Evaluation of temperate legumes for use in tropical perennial grass pastures in central western NSW

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Abstract
Central western NSW is characterised by aseasonal, low (<500 mm MAR) and highly variable rainfall resulting in gaps in feed-based production. In a MLA funded project we aim to provide flexibility to livestock enterprises with improved pastures that incorporate temperate and tropical legumes into tropical perennial grass (TPG) pastures. In June 2013, 16 temperate legumes and two non-legume treatments were sown into replicated plots at Trangie. Herbage mass was assessed at approximately 6 week intervals between mid May and late October 2014. Two attempts to establish digit grass (*Digitaria eriantha*) cv. Premier into the plots failed. The highest herbage mass values were recorded for barrel medic (*Medicago truncatula*) cv. Caliph (1,952 kg DM/ha) and cv. Jester (1,632 kg DM/ha), and woolly pod vetch (*Vicia villosa*) cv. Haymaker (1,058 kg DM /ha). The lowest herbage mass was recorded for French serradella (*Ornithopus sativus*) cv. Margurita, Persian clover (*Trifolium resupinatum*) cv. Nitro Plus and purple clover (*T. purpureum*) cv. Electra (<200 kg DM/ha). Here, a tropical grass was absent and it is expected that the values for legume herbage mass may be lower, in particular under low rainfall conditions where competition between grass and legume for water becomes critical. Whether differences in seasonal growth between temperate legumes can be exploited as part of composite pasture mix is unknown and will provide a focus for continuing studies. Having a legume that can provide a consistent growth under varying seasonal conditions may prove a distinct advantage in central western NSW.

Key words
Cultivar, evaluation, herbage mass

Introduction
The incorporation of legumes into tropical grass pastures offers the potential to reduce nitrogen fertiliser input but also increase the year-round productivity of pastures (Harris *et al*. 2014), resulting in more resilient pasture systems. In central western NSW, the climate is characterised by aseasonal, highly variable, low median annual rainfall (<500 mm). This results in feed gaps that can occur at critical times for livestock enterprises, often being met by supplementary feeding (Moore *et al.* 2009). In central western NSW, lucerne (*Medicago sativa*) has been commonly sown, generally as a pure sward (e.g. Bowman *et al*. 2002) but temperate annual legumes such as *Medicago* spp. are also widely used. However, the development of hard seeded legumes such as biserrula (*Biserrula pelecinus*) and serradella (*Ornithopus* spp.) have shown potential in southern NSW (Hackney *et al*. 2012a,b,c) but their use in central western NSW has not been tested.

A lack of practical agronomic information and the identification of suitable companion legumes in grass/legumes mixes are major factors preventing the broad-scale adoption and use of grass/legume mixed pastures in NSW (McCormick *et al.* 2009). A project funded by Meat and Livestock Australia is currently underway to identify productive, persistent legume companions for tropical grass pastures. Sites are located at Trangie in central western NSW and Manilla and Bingara in North-West NSW. This research will aim to develop management guidelines for tropical pastures (legumes and grasses) in central and northern NSW. In this paper we describe preliminary results for herbage mass production and cover of temperate annual legumes sown at Trangie over the first growing season, following establishment.

Method
The site was located on a brown Chromosol soil at the Trangie Agricultural Institute, Trangie (31^{0}56’18.80 S, 147^{0}56’18.80 E). Twelve months prior to sowing, the site was sprayed three times with glyphosate (2 L/

ha; 450g/L a.i) and cultivated with offset disks 6 weeks prior to sowing digit grass (*Digitaria eriantha*) cv. Premier (1 kg/ha viable seed) in November 2012 using a 6-row single disk seeder. The grass failed to establish due to poor summer rainfall (Table 1) and the site was sprayed again with 2 L/ha glyphosate in February 2013. In June 2013, 16 temperate legumes (Table 2) and two non-legume treatments (50 kg nitrogen (N)/ha and nil N controls) were sown at commercial seedling rates (Table 2) into three replicated plots in a spatially balanced design using the same single disk seeder. Plots were 1.5 x 6.7 m with a 0.3-0.5 m buffer around each plot. All legumes established and set seed in the establishment year. Digit grass was resown in October 2013 and again failed leaving the plots as pure legume. In early March 2014 and mid-July 2014, the experiment was sprayed with 820 mL/ha with fluazifop-P (128 g/L a.i) to control annual ryegrass (*Lolium rigidum*). Superphosphate (8.8% phosphorus, 11% sulphur) was applied at 100 kg/ha in mid-May and July 2014.

Herbage mass of legumes within each plot was determined using a modified comparative yield method (Lodge and Harden 2011) at approximately 6 weekly intervals between mid-May and late October 2014. All plots were cut to 5 cm after the first measurement in May 2014 using a rotary mower with a catcher and herbage removed from the plots. Cover was estimated by counting the number of cells that contained sown legume in a permanent quadrat (1 x 1 m, subdivided into 100 cells) located within each plot. Three quadrats were located over the centre four rows within each plot and cover was measured on four occasions; mid-October 2013, mid-May, July 2014 and late August 2014. These measurements provided an indication of recruitment and habit of individual legumes. Dry matter (DM) was modelled for each time period using the mixed linear model DM ~ Variety + random (Rep) + **R,** where **R** is a covariance matrix which includes autoregressive terms for row and column, where appropriate. In addition to this the dry matter values from all time periods were combined into a single dataset and analysed using the mixed linear model, DM ~ Variety + Time + random (Rep + spl (Time)) + **R** where **R** = **T** (time) □ **R** (row) □ **C** (column) is a covariance matrix which includes covariance matrices for time period as well as autoregressive matrices for row and column, where appropriate. The random spline term is used to model non-linear changes in dry weight over time.

Results and Discussion

Significant ($P<0.001$) differences in predicted dry matter (DM) were found between cultivars (Figure 1). The best performing cultivars were the barrel medics (cvv. Caliph and Jester) and woolly pod vetch (cv. Haymaker) that achieved an equivalent of 1,952 kg DM/ha, 1,632 kg DM/ha and 1,058 kg DM/ha, respectively, in early spring. We also observed that these legumes also had seedling regeneration densities ranging 146-233 plants/m^2. Barrel medic has had a long history of use within central western NSW (e.g. Michalk and Beale 1976) and its winter dominant growth has the potential to provide seasonal complementary, quality feed within a tropical grass pasture (Clarkson *et al*. 1991). These three legumes also provided the highest cover exceeding 66% at each assessment (Table 2). Seasonal patterns of growth indicate peak production for barrel medics cvv. Caliph and Jester occurred over winter but woolly pod vetch reached highest production in early spring, and snail medic cv. Silver in mid spring (equivalent to 522 kg DM/ha). This suggests there may be opportunities for exploiting differences in growth patterns within legume mixes.

Table 1. Monthly and long term average (LTA) and median (LTM) monthly rainfall (mm) at the Trangie site (Bureau of Meteorology site number: 051049, 1922-2014).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	81.4	63.0	119.4	3.2	35.6	25.4	31.2	0.4	23.4	8.0	25.0	5.2	421.2
2013	9.6	22.4	57.4	0.0	17.0	107.4	25.4	6.0	55.0	3.2	2.0	31.6	337.0
2014	29.4	58.4	80.0	34.0	11.8	57.4	34.0	34.0	9.8	2.6	6.2	79.6	437.2
LTA	53.5	52.1	47.4	39.2	37.4	35.9	34.3	32.1	31.5	45.8	45.6	41.1	495.4
LTM	39.0	31.1	26.7	23.2	31.5	28.2	30.6	25.7	23.7	35.5	36.4	33.0	470.5

There were a number of relatively unproductive cultivars, producing equivalent to <199 kg DM/ha; French serradella cv. Margurita, Persian clover cv. Nitro Plus and purple clover cv. Electra. These legumes also had low regeneration plant densities (<20 plants/m^2). This is surprising as there have been some reports of successful stands of purple clover, albeit east of Trangie, however adaptive differences between species and cultivars to site characteristics such as soil will be examined using on-going multiple site experiments. It may be that poor performance was linked to low seed production (all species set seed, but seed yields were not recorded) and/or a decline in rhizobia numbers over the course of the experiment especially since plant numbers have declined each year. Although all legumes were inoculated with recommended rhizobia strains, and nodules were found on plants in the establishment year, biserrula and serradella both have specific rhizobia strains requirements (Hackney *et al*. 2012a,c).

Table 2. Sowing rate (kg/ha viable seed) and cover (%) of 16 temperate annual legumes sown at Trangie Agricultural Research Centre.

Temperate legume and cultivar	Sowing rate (kg/ha)	Cover (%)			
		17/10/13	19/05/14	14/07/14	27/08/14
Arrowleaf clover (*Trifolium vesiculosum*) cv. Cefalu	1	55.0	40.6	45.8	43.1
Barrel medic (*Medicago truncatula*) cv. Caliph	5	88.9	74.5	79.7	77.0
Barrel medic cv. Jester	2	81.4	67.0	72.2	69.5
Biserrula (*Biserrula pelecinus*) cv. Casbah	1.5	49.0	34.6	39.8	37.1
Bladder clover (*T. spumosum*) cv. Agwest Bartolo	3	37.8	23.4	28.6	25.9
French serradella (*Ornithopus sativus*) cv. Margurita	1.5	28.8	14.4	19.6	16.9
Gland clover (*T. glanduliferum*) cv. Prima	2	35.9	21.4	26.7	24.0
Persian clover (*T. resupinatum*) cv. Nitro Plus	1	13.0	0.0	3.9	1.1
Purple clover (*T. purpureum*) cv. Electra	1	40.1	25.6	30.9	28.2
Rose clover (*T. hirtum*) cv. SARDI Rose	1	24.9	10.5	15.7	13.0
Snail medic (*M. scutellata*) cv. Silver	7	50.0	35.5	40.8	38.1
Subterranean clover (*T. subterraneum*) cv. Campeda	3	45.1	30.6	35.9	33.2
Subterranean clover cv. Dalkeith	10	46.0	31.5	36.8	34.1
Woolly pod vetch (*Vicia villosa*) cv. Capello	6	81.3	66.9	72.1	69.4
Woolly pod vetch cv. Haymaker	6	90.6	76.2	81.4	78.7
Yellow serradella (*O. compressus*) cv. Santorini	3.5	65.5	51.1	56.3	53.6

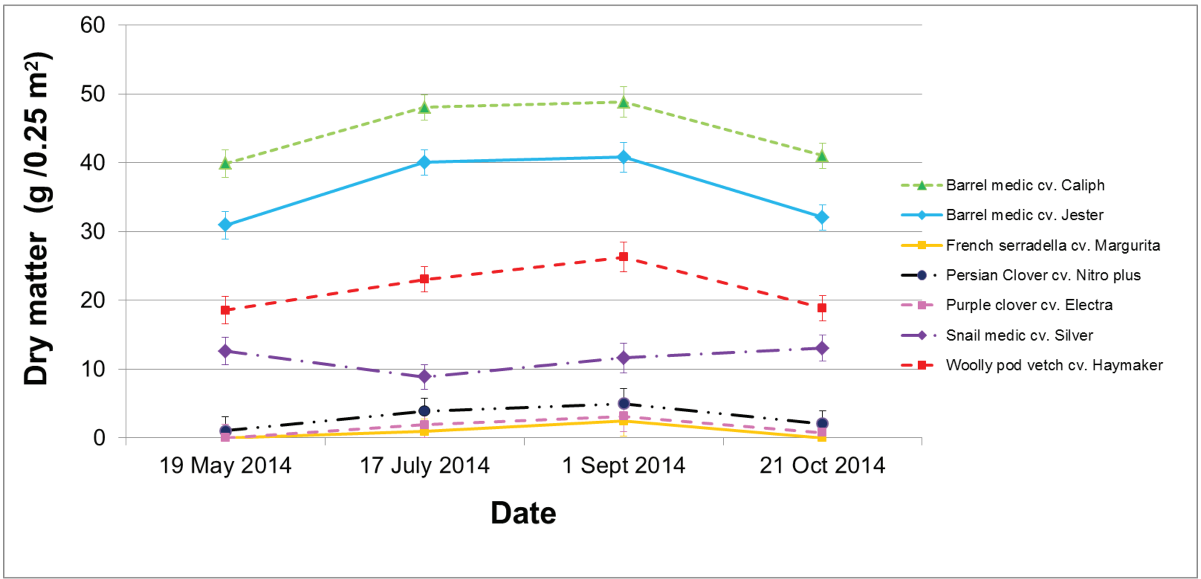

Fig. 1. Seasonal patterns in mean predicted dry matter production ($g/0.25^2$) and standard error for a selection of cultivars.

Seasonal rainfall variation has a significant impact on annual pastures, especially in the more arid western NSW. The success of temperate annual legumes initially depends on sufficient rainfall for establishment and finally sufficient rainfall for seed set. Smith and Cooper (1996) determined that the probability of rain exceeding 25 mm in each month during April and May (establishment) at Trangie ranged 0.47-0.55. In September (flowering and seed set), the probability of >25 mm rainfall was 0.49. Maintaining a seed bank is essential to the long term persistence of annual legume and a large seed bank provides 'insurance' for years unfavourable for annual legumes. The inability to successfully establish digit grass sown in mid- October/ November at this location suggests that an early spring sowing (possibly September) may prove a better option for central western NSW.

Conclusion

Although this is an ongoing study, it appears there are useful levels of variation in seasonal growth patterns that may provide opportunities for legume mixes and complementarity with tropical grass pastures. The ability for these species to produce a second season of production will be based on a capacity for cultivars to set seed to produce a sufficient seedbank. To-date, the results highlight a superiority of the medics and potential of woolly pod vetch in central western NSW.

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