Poster papers
Investigating the impact of cover cropping on a native pasture system in southern Queensland

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Abstract: Initial data showed that cover cropping with barley increased (\(P < 0.05\)) peak standing dry matter in a summer-active native perennial grass-based pasture, which had high ground cover, despite little rain and low soil moisture. Ground cover (%) increased (\(P < 0.05\)) under cover cropping with the addition of nitrogen, particularly where initial ground cover values were low. Further measurements of stored soil water, total herbage mass and ground cover over the 2011 season will enhance our understanding of the potential for cover cropping in south-east Queensland cropping belt.

Key words: pastures cropping, ground cover, dry matter

Introduction

Growing cereals in northern New South Wales and south-east Queensland generally involves annual winter cropping preceded by a period of fallow (Hayman and Alston 1999; Marley and Littler 1989). The soils cropped in these areas are clays with a relatively high water-holding capacity and are often associated with brigalow (\textit{Acacia harpophylla}) vegetation (Freebairn et al. 2009). Soil fertility in the region has decreased due to a reduction in the levels of soil organic carbon and total nitrogen (N) as a direct result of soil erosion and continuous cropping (Marcellos and Felton 1992). Cover cropping (i.e. direct drilling a winter annual cereal crop into a living native perennial grass-based pasture exploiting the differential growth patterns of the crop and the pasture while minimising damage to the pasture itself), which has been gaining popularity and interest among farmers throughout eastern Australia (Waters et al. 2008), may be a way of confronting the shortfalls for annual cropping and fallows by producing more biomass and providing year-round ground cover, intercepting more light for photosynthesis and providing less opportunity for weed germination and soil erosion (Bruce and Seis 2005). To explore the potential of cover cropping in south-east Queensland we investigated the impact of cover cropping on total plant dry matter of a native pasture system.

Methods

An experimental site was established on a summer-active native perennial grass-based pasture (dominated by \textit{Bothriochloa macra} and \textit{Dicanthium sericeum}) at “Biribindibil” (28° 24’42” S, 140° 50’1”E), Toobeah, about 50 km west of Goondiwindi, Queensland in 2009. The site consisted of two side-by-side paddocks, one with low ground cover (<40%) and the other with high ground cover (>70%). Four replicates of four treatments were randomly allocated to plots (4 x 20 m) in each paddock. Treatments (native pasture, tilled native pasture, native pasture cover cropped with barley (\textit{Hordeum vulgare} cv. Grout) and native pasture cover cropped with barley plus N), commenced on 24 June 2009. Nitrogen (50 kg N/ha) was applied as urea by surface spreading at the time of planting, targeting both crop and pasture in the native pasture cover cropped with barley+N treatment, commenced on 24 June 2009. Nitrogen (50 kg N/ha) was applied as urea by surface spreading at the time of planting, targeting both crop and pasture in the native pasture cover cropped with barley+N treatment. A custom-built tilco tyne planter with press wheels was used for sowing the barley using four tynes on a 25 cm row-spacing. The tilled native pasture treatment was applied by using two passes of the planter without press wheels. Peak standing dry matter (kg DM/ha) was assessed by harvesting total (native pasture+barley) plant dry matter from a single quadrat [1 x 1 m] per plot on 30 March 2010. Treatments were not grazed by livestock, but native animals were not excluded.

Results and discussion

In the first season of the study, rainfall was below average and stored soil moisture was low
(<200 mm) resulting in a poor stand of barley. However, total plant dry matter was significantly greater ($P < 0.05$) for treatments in the high ground cover paddock compared with low ground cover paddock (Table 1). For treatments in the high cover paddock, sowing barley or sowing plus added N significantly increased ($P < 0.05$) total plant dry matter by 56% compared with native pasture alone (Table 1). While the tilled native pasture had indications of more dry matter compared with the native pasture for both low and high ground cover situations, the differences were not statistically significant.

Cover cropping with barley plus the addition of N almost doubled ground cover (from 50 to 80%) when compared with the other treatments (Table 1). With low rainfall, soil moisture was limited and so the barley crops did not progress through to the harvestable grain stage. Where ground cover was already high (>70%), the benefit of additional herbage mass generated by cover cropping was minimal, particularly considering the expense associated with generating the higher herbage mass.

In winter, the summer-active native perennial grasses were frosted or dormant, reducing the amount of ground cover in both the high and low ground cover paddocks. Summer-active species respond to seasonal rains in spring and summer, increasing ground cover. The addition of N not only improved growth of the sown barley, but appeared to bolster growth of the native species. To determine the exact role of barley in the ground cover response would require the inclusion of another treatment of native pasture with N applied.

Measurements of stored soil water, total herbage mass (using a higher sample number within each plot) and ground cover over the 2011 season will further our understanding of the potential for cover cropping in the south-east Queensland cropping belt.

**Acknowledgments**

This study was possible thanks to the collaboration of Mr Alex Sullivan, "Biribindibil".

**References**

Bruce S, Seis C (2005) Lift ground cover and reduce drainage with pasture cropping. In 'Farming Ahead.' pp. 2.


**Table 1. Total plant dry matter (kg DM/ha) on 30 March 2010 and ground cover (%) on 7 October 2010 at “Biribindibil”. Values followed by the same letter in each column are not significantly different ($P > 0.05$).**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pasture</th>
<th>Dry matter (kg DM/ha)</th>
<th>Ground cover (%)</th>
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</thead>
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<tr>
<td>Native pasture</td>
<td></td>
<td>1820c</td>
<td>50bc</td>
</tr>
<tr>
<td>Tilled native pasture</td>
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<td>Lower cover</td>
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<td>Native pasture cover cropped with barley+50 kg N/ha</td>
<td></td>
<td>2160c</td>
<td>80a</td>
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<tr>
<td>Native pasture</td>
<td></td>
<td>2340c</td>
<td>60b</td>
</tr>
<tr>
<td>Tilled native pasture</td>
<td></td>
<td>3020ab</td>
<td>50bc</td>
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<tr>
<td>Native pasture cover cropped with barley</td>
<td>Higher cover</td>
<td>3550a</td>
<td>40bc</td>
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<td>3290a</td>
<td>80a</td>
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</table>
Managing tropical perennial grasses for livestock production – a case study
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Abstract: On Tom Bowmans property “Tarploy” near Barraba, 190 ha of tropical perennial grass pastures have been established over several years. Paddocks are divided into blocks of 10 to 15 ha using single wire electric fencing with watering points supplied to each paddock. When the tropical perennial grasses are actively growing (November–February) Tom tries to use a stocking density of about 250 animals/10 ha and moves stock to the next block every 3 to 5 days, allowing 15 days for the pasture to recover before the next grazing. Stock are generally moved when there is 1200 to 1500 kg DM/ha left in the paddock.

Key words: filling feed gaps, pasture quality, livestock growth rates

Introduction

There has been a widespread interest in tropical perennial grasses over the past 10 years and a rapid increase in the area sown. Estimates from commercial seed sales in New South Wales (NSW) indicate that over 250,000 ha have been sown in the last three years. This has greatly improved the pasture feedbase in northern inland NSW, providing increased options for producers over the warmer months of the year.

Tropical perennial grasses are drought tolerant and can produce up to 20 t/ha of dry matter (DM) in a growing season (Harris et al. 2010). These grasses also have a role in providing persistent perennial species in the landscape and year round high levels of ground cover if well managed. Tropical perennial grasses have high water use efficiencies compared with native perennial grasses. In trials in the Tamworth region, Premier digit grass (Digitaria eriantha) produced almost 30 kg DM/ha for each millimetre of water used (Harris et al. 2010).

Good soil nutrition is essential for tropical perennial grasses to achieve optimum growth and quality for animal production. Given adequate moisture these grasses are responsive to increased nitrogen (N) and as a rule of thumb, can produce an additional 100 kg DM/ha in the growing season for every kg/ha of N applied (Harris et al. 2010).

Tropical perennial grasses grow quickly and one of the biggest challenges is to maintain high feed quality. This can be achieved with both good plant nutrition and appropriate grazing management strategies. Plant nutrition can be improved by applications of fertiliser to raise soil phosphorus, sulfur and N to a productive level for tropical perennial grasses, and replace these nutrients (particularly N) when required. Well managed legumes can supply much of the N required by these grasses.

Effective grazing management should be planned to maintain pasture in the vegetative growth stage prior to stem elongation as pasture quality declines rapidly when stem elongation is initiated. When there is good soil moisture and fertility, and warm summer conditions, tropical perennial grasses have high growth rates and require regular grazing at high stocking densities to maintain the high quality, leafy pastures required for maximum livestock production.

Case Study – Tom Bowman, “Tarpoly”, Barraba

Producers are recognising the important role tropical perennial grasses have in filling gaps in the feedbase to increase production and sustainability. Tom Bowman is an excellent example of a producer who is using tropical perennial pastures to increase cattle production on the family property.

Tom said they have established 190 ha over several years with a mixture of Premier digit grass, Katambora Rhodes grass (Chloris gayana),
Bambatsi panic (*Panicum coloratum* var. *makarikariense*) and Gatton panic (*Megathyrsus maximus*). The pasture has been sown after at least 2 years of growing oats for winter fodder and controlling weeds throughout the crop and fallow periods. Tropical grasses are direct drilled in early to mid November, following the final oat crop, with adequate seed to establish 10 plants/m².

Paddocks are divided into blocks of 10 to 15 ha using single wire electric fencing with watering points supplied to each paddock. Tom realised that for maximum livestock production he needed small paddocks and high stocking rates to maintain the tropical grasses at the leafy growth stage –Phase II (Prograze Manual 2006) in periods of peak growth. During the warmer months when the tropical perennial grasses are actively growing (November–February) Tom tries to use a stocking density of about 250 animals to 10 ha and moves stock to the next block every 3 to 5 days, allowing 15 days for the pasture to recover before the next grazing. Stock are generally moved when there is 1200 to 1500 kg DM/ha left in the paddock and ideally placed into the new paddock before stem elongation commences (late Phase II).

Soil nutrition is maintained at a moderate to high level on “Tarpoly” and additional N is applied to increase pasture growth, and maintain protein levels, when required. Dry lick supplements have been used to maintain livestock weight gains if pasture quality deteriorated due to seed head initiation when insufficient cattle were available to maintain grasses at the leafy growth stage. Tropical grasses increase livestock production on “Tarpoly” by providing greatly increased quality fodder in the late spring/summer months. This increased fodder allows Tom to purchase trade steers in spring and fatten them during this period of rapid grass growth. He says it can be difficult to keep these grasses at the leafy growth stage as large stock numbers and strict rotational grazing are required. However, by maximising the energy and protein of his pasture, Tom has been able to achieve livestock growth rates of about 1.5 kg/ha/day. He gave an example of a mob of steers that increased from an average weight of 400 kg to 480 kg over 50 days of grazing perennial tropical grasses.

Another important addition these grasses provide to the feedbase on “Tarpoly” is filling the autumn feed gap for weaners. Tom stated that their native pastures only provide low quality fodder in autumn which is unsuitable for weaners. However, with well planned grazing, tropical grasses will provide suitable pastures through late summer/autumn, until oats are available for winter fodder.

**Acknowledgments**

The author thanks Tom Bowman for sharing the valuable information on tropical perennial grass management contained in this case study.

**References**

Benefits and uses of plantain (*Plantago lanceolata*) cv. Ceres Tonic in livestock production systems in New South Wales

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**Abstract:** This paper highlights some key attributes of plantain (*Plantago lanceolata*) as a forage species and outlines the generic benefits of plantain cv. Ceres Tonic. It explores four different ways of using Tonic plantain as a component of perennial pastures, as a companion with either summer-growing brassicas or lucerne and as a monoculture.

**Key words:** pasture mixes, medicinal herb, lactation feed

**Introduction**

Narrow-leaved plantain *Plantago lanceolata* has had a long history of use as a forage plant being sown in pasture mixes in the United Kingdom and Europe since the 1700s (Foster 1988). *Plantago lanceolata* is highly valued as a medicinal herb and is known to contain many biologically active-compounds.

As a grazing herb, the species was first introduced as proprietary cultivars into the Australasian seed industry via the AgResearch cv. Grassland Lancelot closely followed by the Agricom cv. Ceres Tonic in the mid to late 1990s. Since this time it has become an important addition to pasture mixes, and more recently has been used as a monoculture.

This paper highlights the generic benefits of Tonic plantain and explores four different ways plantain is being used commercially in livestock production systems.

**Key attributes**

Plantain has some key attributes as a forage species. These are;

1. Excellent dry matter production, particularly winter activity (Moorhead and Piggot 2009). In many environments, plantain produces similar amounts of forage to perennial ryegrass. A feature of plantain’s productivity is its rapid response to moisture in autumn.


3. Increased performance of sheep compared with ryegrass during lactation (Judson *et al.* 2009) and post-weaning (Moorhead *et al.* 2002).

4. Increased supply of trace elements to grazing livestock, resulting in increased liver concentrations of particularly copper, cobalt, and selenium (Moorhead *et al.* 2002).

5. Reduced impact of internal parasites. Ewes grazing Tonic plantain had significantly lower faecal egg concentrations than their counterparts grazing ryegrass (Judson *et al.* 2009).

**Ways of using plantain**

1. **Tonic as a component of a perennial pasture**

The initial use of Tonic plantain in Australia was as a companion species in pastures mixes. Although pastures benefited from the inclusion of Tonic, the need to spray many perennial pastures for weeds such as capeweed and thistle species, limited the area of adoption because many of the herbicides used were equally effective on plantain. As a companion species, Tonic plantain improves summer quality, autumn recovery and winter activity of perennial pastures.

2. **Tonic as a companion with a summer brassica**

Tonic has been widely used as spring-sown component of a brassica crop. Jacobs *et al.* (2006) reported that plantain (along with chicory) sown with summer forage brassica crops in the spring can increase forage production in the following autumn, and reduce weed ingress into newly sown pastures in their first year. The presence of...
plantain in a brassica crop can also mitigate, to some degree, animal health issues which can arise on brassica monocultures from time to time.

3. Tonic as a mono-culture

The experience gained in summer brassica crop mixes led to the evaluation of Tonic plantain as a monoculture. Initially, this work focussed on summer liveweight gain of weaned lambs. In these studies, Tonic plantain supported greater liveweight gain and a higher stocking rate than those grazing perennial ryegrass and also elevated liver copper and selenium concentrations (Moorhead et al. 2002). Although the liveweight gain potential of Tonic in summer is greater than ryegrass, it is generally less that of summer legumes, summer brassica and chicory.

More recently Judson et al. (2009) evaluated Tonic plantain as a lactation feed for twin-bearing ewes lambing in August. The winter and early spring activity of Tonic provided sufficient feed to support twin-bearing lactating ewes in early spring. The ability to consume more plantain, probably as a result of its fast rumen degradation rates, improved the weaning weight of the lambs by between 10 and 34% over the four years of studies. Ewes were also heavier at weaning by up to 14 kg. In a farm system, where the sale of cull ewes or last-lambing ewes is a valuable income stream, using a lactation forage that puts weight on the ewe by weaning is a real asset.

4. Tonic as a companion with lucerne

Lucerne systems are characterised by excellent summer growth, particularly in hotter, drier environments. Although specific genotypes of lucerne have been bred for increases in winter activity, this may come at the cost of persistence. Where lucerne is used in sheep systems in drier environments, winter-active species need to be included in the farming system to fill feed gaps left by inactive lucerne in winter and early spring. Such species have included cereals and short rotation ryegrass. More recently, adding Tonic plantain to lucerne stands has provided valuable feed in early spring and late autumn, which complements the summer production of lucerne.

References


Australian breeding of persistent perennial ryegrass without endophyte

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Out of the four perennial grasses cocksfoot, perennial ryegrass, phalaris and tall fescue, perennial ryegrass would be highest selling species sold in Australia. Perennial ryegrass has been popular due to its ease of establishment, management and good forage quality. Perennial ryegrass is also a commonly used species in New Zealand and Europe for forage and north America for turf. A majority of the perennial ryegrasses used in Australia are bred in those countries and then marketed in Australia. There are over 6 million ha of perennial ryegrass based pastures in Australia (Reed 1996). The majority of the perennial ryegrass material used in overseas breeding programs is based on germplasm originally collected from northern European or southern Mediterranean germplasm regions. However there has been little work done with north African based material which has summer dormancy characteristics which may be of significant value in the hotter, drier climate of Australia. Currently available perennial ryegrass cultivars are generally suited to an annual rainfall of >650 mm. With climate change, the predictions are that annual rainfall will decrease and temperatures will increase. If this occurs, then unless a far greater effort is placed on breeding cultivars better suited to Australia's environment we are likely to see a the current perennial ryegrass zone shrink as a result of poor ryegrass persistence.

Perennial ryegrass plants can contain endophyte. Endophyte is a fungus that often occurs in perennial ryegrass as well as some other perennial grasses. The natural form of endophyte often causes the syndrome known as 'ryegrass staggers'. The affects on livestock and subsequent costs to producers are significant. New Zealand research has selected novel endophytes existing in nature and inserted these into ryegrass plants to retain positive effects of insect resistance and reduce negative animal effects. One of the major claims about endophyte is that endophyte is required in a variety for it to be persistent. Some Australian trials have demonstrated that Australian bred perennial ryegrass is potentially better adapted to some regions than perennial ryegrass bred overseas. As a result of these trials the evidence is mounting that an important consideration when selecting a cultivar should first be how well adapted is it to the region and use that the farmer requires and then after that endophyte issues should be considered.

One advantages that perennial ryegrass has as a species is its diversity in heading dates or maturity. It begins to head from 6 October to the 27 November. This difference in the heading dates can be used to select the right variety for a specific location and may also help with persistence. Perennial ryegrass usually has a spring dry matter (DM) production peak of nearly 60% of its annual DM production close to its heading date. Allowing perennial ryegrass to head can help increase persistence. To take advantage of this peak it is important to match the right heading date in the right environment. Early heading perennial ryegrass varieties which are based on the Australian Kangaroo Valley germplasm such as Boomer, Roper and Fitzroy, have the DM production peak in late winter/early spring, so these varieties are best suited to early country rather than late country. These early varieties still need adequate rainfall to persist. The mid heading varieties are your 'all rounder' that can be used in most locations including dry and wet. Examples of these are Camel, Avalon and Victorian. Late heading varieties are best suited to high rainfall, late country that holds moisture into early summer. This is usually on flats or on the southern slide of slopes. All late heading varieties are bred overseas and include Platinum, Banquet II and Bealey.

Medea was one of the most persistent perennial ryegrass variety ever introduced into the
Australian market, Medea, had low endophyte (Table 1). Medea had the ability to go dormant in summer, giving it greater persistence than the non-summer dormant varieties. Currently there are no summer dormant perennial ryegrasses available in Australia. Anthony Leddin, Valley seeds plant breeder, through his award of the 2009 Young Scientist of the Year for Meat and Livestock by MLA is developing summer dormant perennial ryegrasses with low endophyte that will persist longer than any variety available in Australia. Leading advocate of Australian pasture research, Dr Kevin Reed, states in one of his papers that ‘Algerian derived lines of perennial ryegrass (with low endophyte) may become a valuable genetic resource for the development of safe, persistent cultivars’ (Reed et al. 1987).

In trials at various locations in Australia, it has been demonstrated that the key to persistence of a plant is breeding with germplasm suited to Australia in Australia. New Zealand breeding in perennial ryegrass has gone down the path of selecting for novel endophytes to try and increase persistence and have no side effects on animals. Most New Zealand perennial ryegrasses have begun with European germplasm material selected from central Europe followed by material selected from southern Europe. Australian breeding has gone down a different pathway. Many varieties developed in Australia have used Victorian or Kangaroo Valley perennial ryegrass as their base. These plants were adapted to the Australian environment from the original seed brought over from England over 100 years. It has been shown to be very persistent and hardy in Australian conditions and some varieties even persist without endophyte. Results from a trial at Balmoral in Western Victoria, with an annual rainfall of less than 600 mm, less than what is recommended to maintain perennial ryegrass stands, show that the persistency of perennial ryegrass bred in Australia without endophyte was greater than those bred in New Zealand with endophyte (Table 1) and both had a similar heading date. This may have also been due to the varieties being able to go dormant in the summer. Persistency is important not only due to the extra cost that is involved in having to resow pastures but also when desirable plants die these are usually replaced with weeds. There is a time and economic cost in controlling weeds and the weeds also place more pressure on existing desirable plants within the pasture for moisture and nutrients.

A good example of the breeding with Australian germplasm for persistency is the program from Valley seeds in the development of Camel perennial ryegrass, a nil endophyte variety. It was selected from Victorian perennial ryegrass plants that were surviving at St Arnard, which has an annual rainfall of 550 mm and had also survived the 1982 drought. Hamilton is on the border of a marginal environment for perennial ryegrass to grow. This is the location where Valley Seeds carry out certified seed production of its Australian bred perennial ryegrass. These paddocks are selected for production of certified seed on the basis that there is less than 1 in 10m² of another ryegrass. Certified seed paddocks of Camel ryegrass with nil endophyte in this region have persisted well beyond the three year period of certified seed production and even through the 2006 drought.

The results from the trial in Yarck, a site that has an early finish to the season (Table 2) suggest that Australian bred or background based material to have greater persistence than material bred in New Zealand, in a tough

<table>
<thead>
<tr>
<th>Species</th>
<th>Cultivar/ecotype</th>
<th>Plant density 1991 (no./m²)</th>
<th>Plant density 1995 (no./m²)</th>
<th>% density</th>
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<tr>
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<td>Medea material (LE)</td>
<td>801</td>
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<td>486</td>
<td>16</td>
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<tr>
<td>Perennial ryegrass</td>
<td>Ellett (SE)</td>
<td>1111</td>
<td>40</td>
<td>3.6</td>
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</table>

Note: LE = Low endophyte, SE = Standard endophyte. LSD for Plant density (no./m²) in 1995 ($P = 0.05$) = 16.6.
Australian environment. This may be due to a number of factors including:

- Adaptation of the parental material to the Australian environment of over 100 years
- The appropriate heading date, early and mid heading would be more suitable to most Australian environments than late heading when it comes to persistence.
- It is possible for nil or low endophyte material to persistence in the absence of insect pests as long as it has strong genetics for persistence.

### Table 2. Plot density (%) on 7/7/10 at perennial ryegrass trial, Yarck central Victoria, Sown 18/4/08.

<table>
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<th>Entry</th>
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<th>Endophyte Type</th>
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<tbody>
<tr>
<td>Camel</td>
<td>96.25</td>
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<td>Australia (Valley Seeds)</td>
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<td>Victorian</td>
<td>94.5</td>
<td>High Wild</td>
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<td>Fitzroy</td>
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<td>Australia</td>
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<tr>
<td>Boomer</td>
<td>93.75</td>
<td>Nil</td>
<td>Australia (Valley Seeds)</td>
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<tr>
<td>Prolong</td>
<td>92.75</td>
<td>Nil</td>
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</tr>
<tr>
<td>Avalon</td>
<td>92.5</td>
<td>High Wild</td>
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<tr>
<td>Kangaroo Valley</td>
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<td>High Wild</td>
<td>Australian Ecotype</td>
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<td>Meridian AR1</td>
<td>90</td>
<td>High AR¹</td>
<td>New Zealand (Kangaroo Valley cross)</td>
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<tr>
<td>Roper</td>
<td>88.5</td>
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<td>LSD (5%)</td>
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<td>% CV</td>
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### References


Effect of ensiling on weed seed viability

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Abstract: Seeds from 10 weed species were ensiled, underwent 48 hour in sacco digestion or both. Seed germination and viability were compared with untreated seeds. Ensiling reduced weed seed viability. Placement in the rumen for 48 hours also reduced viability though the effect was more variable between species. The greatest reduction in viability occurred with the combination of treatments.

Key words: weed seed, silage, viability

Introduction
Based on anecdotal evidence it is generally assumed that ensiling renders most weed seeds non-viable but this has only been scientifically tested on a very limited basis (Blackshaw and Rode 1991; Mayer et al. 2000). A preliminary experiment was conducted at the Wagga Wagga to determine the effect of ensiling on the viability of seeds of 10 Australian weed species.

Methods
Weed seeds of different species were placed in Dacron bags (50 seeds per bag) of the type used for degradability studies and ensiled for three months in chopped cereal forage. Two bags of each weed species were placed in each of four plastic bag mini-silos (replicates). Upon opening one bag of each weed species from each silo plus a bag containing 50 untreated seeds were placed in the rumen of one of four mature Red Poll steers for 48 h. Bags from each mini-silo were placed in the rumen of the same animal. Weed seed germination and viability was tested against control seeds. After 18 days ungerminated seeds were tested for viability using the tetrazolium test.

Results and discussion
The viability of untreated seeds varied with species (Table 1). Viability of wireweed seed used in this experiment was very low while that of the grass weeds was generally high. Ensiling reduced the viability of seeds. Digestion also reduced the viability of most weed seeds though the effect is highly variable. The combination of ensiling plus digestion rendered all seeds non-viable except for those of marshmallow. It was concluded that ensiling prior to feeding to ruminants is an effected strategy as part of an Integrated Weed Management package.

Table 1. Effect of treatment on weed seed viability.

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Control</th>
<th>Silage</th>
<th>Digestion</th>
<th>Silage + digestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley grass</td>
<td>96</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Brome grass</td>
<td>69</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Silvergrass</td>
<td>98</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Wild oats</td>
<td>79</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Marshmallow</td>
<td>58</td>
<td>37</td>
<td>33</td>
<td>43</td>
</tr>
<tr>
<td>Paterson’s curse</td>
<td>31</td>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Prairie ground cherry</td>
<td>90</td>
<td>0</td>
<td>87</td>
<td>0</td>
</tr>
<tr>
<td>Silverleaf nightshade</td>
<td>91</td>
<td>1</td>
<td>92</td>
<td>0</td>
</tr>
<tr>
<td>Wild radishshade</td>
<td>41</td>
<td>1</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Wireweed</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

References
Travel grant report
Report of travel to New Zealand to attend the 15th Australian Society of Agronomy Conference and visit two NZ Agresearch Institutes

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Purpose of travel
As Secretary of the Australian Society of Agronomy (ASA) it was essential that I attend the ASA biennial conference (held in Christchurch) to ensure the smooth running of this event. In addition, I delivered a conference paper and also visited the NZ Agresearch Institutes at Lincoln and Palmerston North to deliver a seminar about pasture grass drought survival and liaise with grassland science colleagues with a view to possible future research collaboration.

Itinerary
Overseas travel commenced on 14/11/2010 and finished on 24/11/2010. Between these dates I visited:

- Lincoln University to attend the conference of the ASA;
- Agresearch Lincoln for liaison with Drs Phil Rolston and Keith Widdup;
- Agresearch Palmerston North for liaison with Dr Zulfi Jahufer and other grassland scientists.

Benefits and outcomes of the travel
As the Secretary of the ASA my activities were focussed on ensuring the successful staging of the Society's conference. Through this conference, (Theme – ‘Food security from sustainable agriculture’) the media profile and importance of agronomy to the Australian economy, society and environment were raised. This is important given the Productivity Commission Review of Australian Rural Industry R&D, ongoing concerns about World Food Security and Murray–Darling Basin water use negotiations. My visits to Agresearch Institutes at Lincoln and Palmerston North were helpful to ensure the ongoing seed production of the most drought tolerant perennial pasture grass in Australasia, Kasbah cocksfoot, while establishing links with scientists who share my research interest in improving the drought resistance of pasture grasses.

Major activities
Activity 1
The 15th Australian Society of Agronomy Conference at Lincoln, New Zealand.

This conference was jointly staged by ASA, the NZ Grassland Association, the NZ Agronomy Society and the NZ Soil Science Society. This was the first time that the ASA Conference has been staged outside of Australia. Overall, there were 510 conference registrants from 14 different countries with 145 of these being Australian while 341 were from NZ. Of the other participants seven were from China, three each were from India and Tanzania, two each were from Brazil and Japan, while one each was from Chile, France, Indonesia, Ireland, South Korea, Russia and USA.

Professor Peter Cornish, a former scientist with NSW Agriculture, was awarded the most prestigious accolade of the ASA, the C.M. Donald Medal. Peter's subsequent Donald Oration extolled the benefits of undertaking farmer participatory research and his humility and enthusiasm inspired his listeners.

Conference plenary presentations covered a diverse range of topics including:

1. Can we feed the world in 2050? (presented by Dr Greg Edmeades, ex CIMMYT);
2. Agricultural productivity in Australia and New Zealand: trends, constraints and opportunities; (Dr Michael Robertson, CSIRO);
3. Promoting food security by supporting Agricultural R&D; (Prof. John Mullen, ex I&I NSW, now Charles Sturt University);
4. The Sustainable Use of Water Resources for Agriculture and Horticulture; (Prof. Brent Clothier, Plant & Food Research NZ);
5. Greenhouse gas fluxes in grazed pastures; (Dr Harry Clark, NZ Agricultural Greenhouse Gas Research Centre);
6. A postscript to “Peak P” – an agronomist’s response to diminishing P reserves (Prof. Peter Cornish, ex NSW Agriculture, University of Western Sydney).

Topic areas of the concurrent sessions included: Climate Change–Future Farming; Simulation and Decision Support; Crop Production–soil water and WUE; Crop Production–N and P use; Pasture production–physiology and breeding; Crop Production–precision agriculture; Crop Production–development and herbicide management; Crop Production–nutrient management; Crop Production–high rainfall zone; Crop Production–physiology & breeding; Crop Production–dual-purpose crops; Managing nutrient loss and water quality; International crop–pasture systems; Forage crop production; Intercrops/cover and companion crops; Pasture production–IPM; Pasture production–spatial management; Dairy pasture production and management.

I presented a paper entitled, ‘The effect of lime application to an acid soil on perennial grass establishment’ in one of the above concurrent sessions.

The complete Conference proceedings can be viewed at: http://www.agronomy.org.au/proceedings/index.htm

Activity 2

On Friday 19 November, I visited the NZ Agresearch institute at Lincoln. While there I met with Drs Phil Rolston (pasture seed production researcher) and Keith Widdup (pasture grass breeder). I am collaborating with Dr Rolston to help in the improvement of seed production of the summer-dormant cocksfoot cultivar Kasbah. This is important for NSW because throughout the droughts of the 2000 decade Kasbah clearly had the best drought survival and production of any of the sown perennial grasses tested in NSW. Seed production of Kasbah is poor and to keep the cultivar in commerce research is needed to improve its seed production. Dr Rolston is essentially the only pastures researcher in Australasia with a primary focus on seed production. I first met Dr Keith Widdup in 2009 at the Summer Dormancy Workshop in the USA. At Lincoln, we visited one of his tall fescue breeding nurseries and discussed the techniques used for the measurement of summer dormancy (an important drought survival trait) expression in grasses.

On Monday and Tuesday 22 and 23 November, I visited the Palmerston North Institute of NZ Agresearch. This shares a campus with Massey University and other research/industrial organisations including Fonterra. There my visit was hosted and coordinated by Dr Zulfi Jahufer, the former NSW Agriculture white clover breeder (1989–1994) at Glen Innes. While at Palmerston North I met Drs Syd Easton (Centre Director), Derek Woodfield (breeder), David Hume (agronomist-endophyte specialist), Jimmy Hatier (pasture physiologist), Bruce Veit (biochemist), Alicia Scott (biotechnologist) & Warren Williams (legume breeder).

On the first day of my visit I gave a seminar attended by approximately 30 scientists entitled, ‘Stories of summer survival and death – the case of cocksfoot’.

Although it is rare for summer droughts to actually kill pasture grasses in NZ there is a lot of interest in reducing productivity losses due to drought and this explains the high level of interest in my talk. I subsequently had good discussions with Jimmy Hatier and Warren Williams both of which could lead to some fruitful future collaborations. With Jimmy Hatier the potential collaboration could extend to a refinement of methods to measure summer dormancy in grasses, a field in which I have previously published. The discussions with Warren Williams focussed on his efforts to cross white clover with other more drought resistant Trifolium spp. with the objective of strengthening drought resistance in this species. Warren often uses annual Trifolium spp. as sources and he is confident that he understands the genetics of perenniality in this genus. I am
involved in the development of perennial wheat amphiploids but a key problem with these is their weak perenniality. It is possible that insights from Trifolium might help in strengthening perenniality in Triticum.

Activity 3

During the weekend (between 19/11/10 and 20/11/10) I visited the dairy farm of Mr J. O'Connor, Kokatahi, via Hokitika (West Coast, South Island). This high-rainfall (+2000 mm) zone is one of the cheapest places in the world to produce milk because feed production is pasture-based (white clover/ryegrass) and as the climate is mild it is possible for the animals to remain outside on the pasture all year. A high proportion of the local milk is exported in various milk powder forms produced by the local cooperatively-owned factory. Jerseys are the major dairy cattle breed used there because of their high milk fat and ease of care (e.g. calving). A high level of mechanisation is used so that on Mr O'Connor’s farm all day-to-day activities, including the milking of 200 cows (using a rotary dairy), were undertaken by one person.

General observations

Broadly speaking pastoral agriculture in NZ operates at a higher level of intensity than that occurring in most of Australia, probably because land prices are much higher. The mild temperate maritime climate with abundant rainfall or cheap irrigation means that farmers can economically apply high levels of input to their pastures. This greater level of investment seems to occur across the board, including education. Perennial ryegrass/white clover is the preferred pasture mix with white clover providing high quality feed and the majority of nitrogen (N) to the pasture. The N fixed by white clover is crucial to the low costs of production of NZ pastoral agriculture and this is currently threatened by the clover root weevil which is decimating many NZ pastures. Biocontrol measures to control the weevil have been undertaken and are described in the paper of Dr P. Gerard.

The research group at Agresearch Palmerston North constitutes one of the larger pastoral research agglomerations in the southern hemisphere. This group is dynamic and outward-looking with scientists of international origin (e.g. France, USA) or having been trained overseas. Moreover, the scientists who constitute this group cover a wide range of disciplines from the molecular to the macro level and we should be developing closer ties with them or we risk being left behind.

Acknowledgments

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