Experimental stylo accessions produce higher yields than commercial pasture legume varieties on light textured soils in southern Queensland.

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Abstract
Pasture legumes are the best long-term option to increase productivity of grass pastures for large areas of Australia, however there are no commercially available, summer-growing legume varieties that are well adapted to sandy and loamy textured soils in the frost prone sub-tropics. A recently completed eight-year project collected 40 accessions of legumes from old pasture evaluation trial sites that were sown more than 20 years ago, as well as two roadside locations. These accessions were compared to 10 commercial varieties and three previously shortlisted accessions across six trial sites (three districts and two soil types) in southern Queensland between 2016 – 2019, during drought years. The five highest yielding accessions of stylos were from two species (*Stylosanthes scabra* and *S. seabrana*) and had 39 – 67% higher yields than the best performing commercial variety when averaged across all trials. These accessions also had good disease tolerance and formed effective nodules with commercial rhizobia. The five highest yielding accessions have been shortlisted for release as new varieties due to their potential to significantly improve productivity for the grazing industries in the sub-tropics of Australia.

Keywords
Stylosanthes, seabrana, scabra, desmanthus, subtropics

Introduction

Pasture legumes have been identified as the best long-term option to increase productivity and profitability from grass-dominated pastures in the sub-humid sub-tropics through increasing pasture biomass and improving diet quality of livestock (Peck *et al.* 2011). However, finding legume varieties that are suited to the frost prone sub-tropics has been challenging due to low and unreliable winter rainfall resulting in poor persistence of temperate legumes (e.g. subterranean clover); while frosty winters and less rainfall during the summer growing season than more northerly districts have resulted in poor persistence of tropical legumes (e.g. shrubby stylo *cv*. Seca). Some legumes have persisted on clay soils (e.g. medic, desmanthus and Caatinga stylo); however there are currently no commercially available summer-growing legume varieties that are persistent on light soils (loams and sands) in southern inland Queensland (Bell *et al.* 2016; Peck *et al.* 2017).

Legume varieties from multiple species of stylo (*Stylosanthes* spp.) have proven to be persistent on light soils under grazing and improve animal production in northern Western Australia, northern parts of the Northern Territory, central and northern Queensland and eastern districts in southern Queensland in regions with low frost incidence and higher rainfall during summer (Bell *et al.* 2016). Commercial varieties of stylo have not been persistent on light soils in inland districts of southern Queensland that have a higher incidence of frost and less rainfall during summer.

Despite commercial varieties of stylo not persisting in southern Queensland, multiple stylos were observed persisting and spreading into adjacent paddocks at old pasture evaluation trial sites on sandy and loamy soils in frost prone inland locations (Peck *et al.* 2017). These stylos were collected and evaluated across southern inland Queensland. This paper describes the performance of these experimental accessions across six evaluation trials in southern Queensland.

Methods

Stylos and other legumes were described and collected at six old pasture evaluation trial sites and two roadside locations in southern inland Queensland between 2012 and 2014 (Figure 1). Forty accessions of legume across three genera and six species were collected and grown out at Mareeba for seed increase to allow evaluation trials to be sown. The seed crop of one experimental accession died from disease before it was able to be harvested resulting in 39 collected experimental accessions progressing to the evaluation trials.

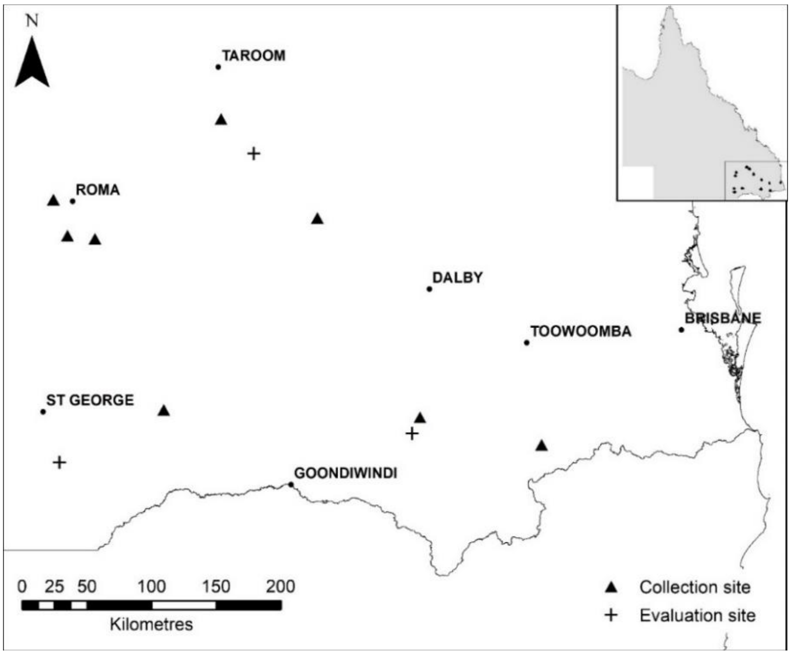

Figure 1. Location of old trials where the experimental legume accessions were collected and the location of evaluation trials. There are two trials located on different soil types at each evaluation site marker (+).

The legume accessions were evaluated on two soil types (sand and loam) in three districts (Wandoan, Millmerran and St George) in southern Queensland; that is six evaluation trials (Figure 1). Ten commercially available legume cultivars were sown alongside the experimental accessions as comparators. Three additional short-listed accessions from previous projects were also sown, resulting in a total of 52 accessions being evaluated in the trials. The planting list is described in Table 1.

Table 1. Summary of the sowing list for the evaluation trials.

Common name	Species	Cultivars	Experimental accessions*	Total sown
Shrubby stylo	*Stylosanthes scabra*	2 (Seca, Siran)	17	19
Caatinga stylo	*S. seabrana*	2 (Unica, Primar)	15	17
Fine-stem stylo	*S. guianensis var. intermedia*	1 (Oxley)	2	3
Sticky stylo	*S. viscosa*		2	2
Desmanthus	*Desmanthus spp.*	3 (JCU2, Progardes blend (JCU 1, 3, 4 and 5), Marc)	4	7
Sensitive plant	*Neptunia gracilis*		1	1
Atro	*Macroptilium atropurpureum*	1 (Aztec)	1	2
Round-leaf cassia	*Chamaecrista rotundifolia*	1 (Wynn)	0	1

* Experimental accessions: Accessions collected from old trial sites and three additional accessions shortlisted from previous projects.

The trial sites were sown in early 2016 and measurements continued until autumn 2019. Measurements included dry matter production, plant density, flowering and seeding, leaf retention, temperature (loggers were installed at trial sites during winter for air and legume canopy temperature) and rainfall. The St George loam trial site failed to establish adequate legume populations due to soil crusting, therefore no measurements were possible at this site. After three summer growing seasons, the better performing accessions were identified for inclusion in additional experiments including disease tolerance and rhizobia studies.

Spatial analysis was conducted to estimate the land area of Queensland where the short-listed experimental accessions would be suited. The analysis considered land-use (excluded non-agricultural land and cropped land), climate zone, frost, tree cover, land type, soil and climate adaptation of existing stylo varieties and evaluation trial results for experimental accessions.

Results

Seasonal conditions

Rainfall was well below average with all three districts drought declared for the duration of the evaluation trials (driest 10-20% of years overall and 2019 being the driest on record). The drought conditions meant that biomass harvests were not possible in all years at all sites; Millmerran trials were harvested in 2017, 2018 and 2019, Wandoan in 2018 and St George sand in 2019. In effect the trials have selected legume lines for performance during drought years as well as southerly latitudes (i.e. frost, seasonality of rain, daylength etc).

The trial sites had a similar number of potential frost days during the evaluation trials as the long-term average for each district. The Millmerran trial sites were the coldest ranging from 12 to 34 days per year with minimum air temperature below 0ºC and 24 to 48 days per year below 2ºC in the years that the trials were measured.

Legume yield

Multiple experimental accessions of shrubby and Caatinga stylo outperformed commercial legume varieties. When ranked from highest to lowest average yield for the 2018 and 2019 harvests across all trial sites, twenty-one experimental lines had higher yields than the best performing commercial variety (*cv*. Unica). Eight experimental lines had significantly ($P<0.05$) higher yields than *cv*. Unica when averaged across the trial sites (Figure 2).

Three Caatinga stylo and two continental biotypes of shrubby stylo accessions have been shortlisted for progressing towards release as cultivars. These accessions had an average yield increase of 28-54% compared to the average of all shrubby and Caatinga stylos, and averaged 39-67% better yield than the best performing commercial variety (*cv*. Unica).

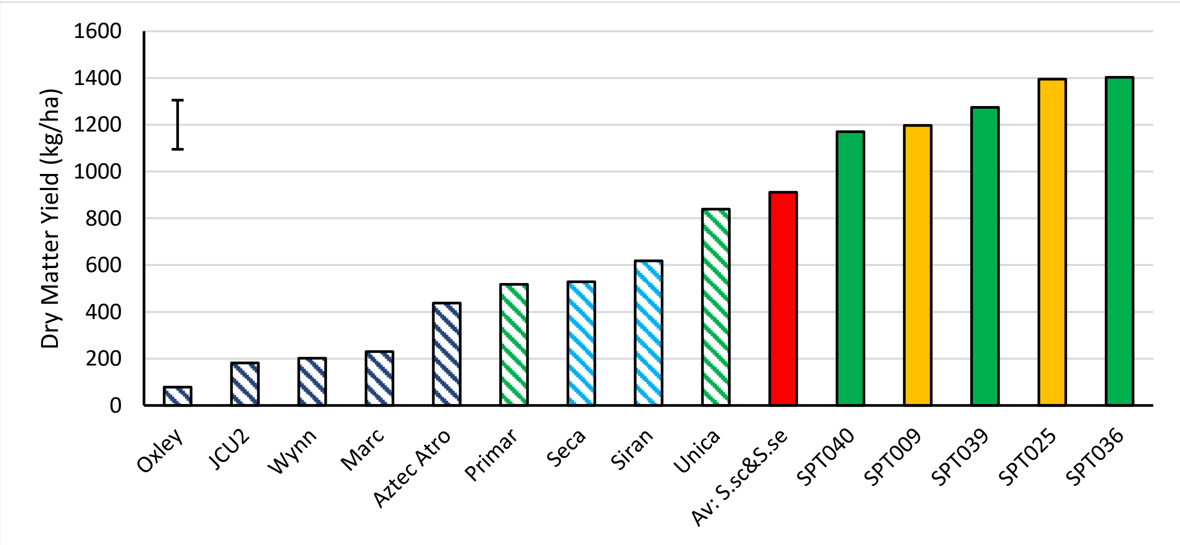

Figure 2. Average dry matter yield for shortlisted legume accessions compared to commercial legume varieties for the 2018 and 2019 harvests across five trial sites in southern Queensland. (LSD bar P<0.05). (Red: Av: S.sc&S.se is the average for all 36 *Stylosanthes scabra* and *S. seabrana* accessions; Green: Caatinga stylo, Amber: continental biotype of shrubby stylo, Blue: coastal biotype of shrubby stylo, Black: other species, cross hatching denotes commercial varieties).

Relative yield between accessions varied across the trial sites. Caatinga stylo was the best performing species across the trial sites, however commercial varieties did not produce the highest yields. Cultivar Primar had low yields at all sites, *cv*. Unica failed to persist at the Millmerran sand site but produced near average or above average yields for other sites. By contrast the shortlisted accessions of Caatinga stylo had average to well above average yields at all sites which suggests better adaptation to the climate and sandy soils than commercial varieties. The shortlisted shrubby stylo accessions had high yields at the Millmerran sites and Wandoan sand; but below average yields at Wandoan loam (the highest clay content soil) and St George sand (driest location). Commercial varieties of shrubby stylo (*cvv*. Seca and Siran) had well below average yields across the trial sites and failed to persist at Millmerran and St George sand sites.

Disease tolerance and rhizobia inoculant testing

A field tolerance to disease experiment was conducted at Mareeba, north Queensland because stylos are common in the district and the high rainfall, tropical climate induces a high disease load for anthracnose and other diseases. Shortlisted accessions varied in their tolerance to disease, but were all considered to have adequate disease tolerance.

A rhizobia inoculant pot trial found that shortlisted accessions all formed effective nodules with the recommended inoculant for the species. Accession SPT025 will be retested due to the seed (from the initial seed increase) being contaminated with another stylo species.

Spatial analysis

Spatial analysis identified 29.2M ha of Queensland that are suited to existing varieties of shrubby stylo with an additional 3.7M ha suitable for the shortlisted experimental lines in southern and central Queensland. Approximately 21.1M ha hectares of Queensland is suitable for commercial varieties of Caatinga stylo and an additional 0.9M ha is suited to the shortlisted accessions across southern and central Queensland. When the areas suited to existing varieties and shortlisted accessions of shrubby and Caatinga stylos are combined, there is 44.3M ha of Queensland considered suitable. The land identified as suitable in Queensland carries approximately 75% of Queensland's and 60% of northern Australia's beef herd which highlights the potential importance of these two species to the northern Australian beef industry. There are additional areas in the Northern Territory and the north of Western Australia that are also suitable.

Conclusion

Experimental lines of shrubby and Caatinga stylo have significantly outperformed commercial varieties of legumes at five trial sites in southern inland Queensland on sandy and loamy textured soils. Three accessions of Caatinga stylo (SPT036, SPT039 and SPT040) and two accessions of continental biotype shrubby stylo (SPT025 and SPT009) were identified as the best performing lines and will be progressed towards being released as new legume varieties. These trial results have shown that new varieties could produce significantly higher legume yield, be more persistent and increase the suitable geographic area for these two important species.

The large area of land that is suitable to shrubby and Caatinga stylo in northern Australia means that there is potentially a large market for seed for both species, including new varieties that extend the range of adaptation into more southerly latitudes. The adaptation of these two species to the moderate to high rainfall districts of northern Australia means that these species are suited to the land that carries most of the northern beef herd.

Further research is required to test promising experimental accessions further north in central and northern Queensland, further south in New South Wales and on other soil types. If the experimental lines perform similarly to existing varieties in northerly latitudes but extend the range of adaptation to southerly latitudes and a wider range of soils, then the value to the beef industry will be higher and the market for seed will be larger.

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