Searching for native perennial legumes with pasture potential

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Abstract

Native Australian perennial herbaceous legumes with potential to be developed as pasture plants for the medium-low rainfall zones of the wheatbelt were collected and screened. The aim was to identify species with characteristics suited for domestication and adaptation for difficult environments, such as highly acid soils, poorly fertile soils, and areas with low rainfall or prone to drought. A literature search identified five target genera: *Cullen*, *Swainsona*, *Glycine*, *Kennedia* and *Lotus*. We collected around 400 accessions, primarily from these genera, from NSW, Victoria, WA, SA and the NT. Most accessions have since been seed increased and the seed is now stored at the Australian *Trifolium* GRC in Perth or the Australian *Medicago* GRC in South Australia. Root nodules were collected and > 500 root nodule bacteria were isolated, with many tested for symbiotic effectiveness on selected host plant species: selected strains were then placed in long term storage. A database is being developed that will link the information on collection sites, plant species and root nodule bacteria. Species of *Cullen*, especially *Cullen australasicum*, show most promise for domestication. Several research projects focussed on *Cullen* are now underway. Other genera with potential niche applications include *Lotus* in dry areas and *Glycine* as an understorey in fodder shrub systems. Further investigation of *Swainsona* may have merit as it contains a large number of diverse species.

Key Words

Native plants, rhizobia, *Cullen*, perennial pastures, dryland salinity, autumn feed gap

Introduction

The development of perennial legumes is considered crucial to increasing water use in managed pastures and thereby reducing the effects of dryland salinity in agricultural landscapes. ?Few perennial legumes are available for the drier areas of the Australian wheatbelt, especially for situations where lucerne is not well suited. Many native legumes may have good adaptation to such situations having often evolved under conditions of low rainfall, frequent drought, short seasons, poorly fertile soils or highly acid soils. Development of natives may also be desirable as they do not face the quarantine restrictions faced by exotic germplasm, may enhance biodiversity of native flora and fauna, and may be considered to have a reduced weed risk (although contamination of local populations by a cultivar must be considered). Whilst further incremental gains are possible with the on-going selection and breeding of existing cultivars of exotic perennial legumes, such as lucerne, the diversity of native germplasm (Bennett et al. 2008) may enhance the possibility of large improvements from a few generations of simple selection.

The agricultural potential of native legumes has been recognised for many years (Maiden, 1889; Millington 1958) and some research has been undertaken (Cohen and Wilson 1981; Dicker and Garden 1984), notably with *Kennedia* (Silsbury 1958), *Cullen* (e.g. Gutteridge and Whiteman 1975, Britten and De Lacy 1979) and *Glycine* (Jones et al. 1996). However, until the commencement of this project there had not been a systematic screening of herbaceous native perennial legumes to identify those with pasture potential (Cocks 2001; Bennett et al. 2002). Following a literature search, target genera were identified: *Cullen*, *Swainsona*, *Glycine*, *Kennedia* and *Lotus.* Seed from species in these genera, along with a large

number of other species, was then accessed from existing collections in Genetic Resource Centres (GRCs) or it was collected from the field.

Field collections

Following the granting of plant collection permits from relevant State and local authorities, a total of 14 collections trips in South Australia, Victoria, Western Australia, New South Wales and the Northern Territory were conducted between 2002 and 2006 at suitable times of year for the collection of viable seed (Hughes *et al.* 2008). Herbarium records were used as a guide to try and ensure populations could be quickly found. For each suitable population, up to 20% of seed from each plant was collected from up to 100 representative plants or 10% of the population. Care was taken to avoid oversampling or unduly disturbing natural populations. Details of the site and populations were recorded on detailed passport collection sheets and photographs taken of the site and plants. A representative herbarium specimen was sometimes collected from each taxon and, where possible, 4-5 healthy, non-ruptured root nodule bacteria nodules were collected and stored on top of cotton wool in a vial of silica gel. Approximately 400 g of soil from the top 10 cm was also collected and later used for isolation of root nodule bacteria and determination of soil pH. Both the seed, herbarium and root nodule bacteria were given unique accession numbers that can be linked back to the collection site via an electronic database.

Around 400 plant accessions, primarily from *Cullen*, *Swainsona*, *Glycine*, *Kennedia* and *Lotus*, were collected and most of these were seed increased and characterised at either the Department of Food and Agriculture, Western Australia, Medina Research Station or at the Waite campus of SARDI. Characters recorded included: survival over two years, plant habit, productivity, phenology and pod maturity, seed yield, pod presentation, dehiscence and shattering traits, and any other potentially deleterious aspects such as spines and strong odours. Seed and data are now stored at the Australian *Trifolium* GRC at Medina (WA) or the Australian *Medicago* GRC at Waite (SA) and are available for future research activities.

Priority species

Cullen was found to be the most promising genus, with a number of species showing good productivity, seed characteristics conducive to mechanical harvesting, adaptation to acid and alkaline soils, and good drought tolerance (Bennett et al. 2008) (Table 1). Of the *Cullen* species, *C. australasicum* showed the most potential for the medium-low rainfall zones (see Dear et al. 2007), although other species may yet be proved equally promising under specific conditions (e.g. *C. pallidum* and *C. patens* in very dry areas and *C. cinereum* and *C. graveolens* on heavy clay soils). *Cullen tenax* is a particularly attractive species, with a high seed yield from aerially presented seeds, good feed quality (Robinson et al. 2007) and good productivity under frequent cutting (Robinson et al. 2007). However, it seems best suited to medium-high rainfall areas (Bennett et al. 2008). *Lotus australis* is drought tolerant and has now been bred for low HCN content (Real et al. 2005). Seed increase and PBR of a low HCN cultivar will commence in 2008 (Real pers. comm.).

Table 1. Characteristics of the five main genera examined and species considered most suitable for further development as perennial pastures for low – medium rainfall zones of the Australian wheatbelt.

	Cullen	*Glycine*	*Kennedia*	*Lotus*	*Swainsona*
Habit	Herbaceous to open sub-shrub (0.5-2 m)	Twining	Groundcover or climbing	Herbaceous, short	Herbaceous to open sub-shrub (0.5- 2 m)

Productivity	Poor-Good	Medium	Poor to Good	Poor	Poor to Good
Retain leaves during summer	Yes	Yes	Yes	Yes	Yes
Seed retained	Yes	No	Varied	No	Varied
Aerial seeds	Yes	No	No	Yes	Varied
Ease of seedling establishment	Good	Good	Often difficult	Good	Good
Other	High variation between and within species	Possible role as a companion species to nurse shrubs	Many best suited to medium to high rainfall. May contain beneficial levels of tannins (Robinson et al. 2007)	Can contain HCN, but low HCN lines now selected (Real et al 2005)	Not all species evaluated, may contain toxins
Priority species	*C. australasicum*, *C. pallidum*, *C. patens*, *C. cinereum*	*G. canescens, G. tabacina*	*K. prorepens*	*L. australis*	Further work required

Rhizobia

Rhizobia were isolated from nodules of legumes grown in the soil collected from the field or directly from nodules sampled in the field. ?Around 500 root nodule bacteria strains were isolated and selected strains have been placed in long term storage at the Department of Primary Industries, Rutherglen and at SARDI to be available for future research. To evaluate the effectiveness of rhizobia, plants were grown under aseptic conditions and inoculated with a single rhizobial strain. ?Comparisons were made with un-inoculated plants and nitrogen-supplied controls. ?Legume genera differed in their host-strain interactions: *Swainsona* had high specificity, while *Kennedia* and *Lotus* nodulated with a range of rhizobial isolates. ?Effective rhizobia were isolated for high priority legumes and some of these have performed well in field experiments. For instance, *C. australasicum* nodulated with rhizobia isolated from five species of *Cullen* including *C. australasicum*, *C. tenax* and *C. cinereum.* The effectiveness of the rhizobial isolates with *C. australasicum* varied from only 66% of the mass of uninoculated plants to over five times the mass of uninoculated plants for the best performing strains after 16 weeks growth in controlled conditions. Thirty two out of a total of 34 isolates produced effective associations with *C. australasicum,* indicating a low specificity in its rhizobial requirements.

Discussion

How will these plants fit into farming systems?

The target farming system for the native plants is a livestock operation in the lower rainfall zones of the wheatbelt in situations where lucerne is not well suited. Adoption will only occur if the natives complement current profitable options, particularly cropping. Thus, the natives may be best suited to soils that are unsuited to cropping due to being poorly fertile, highly acid, or rocky, or have a poor water holding capacity. The economic value to the system will be enhanced if the natives can provide green feed in the autumn feed gap and are persistent under grazing. Thus, species that hold onto leaves under drought stress better than lucerne are desirable. Of most benefit may be species that can accumulate a substantial amount of edible biomass, but do not suffer negative impacts (ie slowed growth or senescence due to flowering or accumulation of large amounts on inedible woody biomass) from the infrequent or light grazing that makes this accumulation possible, and then retain this biomass during summer. In this context, medium to low palatability may be advantageous, as this trait would allow plants to accumulate biomass during winter and spring, whilst accompanying exotic annual legumes and grasses are grazed.

On-going activities

Further exploratory research may be justified on many genera, notably *Swainsona*. However, this project has identified *Cullen* as the genus with highest agricultural potential and there are a number of on-going research projects focussed on *C. australasicum* and other *Cullen* spp. These projects include an examination of the breeding system of *C. australasicum* and its ability to cross with other species (molecular markers have been developed for this purpose) and the tolerance of herbicides by *C. australasicum*. Tolerance of phosphorus fertiliser, drought, waterlogging and soil acidity are also being investigated for a variety of *Cullen* species and native species. *C. cinereum* and *C. graveolens* will be trialled in 2008 on heavy clay soils with subsoil constraints at Mukinbudin (< 300 mm average annual rainfall). These species have shown remarkable productivity under similar conditions in the Fortescue River Floodplain in northern Western Australia (Nicol 2006). Two accessions of *C. australasicum* will be trialled at three sites in the medium-low rainfall zone of the WA wheatbelt in 2008/09 at part of a RIRDC-funded project. Impacts of variation in plant density and grazing times on productivity and survival will be examined. SARDI is investigating harvest technologies for *C. australasicum* in a project funded by RIRDC and SARDI will also commence selection and breeding of *C. australasicum* within a FFI CRC/GRDC project involving DAFWA, SARDI and UWA. This project will also investigate a range of exotic perennial legumes which show promise for medium-low rainfall areas. The use of unpalatable nurse shrubs to facilitate the growth of a palatable climbing species (*Glycine canescens)* is being investigated with the FFI CRC Enrich project and this project is also investigating the regional adaption and bioactivity of *Kennedia prorepens*. A small RIRDC-funded project at UWA is investigating grain legume potential of selected native species. Overall, a broad range of research activities focussed on native legumes are now underway, with the ultimate aim of release of a cultivar.

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