final report

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Cooks Myall – Legumes in tropical grass

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Abstract

Cooks Myalls Landcare Group members have been successfully sowing subtropical grasses, primarily bambatsi panic, premier digit, Gatton panic and Rhodes grass for almost a decade and find they persist and perform well in favourable seasons. Members now seek ways to increase the productivity and returns from these pastures.

Nitrogen availability is a key driver of growth which can be supplied to the pasture in a number of ways. Application of urea, via topdressing is the most common way of providing nitrogen but members were interested in improving grass growth and quality using companion legume species to fix nitrogen.

Two trials were sown comparing ways of increasing subtropical grass production over summer. The first compared two mixes of temperate annual legumes with urea application and the second comparing two cultivars of the tropical legume Desmanthus with urea.

In the years of the trial neither urea nor the temperate legume treatments significantly changed the production or quality of the subtropical grasses compared with the control, however where the temperate legumes were sown, winter pasture production and quality was dramatically improved and it was considered worthwhile for that reason alone. The most productive and persistent legume sown were new varieties of Sub. clover (Trifolium Subterraneum).

Desmanthus was new to the district and low summer rainfall along with poor seed germinability prevented successful establishment so this trial was abandoned. More work may be needed to look at the adaptation and agronomy of the plant itself before any further large scale plantings could be tried.

Executive Summary

The aim of the Cooks Myalls project was to investigate the most effective means of driving the production of their subtropical grass based pastures. Availability of nitrogen was identified as a limiting factor producers had control over. Topdressing pastures with urea is the most common method of applying nitrogen to pastures. Group members were however interested in looking at planting companion legume species to fix nitrogen for the grass species to utilise over summer. Legume species also have the added bonus of providing added grazing production for producers, further increasing production.

Two trial sites were established both with a grass only control treatment and urea topdressed treatments alongside a range of grass plus legume treatments. At “Cooks Myalls” two mixes of annual temperate legumes were sown in the autumn preceding the subtropical grass sowing while at “Thuruna” two different varieties of Desmanthus were trialed and sown in conjunction with the grasses.

Desmanthus had not been grown in the area before. While it failed to establish in this trial, more work detailed agronomic trials to look at the adaptation of the species to the area may be useful before the species is totally discounted as an option.

The annual temperate legumes established well but by the end of the trial it was confirmed the most productive and persistent species remains appropriate cultivars of sub clover. The winter growing annual legumes also provided significant mass feed of extremely high quality at a time of year the subtropical grasses are dormant and low in feed quality so providing year round productivity for producers.

While the trial results indicate neither legumes nor topdressed urea increased the production of the subtropical grasses over summer the summer seasons experienced during the trial were very dry and did not give the treatments a fair chance of success. Producer experience suggests that providing nitrogen via topdressing is a most effective means of increasing herbage production of subtropical grass pastures but applications are used tactically in accordance with seasonal conditions. It is still possible that nitrogen fixed by temperate legumes would make a difference to summer grass production in seasons with better summer rainfall.

Even though the annual temperate legumes probably fixed nitrogen they also caused shading of the new grass tillers early in the growing season and also robbed the soil of valuable moisture at the start of the subtropical grass growth season. Group members identified this as a compromise to summer grass production born from having species growing year round, an effect which can is exacerbated by poor summer rainfall.

More work could be done in Central West NSW to evaluate methods of establishing the legumes into the grass pasture. In this trial temperate legumes were sown first in autumn and subtropical gasses sown in the following summer after the legumes had reached maturity and seeded. In dry years this limits the amount of soil moisture available to establish the grasses. Conversely establishing the subtropical grass pasture before sowing the legumes may have a similar influence on the legume establishment however rainfall is often more reliable in the region over autum and

winter. Managing the residue of the first first sown species to enable satisfactory establishment of second could also be further researched to establish best practice.

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1 Background

1.1 Cooks Myall Landcare Group

Cooks Myall Landcare Group was formed in 1991 and has been active for 26 years. It currently consists of 22 family businesses, covering an area of 35,000 ha supporting around 25,000 sheep and 600 cattle. The pasture base has traditionally consisted of annual grass and native grass pastures along with subterranean clover and lucerne sown when paddocks are spelled from cropping.

The group initially formed to deal with soil salinity issues and the initial projects conducted by the group involved fencing 40 km of remant and new tree lines, evaluating a range of salt tolerant grasses and conducting farm agroforestry trials to determine the effectiveness of trees in lowering the water table.

The group has always been proactive gaining knowledge and implementing new strategies to increase productivity and profitability, and improve land management and sustainability. Members have been involved in Prograze courses, Acid Soils and Holistic Management workshops.

1.2 Interest in subtropical grasses

Cooks Myall Landcare Group have had an interest in subtropical pastures for almost a decade being motivated by the need for a pasture with high ground cover year round as well as providing high quality feed for animals. The group sowed the first commercial subtropical grass evaluation in the Parkes region in 2009 consisting of five 20 ha blocks sown on a range of soils to a mix consisting of digit grass (*Digitaria eriantha* cv. Premier), Rhodes grass (*Chloris gayana* cv. Katambora), Bambatsi panic (*Panicum coloratum* cv. Bambatsi) and panic grass (*Megathyrsus maximus* cv. Gatton). These small areas showed the productivity of the grasses and that they were effective at filling the traditional autumn feed gap with a bulk of forage able to be carried into winter which could be utilised with supplements.

Literature and local observations confirm the need to fertilise regularly in order to maintain productivity, in particular with nitrogen (N). Nitrgen application is costly in both time and money and depending on the N sourced used, needs to be immediately prior to rainfall to minimise volatilisation. Alternative cost effective sources of N would be advantageous. Dr Suzanne Boschma was invited to speak to the group in December 2012. She spoke of the opportunities and challenges of temperate annual legumes and a summer growing legume called desmanthus (*Desmanthus virgatus*) that was showing potential in northern NSW. These opportunities spiked the interest of the group in sowing legumes with sub tropical grasses and lead to the formation of a producer research project under the MLA PRS program.

2 Project Objective

By 1 September 2017, to determine the effectiveness of growing temperate or subtropical legumes in subtropical grass mixes compared with adding nitrogenous fertiliser for increasing pasture growth, total biomass and feed quality

3 Methodology

The project consisted of two experiments sown on commercial properties located 20 km north west of Parkes: 'Cooks Myall' and 'Thuruna'. The area has an average annual rainfall of 529 mm with a median of 518 mm (Bureau of Meteorology site 50016, 1882-2017). Rainfall is relatively evenly distributed across the seasons with a slight summer dominance (29% cf. 23-24% for each of the other three seasons). September is traditionally the driest month of the year (37 mm) and January the wettest (53 mm). At Parkes, the nearest town with temperature records, July is the coldest month of the year (2.4-14.2^{o}C average minimum and maximum respectively) while January is the hottest month (17.5-33.5^{o}C)(Bureau of Meteorology site 65068, 1941-2017).

3.1 Temperate annual legumes – 'Cooks Myall'

The experiment evaluating temperate annual legumes was located on the property 'Cooks Myall' (33^{o}02'58.83"S, 148^{o}01'00.44", 292 m). The plots were located on a red-brown medium clay with pH ($CaCl_2$) of 5.9 in a section of a 14 ha paddock with a gentle, southwest slope. Prior to the experiment, the site was a degraded pasture dominated by low quality perennial grasses, predominantly corkscrew (*Austrostipa setacea*) and rough spear grass (*A. scabra*), Patterson's curse (*Echium plantagineum*), Saffron thistle (*Carthamus lanatus*) and Variegated thistle (*Silybum marianum*) and other broadleaf weeds. During the 8 weeks prior to sowing the experimental area was sprayed on four occasions. In early April the area was sprayed with glyphosate (450 g/L a.i at 1.5 L/ha) and 2,4-D ester (680 g/L a.i. at 0.6 L/ha). A paraquat and diquat mix (135 and 115 g/L a.i. respectively) was applied mid-April at 2 L/ha, and a mixture of glyphosate (1 L/ha) and oxyfluorfen (240 g/L a.i. at 75 ml/ha) in late April. Two days prior to sowing, the experimental area was sprayed with MCPA (750 g/L at 930 mL/ha) and dimeothoate insecticide (400 g/L at 100 mL/ha).

3.1.1 Treatments

The experiment consisted of four treatments: two legume treatments and two non-legume treatments sown in mixtures with subtropical grasses. The experiment was a randomised complete block design with four replicates. On 30 May 2014 the two temperate annual legume treatments were sown with a flexi coil tyned air seeder with 300 mm spacings into plots 10.7 x 320 m (total experimental area was 128.4 x 320 m). 70 kg/ha of MAP was applied through the seeder at sowing The four treatments were:

1. Tropical grasses without any sown legume (control). Herein referred to as grass-N (T1).
2. Tropical grasses fertilised with 100 kg/ha urea (46 kg N/ha). Herein referred to as grass+N (T2).
3. Tropical grasses sown into a mixture of gland clover (*Trifolium glanduliferum*) cv. Prima (20% by weight), balansa clover (*T. michelianum*) cv. Bolta (20%), subterranean clover (*T. subterraneum*) cv. Losa (20%), spineless burr medic (*Medicago polymorpha*) cv. Cavalier (20%) and biserrula (*Biserrula pelecinus*) cv. Casbah (20%) sown at a total of 10 kg/ha. Herein referred to as grass+legume1 (T3).
4. Tropical grasses sown into a mixture of subterranean clover cv. Mintaro (20% by weight), snail medic (*M. scutellata*) cv. Silver (20%), bladder clover (*T. spumosum*) cv. Bartolo (20%),

arrowleaf clover (*T. vesiculosum*) cv. Cefalu (20%) and Persian clover (*T. resupinatum*) cv. Nitro Plus (20%) sown at a total of 10 kg/ha. Herein referred to as grass+legume2 (T4).

All legume seed were purchased preinoculated. All plots were sprayed on 3 October 2014 with haloxyfop (520 g/L a.i. at 100 mL/ha) to remove grass weeds, including wild oats (*Avena fatua*), ryegrass (*Lolium* spp.) and barley grass (*Hordeum* spp.). Urea (46% N) was applied to the grass+N plotrs at 120 and 100 kg/ha in December 2015 and 2016 respectively. Urea was applied prior to a forecast rainfall event to minimise volatilisation. All legumes were allowed to set seed in spring each year.

The subtropical grasses were sown into all plots on 24 December 2014 using the same disc seeder. The grasses were sown at 5 kg/ha coated seed and consisted of digit grass (*Digitaria eriantha*) cv. Premier (85% by weight), Rhodes grass (*Chloris gayana*) cv. Katambora (10%) and Bambatsi panic grass (*Panicum coloratum* var. *makarikariense*) cv. Bambatsi (5%).

Soils (0-10 cm and 0-60 cm) were collected for analysis in spring 2014, and the surface (0-10 cm) sampled each autumn until 2016. Soil pH was acidic (pH 5.1) with very little Aluminium in the soil solution. Soil phosphorous levels were low at with Colwell P at 16 mg/kg sitting at less than half the desirable level for best growth of traditional temperate legumes such as subterranean clover (Table 1).

Table 1. Soil characteristics at 'Cooks Myall' and 'Thuruna' experimental sites.

	'Cooks Myall'		'Thuruna'	
	0-10 cm May 2015	0-10 cm June 2016	0-10 cm Oct. 2014	0-60 cm Oct. 2014
pH (1:5 $CaCl_2$)	5.1	4.9	4.6	-[a]
EC (1:5 H_2O; dS/m)	0.21	0.20	5.50	-
Organic carbon (Walkley Black; %)	1.70	1.70	1.95	-
Nitrate nitrogen (KCl; mg/kg)	76	81	23	12
Ammonium nitrogen (KCl; mg/kg)	5	5		8
Phosphorus (Colwell; mg/kg)	16	16	26	-
Potassium (Amm-acet.; cmol+/kg)	2.4	1.9	1.4	-
Sulfate-S (KCl_{40}; mg/kg)	9.7	8.8	6.6	9.5
Calcium (Amm-acet.; cmol+/kg)	8.5	6.9	4.5	-
Magnesium (Amm-acet.; cmol+/kg)	2.4	2.1	1.3	-
Calcium:Magnesium ratio (cmol+/kg)	3.5	3.3	3.6	-
CEC (cmol+/kg)	13.4	11.1	7.6	-
Sodium (Amm-acet.; cmol+/kg)	0.03	0.05	0.07	-
Aluminium (KCl; cmol+/kg)	0.10	<0.10	0.35	-
Aluminium saturation (%)	0.7	0.9	4.7	-
Copper (DTPA; mg/kg)	3.60	3.70	2.63	-
Zinc (DTPA; mg/kg)	1.70	1.10	3.63	-
Manganese (DTPA; mg/kg)	74.0	75.0	64.4	-
Iron (DTPA; mg/kg)	31.0	33.0	94.2	-

[a]Not analysed

Mono-ammonium phosphate (10% nitrogen (N), 21.9% phosphorus (P), 1.5% sulphur (S), 1.6% calcium kg/ha) was used at 70 kg/ha in May 2014 when the legumes were sown and single superphosphate with molybdenum (Mo) (8.8% P, 11% S, 0.025% Mo) was also spread at 100 kg/ha in May 2015. Single superphosphate was applied again in December 2015 at 100 kg/ha, and in autumn 2016 at 100 kg/ha .

In August 2015, the experiment was sprayed while the subtropical grasses were dormant with clethodim (240 g/L a.i. at 350 mL/ha) and haloxyfop (520 g/L a.i. at 50 mL/ha) to control grass weeds and dimethoate (100 mL/ha) was added to control red-legged earth mites. Ultimate densities of sub tropical grasses was lower than desired in Summer 2015-16 so it is possible that the grass selective herbicides had a negative impact on the perennial grass population but temperate grass weeds were very dense at the time of spraying after a number of frosts so it is probably more likely competition from these grass weeds was more damaging than the herbicide.

In July 2016, omethoate (290 g/L a.i. at 100 mL/ha) and MCPA (750 g/L a.i. at 750 ml/ha) were sprayed to control red-legged earth mite and broad leaf weeds (predominantly saffron thistle, shepherds purse (*Capsella bursa-pastoris*) and Patterson's curse) respectively.

3.1.2 Assessments

Due to the size of the plots, the assessments were restricted to a designated area in each plot 50 m long by full plot width, 20 m from the southern end of the experiment.

Seedling establishment

In each plot the number of seedlings of sown species were recorded in ten quadrats (0.4 x 0.5 m in 2014-2016 and 0.1 x 0.5 m in 2017) and converted to plants/m^2. The legumes were identified to species. Temperate legume establishment was assessed in September 2014 and regeneration assessed in September 2015, June 2016 and May 2017. Subtropical grass seedlings were counted in May 2015.

Dry matter production

Herbage mass (kg DM/ha) of each plot was determined using a BOTANAL assessment technique (Tothill et al. 1992). In each plot, total herbage mass was visually estimated in 16 quadrats (0.4 x 0.4 m quadrat) using a continuous 0-5 scale, where 0 was nil herbage mass and 5 was maximum herbage mass in the experiment. Botanical composition was estimated by allocating dry-weight rankings of species divided into five categories: sown subtropical grass; sown temperate legume; other summer grass; winter growing grass; and broadleaf weed. Each category was also assessed for percent-green.

At each assessment, 15 calibration quadrats (0.4 x 0.4 m) were selected to span the range in total plot herbage mass in the experiment and visually assessed using the above scale. Calibration quadrats were cut to a height of 10 mm above ground level using battery operated shears and the harvested material dried in a dehydrator at 80°C for 48 h. Calibration quadrat scores and dry weights were regressed (linear or quadratic, R^2>0.80) and quadrat scores converted to kg DM/ha.

Herbage mass was not assessed during the establishment year, but was assessed twice in 2016 (May and September) with a final assessment conducted in January 2017. Herbage mass was also assessed in July 2016 by cutting single representative 0.5 x 0.5 m quadrats from each treatment plot in replicates 1 and 2. The samples were dried at 80°C for 48 hr, weighed and dry weight converted to kg DM/ha.

The experiment was grazed with sheep after each assessment and allowed to set seed each year. Grazing was generally conducted over a 5-14 day period with about 450 ewes and lambs or 1050 ewes.

Nutritive value

Tropical grass samples were collected for nutritive value analysis in February 2016 and March 2017. Vegetative green subtropical grass leaf, representing the herbage livestock would be selectively grazing, was collected from each plot by randomly collecting 'grab' samples at grazing height across the assessment area in each plot. The samples were subsampled and the subsamples stored in an esky with ice blocks to ensure they remained cool.

The samples collected February 2016 were frozen then sent to SGS for analysis, via Landmark at Parkes. Unfortunately the samples were lost in the mail and had deteriorated when they arrived at the laboratory for analysis. Caution is warranted when interpreting the results. The samples collected in March 2017 were dried in a dehydrating oven for 48 h at 65°C then sent to NSW DPI Diagnostic Analytical Services for analysis. All samples were analysed for protein (%), metabolisable energy (ME, MJ/kg), acid detergent fibre (%) and neutral detergent fibre (%).

3.1.3 Statistical analyses

The data were tested for normality and transformed when necessary. Where there were significant treatments or interactions, pairwise comparisons were conducted using least significant difference (P = 0.05). All analyses were conducted using ASREML 4.1 (VSN International, 2017).

Seedling establishment

Seedling densities were analysed using a linear mixed model with pasture treatment x component as the fixed term and replicate as the random term.

Dry matter production

Herbage mass (kg DM/ha) data collected May and September 2016 and January 2017 were analysed. At each sampling date, each component that had values greater than zero were analysed, commonly subtropical grasses, temperate legumes and 'other species' (varied with time of year but included summer-growing grasses that were not sown, winter grasses and broadleaf weeds). The green and dead proportions were analysed independently using a linear mixed model with pasture treatment x component as the fixed term and replicate as the random term.

Nutritive value

Data were analysed using a randomised complete block linear mixed model.

3.2 Desmanthus – 'Thuruna'

The second experiment was located at 'Thuruna', 40 km north west of Parkes (32°59'25.68"S 147°56'20.59"E, 302 m). The site was a red loam with submerged reefs and outcrops of quartz. The paddock was located on the top of a low hill with a slope to the east and west.. The trial plots were located on the westerly aspect of the paddock.The paddock had been cropped in sequence with canola and barley over the two years prior to commencing the experiment so as to reduce weed burden. Field peas cv. Hayman were sown at the site in April 2014 and sprayed out in October 2014 with glyphosate (450 g/L a.i. at 1.5 L/ha) and 2,4-D ester (680 g/L a.i. at 400 mL/ha). The soil pH ($CaCl_2$) was 4.6 with an aluminium saturation of 4.6% (Table 1).

3.2.1 Treatments

The experiment consisted of four treatments: two non-legume treatments and two legume treatments. All plots were also sown with a mixture of subtropical grasses. The experiment was a randomised complete block design with four replicates. The four treatments were:

1. Tropical grasses without any sown legume (control). Herein referred to as grass-N (T1).
2. Tropical grasses top dressed annually at the start of the growing season (early summer) with 100 kg/ha urea (46 kg N/ha). Herein referred to as grass+N (T2).
3. Tropical grasses sown with desmanthus (*Desmanthus virgatus*) cv. Marc. Herein referred to as grass+Marc (T3).
4. Tropical grasses sown with desmanthus cv. Progardes. Herein referred to as grass+Progardes (T4).

On 22 November 2014, desmanthus was inoculated and sown at 2 kg/ha and the grasses were sown at 3 kg/ha (coated seed) using the same disc seeder used to sow the temperate legume experiment. The seed were sown at 10 mm depth into plots with dimensions 12 x 320 m (total experimental area was 144m x 320 m). The grass mix consisted of digit grass cv. Premier (60% by weight), panic (*Megathyrsus maximus*) cv. Gatton and Rhodes grass cv. Katambora (10%). Mono-ammonium phosphate and pelletised Calciprill® lime were also applied at 70 and 150 kg/ha at sowing.

Soils (0-10 cm and 0-60 cm) were collected in October 2014 for analysis (Table 1). A second soil sample (0-10 cm) was tested in September 2015. MCPA (750 g/L a.i. at 300 ml / ha) was applied 3 days after sowing to control a mixture of broadleaf weeds but primarily caltrop (*Tribulus terrestris*) and seedling heliotrope (*Heliotropium* sp.) and aid establishment. Single superphosphate was applied at 100 kg/ha on 30 October 2015. The paddock was lightly grazed for a 2 weeks in late June 2015 with sheep at 1.6 sheep/ha. The experiment was inspected in spring 2015 and only a couple of plants of desmanthus were found. The experiment was closed in mid-December.

3.2.2 Assessments

Due to the size of the plots, assessments were restricted to a designated 50 m length of each plot, 20 m from the end of the expereimtn.

Seedling establishment

On 29 February 2015, the number of subtropical grass and desmanthus seedlings were recorded in ten quadrats (0.2 x 0.8 m) per plot and converted to plants/m^2.

Dry matter production

On 20 May 2015, herbage mass was assessed. In each plot, ten quadrats (0.5 x 0.5 m) were randomly placed on the ground at twenty step intervals. In each quadrat botanical composition was assessed, with a percentage (%) of total botanical composition being allocated to one of four groups: subtropical grasses, other grasses, desmanthus and broadleaf weeds, with the total being 100%. A herbage mass rating of 0 to 5 was also assigned to each quadrat, where 0 was bare ground and 5 was maximum herbage. Calibration cuts were taken as representatives of each herbage mass rating score, but there were insufficiant samples to develop a suitable calibration to convert the ratings to kg DM/ha.

3.2.3 Statistical analyses

The data were tested for normality and transformed when necessary. Where there were significant treatments or interactions, pairwise comparisons were conducted using least significant difference (P = 0.05). All analyses were conducted using ASREML 4.1.

Seedling establishment

Seedling densities were analysed using a linear mixed model with pasture treatment x component as the fixed term and replicate as the random term.

Dry matter production

Each component that had values greater than zero were analysed, that is, subtropical grasses, broadleaf weeds, and other summer-growing grasses. Each component was analysed independently using a linear mixed model with pasture treatment x component as the fixed term and replicate as the random term. Principal components analysis was also conducted for the three components and herbage mass score.

4 Results

4.1 Rainfall

Rainfall was average or above average 4 of 5 months prior to sowing the temperate legumes in 2014 then below average for the following 6 consecutive months (Figure 1). A total of 610 mm was received; 15% above the long term average but this total is not reflective of the relatively poor growing conditions for the newly sown temperate legumes at Cooks Myalls.

During 2015 rainfall was 67 mm (13%) below average, with monthly rainfall total below average for 9 months of the year. A dry period through January to March was detrimental to the establishment of both subtropical legumes and grasses at Thuruna and hampered establishment of subtropical grasses at Cooks Myalls. By contrast, during 2016 rainfall was about 250 mm (almost 50%) above average with monthly rainfall being average of higher 11 months of the year. Despite this January and February rainfall in 2017 was again very low and growth of subtropical grass species was again severely limited.

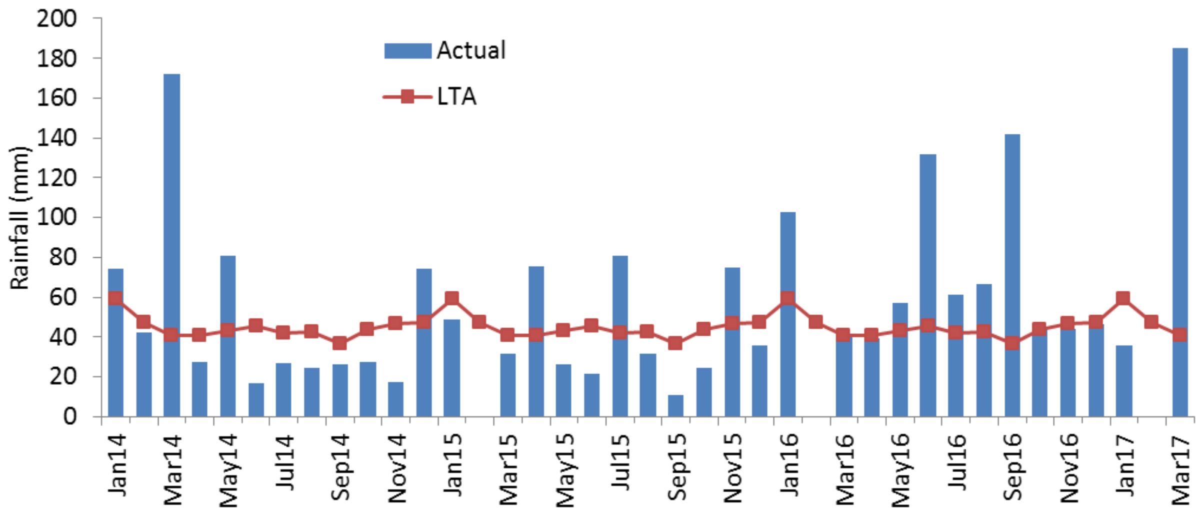

Figure 1. Actual and long term average (LTA) monthly rainfall at 'Cooks Myall', Parkes. LTA data are from BOM site 50016 (1882-2017).

4.2 Temperate annual legumes

4.2.1 Seedling Establishment

Tropical grasses established in all plots with an average density of 34 plants/m^2. There were no significant differences between the four treatments ($P > 0.05$).

In the establishment year, mean total seedling densities of the temperate legumes for T3 (41 plants/m^2) and T4 (49 plants/m^2) were similar ($P > 0.05$) (Figure 2c). Within T3, gland clover had the highest plant density (23 plants/m^2) while the other species ranged 2 (balansa clover) to 6 plants/m^2 (biserrula) (Figure 2a). In T4, Persian clover and bladder had the highest seedling density (12 plants/m^2) with subterranean clover and arrowleaf clover both having similar densities (10 plants/m^2). Snail medic had the lowest establishment density (6 plants/m^2) (Figure 2b).

In 2015, the legume treatments (T3 and T4) had higher seedling densities than the other treatments (T1 and T2). Subterranean clover in both legume treatments had higher regenerating seedling densities than the other legumes and their total density increased each year of the experiment (Figure 2a,b). In contrast, gland clover (in T3) and bladder clover (in T4) increased slightly with 38 and 44 plants/m^2 respectively, in 2016. All other legumes had less than 15 plants/m^2.

Total legume density in the two legume treatments increased each year of the study; from an average of 45 plants/m^2 in the establishment year to about 500 plants/m^2 in 2017 (Figure 2c). Subterranean clover ultimately comprised the largest proportion of the seedlings in both legume treatments. Legume densities were also recorded in the non-legume treatment plots (i.e. grass-N and grass+N plots) in 2015 and 2017, with an average of 23 plants/m^2 in 2015 and 101 plants/m^2 in 2017 (Figure 2c). There were significantly fewer legumes in the non-legume treatment plots.

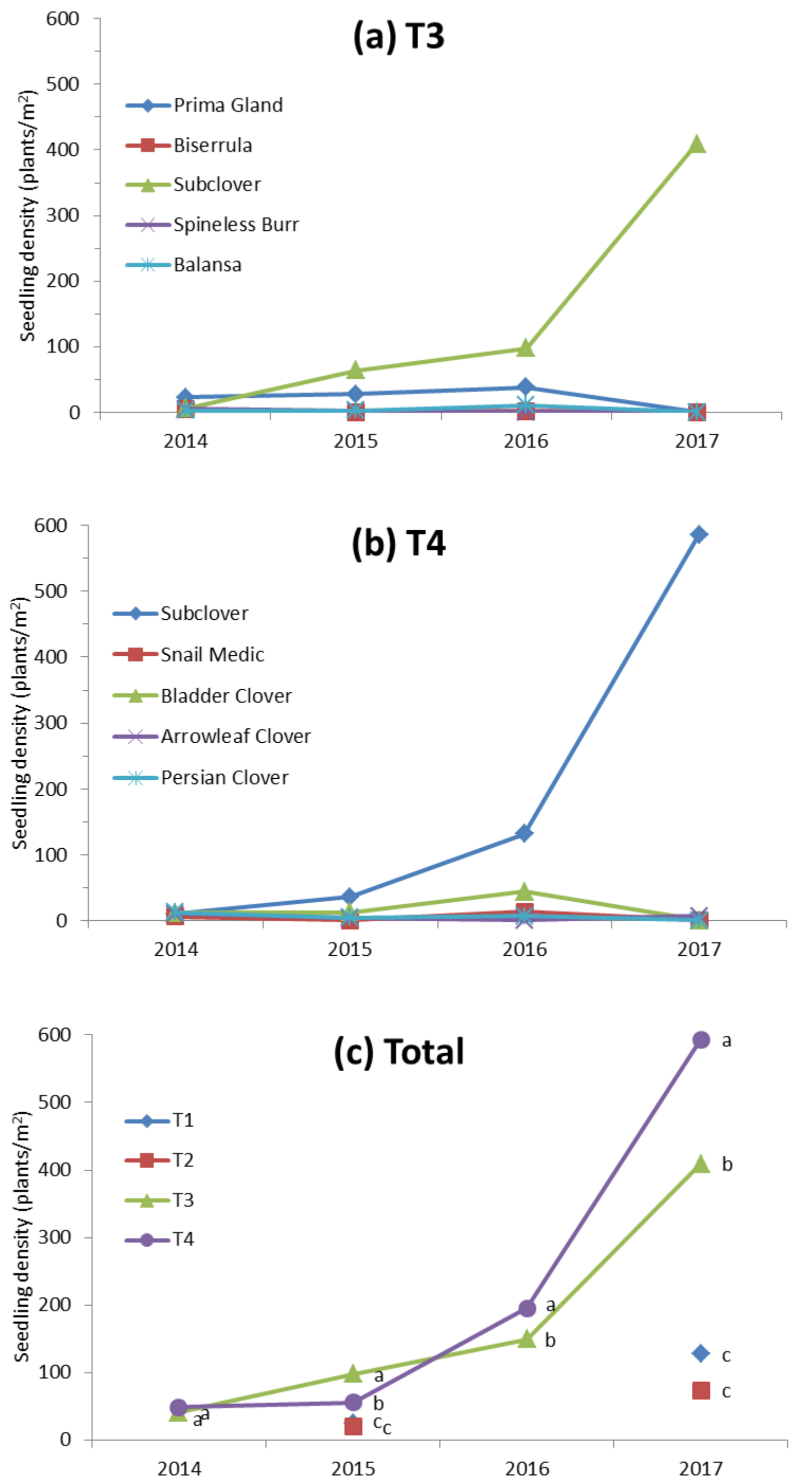

Figure 2. Seedling densities for individual species in (a) T3 and ((b) T4, also (c) total legume density for 2014-2017.

4.2.2 Dry matter production

Herbage mass was assessed by botanal 3 times over a 12 month period during 2016-7; in May 2016 (end of the summer growing season), September (spring) and January 2017 (early summer). Indicative quadrat cuts were also conducted in July 2016 as a guide to the amount of herbage being produced.

In May, the legumes had not regenerated sufficiently to cut and the vast majority (about 90%) of the herbage assessed was subtropical grasses (Figure 3a). The grass+legume1 (T3), grass+N (T2) and grass-N (T1) treatments had the highest herbage mass (4500 kg DM/ha). Subtropical grasses in the grass+legume2 (T4) treatment had slightly lower herbage mass, but were not statistically different to the grass-N treatment. Dead herbage mass was less than 300 kg DM/ha (Figure 3a).

In July 2016, quadrat cuts indicated that herbage mass ranged from 1000 kg DM/ha in the grass-N (T1) treatment plots to 2300 kg DM/ha in grass+legume2 (T4). The majority of the herbage in the grass-N and grass+N (T1 and T2) plots were winter growing annual grasses and broadleaf weeds, while the majority of the herbage (estimated to be at least 60%) was temperate annual legumes in the two sown legume treatments (T3 and T4) (data not shown).

In September, near the end of the legume growing season, the temperate legumes in the grass+legume2 (T4) treatment had the highest herbage mass (2912 kg DM/ha, $P < 0.05$) (Figure 3a). Legumes in the grass+legume1 (T3) were ranked second with 2075 kg DM/ha and had similar herbage mass as the other components in the T3 and grass+N (T2) treatment plots. The background temperate legume recorded in both the grass-N (T1) and grass+N (T2) treatment plots was significantly less than the sown legumes (T3 and T4). There was no green subtropical grass as growth was just commencing after being frosted over winter (Figure 3a).

In January 2017, the residual dead herbage mass was 2500-3000 kg DM/ha following excellent legume and annual grass growth during the previous winter-spring (Figure 3a). Subtropical grass growth was significantly less in the grass+legume2 (T4) treatment than the grass-N treatment (T1) but similar to the grass+N (T2) and grass+legume1 (T3) treatments. (Figure 3a). This reflected observations of slower growth of the subtropical grass in the legume plots possibly due to shading from the legumes.

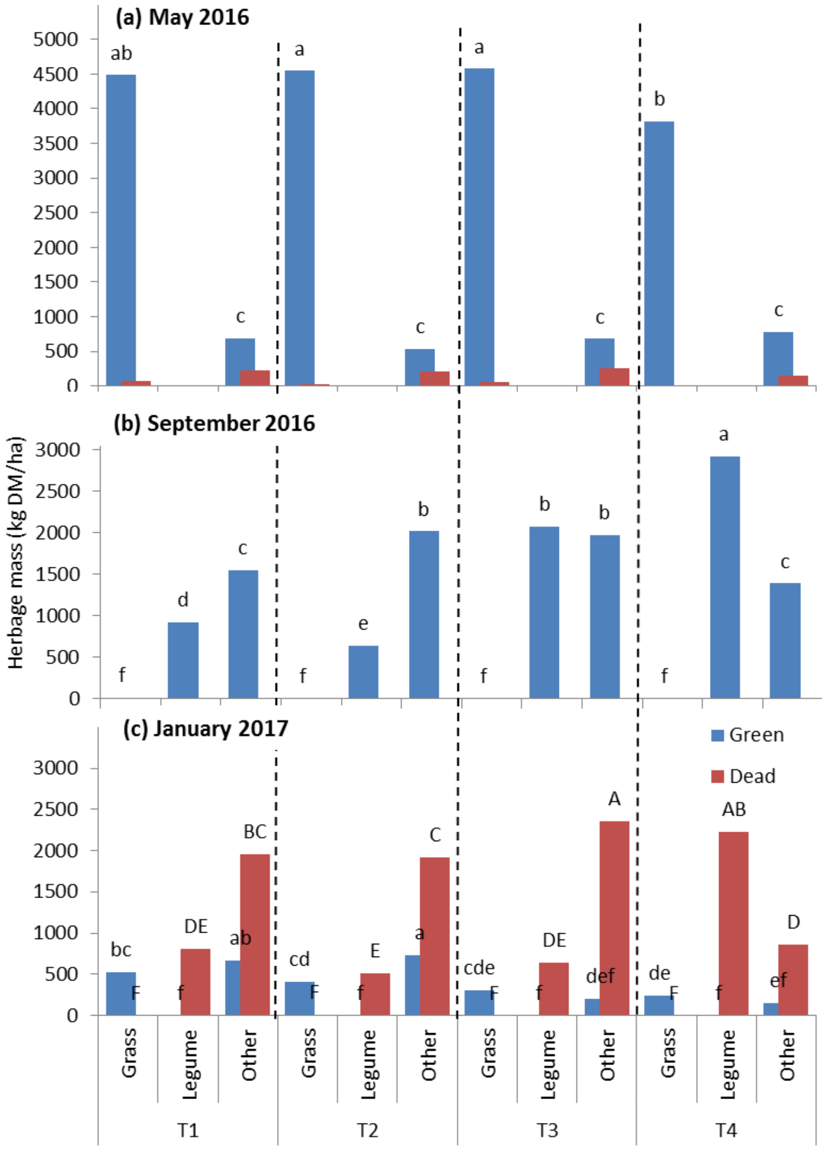

Figure 3. Green and dead herbage mass (kg DM/ha) in (a) May 2016, (b) September 2016 and (c) January 2017 for sown subtropical grasses (Grass), Temperate annual legume (Legume) and other grasses and broad leaf weeds (Other). The treatments are: grass-N (T1), grass+N (T2), grass+legume1 (T3) and grass+legume2 (T4). At each assessment, bars with the same letter and case (i.e. upper or lower) were not significantly different (P = 0.05). Note that Legume in T1 and T2 are background not sown legumes.

4.2.3 Nutritive value

There were no significant differences in any of the nutritive value components assessed in January 2016. This may have been due to the deteriorated state of the samples when they arrived at the laboratory (Table 2).

For the March 2017 sampling the subtropical grasses in the grass+legume2 (T4) and grass+N plots had the highest crude protein content (19-20%, $P < 0.05$). The grasses in the grass-N treatment had the lowest crude protein content (17.8%), but was only significantly lower than the grass+legume2 (T4) (Table 2).

There were no significant treatment differences in metabolisable energy for either sampling date although in line with crude protein measures the grass+N (T2) and grass+legume2 (T4) treatments were highest in absolute terms at the March 2017 sampling.

Table 2. Crude protein (%), metabolisable energy (ME, MJ/kg DM), acid detergent fibre (ADF, %) and neutral detergent fibre (NDF, %) of subtropical grasses in the four treatments. Letters with the same letter are not significantly different (P = 0.05).

	Treatment	Crude protein (%)	ME (MJ/kg DM)	ADF (%)	NDF (%)
		January 2016			
T1	Grass-N	16.4	7.9	35.5	67.4
T2	Grass+N	17.4	8.1	36.1	66.3
T3	Grass+legume1	17.1	8.2	35.1	66.0
T4	Grass+legume2	17.0	8.1	35.7	66.1
		NS[1]	NS	NS	NS
		March 2017			
T1	Grass-N	17.8 b	8.9	28.0	59.0
T2	Grass+N	19.0 ab	9.2	26.5	57.5
T3	Grass+legume1	17.9 b	8.9	27.0	58.0
T4	Grass+legume2	20.1 a	9.5	25.5	55.8
		Sig[2]	NS	NS	NS

[1]NS = not significant, [2]Sig = significant (P = 0.05)

4.3 Desmanthus

4.3.1 Seedling establishment

Three months after sowing, the subtropical grasses had established well with plant densities ranging 38 (grass+Progardes) to 44 plants/m^2 (grass-N and grass+N) across the four treatments (P < 0.05). Desmanthus had poor establishment averaging 1 plant/m^2 (P < 0.05). This was disappointing because while there were few seedlings of Marc desmanthus, there were large numbers of Progardes desmanthus observed when the experiment was inspected in mid-December. However these failed to establish over the summer period before they were counted in late-February.

4.3.2 Dry matter production

The four treatments had similar total herbage mass in May 2015 (P > 0.05), however the proportion of herbage mass comprising of sown subtropical grass, other grasses and broad leaf weeds was significant as was the principal components analysis (P < 0.05) which accounted for 78% of the variability in the data. The biplot diagram showing the projection of these data on a 2-dimensional plane created from the first and second principal components is shown in Figure 4. Nitrogen had not been applied to the grass+N (T2) treatment and desmanthus had died during the previous summer (T3 and T4), however it is interesting to note that as herbage mass of the subtropical grasses increased, the herbage mass of the other grasses decreased (vectors pointed in opposite directions are inversely correlated), highlighting the competitive effect of sown subtropical grasses (Figure 4). Herbage mass of the broadleaf weeds was not correlated with either of the grasses (vectors are almost perpendicular) but was inversely related to herbage mass score indicating that regardless of grass composition higher herbage mass leads to lower broadleaf weeds.

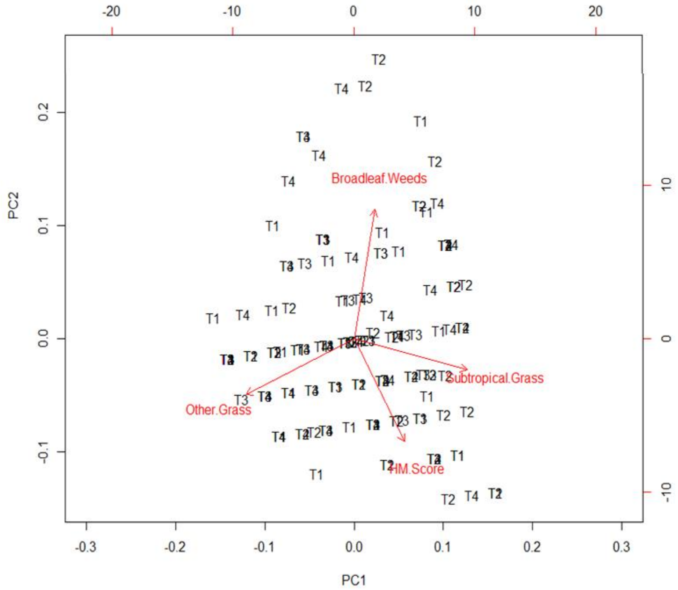

Figure 4. Biplot diagram showing the projection of these data on a 2-dimensional plane created from the first and second principal components. T1, subtropical grasses-N; T2, subtropical grasses+N; T3, subtropical grasses+legume1; and T4, subtropical grasses+legume2.

4.4 Extension and communication

Date	Activity	Number of people
February 2016	Newspaper articles in the Parkes Champion Post about trial and radio advertisements for an upcoming field day were broadcast	
13 March 2016	Tropical grass field day	Called off due to very poor growing conditions at time
13 March 2016	An alternate Tropical grass farm walk activity was organised at short notice due to interest from local stock agents, agronomists and other professionals. Livestock agents and agronomists from 3 supply stored from Forbes and Parkes inspected the trial plots as well as producers from neighbouring farm.	19 in attendance.
17 September 2016	Temperate legume field day was held at 'Cooks experiment. Dr Belinda Hackney, Local Lands Service was a guest speaker. *The field day was advertised on local radio and the field day flier circulated through local/regional stock agents and supply stores* as well as registering the event with Sheep	Strong support attended by 40+ people, some travelling up to 100 km away

	Connect.	
March 2017	A sub tropical grass field day was organised and advertised	Again called off due to very poor growing but there will be an excellent opportunity for the group to host a subtropical grass field day early in 2018 after excellent early summer rain at the end of 2017.

4.5 Participant reactions

Participants were disappointed that the experiment did not show additional grass production due to addition of legumes to their subtropical grass based pastures compared to addition of urea, however the dry seasons, acid soils (poor legeume nodulation therefore minimal N fixation) and low subtropical grass plant densities hindered any response. Despite this, a lot was learnt about establishing companion species and other positives resulted within the overall 12 month production sytem by having legumes present. The shading effect and depletion of the moisture profile by having the legume component present could be viewed as negative impacts of this production system but need to be weighed against the significant increase in dry matter production and forage quality over winter. The relative value of these opposing effects will depend on the individual farm system and the relative value of winter and summer forage in that system. This experiment has highlighted that while the region has an almost even rainfall distribution, rainfall is actually highly variable, month to month and year to year. This variability has significant consequences for production of both temperate and subtropical pasture species and therefore livestock production. One advantage of subtropical grass-temperate legeume mixes though is that they maintain high ground cover year round, and there are species which can repsond to rainfall an any time of the year providing quality forage for livestock production.

Disc seeders were used to sow into the first established species and those participating in the trail view that as best practice when dealing with heavy residues.

Producers agreed that if the season appeared favourable going forward, topdressing with urea was the best option for providing nitrogen to their grasses and provided flexibility to make informed management decisions on the go.

Due to seasonal trends in the Parkes district where summer rainfall can be marginal participants argreed it was a good risk management tool to plant winter growing legumes in their subtropical grass pastures an ensure high levels of production over winter and spring.

Participants felt that in marginal years this may inhibit grass production by depleting stored soil moisture levels and this does require consideration when considering this system.

Summer growing legumes such as desmanthus would allow stored soil moisture levels to be built up over the dormancy period, however more work needs to be conducted to determine the species adaptation to the area (e.g. frost tolerance and persistence). Sowing in a greater range of soil types (in particular alkaline soils) also needs to be tried.

Participants noted there is a lack of broadleaf weed control options available for treating areas sown with desmanthus. This could prove to be a major limitation in successfully establishing the species as there is typically a large burden of vigorous broadleaf weeds which germinate on rain events in late sping and over summer, at the same time as the less vigourous desmanthus seedlings emerge. Placing emphasis on paddock selection and history may aid the chances of success. Planting the desmanthus as a stand alone pasture the year prior to seeding the subtropical grass pasture may also be worth considering.

4.6 Producer Research Site Program

Cook Myalls Landcare Group elected to do whole paddock trial areas. The group wanted to simulate commercial conditions as closely as possible. Grazing with stock was also done at strategic times throughout the trial to further simulate the challenge real world conditions.

Replications were whole airseeder widths for ease of setup and also to utilise participants existing equipment.

A big range of temeperate annual legumes with had the added effect of demonstrating the ability of each species to regenerate and persist over the course of the trial

5 Discussion

5.1 Temperate annual legumes

Seedling density of subterranean clover increased year on year throughout the experiment, while the majority of the other legumes tended to decrease. This reinforces the choice of subterranean clover as a species adapted to this environment. Gland and Balansa clover also increased during the study suggesting they are species worthy of considering in a seed mix. The main differences between the two subterranean clover cultivars in this study are their subspecies and maturity. Cultivar Losa belongs to the subspecies *subterraneum* and is an early season type with black seeds and high hard seed levels. Cultivar Mintaro is a mid-season *brachycalycinum* cultivar with moderately hard seed levels and cream-coloured seed.

Each legume treatment in this study contained five legumes. Generally the advantage of sowing a variety of legumes is they find their niche within a paddock and have different growth characteristics alloowing different species to produce more in different yearsleading to reasonable legume growth in most years. The challenge though, especially with aerial seeded types, is choosing species or cultivars that have growth patterns that are somewhat complimentary to maximise utilisation and simplify management. For example, a legume mix that included spineless burr medic and arrowleaf clover could result in destocking for many months because the burr medic flowers early (August) while arrowleaf clover flowers late (November), sometimes not senescing until December if the season is suitable.

Consolidating herbage production data into a 12 month feed year shows the effect of the three contrasting treatments that address the project objective to determine the value of adding legumes to increase subtropical pasture growth, total biomass and feed quality compared with nitrogen fertiliser: unfertilised subtropical grass (grass-N; T1), fertilised subtropical grass (grass+N; T2) and subtropical grass with temperate annual legumes (in this example grass+legume2; T4) (Figure 5).

Late summer subtropical grass production was similar for all treatments in 2016 suggesting that neither the application of N nor the fixation of N by legumes was able to increase summer grass production beyond the base unfertilised treatment. For applied N to be effective timing of application can be critical and the dry summer of 2015-16 probably did not give the grasses the best opportunity to respond to applied urea.

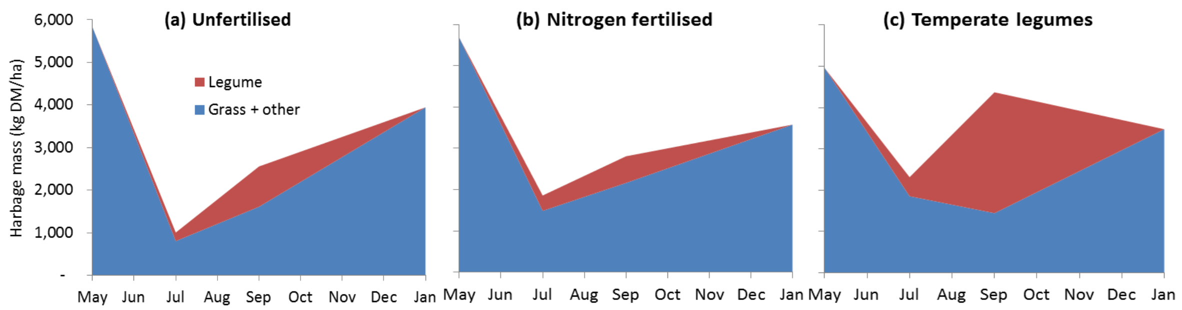

Figure 5. Comparison of annual distribution of feed provided by a subtropical grass pasture that is (a) un-fertilised, (b) fertilised with nitrogen and (c) grown with temperate annual legumes. Grass + other represents subtropical grasses with other grass and broad leaf weeds and Legume is either background (for example, burr medic) or sown legume.

N fixation from the sown legumes was also questionable. Observations of nodulation score and the condition of nodules by Dr Belinda Hackney at the field day held in September 2016 suggested that rhyzobium were not operating efficiently and the fixation of large amounts of N was unlikely. Unfortunately this can lead to legumes being net users of soil N rather than contributors which might also explain further the lack of any biomass differences between the grass+legume treatments and the grass-N treatment at Cooks Myalls

Winter production was however significantly enhanced on the grass+legume treatments compared with the treatments where only subtropical grasses were sown.. The naturalised legumes that commonly exist in pastures include a range of medics, such as burr medic (*M. polymorpha*) along with naturalised strains of subterranean clover. While these legumes make a contribution to winter-spring production, when new varieties of well adapted temperate annual legumes are sown the potential cool season growth is significantly greater. One consequence can be that during years with good legume growth the subtropical grasses can be shaded and late spring soil moisture can be low resulting in slow spring recovery and t reduced early summer production from the subtropical grasses.

Considerations:

(a) Autumn rainfall is required for the legumes to regenerate. If poor autumn rainfall is received legume production will be minimal resulting in less winter production for livestock and less N produced for subtropical grass production. In the Parkes area rainfall can be highly variable, but long term it is almost evenly distributed throughout the year meaning that temperate legumes are likely to make a positive contribution in most years.
(b) Legumes must be inoculated with the correct rhizobia and growing in soil conditions conducive to the legume / rhizobia symbiosis.. A recent survey (Hackney *et al.* 2017) showed that less than 10% of pasture paddocks in the Central West of NSW are effectively nodulated with the key factors affecting nodulation including soil pH, nutrient availability and in some cases the use of residual herbicides. Dr Hackney dug up some plants while attending a field day at the experimental site and noted that the legumes were not well nodulated. This could be due to limited live rhizobia on the pre-inoculated coated seed that was sown. The soil pH in $CaCl_2$ at this site was 4.9 which Dr Hackney observed was low for best nodulation. Drew et al (2014) suggests this pH would be to low for effective nodulation in naturalised medics and suboptimal for the performance of Rhizobia strains adapted to clovers.
(c) A consequence of winters suitable for good legume growth is the legumes can shade the subtropical grasses resulting in slow spring recovery and therefore reduced early summer production.

5.2 Desmanthus

Establishment of the two Desmanthus varieties sown at Thuruna was too poor to enable the testing of their effectiveness in fixing nitrogen for improved subtropical grass production.

A number of factors may have contributed to this result:

1. A herbicide application of MCPA 750 was applied at 300mL/ha for the control of broadleaf weeds when the desmanthus was at a size of 10-15cm. Plant damage was noted following this spray, with the desmanthus plants burnt back, however regeneration was observed. At the time of establishment counts, the largest desmanthus seedlings were 5cm in height, suggesting hindrance as a result of the herbicide application.
2. The high density of grasses established may have out competed the desmanthus
3. Shortly after sowing in November the trial paddock received a very heavy rain event with 76 mm falling in one shower. The paddock washed heavily, which may have affected the germination of the small seeded desmanthus.
4. The low establishment rates of the Marc desmanthus may be attributed to a low sowing rate of germinable seed. Germination tests on the Marc desmanthus confirmed that the germination was 17% with 67% hard seed. As the sowing rate was 4 kg/ha this works out to be only 0.68 kg/ha of germinable seed. This may also explain the low number of plants

The biggest site issue was low pH and aluminium. The soil with pH ($CaCl_2$) was 4.6 with an aluminium saturation of 4.6%; higher than the optimal levels for legume growth and may limit performance and nitrogen fixation.

Further plot scale research into growing desmanthus in pure swards might provide clearer insight into its adaptation to the region and potential for use in mixed pasture swards and contribution to nitrogen efficiency.

5.3 Outcomes in achieving objectives

5.3.1 Impact of growing temperate and subtropical legumes with subtropical grasses on feed quality

Notwithstanding issues with sample degradation in 2016 there was little evidence that the addition of legumes or the use of applied urea made any difference to the digestibility of the subtropical grass component of the treatments as compared with the control with no sown legumes or applied urea.

Crude protein levels at the March 2017 sampling demonstrate a small but significant impact on protein level in favour of the grass+legume2 and grass+N treatments compared with the grass-N treatment. Despite this the crude protein of all treatments was sufficient to ensure that performance was limited primarily by digestibility and any differences in crude protein level would not yield an improvement in animal performance when grazing the subtropical grass over the summer.

The failure of either the desmanthus subtropical legume cultivars to establish at Thuruna precluded the evaluation of their potential impact on feed quality in subtropical grass pastures. As resowing was not a viable option this objective was abandoned and the PRS contract varied to reflect this in 2016.

1.3.2 The value of growing temperate and subtropical legumes for increasing subtropical pasture growth

Neither the application of urea fertiliser nor the addition of new temperate legumes led to an increase in the production of subtropical grass biomass in either 2016 or 2017 compared to the grass only treatment. This result is most likely due to the less than ideal growing conditions over both summers of the trial. Early summer soil moisture levels were not at a level that would trigger application of Urea as a commercial decision so it is not surprising that the treatments showed no significant response in summer/autumn pasture growth. These conditions would have equally hampered the potential response to any nitrogen fixed by the temperate legumes. Total annual biomass was however enhanced in the grass+legume treatment due to the significant increase in the production of high quality herbage over winter. This increased winter production potentially came at the expense of early summer grass growth due to shading and competition for soil moisture.

The failure of desmanthus at Thuruna made evaluation of its impact on pasture growth impossible.

5.4 The value of the research results (Benefits/Costs)

While there was no significant difference in summer pasture growth resulting from the applied urea the seasonal conditions were not conducive to achiving a significant response to applied N. There is considerable cost in purchasing and spreading urea and while not in the scope of the project it is the experience of local producers thatit would be economically favourable to provide extra nitrogen given more favourable season conditions.

While annual temperate legumes also did not notably increase hebage mass relative to the grass only treatment the legume treatments were also not significantly different to the urea treatment suggesting that seasonal conditions were overriding potential responses in summer/autumn pasture growth. Despite this there are a range of noted benefits to producers. The legumes grow at times when the subtropical grasses are frosted and not growing. This means there is potential for year round green feed in a producer's paddock.

Ground cover is also maintained year round providing great environmental outcomes. Legumes are high quality forage meaning overall year round livestock productivity may well be increased, despite not lifing the productivity of the grass component.

While the legumes coupled with grasses could provide producers with a highly productive well balanced mix there are some drawbacks. The shading effect of legume residue and competition for soil moisture in late spring may inhibit the early growth of grasses as noted in the results.

Overall the project has shown:

1. Sub clover is a highly adapted legume in Parkes district
2. Addition of Legumes in sub tropical pasture gives the potential for pasture growth across more months of the year
3. Rainfall is highly variable and while temperate legumes don't make a huge contribution in all years –when they do grow they make a large contribution.
4. It is important to check Rhizobium nodulation to ensure legumes are fixing N to ensure producers gaining the full benefit from their investment.
5. In the years of the trial there was no additional benefit to adding N over legumes. In fact there was only limited evidence of beneft to summer grass growth of either compared with a grass only treatment. Although poor nodultation, therefore limited N fixation is likely to have occurred, so comparison is difficult and the seasons in whicht this experiment was conducted were challenging (mostly dry). To see benefit from additional N (bag N or fixed by a legume) you need rainfall

5.5 Promotion of research results and its effectiveness

A large group of district farmers attended the spring field day in 2016. Mixed farmers showed a lot of interest in the work being carried out and were keen to see how their operations could benefit from what was being learned. Many producers felt the use of urea was a good option as they had the flexibility to apply at a time they felt the seasonal conditions were in their favour to ensure increased production could be achieved.

A lot of attendees were keen to plant an annual temperate legume species with their subtropical grasses despite no big jump in grass herbage mass. Having year round green feed was appealing to producers and having high quality green legume mixed with the dry grass residues over winter increases the productivity of a paddock.

While it was surprising to find there was minimal nodulation in the legumes on Cooks Myalls, despite a near perfect preparation with an extrememly light history of chemical usage, producers were happy to learn there were ways to rectify the situation by new ways of introducing rhizobia. Major opportunities related to management of soil pH and to use of fresh inoculum rather than pre inoculated seed.

Through work conducted previously and in this project, the group were able to advise attendees as to the best way to prepare a paddock for establishing grasses and also establishing legumes in a subtropical grass pasture. Presowing temperate legumes gave excellent results with populations of subterrananean clover in particular increasing over the three years of the experiment. Many successful pasture sowings have occured across the district as a result of this work.

5.6 Effectiveness of the participatory research process

Local producers were excited to see large plot research being carried out in their area, in their conditions, using commercial equipment rather than reading data relating to small trial plots in a different part of the country in a different environment.

Producers enjoyed the opportunity to attempt something not seen as a traditional practice and try species not grown in the district before.

Due the commercial scale of the project areas producers were able to more easily see how the ideas could be more broadly implemented and managed.

Producers gained a lot from being able to network both within the Cooks Myalls group and a broader cross section of district producers at their field days. Lots of fresh ideas were generated for ways to build upon this area of research.

The group has gained a lot of valuable knowledge from being able to work with researchers in the field just as researchers have gained commercial knowledge of how farms in the district are run and managed.

The group would still like to look at possible summer growing legumes however smaller scale trials may be better to establish their adaptability and ability to regenerate in the district.

6 Conclusions/ Key Messages /Recommendations

The temperate legume findings from the project are extremely relevant to all members of the group as the work was carried out under conditions and using management practices considered commonplace in the district.

While the addition of legumes did not increase subtropical grass herbage mass production, the group did identify a wide array of other positive production outcomes.

The group felt that should a producer have a favourable start to the grass growing season with favourable weather forecasts going forward urea was still a good option to provide extra nitrogen to their pastures even though the weather experienced and the final plant population of the subtropical grasses in the trial plots was not conducive to increasing production using urea during the trial period

While the urea treatments didn't perform at a higher level in the trial applications were made regardless of moisture availability and apart from the initial year, an above average wet summer was not encountered during the trial to enable peak production.

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