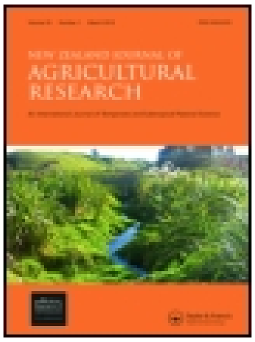

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# Harvesting, processing, and marketing Australian native grass seeds

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**Abstract** A number of useful Australian native grasses have been identified for various situations: for turf, amenity, and ornamental purposes; for revegetation of mine spoil, roadsides, and degraded land; and as forages. Their commercialisation depends on developing appropriate seed-harvesting and processing technology, thereby ensuring that seed is produced in a form that can be sown satisfactorily and gives reliable establishment. While conventional header harvesters can be used with some species (e.g., *Astrebla lappacea*), beater and (especially) brush harvesters have been more successful with many others, particularly grasses with light, difficult-to-handle, chaffy seeds. After harvest, chaffy seeds can be processed to make their subsequent handling and sowing easier. Choice of processing method depends on the structural complexity of the dispersal units and on the particular chaffy appendages involved. Awns and sterile spikelets are comparatively easy to remove, with surface hairs and bristles the most difficult. Market acceptance, however, ultimately depends on the value that consumers place on convenience and ease of handling versus any costs added through processing.

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**Keywords** seed harvesting; seed processing; seed handling; seed marketing; Australian native grasses

## INTRODUCTION

Several useful native grasses have been identified for a variety of different purposes and situations in Australia: as turf, amenity, and ornamental species; for revegetation and stabilisation of mine spoil, roadsides, and degraded land; and for forage use (e.g., Lodge & Peterson 1987; Dowling & Garden 1990). Over the past decade or so, interest in planting native grasses for such purposes has increased, particularly in the southern states, and is now also gaining momentum in northern Australia.

The commercial availability and use of such species depends on having access to supplies of good quality seed in a form that can be sown satisfactorily and gives reliable establishment. This, in turn, depends on developing appropriate seed-harvesting and processing technology so that the necessary seed can be produced. The development of reliable and profitable seed markets, however, is also an integral part of commercialisation because it provides the necessary economic incentive for seed producers. This paper deals with recent advances in seed harvesting and processing, and outlines the need to link seed production to marketing for a viable native grass seed industry to be developed.

## SEEDING CHARACTERISTICS OF NATIVE GRASSES

Australian native grasses are still essentially undomesticated, and their "wild" attributes have important implications for seed production.

Unlike the cereals (where prolonged selection pressure has ensured that they meet the requirements for a single destructive seed harvest), native grasses produce their seeds over a period of several weeks during which there is a continual turnover of seeds. New inflorescences (or seed heads) develop progressively over this period; flowering within each inflorescence then spans a number of days or even weeks; and the developing seeds ripen and eventually become detached from the parent plant through shattering (i.e., collapse of the basal abscission layer).

Native grasses also cover a wide range of habit and form, not least in the structures of their inflorescences and their "seeds". The inflorescence is commonly an open-branched panicle or similar structure (e.g., *Bothriochloa, Chloris, Dichanthium*). Alternatively, it may be a spike or spike-like panicle (e.g., *Astrebla, Danthonia, Microlaena*). Inflorescences are mostly less than 20 cm in length, but for *Themeda triandra* (kangaroo grass), its false panicles can extend 30–50 cm vertically, making harvesting more difficult.

While the flower (floret) structure of different grass species is relatively uniform, there is wide variation in the ancillary structures or appendages associated with the florets. These appendages serve to protect and aid in the dispersal of the caryopses, or grains. Caryopses are often shed from the parent plant enclosed in such structures to form dispersal units (diaspores), commonly referred to as "seeds", which for native species are often light, chaffy, and difficult to handle. Appendages that contribute to the characteristically "fluffy" appearance of such seeds include a hygroscopically active awn with one or more knees at which bending or flexing can occur; a rigid hygroscopically passive awn; a mucro; long or short hairs and/or bristles on the spikelet surface; attached sterile spikelets; and antrorse (i.e., backwardly pointing) short hairs or stiff bristles around the base (= callus).

Collectively, these wild attributes aid natural colonisation and assist sown grasses to persist and spread, especially under harsh climatic conditions as are frequently experienced in Australia, but also pose difficulties for seed producers. Those problems must be overcome if native grasses are to be successfully commercialised.

## HARVESTING

Some native grasses can be harvested successfully with conventional all-crop headers. *Astrebla lappacea* (curly Mitchell grass), for example, lends itself to direct heading because it does not shatter readily and retains a high proportion of seeds on the head (Bowman 1992). Dryland yields of up to 200 kg/ha of spikelets have been recorded. On the other hand, *Danthonia* species (wallaby grasses) are not well suited to direct heading, though windrowing a few days before picking up and threshing the dried crop through a header has given promising results with *D. richardsonii* cv. Taranna near Forbes, New South Wales (G. West pers. comm.).

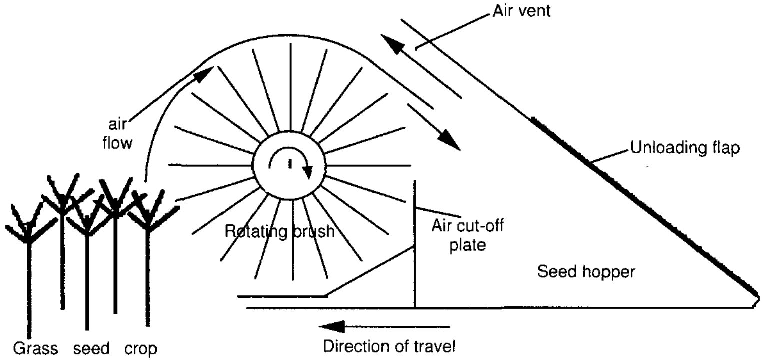
Many native grasses are difficult to harvest by conventional means, especially those with light, difficult-to-handle, chaffy seeds. For these species, there are encouraging alternatives available in the form of beater and (particularly) brush harvesters.

A wide variety of innovative beater harvesters have been built in Queensland, often in farm workshops, and are used extensively to harvest seed of the introduced pasture species *Cenchrus ciliaris* (buffel grass). The simplest design is an open-fronted box fitted with downward rotating beaters (or paddles) to remove seeds by their impact on heads trapped against the leading edge of the machine (Cavaye 1991). The box is covered at the top and back with gauze, and is mounted in front of a tractor or farm vehicle. Larger, more sophisticated beater machines with much greater harvesting capacity have been built, often on modified all-crop headers and cotton pickers; these also incorporate some form of primary cleaning. While beater harvesters have been used to recover seed of *Heteropogon contortus* (black speargrass) (D. P. Sinclair pers. comm.), brush harvesters appear to be adapted to a wider range of native grasses.

In 1981, Aaron Beisel developed the first brush harvester (called the Woodward Flail-Vac Seed Stripper) in the United States, primarily to harvest *Bothriochloa* species (Beisel 1983; Dewald & Beisel 1983). Central to his concept is a flailing brush which rotates upwards at its leading edge. The hypothesis was that this would break fewer stems and thus harvest a cleaner product than would be possible with a downward rotation.

Placement of a shroud over the brush creates a cross flow fan action which generates sufficient air velocity to gather seed heads into the flailing brush. The shroud also controls air speed by restricting and expanding the clearance between shroud and brush, and directs the flow of air and seed into a wedge-shaped seed hopper behind the brush. The

**Fig. 1** Schematic diagram of the basic brush harvester design (Jensen et al. 1993—after Dewald & Beisel 1983).




triangular shape of this seed collection bin reverses the direction of airflow, depositing the seed into a dead air space on the floor while the air escapes through the exit vent formed between the top of the seed bin and the top of the curved shroud. The wind board, or cut-off plate, at the lower front of the bin and directly behind the brush helps control air movement and is essential to retain seed in the bin. The rear of the top of the bin is hinged to open by gravity, allowing seed to discharge when the stripper is in a dumping (vertical) position. These various components are shown diagramatically in Fig. 1.

The success of the Woodward Flail-Vac Seed Stripper with previously difficult-to-harvest species and its rapid commercial adoption in the United States encouraged subsequent investigations into the potential of brush harvesting for chaffy seeded native and exotic grasses in Australia (Jensen et al. 1993). Successful trials with species as diverse as *Bothriochloa bladhii* (forest bluegrass), *Bothriochloa ewartiana* (desert bluegrass), *Danthonia richardsonii*, *Dichanthium sericeum* (Queensland bluegrass), *Heteropogon contortus*, *Monachather paradoxa* (mulga oats), *Themeda triandra*, and *Thyridolepis mitchelliana* (mulga Mitchell grass) suggest that many of our more difficult native grasses could be suited to brush harvesting. With *D. sericeum*, for example, trials in 1988 and 1991 over a range of brush and ground speeds measured efficiencies of recovery of 34–47% and 18–30% respectively. Table 1 shows the high quality possible with brush-harvested seed.

Like any other method, brush harvesting does not suit all grasses equally well. For large-scale production of easily harvested smooth-seeded grasses, brush harvesters offer no advantage over conventional header harvesters with their greater capacity, hence their ability to cover the ground more quickly. Rather, its advantage lies with previously difficult-to-harvest chaffy-seeded species; and even here its effectiveness varies. Because of the narrow harvesting zone, brush harvesting is most effective with, and produces the cleanest seed from, grasses which carry their seed heads at an even height above the foliage. It also allows multiple harvests to be taken progressively as the seed crop continues to ripen because most of the immature seed heads remain intact after brush harvesting.

**Table 1** *Dichanthium sericeum* seed quality from brush-harvesting trials in southern Queensland.

| Year | Sites | Seed samples (no. tested) | Irish purity[a] (%) | Caryopsis count[b] (%) | Tetrazolium viability (%) |
|---|---|---|---|---|---|
| 1988 | Dalby | 9 | 78–84 | 81–91 | 71–82 |
| 1991 | Emu Vale | 4 | 85–87 | – | 88–92 |
| 1994 | Southbrook, Greenmount | 2 | 78–84 | 74–85 | 69–82 |

[a]Proportion by weight of all sessile spikelets (i.e. ± caryopses).
[b]No. of caryopses per 100 sessile spikelets.

Brush harvester development has continued in the United States (Dewald et al. 1993; Whitney & Solie 1994), and Australian research has also extended the range of designs available, depending on the scale and mobility of harvesting required (Jensen et al. 1993). In addition to tractor-mounted machines derived from the original Woodward Flail-Vac Seed Stripper, brush harvesters now range from a larger continuous flow machine to a smaller tow-behind model fitted to a four-wheel drive vehicle. In Canada, an even smaller-scale brush harvester fitted to the end of a hand-held brushcutter is available (Collicutt & Morgan 1993); and in southern Germany, a locally designed brush machine is used to harvest seed of the low-growing turf species *Poa supina* (P. Berner pers. comm.).

## PROCESSING

Most chaffy seeds can be sown through specialised planters with varying degrees of difficulty, but their distribution invariably is uneven and the seeding rate can fluctuate considerably. Alternatively, the chaffy seeds can be processed to remove some or all of their appendages, so that they flow more freely and can be sown uniformly.

### To process or not to process?

It is important to understand the functions of the various chaffy seed appendages, and to identify any beneficial effects they may have for particular seeds during establishment. There is little point in attempting to remove chaffy seed appendages if the outcome is likely to be deleterious to field establishment. Most critical studies support a dispersal role for the prominent hygroscopically active awns on many native grass seeds (e.g., *Bothriochloa*, *Dichanthium*, *Heteropogon*, *Themeda* spp.), and the rigid hygroscopically passive awns on others apparently ensure that the falling seeds become embedded in the soil surface. The role of other chaffy seed appendages is less clear, though the floral "husk" and surface hairs or bristles can obviously influence moisture relations around the caryopsis during germination.

### Processing objectives

Where processing is carried out, the basic aim is to remove appendages that interfere with the separate and independent movement of seeds. Trimming of the normal chaffy seed units is generally preferable to the complete removal of caryopses, although the latter may sometimes appear an attractive option with grasses such as *Astrebla* or *Danthonia* spp. (e.g., Dowling & Garden 1990; Bowman 1992). Leaving protective husks around the caryopses reduces the risk of physical damage during processing, especially where caryopses are tightly held within the surrounding floral husk (Loch 1993a). It also improves the reliability of field establishment under marginal moisture conditions because naked caryopses are more likely to germinate on a small "false start" rainfall event with subsequent losses in the absence of useful follow-up rain. Processing also should be carried out at a sufficiently high rate per hour to minimise the cost of treatment and make it commercially viable.

### Structure and form of chaffy seeds

Current work is evaluating various processing options to streamline the handling of chaffy seeds from both native and exotic grasses. As a working guide to processing requirements, Loch & Harvey (1995) divided chaffy-seeded species of some economic interest or importance into six broad groups, and their initial classification has been refined in this paper by the addition of one further group. Categories are based on the complexity of dispersal units and on the particular chaffy appendages involved. Descriptions are given using native species as examples where possible, but also including relevant exotic grasses which have been the main focus of previous work on seed processing. This experience with comparable exotic species should provide future guidelines for additional native species.

#### *Complex dispersal units*

Examples of complex dispersal units are the spikelet clusters (or involucres) produced by *Themeda triandra* and the intact inflorescences dispersed by *Spinifex sericeus* (beach spinifex). With *T. triandra*, each involucral cluster comprises one or two bisexual spikelets surrounded by six or more male spikelets (Woodland 1964). *S. sericeus* is a dioecious species with the female inflorescences forming large globular heads up to about 30 cm in diameter, each consisting of numerous spikelets attached to long bristle-like bracts (Tothill & Hacker 1983; Stanley & Ross 1989).

#### *Simple dispersal units with hygroscopic awn*

Dispersal units of *Bothriochloa* and *Dichanthium* species typically consist of a rachis internode and two attached spikelets, one a sessile spikelet (fertile) with a long hygroscopically active awn and the other an awnless pedicelled spikelet (sterile) (Loch 1993a). Seeds of the more commonly used introduced species such as *Bothriochloa insculpta**[a] (creeping bluegrass), *Bothriochloa pertusa** (Indian bluegrass), and *Dichanthium aristatum** (Angleton grass) also have short hairs and bristles on the glumes and a bearded callus at the base. The amount and length of surface hairs, however, varies considerably among native species, with *Bothriochloa erianthoides* (satintop) conspicuous for its long dense silky hairs and greatly reduced awn, and *Dichanthium sericeum* (Queensland bluegrass) intermediate with regard to surface hairs.

Seeds of *Heteropogon contortus* (black speargrass) and *Themeda* spp. are shed from the plant as elongated awned spikelets (± short surface hairs) with the caryopsis tightly adpressed within the tough husk formed by the glume(s) and/or lemma (Stanley & Ross 1989). These seeds typically have a sharp-pointed basal callus and a long, easily detached, geniculate awn arising from the lemma.

*Simple dispersal units with rigid awns and papery husk*

In *Chloris* species, the seed comprises the whole spikelet minus the glumes which are not shed at maturity (Stanley & Ross 1989). It consists of 2–7 florets, usually with two rigid passive awns (arising from lemma apices on the lower two florets) and a sharp hairy callus at the base. The spindle-shaped caryopses are relatively easy to detach from this husk. In some species, the lemma of the lowest floret is fringed with hairs forming a characteristic brush near the top, with a short prominent nerve (usually hairy) on each side. Currently, the introduced *C. gayana** (Rhodes grass) is the most prominent example of this group, though other species (both native and exotic) are also attracting some attention for revegetation purposes.

*Simple dispersal units with rigid awns and tough husk*

Seeds of *Microlaena stipoides* (microlaena) are shed in the form of elongated spikelets, minutely scabrid on the surface (lemmas) and with stiff terminal awns (Stanley & Ross 1989). These are strongly weighted towards the base by the relatively large caryopsis enclosed (R. D. B. Whalley pers. comm.). Comparable grasses include *Elymus scaber* (common wheatgrass), another native species, and *Bromus catharticus** (prairie grass) for which effective seed-processing technology has been developed at a commercial level.

*Simple dispersal units with surface hairs*

These species lack a prominent awn and may be dispersed either as spikelets (e.g., *Melinis repens**—red Natal grass; *Thyridolepis mitchelliana*) or as florets (e.g., *Danthonia* spp.; *Monachather paradoxa*), generally with long dense surface hairs and/or soft bristles on the glumes or lemma (Stanley & Ross 1989; Loch 1993a). While some *Digitaria* spp. produce glabrous spikelets, the seeds of a number of others have varying degrees of surface pubescence; the latter include *D. brownii* (cotton panic), *D. milanjiana** (finger grass), and *D. smutsii** (syn. *D. eriantha**—digit grass).

*Simple dispersal units with stiff surface bristles*

The spikelets of *Astrebla lappacea* are shed intact, each comprising 4–6 florets. They are beset with short rigid bristles or bristle-like awns arising from the lemmas on individual florets (Tothill & Hacker 1983; Stanley & Ross 1989).

*Fascicles*

Seeds of *Cenchrus ciliaris** (buffel grass) are sold in the form of fascicles, each consisting of clusters of spikelets (usually 1–3) surrounded by an involucre comprising two rows of wavy bristles (Loch 1993a). While this is the best-known example, several *Pennisetum* species (e.g., *P. alopecuroides*—swamp foxtail) also produce fascicles with involucral bristles surrounding 1–several spikelets (Stanley & Ross 1989).

**Seed-processing methods and equipment**

There is a range of equipment that can be used to process chaffy grass seeds, removing inert appendages and even the husk surrounding the caryopsis (Loch 1993a). This equipment can be broadly grouped according to method into threshing and sizing, rubbing, physical impact, stirring, burning, and aerodynamic conditioning; all except the last category require subsequent cleaning (winnowing) of the processed seed. Different methods, however, suit different seed structures and much of the previous work has focused on exotic species.

[a]Exotic species marked with an asterisk

*Threshing and sizing*

Equipment includes hammermills, header harvesters, and peg-drum threshers. Processing rates are generally higher than for other methods, but there is a risk of damaging seed through over-aggressive threshing.

Hammermills operated at less than half the normal grinding speed have been used to process chaffy seeds for almost 60 years (Loch 1993a). Treatment ranges from de-awning to the complete dehulling of caryopses, and screen perforations need to be slightly larger than the size of the processed seed units. Straw should be removed before hammermilling to avoid being broken into smaller fragments, as happened when some early commercial lines of *B. insculpta** cv. Bisset seed were hammermilled (N. Blanch pers. comm.).

Dried material can also be threshed by conventional header harvesters and peg-drum threshers, breaking it up and performing primary cleaning. Loch et al. (1994) used both machines to break up the complex chaffy involucres of *T. triandra* into separate free-flowing spikelets, removing 80–90% of the original weight and leaving a higher quality, more easily handled product.

Hammermilling and peg-drum threshing have given variable results in terms of caryopsis damage with *S. sericeus* (Harty & McDonald, 1979; Watt & Wickham, 1983; McKenzie et al. 1989). This probably reflects differences in screen size and threshing speed between these experiments.

*Rubbing*

Equipment includes resilient tapered (cone) threshers, belt threshers, brush scarifiers, and dehuskers. With the cone thresher, seed passing through the machine is rubbed by the rotating resilient inner surface against a second resilient surface lining the stationary outer cone. A range of chaffy grass seeds (e.g., *Andropogon gayanus**, *Bothriochloa bladhii* subsp. *glabra**, *B. insculpta**, *B. pertusa**, *Dichanthium annulatum**, *D. aristatum**) can be treated through a cone thresher (Loch et al. 1988; D. S. Loch & G. L. Harvey unpubl. data). This facilitates subsequent cleaning (mainly by aspiration), though long straws should be removed beforehand to avoid rubbing them down to fine fragments that are more difficult to remove. Recent work, however, indicated that cone threshing is less successful with the native *D. sericeum* than with similarly structured exotic species, probably because it has more surface hairs and more persistent surface hairs than the other species.

In previous work (Maze 1982; Watt & Wickham 1983; McKenzie et al. 1989), cone threshing was used to process *S. sericeus* satisfactorily (albeit slowly) with little seed damage. Care is needed, however, because the caryopses are large, soft, and easily damaged, as shown in recent cone threshing trials where 10–20% of the caryopses extracted were broken (D. S. Loch & G. L. Harvey unpubl. data).

Belt threshers consist of two endless belts operating face to face and moving at different speeds in the same direction, in either the vertical or the horizontal plane, but have not been as effective with chaffy seeds as cone threshing (Loch 1993a). Brushing machines (scarifiers and polishers) have also given satisfactory results in extracting *C. gayana** caryopses and trimming *B. insculpta** seeds. Based on successful results with a small-scale bench model (G. M. Lodge pers. comm.), a brushing machine fitted with flexible rubber flails instead of brushes and an appropriate outer screen might prove a useful option for extracting naked caryopses from seeds of *Danthonia* spp. on a larger commercial scale.

*Physical impact*

The filament thresher is generally unsuitable for processing grass seeds because of its very slow processing rate and substantial damage to naked caryopses (Loch 1993a). A more practical alternative developed for the introduced *Bothriochloa insculpta** (N. Blanch pers. comm.) is to pass the scalped seeds through a fan (to dislodge awns, sterile spikelets, etc) before screening to remove the awns and other inert material, leaving a more free-flowing product. Processing rates vary but are still relatively slow (generally 30–60 kg/h), especially with brush-harvested seed which starts with more of the awns and sterile spikelets in place than with header-harvested seed. Header harvesting, by comparison, breaks the seed units up to some extent.

*Stirring*

The gentle mixing action of a debearder (deawner) rubs and stirs dried seeds, breaking off awns and other appendages. Although not assessed so far with Australian native grasses, Brown et al. (1983) found that a debearder (in conjunction with an air-screen cleaner) improved purity, germination, and handling qualities of *Andropogon gerardii** and *Sorghastrum nutans** seeds without apparent damage.

*Burning*

Attempts to remove chaffy appendages from various seeds using naked flames have usually proved unsuccessful, often damaging a high percentage of the seeds (Loch 1993a). One notable exception seems to be *C. ciliaris**, perhaps because the involucral bristles offer greater protection for the enclosed caryopses than in most other grasses. Pogue (1983), for example, found that a series of mild flame treatments had no detrimental effects on the germination of *C. ciliaris**. Burning has also been used in Germany to remove awns from seeds of *Arrhenatherum elatius** (oat grass), though with mixed results (E. Langels pers. comm.). Processing involved dropping *A. elatius** seeds through a flame at rates of 200–300 kg/h, but there is a risk that fire could start in seed blockages and spread through the shed.

*Aerodynamic conditioning*

A radically different approach to the processing of chaffy grass seeds has been taken in the Woodward Chaffy Seed Conditioning System described by Dewald et al. (1983, 1986, 1987). This system centres around aerodynamic principles, but also integrates prior mechanical conditioning to improve the efficiency of aerodynamic processing. Seeds are scalped and individualised before being accelerated in a jet of air which segregates them into density (quality) classes in a momentum discrimination chamber. Preliminary Australian work with this system has demonstrated an ability to separate light and heavy seeds with *Bothriochloa* and *Dichanthium* spp. and *Danthonia richardsonii* (D. S. Loch & G. L. Harvey unpubl. data). However, further studies are needed to calibrate the cut-off point for these different species similar to that done by Dewald et al. (1983) in Oklahoma. In addition, processing rates are slow (10–20 kg/h), and only some of the awns were removed from *D. sericeum*, unlike *B. insculpta** where awns are more easily detached from the fertile spikelets. There is also variation in processing rate between and within species depending on the amount of surface hairs: for example, *B. bladhii* subsp. *glabra** which has fewer and shorter hairs, is quicker and easier to process than the native *B. bladhii* subsp. *bladhii*.

**Future research**

The most difficult seeds to process satisfactorily are those with short surface hairs or bristles that are not easily removed without also taking all of the floral husk surrounding the caryopsis. Even within the structurally similar *Bothriochloa-Dichanthium* complex, species with more surface hairs (e.g., *D. sericeum*) contrast with less hairy species that are easier to process (e.g., *B. insculpta**, *B. pertusa**, *D. aristatum**). Different processing methods will be required for these grasses.

There is also a need where possible to increase processing rates for greater economy. Market acceptance ultimately depends on the value that consumers place on convenience and ease of handling versus any costs added through processing.

## TARGETING PRODUCTION

The commercial success of seed production for any species, native or exotic, ultimately depends on markets for that seed (Loch 1993b). Real and sustainable demand is required, usually from the private sector; however, government policy (e.g., land rehabilitation, roadside plantings, conservation use) can help to create demand, as occurred through the Soil Bank and the Conservation Reserve Programs in the United States (Johnson & Beutler 1988). At the same time, sufficient seed must be produced to meet demand and at a price acceptable to the market—seed cannot continue to be produced without markets, and markets will not continue without seed to sustain them.

Of the numerous useful native grasses identified for various purposes (e.g., see Lodge & Peterson 1987; Dowling & Garden 1990), few could currently be considered "commercial" in terms of reliability of both seed availability and demand. *A. lappacea* has been the main species marketed for several years, but even here supply depends on seasonal conditions. Estimates of 1993/94 production from commercial sources (D. S. Loch unpubl. data) put the current state of native grass seed production into perspective: *A. lappacea* (up to 10 t) still dominates followed by *D. richardsonii* (1.5 t) and *D. sericeum* (1 t), with progressively smaller quantities of *Danthonia linkii, T. triandra, M. stipoides, H. contortus*, and other species. The immediate problem in progressing further with numerous small lines of seed is the fragmentation evident in both production and demand. Eventually, someone has to take the risk of producing seed of a particular species to test demand often rumoured to exist.

Which seeds should we be producing? Undoubtedly, widely adapted species that tend to dominate natural stands will provide the future "bread-and-butter" lines for producers of native grass seeds. Examples include *Astrebla* spp., *Bothriochloa* spp. (especially *B. bladhii* and *B. decipiens*), *Danthonia* spp., *D. sericeum*, *M. stipoides*, *M. paradoxa*, *T. triandra*, and *T. mitchelliana*. Sowing of native grasses also needs to be more closely and critically targeted than previously. It should not simply be a case of buying *A. lappacea* (because it is available and cheap) to fulfil a contract to plant native grasses near Sydney, for example. Adapted species (preferably in mixtures and including native legumes if possible) should be identified for different areas, and research into sowing methods (including seeding rates) is needed to improve the reliability of establishment. Accurate quality descriptions of seed being marketed are also required, together with guidelines to the quality that can reasonably be expected from seeds of different species.

For successful commercialisation of any new species, production (seed supply) and marketing (promotion) must go hand in hand. Seeds of a wide range of native grasses can be produced, and entrepreneurial farmers will produce these if reliable markets are available. Major species could be produced relatively cheaply from dominant native stands (e.g., *Astrebla* spp., *B. bladhii, D. sericeum, T. triandra*), whereas others that occur in small discontinuous areas or as minor components may need to be established as pure stands for seed production or sold as part of a properly described seed mixture. In general, specially selected cultivars are unnecessary at this early stage of industry development; rather, the first priorities are to ensure that reliable supplies of seed reach the market and that the quality and composition of this seed are accurately described, before looking at which might still be needed in terms of plant breeding.

## CONCLUSIONS

Recent work has highlighted alternative methods of harvesting and processing that will go a long way towards coping with seed production problems of a diverse range of Australian native grasses. However, the commercial success of the fledgling native grass seed industry also depends on better communication and greater cohesion between producers and users of these seeds. Essentially, end users need to know which species to use, and how to establish and manage them. Conversely, producers need to know what species are required, in what quantities, in what form, and whether end users are prepared to pay specialist prices for specialist seeds.

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