some lines of seed will need only minimal preparation for sowing through a "chaffy" seedbox. Such samples of seed have been harvested at DLWC, Cowra this year both from nursery plots and from natural stands of *Paspalidium jubiflorum, Enteropogon* spp., *Chloris venticosa, Microlaena stipoides, Bothriochloa macra, Dichanthium sericeum, Stipa bigeniculata* and *Themeda triandra*. The Mt. Lofty Ranges Native Pasture Association is currently successfully brush harvesting and selling grass seed of a number of species including *Danthonia, Microlaena* and *Themeda* after only rudimentary cleaning to remove seedheads and straw (R. Myers *pers. comm.*).

Techniques for sowing native grasses

Special seed boxes that can accurately metre out

Table 3. Native grass sowing options for major climatic zones (Source: Silcock and Scholz 1996).

Rainfall regime characterised by:	>500 mm reliable soil moisture	> 350 mm reliable rainfall events	<250 mm unreliable rainfall
Establishment problems	existing pasture competition	maintaining soil moisture	harvesting and maintaining soil moisture
Methods to overcome limitations	control existing pasture with spraying and cultivation	reduce runoff; increase infiltration	ponding water; controlling runoff; increase infiltration
Technology used	band seeder; cultivator	discing; pitting; presswheels	ponding banks; contour furrows

non flowing/chaffy seed suited to a wide range of species are commercially available (S. Von Pein *pers. comm.*). Scholz (1995) describes several machines useful for revegetation of rangelands none of which require naked seed to operate.

Although there are many instances of successful establishment of native pastures from seed the difficulties should not be underestimated. Australian grasses have generally evolved under a low disturbance-high stress environment and are generally described as stress tolerators (Whalley 1996). As such they demonstrate characteristics such as tolerance to moisture stress, adverse soil conditions and low fertility but do not necessarily establish easily or compete strongly with other species. Whalley (1996) further suggests that selecting native species for ease of establishment may reduce their ability to handle environmental stress.

To date large scale establishment experimentation has been restricted by lack of suitable seed and therefore recommendations are general and need to be adapted to suit specific requirements. Table 3. represents the main challenges and sowing options for each major climatic zone and Table 4. describes successful sowing techniques for native grass species with a high commercial potential.

Below 500 mm rainfall, the most critical factor is adequate soil moisture but in higher rainfall zones, competition from annual weeds presents the most serious challenge to the successful establishment of native grasses. In addition, in these higher rainfall areas most interest in natives is associated with some level of land degradation or minesites where specific soil problems mitigate against the use of exotic species. In such areas cultivation may not be possible and soil surface conditions for seedlings far from ideal (*eg.* extremes in soil pH, Roe 1996).

To maximise the chance of successful establishment it is important to plan ahead and to have definite strategies in place for the pre-sowing, sowing/establishment and first year management phases of the operation (Silcock and Sholz 1996).

Pre-sowing

Silcock and Scholz (1996) and Scholz (1995) both recommended that sites be chosen carefully and seed concentrated over small areas to ensure success. Given the high cost of seed (at least initially) it may be wise to attempt small areas until larger areas can be more confidently tackled. Seed quality is obviously an important issue and will need to be addressed if the effort and expense of sowing is to be justified. Serious consideration should be given to using local provenance seed rather than importing seed from distant areas which are possibly climatically dissimilar. Coats and Van Leeuwen (1996) outline when it may be considered appropriate to use provenance material.

In higher rainfall areas, thought should be given to spraying annual weeds at least one season before sowing to reduce soil weed seed banks. Spraying weeds immediately prior to sowing has not always been effective in controlling competition. To date few native grasses have been screened for tolerance to different herbicides and there is no unaminity in the data to recommend individual chemicals for native grasses generallly (Campbell and Van de Ven 1996; Keys and Simpson 1993; Silcock 1991).

Sowing

Optimal sowing times will depend upon species and the likelihood of germination and follow up rainfall. Each species will have its own optimum germination temperature Grice *et al.* 1995, Silcock *et al.* 1990). In general sowing should be timed to allow the seedling opportunity to flower before plants enter their dormant phase. This tends to mean that warm season plants, mainly C4 types are generally sown in spring (*eg. Dichanthium* spp. and *Bothriochloa* spp.)whilst cool season plants, mainly C3 types are sown in autumn (*eg. Danthonia* spp.). A wide range of species have been found to exhibit hyrodpedesis, suspension of the germination process if there is insufficient moisture, as an adaptation to germination under conditions of sporadic rainfall events. Seed viability and embryo hydration is maintained and normal germination recommences provided follow up rain occurs within a few weeks (Watt 1978).

It is generally appreciated that for significant germination to occur, at least two days of moist seedbed conditions are necessary. Two days of

Table 4. Sowing and harvesting options for native grasses of interest in central western NSW (Adapted from Waters *et al.* 1997 and Waters and Johnston 1996).

Species/ Common name	Use	Preferred soil type	Comments	Harvesting/sowing[1]	Sources
Astrebla lappacea Curly Mitchell grass	Forage	Heavy grey clays	High proportion harvestable ; seed; long lived; palatable; withstands moderate grazing	Conventional header and brush harvester/drum seeders; aerial, broadcast & light harrow	1, 2, 3
Astrebla pectinata Barley Mitchell grass	Forage/ Rehabilitation	Heavy grey clays heavy red soils	High proportion harvestable seed; high seed retention; withstand moderate grazing;	Conventional headers and brush harvester; broadcast & light harrow	1, 4
Bothriochloa bladhii Forest bluegrass	Forage	Loam and clays	Sticky seed; difficult to handle	Brush harvester	5
Bothriochloa decipens Pitted bluegrass	Forage/ Rehabilitation	Low fertility loams and clays	Sticky seed; difficult to handle	Brush harvester	6
Bothriochloa macra Redleg grass	Amenity Forage	Loams and clays	Sticky seed; difficult to handle	Brush harvester	7, 8
Chloris truncata Windmill grass	Forage	Wide range of soil types	Will colonise denuded areas readily; difficult to harvest large amount of seed because of open inflorescence	Hand harvest; broadcast	9
Cymbopogon refractus Barbed-wire grass	Rehabilitation	Wide range of soil types		Brush harvester	10
Danthonia caespitosa White top	Forage	Clays to light sandy loams	Will recruit readily; needs winter/spring rain	Brush harvester; broadcast, band seeder, crocodile	7, 11, 12
Danthonia linkii Wallaby grass	Forage	Clays to light sandy loams	Will recruit readily; needs winter/spring rain	Brush harvester, windrowed; broadcast & light harrow, bandseeder	7, 13
Danthonia richardsonii Wallaby grass	Forage/ Amenity	clays to light sandy loams	Will recruit readily; needs winter/spring rain	Brush harvester, windrowed; broadcast & light harrow, bandseeder	7, 13
Dichanthium sericeum Queensland bluegrass	Forage/ Amenity	Alkaline clays	Seeds tend to cling together making handling difficult; will recruit and establish easily with adequate summer rain	Brush harvester; broadcast, bandseeder & light harrow	9, 14, 15
Digitaria brownii Cotton panic	Forage	Sandy loams & hard red earths	Post-harvest dormancy (2 years or more); seedlings appear to be moisture sensitive; surface sown	Brush harvester; broadcast and light harrow	15, 11
Elymus scaber Common wheat grass	Rehabilitation	Wide range of soil types	Low seed fill; may sterile florets	Hand and brush harvester	7, 16
Enneapogon avenaceus Bottle washers	Forage	coarse-textured types	Will readily colonise bare areas; good pioneer species	Broadcast	4, 15
Enteropogon acicularis Curly windmill grass	Forage	Sandy loams to heavy clays	Harvesting difficult because of open inflorescence	Broadcast	4, 9, 15
Microlaena stipoides Microlaena	Forage/turf Amenity	Acidic soil	Cooler climate; shade tolerant	Brush & vacuum harvester; hydromulching & broadcast	7, 17
Panicum decompositum Native millet	Forage/ Rehabilitation		Strong post-harvest dormancy (>6 years); good rehabilitation species		4, 12,18
Paspalidium constrictum Box grass	Forage	Sandy loams to loams	Low germination rates	Brush harvester	11
Themeda triandra Kangaroo grass	Amenity	Well drained sandy to clay soils	Low numbers of seed/kg; Spikelets predonimantly sterile	Brush harvester	13, 19

Sources

1. Waters and Munnich (1995); 2. Bowman (1992); 3. Campbell and Bowman (1992); 4. Reu (1995); 5. D.S.Loch (*pers. comm.*); 6.T.A.Jensen (*pers. comm.*); 7. Lodge (1996); 8. R.D.B.Whalley (*pers. comm.*); 9. Torpy *et al.* (1994); 10. G.Borschmann and T.A.Jensen (*pers. comm.*); 11. C. Waters (unpubl. data); 12. G.Scholz (*pers. comm.*); 13. Lodge (1995); 14. D.S.Loch (unpubl. data); 15. Scholz (1995); 16. M.A.Murphy (*pers. comm.*); 17. Murphy (1995); 18. M.Clark (*pers. comm.*); 19. Loch *et al.* (1994).

moist conditions can be achieved from single significant fall of rain provided the following days are overcast or that moisture is retained by a surface mulch of organic matter. Rates at which the soil surface dries out are critical. Being non tap rooted plants grasses also require follow up rainfall to allow development of the adventitious root system before they can really be considered 'established'.

Whalley *et al.* (1978) found that under average field conditions seminal root systems would only support a plant for between 6-10 weeks. Whilst these moisture constraints affect the establishment of grasses in more arid areas, they should generally be easily met in higher rainfall areas. In summer dominant rainfall areas with intense summer storms and high evaporation rates, establishment may be difficult to achieve with some species.

Where moisture at sowing is likely to be limiting there may be advantages in using seed which is still in the floret rather than naked caryopses. Structures and appendages attached to many native seeds play a role in delaying and staggering germination of seeds protecting some seed from false breaks. Awns, especially where hygroscopic, aid optimal seed placement. *Themeda* surface broadcast late December 1996 on an exposed western site at Lithgow had established well two months later despite limited falls of rain over the period.

Ants are important harvesters of seed from the surface of the soil and are likely to be a problems in some areas especially over the summer months when they are most active. Surface sown or lightly buried seed is most likely to be at risk and treatment with an insecticide advisable. Two chemicals are currently registered for this purpose: Bedicarb and Permethrin. Both have been shown to be effective in reducing ant theft (Campbell and Gilmore 1979).

Sowing rates

Because of the large variation in the numbers of viable seeds per kilogram of seed material, sowing rates will vary. Silcock and Scholz (1996) suggest a general sowing rate of between 100 - 200 germinable seeds per square metre. The greater the level of expected weed contamination, the less reliable the rainfall the greater should be the sowing rate.

Fertilizer application

There is no evidence in the literature to suggest that superphosphate increases establishment rates in normal pasture situations. In fact as native grasses are extremely efficient utilizers of phosphorus in comparison with annual weeds, broadcasting fertilizer could disadvantage sucessful establishment of native species.

Sowing technologies

Ideally seed needs to be metered out at a known rate, placed accurately at the required sowing depth with good soil seed contact. Free flowing native grass seeds can be sown effectively using conventional seed box metering systems *eg.* Mitchell grass and *Paspalidium spp.* Non flowing chaffy seeded lines need special sowing equipment such as that developed by Weideman and Kelly (1996). Similar designs are available commercially, and capable of metering out extremely chaffy samples with reasonable accuracy. These designs can be used in conjunction with either conventional or direct drill tillage equipment.

Equipment that minimises soil distrubance may have the advantage of reducing weed competition by not bringing more weed seed to the surface to germinate. The "Bandseeder" is a rugged 3 point linkage, direct drill machine which uses a herbicide to suppress weed competition. Initially developed to introduce legumes into existing grassy pastures, if fitted with appropriate seedboxes may also have other applications on rougher country.

There is also interest in sowing native grasses where conventional tillage equipment has little application. Scholz (1995) reviews four different seeding machines suitable for revegetating log littered woody weed infested rangelands, finally concluding the 'Crocodile' seeder to be the most appropriate. An Australian design, the 'Crocodile' is able to be towed behind a 4WD vehicle. It com-prises one pass seeding operation creating a water harvesting pit into which seed is placed. Woody weeds are knocked downand only 50% of a given area is cultivated to minimise the erosion hazard. Although designed primarily for rangeland applications it may also be useful in monesite rehabiliation or in non arable areas of the high rainfall zones.

Seeding devices do not need to be complex nor expensive. *Danthonia* seed has been sucessfully broadcast using a weldmesh panel bolted to the top of a small scarifier. The bouncing of the implement causing the chaffy seed to fall through the mesh to be lightly covered by the tynes (P. Nolan *pers. comm.*).

Broadcasting seed is probably the least technical method of sowing, and may be appropriate where areas are small or inaccessible, where seed is expensive or extremely chaffy. This method relies on seeds locating the often limited number of suitable germination sites. Success using this method will be gretaer for the larger seeded awned species that will be able to bury into the surface and in situations where a surface mulch provides a relatively favourable seedbed. Many successful establishments of *Themeda triandra* have been achieved using this method. Here, sowing rates as low as 5 - 10 vaiable seed (75 - 140 g seed material)/m^2 have resulted in adequate plant establishment (P. Nolan *pers. comm.*). In land and Water Conservations trails at Cowra establishment of surface sown plots of microlaena at six months compared favourably with direct drilled plots although plants were smaller.

Conclusion

Interest in harvesting and sowing native grasses is gaining momentum. A recognition of the benefits of using Australian native perennial grasses has spurred this interest. The adaptation of the brush harvester technology to Australian native grasses has allowed seed from a wide range of species to be successfully collected. However, as most seed comes from natural stands yields are often low and weed contamination high. Considerable advances in seed yield and quality could be achieved if management packages for seed production could be developed for these natural stands. As more seed from different species is being successfully harvested, sowing and establishment methods are being evaluated. Achievement of successful sowing methods will not necessarily be an easy task as seedlings of many Australian native grasses grow and develop relatively slowly and compete poorly against both grassy and broadleaf weeds. To be successful it will be necessary to plan ahead and develop management strategies for pre-sowing, and post sowing stages. These are the challenges that need to be overcome in order that native grasses are successully utilised in this country.

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