# Legacy pasture evaluation trials delivering new persistent legume varieties

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**Abstract**

Pasture legumes are the best long-term option to increase productivity and profitability from grass-dominated pastures in the sub-humid, sub-tropics and tropics of Australia through improving pasture yield, diet quality and performance of livestock. However, finding legume varieties that are persistent and productive in the long-term for the climatic zone and grazing systems has been challenging.

Queensland graziers report that long-term persistence (20 to 50 years) of legumes is their highest priority trait for selecting new varieties. Legume and livestock productivity was a second order priority; other traits such as seasonality of growth, ease of establishment, seed production, and methane reduction potential were considered important but of lower priority.

Research funding cycles are typically 3 to 5 years, which means long-term persistence of legume accessions cannot be directly measured before release as new varieties. However, there is a network of old pasture evaluation trial sites in the study area which provides an important opportunity for selecting persistent varieties.

Forty-eight pasture evaluation trial sites that were sown between 1978 and 2008 were inspected across southern and central Queensland to identify legumes that persisted in the long-term. Most of the sites had been 'abandoned' as research trials for >10 years and generally incorporated back into the grazing property. The two outstanding genera for long-term persistence were *Stylosanthes* and *Desmanthus* with some accessions demonstrating long-term persistence across broad geographic locations.

Legume persistence at these legacy trial sites has supported new research. Accessions of legumes were described and collected from old trial sites and evaluated across six new sites in southern Queensland. Five new *Stylosanthes* varieties have recently been released for commercial production demonstrating better persistence and 40 to 70% higher yields (averaged across trial sites) than the best performing commercially available legume stylo varieties. On-going research is identifying persistent and productive *Desmanthus* accessions for potential commercialisation as new varieties.

## Introduction

Pasture legumes have been identified as the best long-term option to improve the productivity of both native and sown grass pastures across large areas of the tropics and sub-tropics in Australia, where there are suitably adapted and productive cultivars available (Peck *et al.* 2011). Finding legumes that are suitable for the Brigalow Belt bio-

region of Queensland and New South Wales (NSW) has been particularly challenging due to its unique climate characterised by a sub-tropical climate with moisture deficits in all months of the year but is not arid (Hutchinson *et al.* 1992). The Brigalow Belt is important for the beef industry because it carries approximately 40% of Queensland's (10.6 million head) and 30% of northern Australia's beef cattle (13.3 million head) herd (ABS 2022).

Graziers advised that most of the legume cultivars that were previously commercially released for use in the Brigalow Belt were not persistent with competitive sown buffel grass (*Cenchrus ciliaris*) pastures typical in the region (Peck *et al.* 2011). The highest priority trait identified by graziers for new legume varieties was long-term persistence described as >20 to 50 years (i.e., graziers only want to sow legumes once). Research funding cycles are typically 3 to 5 years, which means that long-term persistence cannot be directly measured before legume accessions are shortlisted and selected for release as new cultivars. Fortunately, there is a network of old trial sites that were established between 1978 and 2008 that enables direct measurement and assessment of long-term persistence under grazing of legumes across a broad geographic area. This paper describes research conducted over the last 15 years that has utilised the old trial sites to identify legume species, cultivars and experimental accessions that have persisted and are productive in the long-term. This research provided better recommendations on which varieties to sow and identified accessions for further evaluation and release as new cultivars that are more productive in the long-term than existing, commercially available varieties.

## Methods

### *Investigation of legume performance in southern and central Queensland*

Forty-eight old pasture evaluation trials located across the Brigalow Belt bioregion were inspected to identify which legume species had persisted in the long-term. Re-visiting and describing these trial sites relied on the interest and input of multiple retired pasture scientists that were former employees of the Queensland Department of Primary Industries (DPI) or Commonwealth Scientific and Industrial Research Organisation (CSIRO) that had established the trials.

The old trial sites were sown between 1978 and 2008. Trial sites were inspected for long-term legume persistence between 2011 and 2023; 36 trials were inspected in 2011, 4 in 2013, 4 in 2016 and 4 in 2023. At the time of first inspection for long-term legume persistence, the trials ranged in age from 5 to 33 years post sowing with the average age being 18 years post sowing. Some of the trials have been inspected for legume persistence over multiple years. All the trial sites had been discontinued as research trials at the time of inspection, with most of the sites reverting to commercial grazier management for >10 years. If still fenced, most of the sites either had the gates open or fences were no longer stock proof, therefore the condition of the sites generally reflected the surrounding paddock. Due to the presence of pasture legumes, many of the sites were preferentially (and therefore heavily) grazed compared to surrounding paddocks. A full description of the methodology used to assess long-term persistence of legumes at trial sites is described in Peck *et al.* (2017).

The old trial sites were initially inspected to describe long-term persistence of commercially available legume varieties; however, these sites also enabled the identification of persistent and productive, non-released accessions for further evaluation and potential release as new cultivars. The activities to identify high-performing accessions for release as new varieties are described in the following sections.

### *Evaluating promising stylo lines for southern Queensland*

A summary of the evaluation methodology is provided in this paper. A full description is available in Peck *et al.* (2022).

Multiple accessions of stylo from multiple species persisted and spread at old pasture evaluation trial sites at more southerly latitudes, with greater frost frequency, than considered suitable for commercial varieties. Forty legume accessions were described and seed re-collected from 8 sites (36 accessions of stylo, 3 desmanthus and 1 *Neptunia*

sp.); however, the seed crop of one of the stylo accessions was severely damaged by disease, resulting in 39 accessions for sowing in new evaluation trials.

The 39 accessions, plus 3 experimental accessions shortlisted from other projects and 10 commercial legume varieties were sown in 2016 at six evaluation trial sites across southern Queensland. One of these trial sites failed to establish with adequate plant density due to soil crusting. The remaining five trial sites were assessed over nine growing seasons.

***Evaluating promising shrubby stylo accessions in central and northern Queensland***

Two accessions of coastal biotype shrubby stylo (*S. scabra*) have been shortlisted from the "evaluating promising stylo lines in southern Queensland" project for further evaluation across central and northern Queensland. Seven evaluation trials are planned for sowing in the 2024/25 growing season to test their performance relative to commercial cultivars.

***Investigating desmanthus persistence and performance in southern Queensland***

Following the success of the stylo selection project, an investigation of desmanthus persistence and performance at 12 evaluation trials in southern inland Queensland has commenced. Each of the sites had a wide range of desmanthus accessions from multiple species sown. Sites are >20 years post sowing. Sites have been inspected for legume persistence, with trials that warrant further investigation reinstated (e.g., fences repaired, or new fences erected). Identification of persisting accessions at trials that had large plots (>50 $m^2$) was completed in 2023 and 2024. One of the large plot trial sites was harvested to estimate yield in 2024. Investigation of persisting accessions at old small plot (approximately 6$m^2$) trial sites commenced in 2024/25.

**Results**

***Performance of commercially available legume varieties in southern and central Queensland***

Observations from the network of old pasture evaluation trial sites demonstrated that some commercially available legume varieties persisted across broad geographical areas of southern and central Queensland; however other legume species and varieties commonly recommended to graziers were not widely persistent. A summary of legume persistence and productivity results for commercially available legume species and varieties across the Brigalow Belt is provided below:

- *Stylosanthes* spp.: Caatinga stylo (*S. seabrana*) was widely persistent and productive on a wide range of soil types, but its productivity was impacted by high death rates of the population in southern districts on clay soils during wet winters. Shrubby and Caribbean (*S. hamata*) stylo are persistent on light textured (loamy and sandy) soils in central and northern Queensland but not in southern Queensland.
- *Desmanthus* spp.: *D. virgatus* was widely persistent on clay soils; however, in many locations, it had a very high population density of small plants with poor leaf retention. Other *Desmanthus* species (e.g., *D. leptophyllus*, *D. bicornutus*, *D. pernambucanus*) maintained an adequate plant density that contributed to animal production in a small percentage of trial sites where they were sown, but did have high dry matter production at some sites.
- *Leucaena leucocephala*: Leucaena persisted on fertile soils with high water holding capacity with good grazing management. Leucaena did not maintain adequate plant populations at multiple sites that had one or more of the following traits: sub-soil constraints, low fertility, heavy frost, and heavy continuous grazing.
- Legume species persisting in niches: Annual medics (*Medicago* spp.) are widely persistent on clay soils with regular frosts in southern Queensland. Butterfly pea (*Clitoria ternatea*) persisted on deeper, basalt derived black earth soils in central Queensland; but has not persisted on other clay soils. Round-leaf cassia (*Chamaecrista rotundifolia*) persisted on very sandy soils in central Queensland and on a wider range of soils in north and southeastern Queensland.

- Legume species that have not persisted on grazed trial sites include: Lucerne (*Medicago sativa*), burgundy bean (*Macroptilium bracteatum*), Atro (*Macroptilium atropurpureum*), fine-stem stylo (*Stylosanthes guianensis* var. *intermedia*). These legumes species should not be recommended for long-term pastures in the Brigalow Belt bio-region climate zone.

These legume persistence results are closely aligned with observations of commercial paddocks and consultation with graziers (Peck *et al.* 2011).

***Superior stylo varieties identified for southern Queensland***

Five stylo accessions were selected for release as new legume varieties for light textured soils in frosty locations in the sub-tropics based on the results from five evaluation trials sown in 2016. Three of the new varieties are Caatinga stylos (cvv. Dura, Cedo, Ultimo), and two are shrubby stylos from the "continental" biotype (cvv. Terra, Roxo).

The five new stylo varieties produced 40 to 70% higher average yields than the best performing, commercially available legume variety (cv. Unica, a Caatinga stylo) across five trial sites in the third and fourth growing season after sowing. These measurements were conducted during severe drought years that were in the driest 10% of years for the districts where the trials were located.

Four of the trial sites were remeasured during the eighth or ninth growing season after sowing to measure performance in average or higher rainfall growing seasons. The Caatinga stylo varieties produced 30 to 60% higher yields (averaged across the four trial sites) than the best performing commercial variety (cv. Primar, a Caatinga stylo). The two new shrubby stylo varieties produced lower average yields than cv. Primar but much higher yields than the commercial varieties of shrubby stylo (more than four times higher average yields).

***Evaluating promising shrubby stylo accessions in central and northern Queensland***

Two accessions of the "coastal" biotype of shrubby stylo were initially shortlisted from the "evaluating promising stylo lines in southern Queensland" project for further study. When grown in a trial at Mareeba, they produced yields that were approximately four times higher than cv. Seca, which is the industry benchmark variety for shrubby stylo and considered well adapted to the north Queensland climate. These two accessions are now being tested more broadly in a wide range of soil by climate locations across central and northern Queensland to see if they produce higher yields or other benefits compared to cv. Seca.

***Investigating old desmanthus trials in southern Queensland***

One outstanding desmanthus accession (breeders code: B-Six) has been identified from the old, large plot trial sites to progress towards release as a new cultivar. At the trial site that was harvested 25 years post sowing, B-six produced approximately double the yield of cv. Marc which has been a widely used and persistent desmanthus variety. B-Six also had clearly better leaf retention. The results from this trial are consistent with visual assessments that were carried out at the other old large plot trial site that was still intact (all other trial sites were ploughed out by the landowners). From historic trial data, B-Six had also produced high yields in the first 5 years post sowing at four old trial sites in southern Queensland and northern NSW and has now demonstrated ongoing persistence.

Other promising accessions are likely to be selected from the old small plot trials after more detailed assessment of performance. For example, one desmanthus accession (SPT017) collected from an old trial site has been sown at 7 new trial sites across southern Queensland and was the highest yielding desmanthus at 5 of the 7 sites.

**Discussion**

More widespread and successful adoption of legumes is critical to sustainably improving the productivity and returns for grazing industries in the Brigalow Belt climate zone that carries 30% of northern Australia's beef herd.

In addition to productivity benefits, these legumes can potentially reduce methane emissions intensity and improve pasture resilience to seasonal variability and grazing.

The network of old pasture evaluation trials across southern and central Queensland described in this paper provided valuable insights about the long-term performance of commercially available legume cultivars as well as identifying better-performing legume accessions for potential release as new varieties. The results from the old trial sites contributed to providing better advice to graziers when selecting legume varieties. The old trial sites also provide a legacy for selecting persistent and productive new legume cultivars. Better varieties combined with better advice will contribute to more widespread and successful adoption of legumes in northern Australia.

Five new stylo varieties that were identified and re-collected from old trial sites have the potential to increase the geographic range suitable for sowing legumes in southern Queensland (i.e. previously there were no suitable commercial legume varieties), as well as improving productivity for large areas where existing varieties are suited. Two additional shrubby stylo accessions were also identified and are being evaluated as potential replacements for cv. Seca, which is the most widely used legume in northern Australia. Additionally, new research has commenced that has identified improved desmanthus accessions, with further work potentially identifying other accessions with useful traits for industry.

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