

Section 4a: Project Results

Experiment 1 (SA): Grazing management strategies for puccinellia pastures to optimise productivity, persistence and sustainability.

Hypothesis: Strategic grazing of a range of puccinellia-based pastures will optimise their productivity (plant and animal), persistence and sustainability.

Objective: Develop grazing management strategies for puccinellia and puccinellia-based pastures to maximise pasture and animal productivity, pasture persistence and the sustainability of the whole system.

Specific Objectives:

1. Determine the financial return from the systems under investigation
2. Understand the environmental impact of these saline grazing systems on water balance and biodiversity.
3. Improve the visual amenity of, and producer pride in, saline land through the introduction and development of saltland pasture systems.

The major grazing experiment compared 5 saline pasture options and 2 grazing strategies (8 treatments) replicated 3 times:

1. Unimproved: Unimproved volunteer saline pasture - mainly sea barley grass, samphire and salt scalds; continuously grazed. This is representative of degraded saline pastures in the region and provides a base line to which the success of the improved pastures can be judged.
2. Puccinellia: Improved saline pasture (established puccinellia-dominant pasture), but with no fertiliser inputs; continuously grazed. This is representative of significant proportions of the 'improved' pastures in the region and will provide a base line for the fertilised puccinellia-based pastures.
3. Puccinellia + Super: Improved saline pasture (established puccinellia-dominant pasture) with added superphosphate; continuously vs strategically grazed. The continuously grazed treatment is representative of a significant proportion of 'improved' saline pastures in the region and will provide a base line for the 'best-bet' treatment with balansa clover (below).
4. Puccinellia + Super + Nitrogen: Improved saline pasture (established puccinellia-dominant pasture) with added super and applied nitrogen; continuously vs strategically grazed. These treatments involved existing puccinellia-dominant pasture with nitrogen applied in autumn to a rate equivalent to the nitrogen input expected from a well established grass/clover pasture). These treatments provide an indication of the level of response (both in productivity and economic terms) achieved through the application of nitrogenous fertiliser rather than nitrogen through a legume (balansa clover). Some producers apply urea to their puccinellia pastures yet are uncertain of the profitability of the practice.
5. Puccinellia + Super + Balansa Clover: Improved saline pasture (established puccinellia-dominant pasture) with added superphosphate + balansa clover; continuously vs strategically grazed. These treatments involved over sowing established puccinellia-dominant pasture with balansa clover in the winter of year 1 (2003). This is the 'best bet' pasture option that capitalises on the results of earlier research showing puccinellia and balansa clover to be the best adapted grass and legume species, respectively, for saline soils in this region. Appropriate management should also result in good persistence of the balansa clover component, which is an area of concern for local producers.

The **aim** of this experiment was to compare the 'industry standard' continuous grazing management with the 'best bet' option of strategic grazing. Continuous grazing was expected to be suitable for pasture and animal production, but not the long-term sustainability of the pasture system. Strategic grazing involved grazing from mid summer, through autumn and the break of the season, winter and early spring. Animals were moved to other parts of a hypothetical farm in spring (mid September) to allow the pasture, but particularly balansa clover, to flower and set seed to enhance its persistence and the sustainability of the whole system.

DRAFT PAPERS

(currently combined, but likely to be split into 2 papers)

Pasture composition, fertiliser regimes and grazing management influence pasture production on saline land in the Upper South East of South Australia.
and

Pasture improvement with puccinellia and balansa clover is a highly productive and profitable system in the Upper South East of South Australia.

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Introduction

With the discovery that trace elements were essential for both pasture and animal growth large agricultural developments occurred in the Upper South East from the 1950s (reference?). The native bush was replaced with highly productive Hunter River Lucerne, which helped maintain the level of the area's groundwater system. By the mid 1970's there was approximately 300,000 ha of dryland lucerne. In 1978 a combination of lucerne aphids, drought and wingless grasshopper decimated this area to such an extent that only 20,000 ha of lucerne remained. Despite considerable efforts, this area only increased to approximately 40,000 ha by ??? due to non-wetting sand, disease, weeds, insects and unfavourable spring rains (references?).

In 1981 a severe flood event inundated large areas of this region. Consequently, the saline groundwater rose to the surface and left bare soil and salt scalds over summer. In 1982 there was a severe drought, which exacerbated the effects of salt having been brought to the surface in previous years. It was at this time that the reality and implications of dryland salinity became a clear. Floods in 1988 and a succession of wet winters further compounded the problem. Today approximately 326,000 ha are affected by dryland salinity in South Australia (reference?). Of this, 251,000 ha (77%) are located in the Upper South East and a further 175,000 ha is at risk. Agricultural production losses caused by dryland salinity in SA are currently estimated at \$26.1 M per annum (2000 data), with over 400 producers directly affected in the Upper South East region.

Continuous grazing is expected to be suitable for pasture and animal production but not the long-term sustainability of the pasture system or some of its components. Strategic grazing involves

grazing from late summer, through the break of the season and winter, but animals are moved to another area of the property during spring and early summer. This is expected to be a better management practice for pasture production and the sustainability of the system.

Methods

Site characteristics

A 60 ha area of saline land was selected in early 2003 for the study on the 'Erelma Downs' property of D & H Sanders near Mt Charles in the Upper South East of South Australia (Easting 419800, Northing 5999150; Hundred of Laffer). This is an area of approximately 475mm annual rainfall with a Mediterranean climate and winter-dominant rainfall pattern. The area was originally cleared of native vegetation (general description of sort of veg???) in ??? (check with Dennis?) and fenced into approximately 45 ha paddocks. An adjacent 400 ha area had been left as remnant vegetation, consisting of ??? vegetation (vegetation type) dominated by ??? (species???). One of the approximately 45 ha paddocks, consisting of a puccinellia-dominant pasture that had been sown in ??? (see Dennis for this), was subdivided into 21 x 2 ha plots for the 'improved' pasture treatments. The other approximately 45 ha paddock, dominated by 'unimproved' species such as sea barley grass (???) and Threkeldia (??? – a samphire-like species) and small quantities of annual and curly rye grass, puccinellia (*Puccinellia ciliata*) and tall wheat grass (*Thinopyrum ponticum*), was subdivided into 3 x 5 ha plots for the 'unimproved' pasture treatments, with the remaining 30 ha kept as a run-off area for spare animals. This paddock had originally been sown to improved species such as ??? in ???.

An EM38 survey was conducted in February 2003 and plots and treatments assigned on the basis of this survey so that each of the replicate treatments were represented in the high, moderate and low salinity regions of the paddocks (see Figure 1?). The area can best be described as a very gently undulating (<5cm relief?) to level plain in an ancient interdunal corridor. Soil is soft sand with a bleached subsurface layer sharply overlying olive-grey mottled clayey subsoil with fragmented or sheet calcrete at shallow depth (30-60 cm). The water table is typically no more than 100-150 cm from the surface. Drainage at the site is poor, with the shallow water table preventing adequate drainage of water from the profile, resulting in at least the lower part of the soil being wet for several months each year. Furthermore, the very low relief at the site results in only very slow surface drainage off the site to recently constructed shallow drains (<1.5 m deep) approximately 600m from the western edge of the treatment areas. The whole profile is also often wet for weeks to months in wetter years. Inherent fertility is low due to the low clay content and moderate to strong leaching.

Initial 0-10 cm soil sampling of the site, supported by detailed soil analyses from these samples as well as those from soil pits at 3 locations at the site, indicated a low inherent fertility at the site. Samples from the experimental paddocks indicated low levels of phosphorus (6-9 mg/kg Colwell P) and deficiencies of copper, zinc and manganese in the surface layer (0-10 cm), but an accumulation of phosphorus in lower layers due to leaching (26-28 mg/kg Colwell P at 25-40 cm). Soil pit samples from the remnant vegetation area also indicated low inherent fertility of the site, low phosphorus and very high potassium levels, moderately low copper and zinc levels and extremely high levels of boron and sulphur.

Experimental treatments

The experiment consisted of 8 pasture, fertiliser or grazing management treatments, each replicated 3 times. The treatments were:

1. Unimproved; continuously grazed – volunteer saline pasture of mainly sea barley grass and threkeldia (samphire-like species) and salt scalds. Plots were 5 ha each.

2. Puccinellia only; continuously grazed – puccinellia-dominant pasture with a strong phosphatic fertiliser history, but no fertiliser inputs during this experiment. Plots were 2 ha each.
3. Puccinellia + Superphosphate; continuously grazed – puccinellia-dominant pasture with 75 kg/ha single superphosphate applied annually in autumn (2 ha).
4. Puccinellia + Superphosphate; strategically grazed – as above (2 ha).
5. Puccinellia + Superphosphate + Nitrogen (urea); continuously grazed – puccinellia-dominant pasture with 75 kg/ha single superphosphate and 50 kg N (as urea) applied annually after the season break (typically early winter) (2 ha).
6. Puccinellia + Superphosphate + Nitrogen; strategically grazed – as above (2 ha).
7. Puccinellia + Superphosphate + Balansa Clover; continuously grazed – puccinellia dominant pasture with 75 kg/ha single superphosphate applied annually in autumn and oversown with 5 kg/ha balansa clover in July 2003 (2 ha).
8. Puccinellia + Superphosphate + Balansa Clover; strategically grazed – as above (2 ha).

The oversowing of the ‘Puccinellia + Superphosphate + Balansa Clover’ pasture plots with balansa clover in July 2003 was achieved by spraying the newly germinated annual species with ??? L/ha of Sprayseed after the break of the season. ??? days later 5 kg/ha of balansa clover (*Trifolium michelianum* cv. Frontier) was sown into the plots using a ??? seeder and the plots were rolled with ??? cultipackers. These plots were only lightly grazed in 2003, but were fully integrated into the grazing treatments in 2004 and 2005. These plots were also subjected to TimeRite[®] treatment in 2003 by spraying in late September with ??? mL/ha ??? to control diapause in red-legged earth mite (*Halotydeus destructor*) [what about 2004?].

Materials balance

Soil samples (0-10 cm) were collected monthly from each plot by walking a diagonal transect across each plot and combining 30 individual soil cores taken along the transect. Samples were dried (80°C for 48 hrs), sieved to pass a 2 mm screen and a 5 g subsample removed. 1:5 soil to water mixtures were prepared, mixed on a mechanical mixer/shaker, allowed to settle for ??? and measured for pH and electrical conductivity to track salinity at the sites using a labCHEM pH electrode and conductivity-TDS sensor and a labCHEM-CP Conductivity TDS-pH-mV-Temperature instrument (TPS Pty Ltd, Springwood, Brisbane).

Rainfall was measured on each visit to the site and daily rainfall records have been obtained from the landholder and the Keith Bureau of Meteorology, ??? km east of the site. Other weather parameters have also been obtained from the Keith weather station.

Groundwater levels and quality were monitored monthly at 2 bore holes in paddocks adjacent to the experimental site. In addition, shallow piezometers (3-3.5m) were placed adjacent to 4 of the experimental plots in late 2004???. One deep piezometer to 10m was also installed. Capacitance water level loggers (Odessey[®], Dataflow Systems, Christchurch, New Zealand) were placed in each of the shallow piezometers to enable continuous recording of groundwater levels.

Performance of pastures

Pasture mass, pasture composition (BOTANAL; reference???) and ground-cover were assessed monthly and samples for nutritive value analysis were collected approximately bimonthly. In 2005 a series of exclusion cages were installed at the site to enable pasture growth rates to be determined. Pasture mass was assessed using a calibrated rising plate meter in 2003 & 2004???, but was changed to calibrated visual assessments in late 2004 and 2005 due to problems of poor calibrations, particularly in the ‘balansa clover’ plots.

The persistence of balansa clover, especially in the oversown plots, was determined by annual counts of the number of germinated seedlings at approximately ??? days after the major break to each season. Pasture composition (BOTANAL) was also used also used in this assessment, as was annual yield of balansa clover seed by the methods of ???.

Performance of grazing animals

1.5-2 year old Merino wethers that had prior exposure to saltland pastures were used for the experiment in 2004 and 2005, but in 2003 animals were purchased from an area 150km to the south of the experimental site and had not previously been exposed to these conditions. Animals were allocated to treatments in June 2003, within 2 weeks of shearing, and in January 2004 and 2005, approximately 4 weeks off shears. A minimum of 10 'core' animals were allocated to each plot and additional animals were added (or subsequently subtracted) depending on expected carrying capacity and actual pasture growth. All animals were treated with cobalt and selenium slow release 'bullets' prior to being allocated to treatments (copper as well in 2003) and were drenched onto the plots into 2003 and 2004. In 2005 faecal egg counts in the preceding month, as well as a drench resistance test indicated that drenching was not needed prior to initial grazing. In 2003 forty spare animals were not treated and blood samples collected from these and 30 treated animals to assess the trace mineral status of each group.

Supplementary feed in the form of whole lupins (*Lupinus* ???) or faba beans (*scientific name*???) were provided to animals in early 2004 and 2005 as survival rations if the pasture mass and quality was determined to be insufficient to support liveweight maintenance of the core animals in each replicate of a treatment. The lupins or beans were trailed out onto the ground in the corner of the appropriate paddocks at weekly or bi-weekly intervals.

Liveweight and condition score (should this be fat score, with a reference to the method?) were measured monthly. Daily rates of wool growth in a number of critical periods of the experiment were measured by application and subsequent measurement of dyebands, using the methods of ??? (????). Annual wool production was determined from annual fleece weights determined at shearing in December each year and the effect of each treatment on wool quality was determined by collection and analysis of mid-side wool samples. Analyses for fibre diameter, staple strength, yield, etc, etc were undertaken by ??? laboratory.

Impact and implications for biodiversity

Plant species and plant functional group diversity in both the grazing paddocks and the adjacent remnant vegetation were assessed in autumn and spring of ??? (what year(s)). Landscape functional analysis, involving the methods of Tongway and Hindley (19??) for a rapid on-site assessment of 11 soil surface indicators designed to assess and score landscape function and stability of an area at a set point in time, was undertaken ??? and ??? [when] in a subsample of the grazing plots and the remnant vegetation. The 11 indicators are then grouped into three indices – stability, infiltration and nutrient cycling, representing major components relating to the function of a landscape.

Microbial respiration and biomass was measured seasonally in 0-10 cm soil cores randomly collected from each of the 8 treatments (and from each of the 3 reps of each tmt???). Samples were refrigerated after collection and prior to being sent to the Department of Agronomy and Soil Science at the University of New England for estimation of the basal respiration rate and biomass of soil microbes using the Respicond system (reference???). Soil was sieved to pass a 2mm mesh to remove stones, roots and large invertebrate animals. Approximately 80 g of sil was added to a respirometer pot with 3 replicate pots used per soil sample. Soil moisture was adjusted

to approximately 75% field capacity, at which point microbial respiration is optimal and moisture conditions are not limiting microbial activity. Soil was then incubated at 20°C for 2 days before being placed in the water bath (20°C) in a respirometer. CO₂ evolution was measured in an electronic respiratory system (Respicond III, Nordgren Innovations AB, Terrangvagen 3A S-903 38 Umea, Sweden). Firstly, average basal respiration rate was measured over 48 hours (mg CO₂/hr/100 g DM soil). Microbial biomass was determined by the Substrate-Induced Respiration (SIR) method (Anderson and Domsch, 1978), whereby the immediate increase in respiration rate after the addition of a glucose substrate is used to calculate the amount of microbial carbon in soil (mg Microbial C/100 g DM soil).

Abundance and diversity of soil surface invertebrates was assessed in October 2004 and May 2005 in the remnant vegetation, the unimproved pasture area and the improved pasture area (i.e. combination of all grazing treatments except the unimproved plots). Ten permanent pitfall traps, consisting of a 400 mL plastic cup, 9mm in diameter and 12 cm high were placed at 10 m intervals along access laneways adjacent to the grazing plots and ??? in the remnant. Replicated???, total of ??? pitfall traps in total. Cups were placed in a same-sized hole in the ground with the lip of the cup level with the soil surface. Each cup was half filled with a 30% propylene glycol and 70% water mixture and were active for 7 days at a time during a sampling event. Invertebrates were sorted to order level with the exception of ants and centipedes, that were sorted to class level.

A fauna survey was conducted in spring of 2003, in which [assessments of small vertebrate fauna were made with the aid of pitfall traps, bird watching ???, ????. In addition, tape recordings of frog calls in the remnant vegetation, unimproved and improved pastures were made in September of each year and assessed by trained staff for the type and abundance of frog types (Environment Protection Authority South Australia Frog Census – www.epa.sa.gov.au/frogcensus/).

Economic analyses

Analyses were conducted for a representative farm of the Upper South region using the whole farm optimisation model, MIDAS, adapted specifically for this analysis. The model describes the biology of production in some detail, to reflect interactions within the farming system. Ten periods of pasture production and senescence are described, as are growth and quality of 3 different pasture mixes and the effect of pastures on livestock production, including liveweight, wool cut, fibre diameter and hauteur. Pasture and grain supplement are allocated by the model to livestock in such a way that the profit of the farm business is maximised. Analysis is conducted on a year-in-year-out basis such that adjustments to farm strategy that farmers may adopt to respond to different season types are not considered. How the effect of changes in production, quality, costs and prices on expected profit can be examined.

The representative farm was 2000 hectares, with an annual average rainfall of approximately 450mm, with 70% of this falling in the growing season between early May and early November. Soils were of low fertility and situated in a landscape with little relief. Drainage was consequently very poor, despite the presence of drainage channels constructed to limit the effect of waterlogging on production. The model farm was set up with three soil types. Deep sand and sand over clay covering 30% of the property each. Lucerne was allocated to grow on the deep sand, and re-established every 10 years. Tall wheat grass was allocated as the dominant species on the sand over clay and was re-established every 20 years. Both pastures were top dressed with 75kg per hectare of superphosphate annually. The remaining 40 % of the farm was assumed to be shallow sand over clay, subject to a rising water table and consequent waterlogging and dryland salinity where the salinity of groundwater is high. Experimental

treatments assessed the production and quality of puccinellea based pastures on these soils, in comparison to unimproved pasture consisting mainly of barley grass.

Growth rates for lucerne and tall wheat grass pastures were estimated using previous studies (eg Auricht, personal communication) and based on local experience. Growth rates of puccinellea pasture were estimated using Grassgro (references ???), a pasture simulation model developed by the CSIRO in Canberra. Pasture growth curves for puccinellia generated by Grassgro were adjusted to reflect differences in treatments measured in the grazing experiments that would be expected over a number of years. Quality of pastures in difference periods was also estimated using local experience and differences between treatments were estimated for an expected season based on the experimental data. Growth rates and quality assumed in this analysis are shown in the Appendix to this section of the report.

[Research data from the experimental site, while very useful in helping to improve the understanding of the system, was found to be of limited use in the economic analysis. This was due to the variation between seasons, the limited life of the project and the number of treatments that could be imposed in the site given constraints on funds.]

Four treatments applied in the grazing experiment were compared in this analysis. They were:

1. Unimproved pasture – barley grass dominant, low growth rate, poor quality
2. Improved puccinellia pasture – puccinellia dominant, high growth rate, moderate quality
3. Improved puccinellia pasture + nitrogen – puccinellia dominant, high growth, good quality
4. Improved puccinellia pasture + balansa clover – puccinellia dominant, high growth, good quality

Differences in growth rate and quality in each period and costs of management were modelled to represent each treatment. The model was run assuming different:

1. Areas of shallow sand over clay
2. Flock structure (wool dominant, merino prime lamb, cross bred prime lamb)
3. Lamb and wool prices

Results

Site Characteristics: Figure 1 demonstrates the seasonal nature of water table depth in the region. This figure highlights the fact that the water table usually reaches or exceeds the soil surface in ‘normal’ years, resulting in waterlogged and/or inundated pastures for up to 3 months at a time. Ironically this only occurred in the first year of this project (2003), whereas in 2004 the water table only reached the surface for a short period and in 2005 it only came to within about 1 metre of the soil surface. All three monitored areas (A7, A10 and the drain) showed the same general trend, as did the piezometer network that was only installed in late 2004??? (Figure ??? – extra groundwater figure with piezo data??).

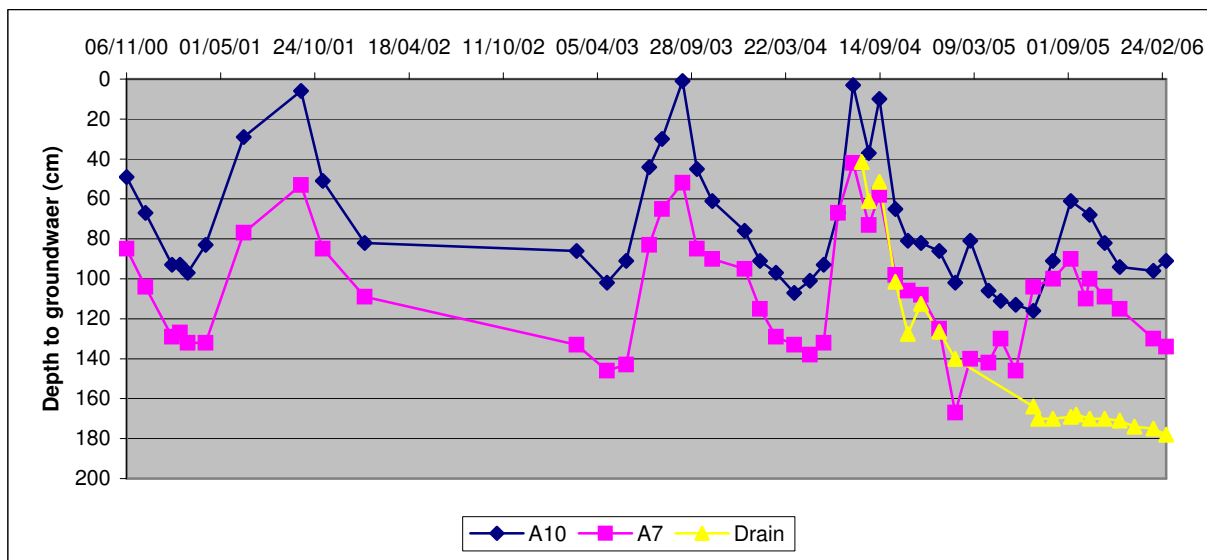


Figure 1: Depth to groundwater in two bores (A7 & A10) and depth to water level in the drain on the ‘Erelma Downs’ property surrounding the experimental site for the duration of this and previous studies.

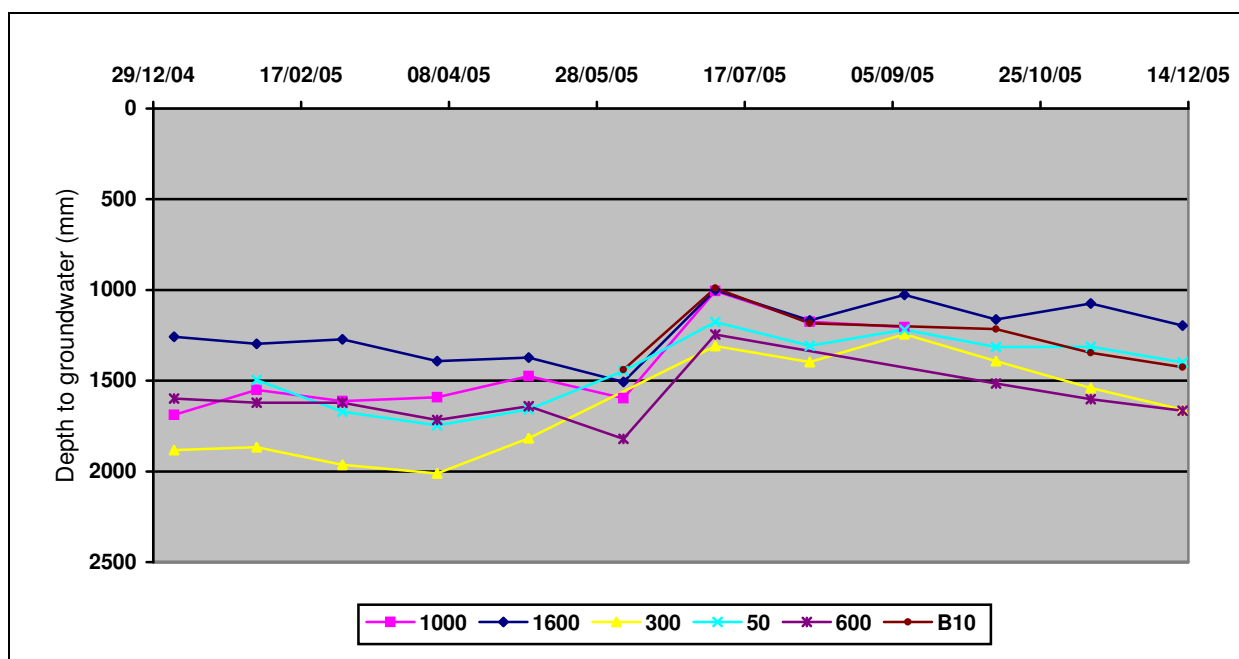


Figure 2: Depth to groundwater in the 6 shallow (to 3.5 m) piezometers installed at and near the experimental site at different distances from the nearby drain. Piezometer ‘B10’ was adjacent to the unimproved pasture plots and piezometers ‘600’ and ‘1000’ were within the improved pasture plot area

Water quality (electrical conductivity, as a measure of salinity) also varied in all areas monitored but not to the same degree as the groundwater levels. The drain water was consistently the saltiest, peaking at 45.2 dS/m in March 2005. In contrast water out of the 2 bores was similar to each other and generally between 15 and 20 dS/m, making it still just suitable for dry sheep and cattle as stock water (dry sheep on dry feed are the most tolerant stock class to salty water, being able to survive at levels up to 25.5 dS/m (DWLBC “Measuring Salinity” Fact sheet)). The drinking water collected from water troughs at the grazing site was the least salty, peaking at 13.2 dS/m in January 2005, but generally ranging between 5 and 8 dS/m and making it relatively

high quality stock water. This water is taken from a bore in the sand range to the west of the experimental site.

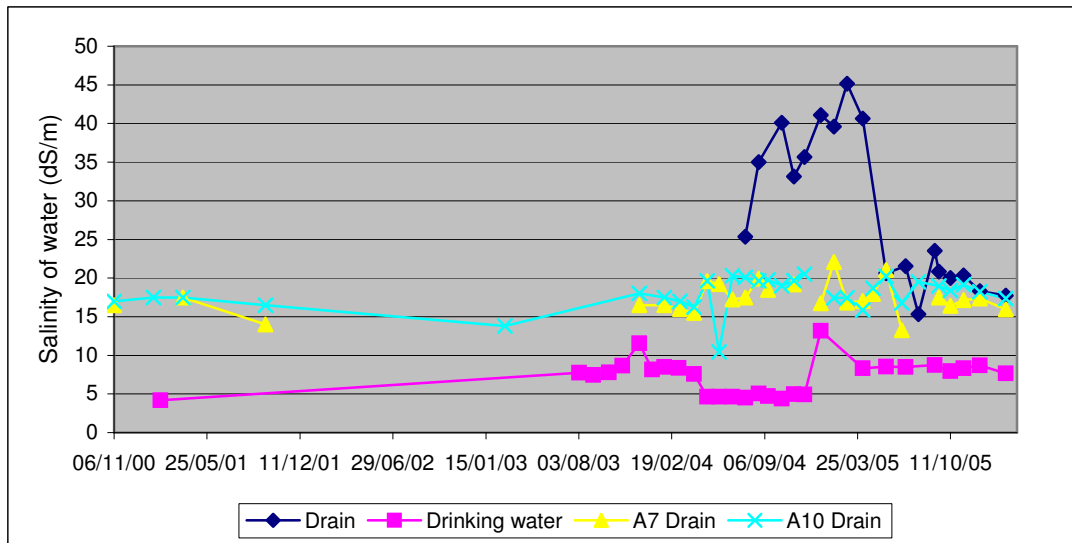


Figure 3: Salinity of water from the two bores, the drain and the drinking water on the ‘Erelma Downs’ property at Mt Charles.

Soil salinity showed a very marked seasonal pattern typical of the region, with levels peaking around 16 dS/m (ECe) in summer each year but dropping to non-saline levels (1-2 dS/m) over winter and early spring (Figure 4). This highlights the transience of salinity in this region, where soil salinity levels generally do not limit winter pasture growth. Figure 4 also shows the inverse relationship between rainfall and soil salinity levels, providing an explanation for this seasonal transience. Germination of annual pasture species in autumn, and flowering and seed set in mid to late spring, are the two times that soil salinity levels are likely to impact on pasture performance in this region. Figure 5 further highlights the seasonal nature of the soil salinity, as well as demonstrating the similarity in this pattern between the 8 treatments involved in the grazing experiment. Soil pH was not as variable as salinity levels (Figure 6), fluctuating around the neutral zone for all treatments and showing some seasonality in this fluctuation.

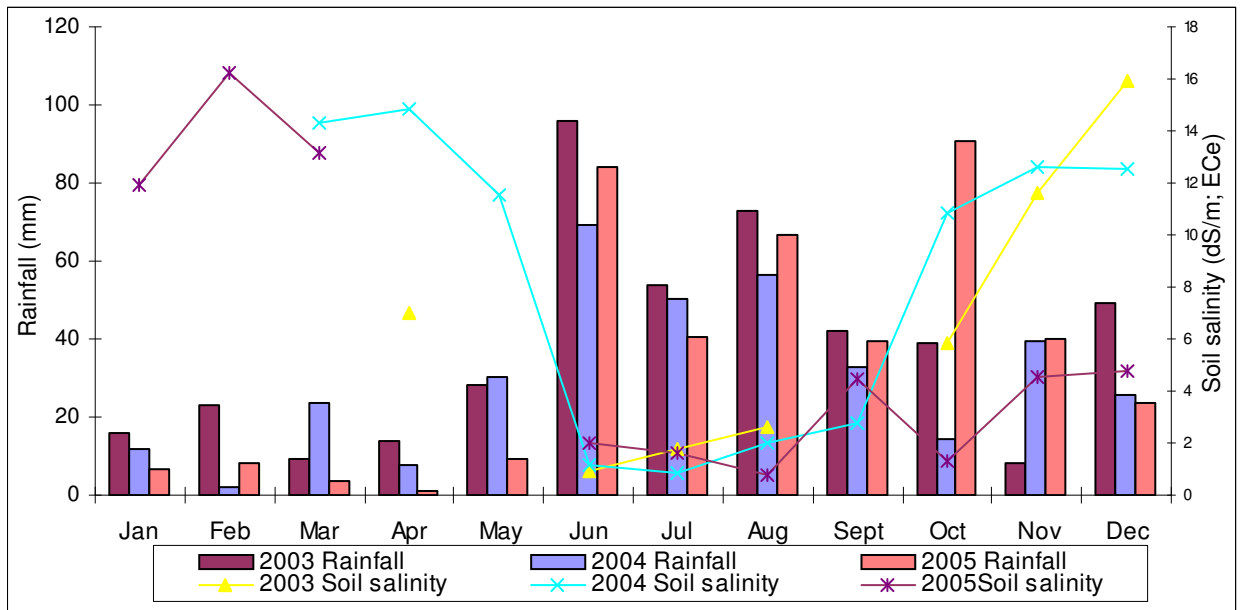


Figure 4: Salinity in the top 0-10 cm of soil averaged across the experimental plots for each of the years of the grazing experiment, along with monthly rainfall for those years.

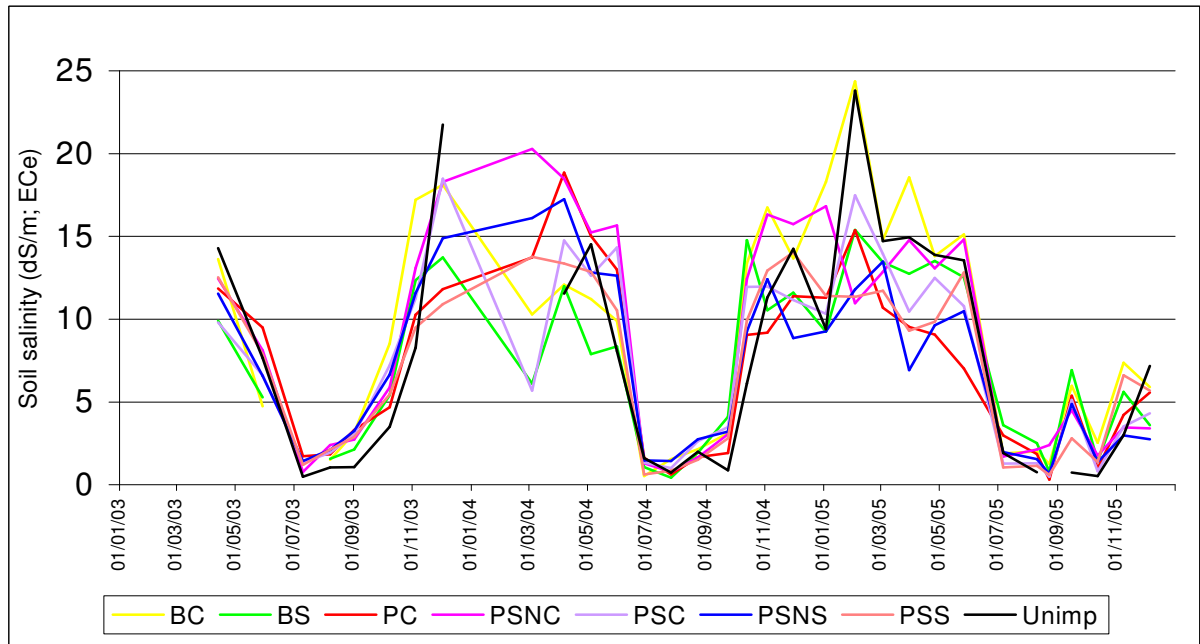


Figure 5: Salinity in the top 0-10 cm of soil for each of the experimental treatments (BC = Balansa Clover, strategically grazed; BS – Balansa Clover, continuously grazed; PC = Puccinellia, continuously grazed; PSNC = Puccinellia + Super + Nitrogen., continuously grazed; PSC – Puccinellia + Super; continuously grazed; PSNS = Puccinellia + Super + Nitrogen, strategically grazed; PSS = Puccinellia + Super, strategically grazed; Unimpr = unimproved).

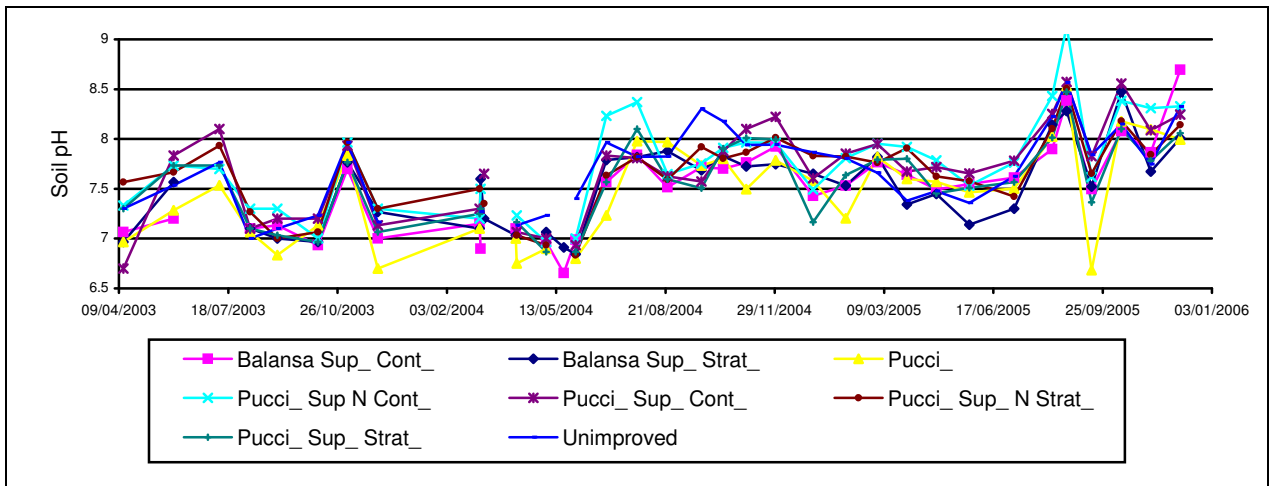


Figure 6: Soil pH for each of the treatments at the grazing experiment.

Pasture productivity: Pasture production was significantly greater in the puccinellia-dominant pastures with nitrogen or balansa clover added (PSN and BC in Figure 7) in 2005. Similar pasture growth data is not available for 2003 or 2004 as the 2005 data was collected from an extensive set of exclusion cages in the grazing plots. Figures 8 and 9 show the pasture mass in each of the treatments (averaged from the three replicate plots) and indicates that grazing management was effective in keeping all animals on a relatively similar level of pasture availability after the 2003 spring flush had been consumed early in 2004. Figure 9 also demonstrates the excellent spring that was encountered in 2005, where pasture growth ‘got away from us’ in all treatments.

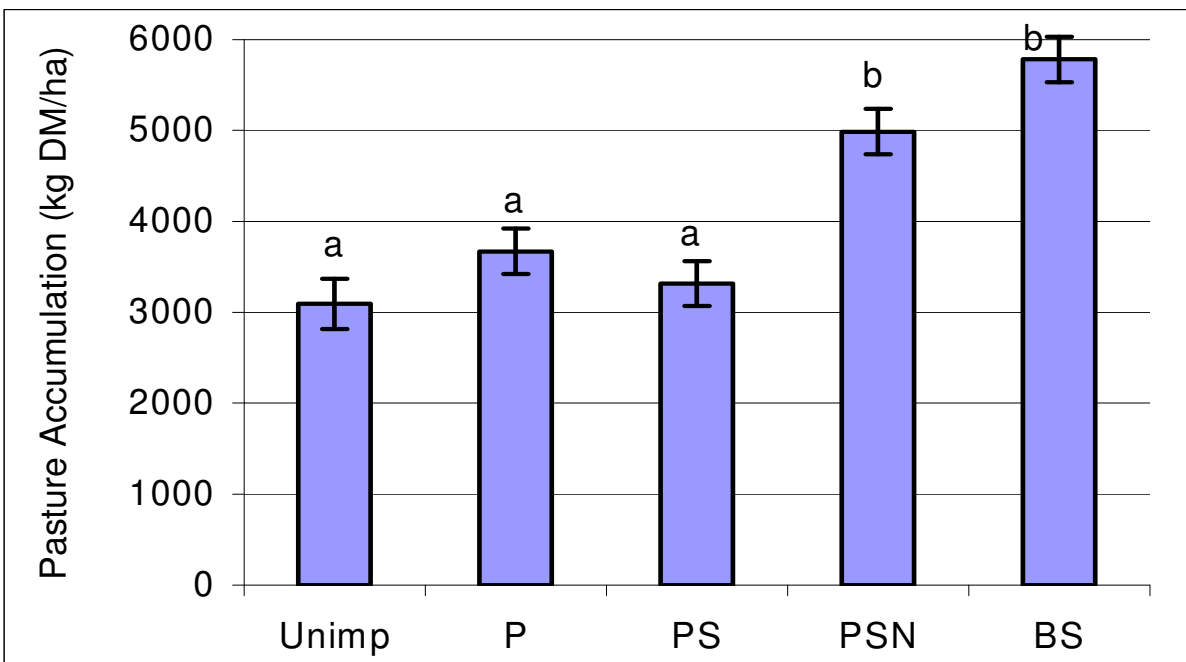


Figure 7: Pasture accumulation in 2005 for unimproved (Unimpr), puccinellia (P), puccinellia + super (PS), puccinellia + super + nitrogen (PSN) and puccinellia + super + balansa clover treatments. Columns with difference letters are significantly different at $P = 0.05$.

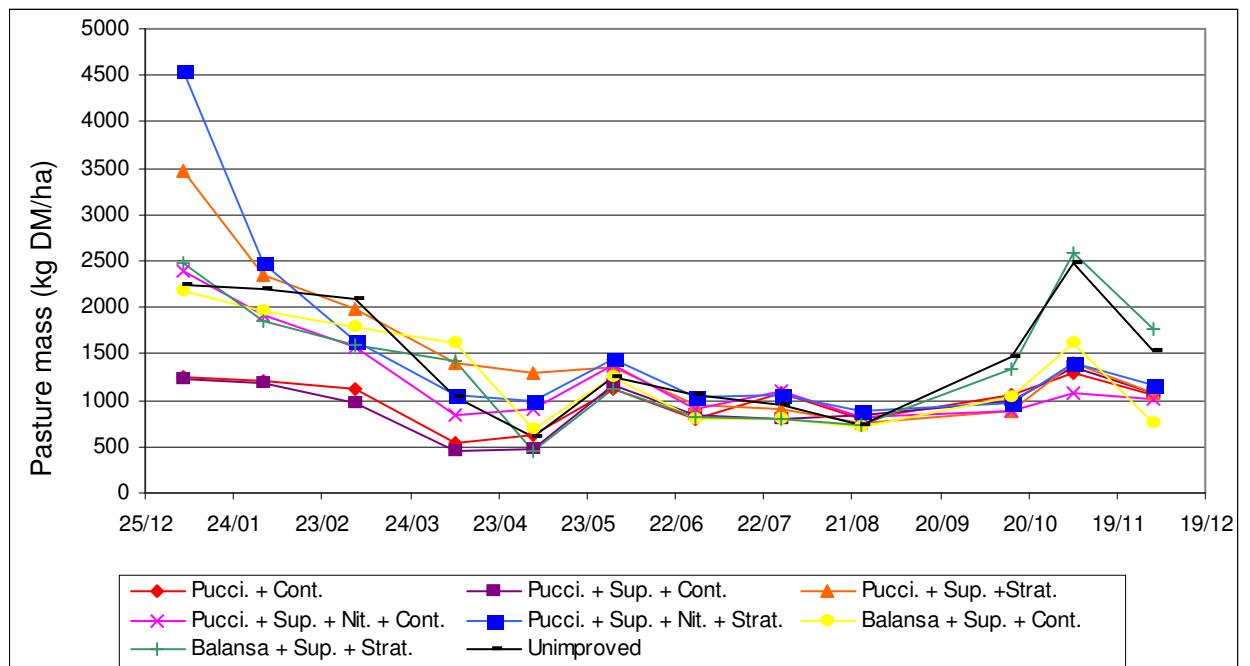


Figure 8: Pasture mass during 2004 for each of the treatments in the grazing experiment.

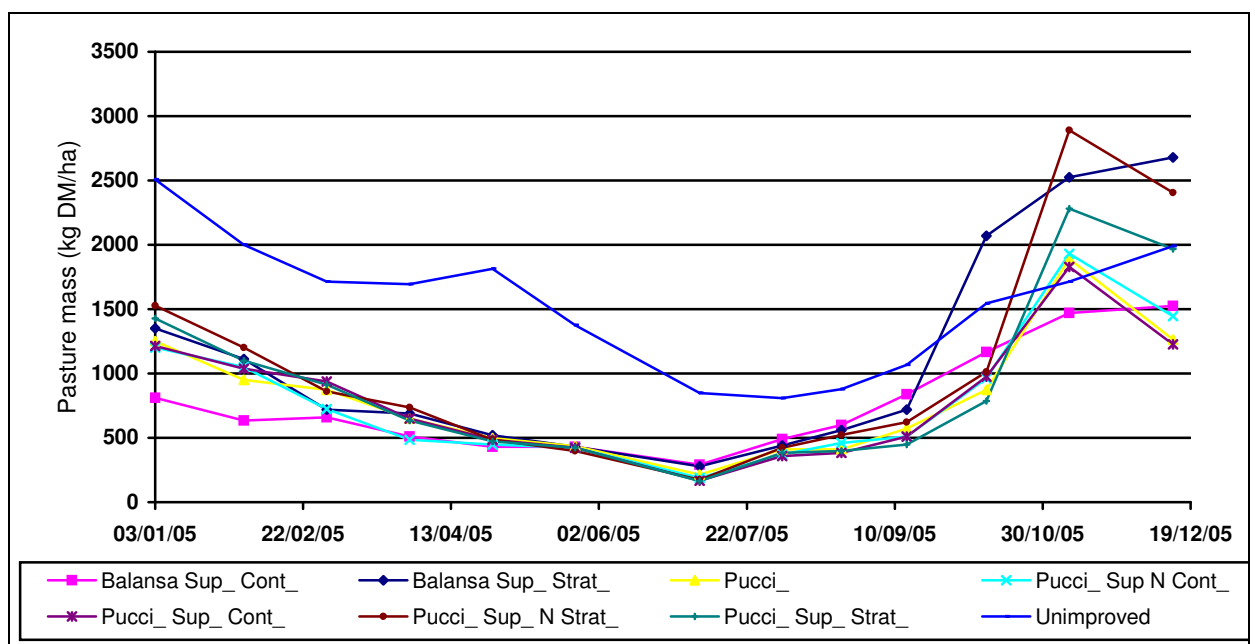


Figure 9: Pasture mass during 2005 for each of the treatments in the grazing experiment.

Pasture composition: Pasture composition was successfully and significantly manipulated by the treatments superimposed in this experiment, with the clover percentage being increased from about 5% to 27.5% by oversowing the puccinellia-dominant pastures with balansa clover. The percentage of barley grass in the sward was similarly decreased from about 29% down to 12 percent with this pasture improvement, whereas the percentage of puccinellia in the sward decreased from about 45% to 39%. There was also a significantly lower level of barley grass in the improved pastures than in the unimproved pastures and less puccinellia in the unimproved pastures than the improved pastures. These provide some explanation, along with the pasture mass data, for the animal performance difference described below.

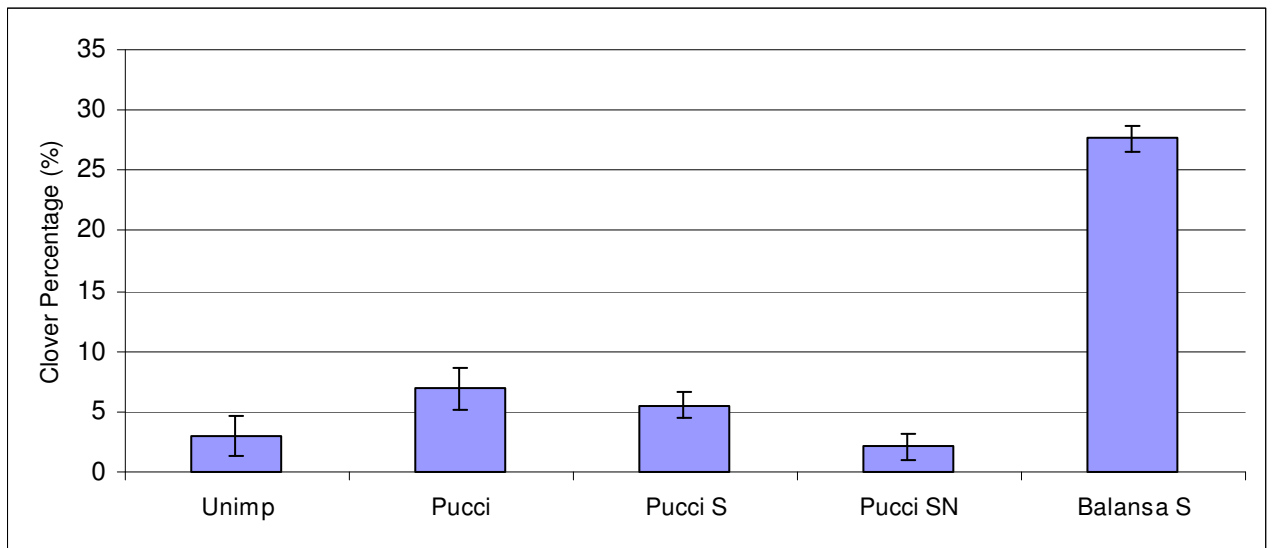


Figure 10: Clover percentage in each of the treatments in the grazing experiment, averaged over 2004 and 2005.

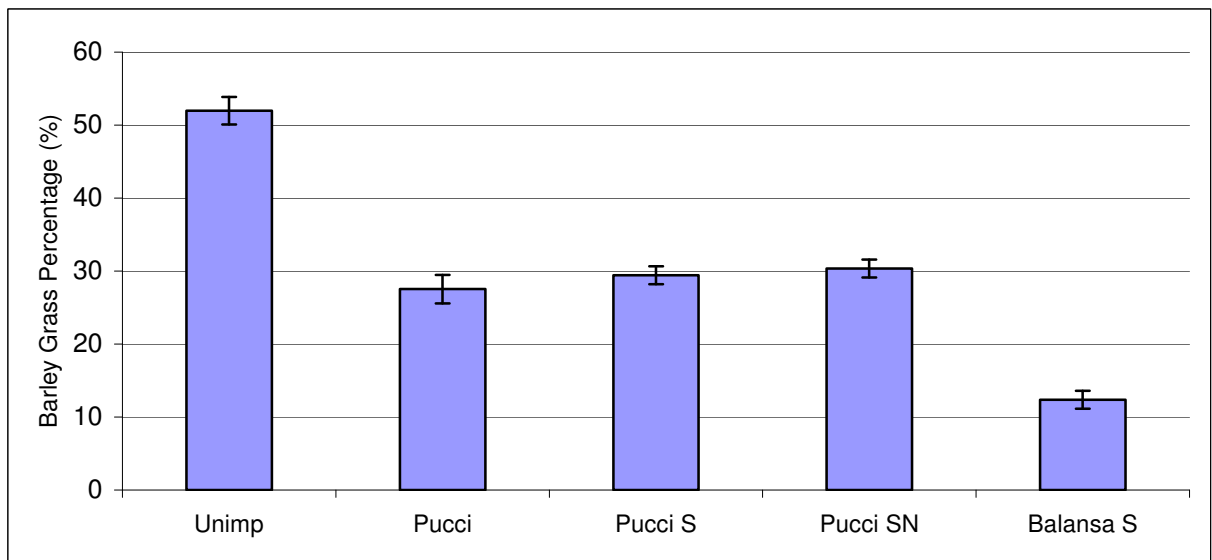


Figure 11: Barley grass percentage in each of the treatments in the grazing experiment, averaged over 2004 and 2005.

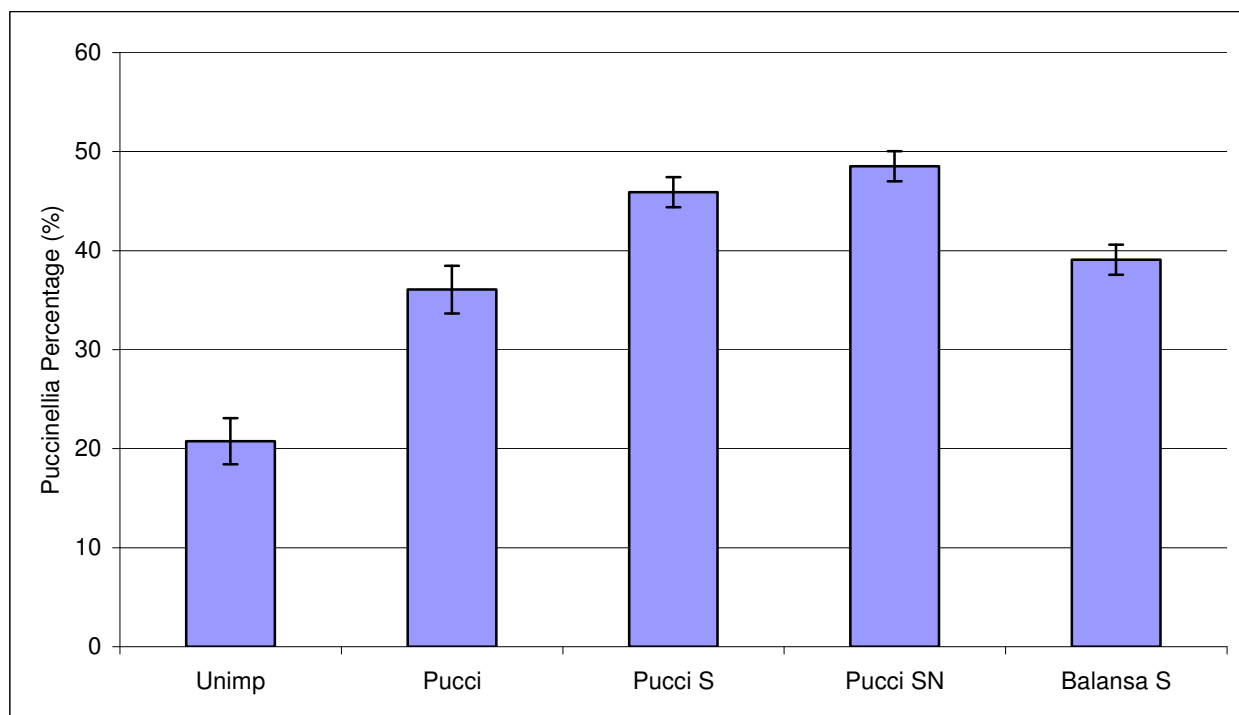


Figure 12: Puccinellia percentage in each of the treatments in the grazing experiment, averaged over 2004 and 2005.

Animal productivity: Significant differences ($P = 0.004$) were found in liveweight gain per hectare between years in this grazing experiment, with the poor start but long spring of 2005 resulting in better animal performance than 2004. Significant differences were also found between some of the pasture treatments across the 2004 and 2005 grazing years (Figure 13), with the Balansa Clover + Super treatment outperforming all except the Puccinellia + Super + Nitrogen treatment and the Unimproved pasture type being significantly lower than all the other treatments. It is important to note that these data need to be reanalysed once it has been possible to convert the liveweight gain data into a more appropriate form, such as metabolisable energy utilised, as this format will more adequately account for effects of different stocking rates and maintenance requirements within the treatments.

Despite this caveat, it is interesting to note that the Puccinellia only and Puccinellia + Super treatments were not significantly different to each other in terms of liveweight gain, indicating that the extra superphosphate applied to the latter treatment did not result in a pasture (see Figure 7) or an animal response. This is likely a result of the relatively strong superphosphate history of the property and the fact that soil test from a number of test pits dug at the site indicated low soil surface Colwell P levels (typically 6-10 mg/kg), but much higher levels at 25-40 cm (26-28 mg/kg). It is proposed that the puccinellia pastures were able to access this available phosphorus for growth due to the sandy nature of the soil.

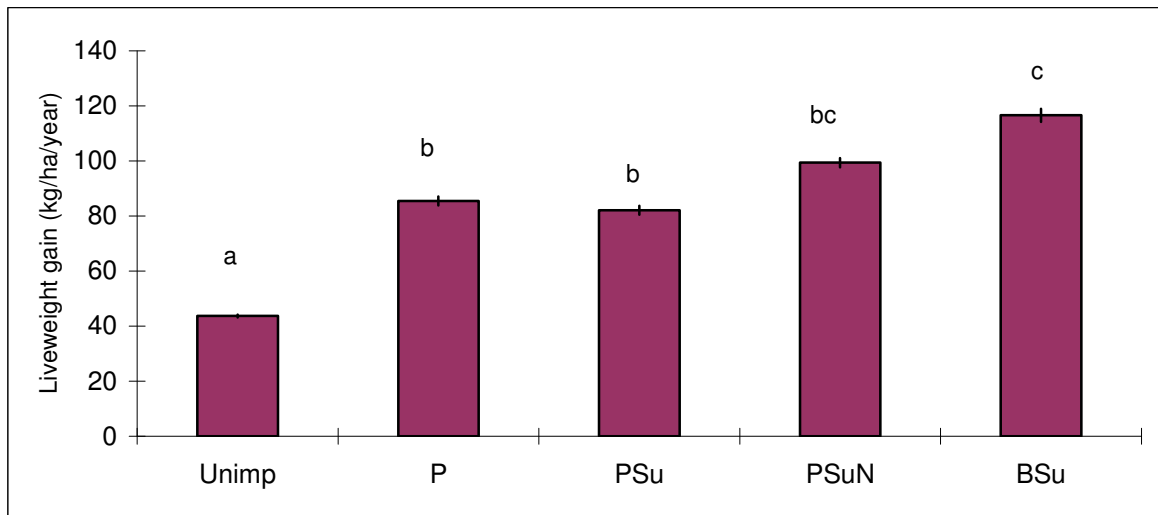


Figure 13: Average liveweight gain per year achieved over 2004 and 2005 for each of the pasture and fertiliser treatments (Unimp = Unimproved; P = Puccinellia only; PSu = Puccinellia + Super; PSuN = Puccinellia + Super + Nitrogen; BSu = Balansa Clover + Super). Different letters against columns indicates significant difference at $P>0.05$)

Furthermore, continuously grazed treatments had higher liveweight gain per hectare than their strategically grazed counterparts (i.e. Puccinellia + Super, Puccinellia + Super + Nitrogen and Puccinellia + Balansa Clover treatments) (Figure 14), however this effect appears to be mainly an effect of the strategically grazed treatment animals being moved from high quality puccinellia-based pasture in spring onto unexpectedly lower quality lucerne-based pasture in 2004. In 2005 there were generally not significant differences between the two grazing strategies. This it appears that a strategic grazing strategy has no beneficial (or detrimental) effects on liveweight gain as long as the alternative pasture type is of similar or greater quality to the spring pasture on which the animals would otherwise have been grazing.

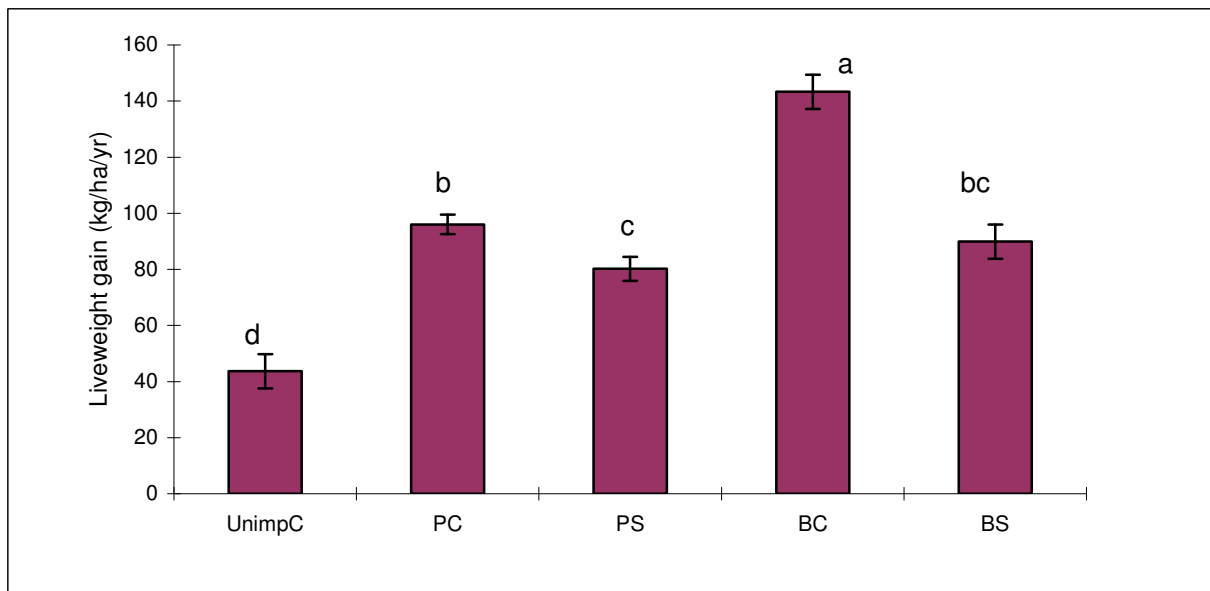


Figure 14: Average liveweight gain per year achieved over 2004 and 2005 for each of the pasture types and the two grazing strategies (UnimprovedC = Unimproved continuously grazed; PC = Puccinellia only continuously grazed; PS = Puccinellia only strategically grazed; BC = Balansa Clover continuously grazed; BS = Balansa Clover strategically grazed). Different letters against columns indicates significant difference at $P>0.05$)

Supplementary feeding: In 2005 the Continuously grazed animals were fed less supplement over the summer-autumn than their Strategically grazed counterparts due to the crash grazing of the Strategic plots at the start of the year to decrease the surplus dry matter left over from the previous spring (remembering that these plots were not grazed from about the time of balansa clover flowering) (Figure 15). As the pasture type was improved (i.e. from Unimproved through to Balansa Clover treatments) the level of supplementary feeding increased. This is likely to be largely a function of the increase in stocking rate in these treatments.

The much early break to the season in 2004 resulted in the sheep being fed significantly less supplement than in 2005 (Figure 16). Furthermore, the Continuously grazed animals were generally fed more than the Strategically grazed ones, due to the high dry matter residues that existed in the Strategically grazed plots from 2003.

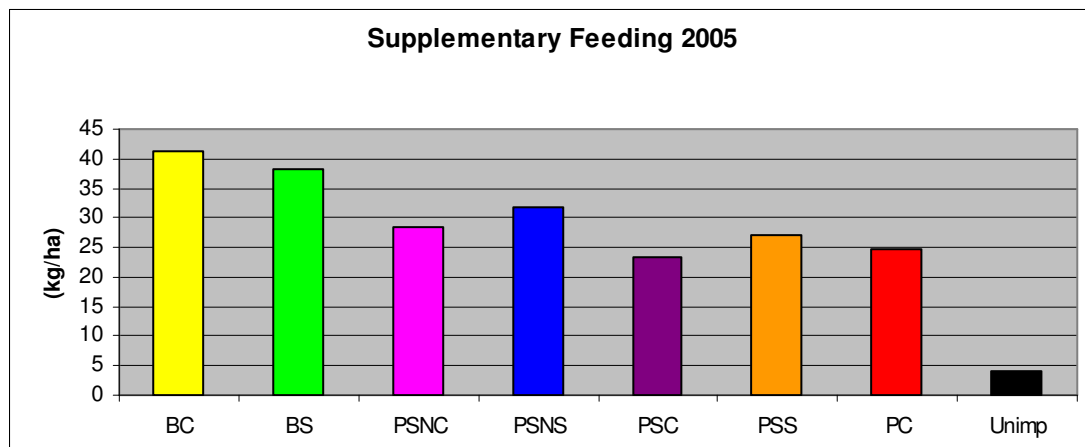


Figure 15: Total supplementary feed distributed in 2005 (BC=balansa continuous, BS=balansa strategic, PSNC=puccinellia super nitrogen continuous, PSNS=puccinellia super nitrogen strategic, PSC=puccinellia super continuous, PSS=puccinellia super strategic, PC=puccinellia continuous and Unimp=unimproved).

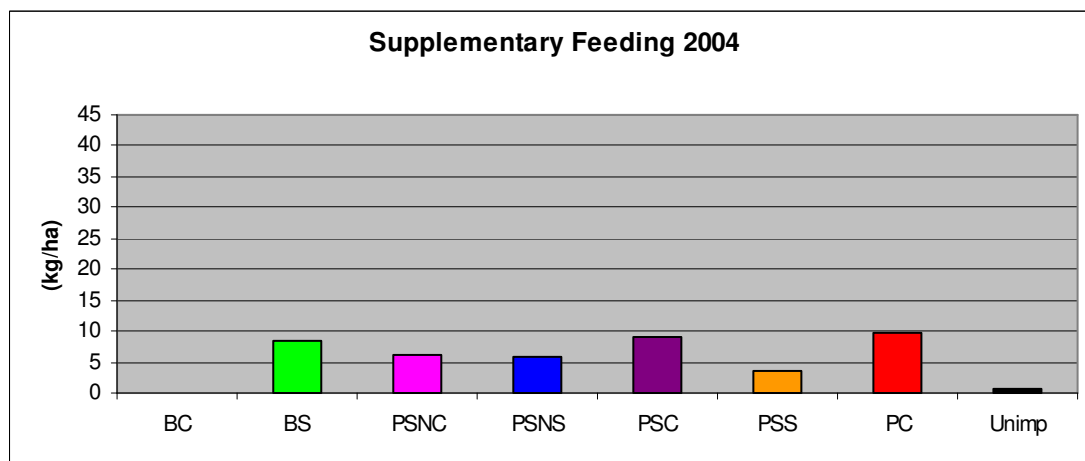


Figure 16: Total supplementary feed distributed in 2004 (BC=balansa continuous, BS=balansa strategic, PSNC=puccinellia super nitrogen continuous, PSNS=puccinellia super nitrogen strategic, PSC=puccinellia super continuous, PSS=puccinellia super strategic, PC=puccinellia continuous and Unimp=unimproved).

Wool production: Largely mirroring the liveweight gain results (above) are those of wool production. Highly significant differences ($P < 0.03$) in greasy and clean fleece weight per animal and per hectare, fibre diameter, coefficient of variation of fibre diameter, yield, staple strength, staple length, percentage of mid-point break and point of break of staples were all shown, indicating the vastly different climatic years encountered in this project.

Of greater interest is that greasy and clean fleece weights per hectare were significantly higher the Balansa + Super treatment than the Puccinellia + Super + Nitrogen treatment, which in turn was higher than the Puccinellia and Puccinellia + Super treatments (not significantly different to each other) and the Unimproved treatment produced the lowest fleece weights per hectare (Figure 17 – clean fleece weight only). Similar effects were evident for coefficient of variation of fibre diameter (Unimproved > Pucci + Super + Nitrogen > Pucci = Pucci + Super = Balansa Clover), length to point of break (Unimproved < Pucci + Super + Nitrogen < Pucci = Pucci + Super < Balansa Clover + Super), but no significant differences were found in yield, percentage of mid-point break, staple strength, staple length or fibre diameter. No significant differences were found between the Continuous and Strategic grazing strategies in any of these parameters.

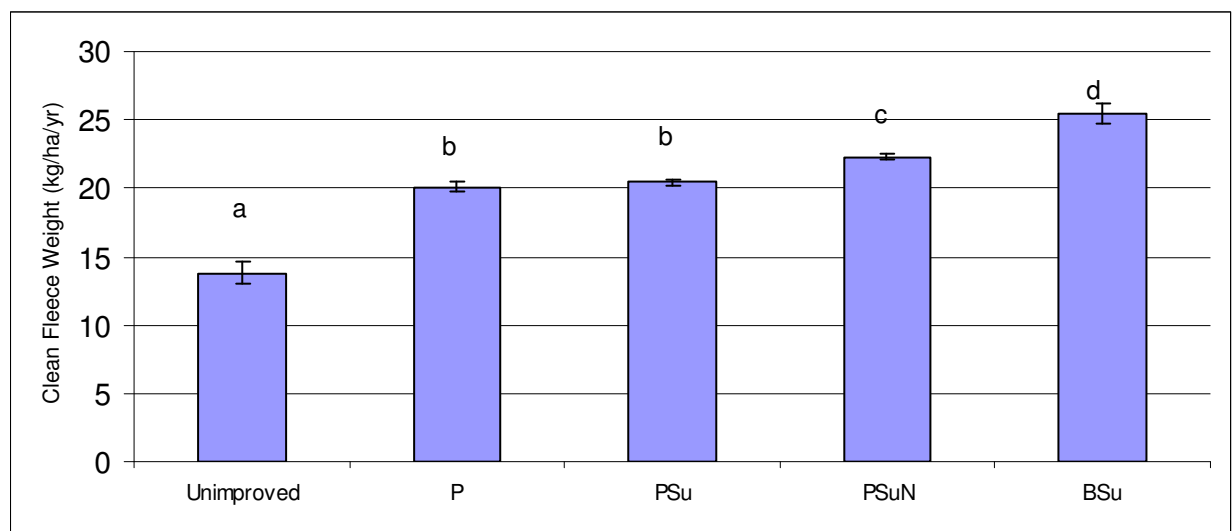


Figure 17: Clean fleece weights per hectare per year for Unimproved, Puccinellia only (P), Puccinellia + Super (PSu), Puccinellia + Super + Nitrogen (PSuN) and Balansa Clover + Super (BSu) treatments.

Persistence of balansa clover: Germination counts in the first year were great; in 2004 we had a very low germination count, but the counts were done too early in May. In 2005 the germination counts were done late in July and therefore we had the same amount germinate as in 2003. In 2006 we completed another germination counts that resulted in very poor germination (Figure 18). It is likely that this 2006 figure is a function of a very early break to the season, followed a prolonged period of dry and warm weather resulting in the death of the germinated seedlings. Further germination counts will be undertaken in 2007 in the hope that sufficient hard seed has remained in the soil to result in regeneration of the balansa clover in the system, otherwise producer predictions that balansa clover last for 2-3 years only will have been supported by these data.

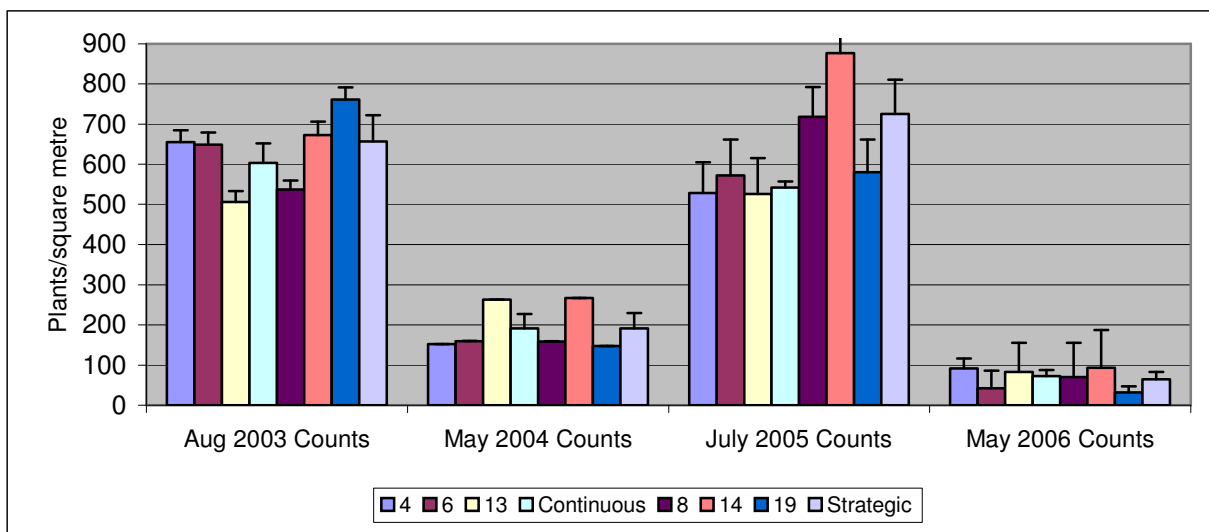


Figure 18: Balansa clover germination counts for each of the plots and an average of the strategic and continuous grazed plots over three years.

Seed yields, as another measure of persistence, were high in December 2003 after the balansa clover was established and then dropped by April of the second year for reasons unknown (Figure 19). From April 2004 onward the seed yields stayed at around the same levels in December and April 2004 and 2005. This data supports the persistence of balansa clover in the newly established sward until December 2005, however further collections have not been made since that time.

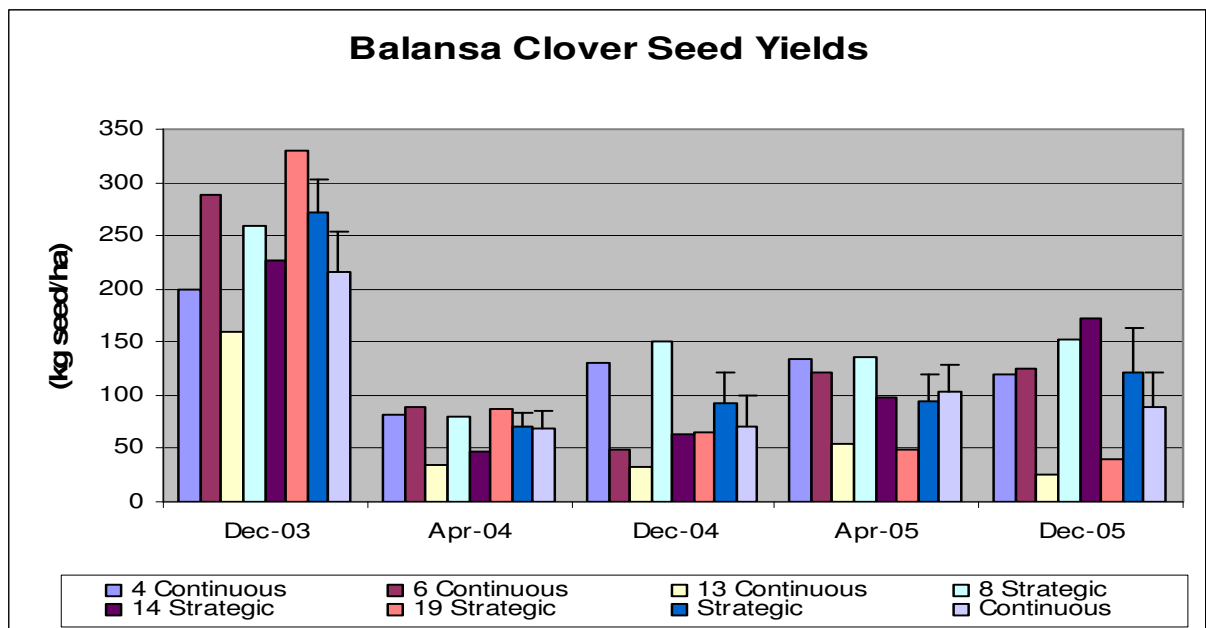


Figure 19: Balansa clover seed yields for each plot and an average of the continuous and strategic grazed plots

An interesting piece of biology that was discovered in this project was ECe of 10 is the threshold for balansa clover germination above this there is no germination and below there can be up to 1750 plants/m².

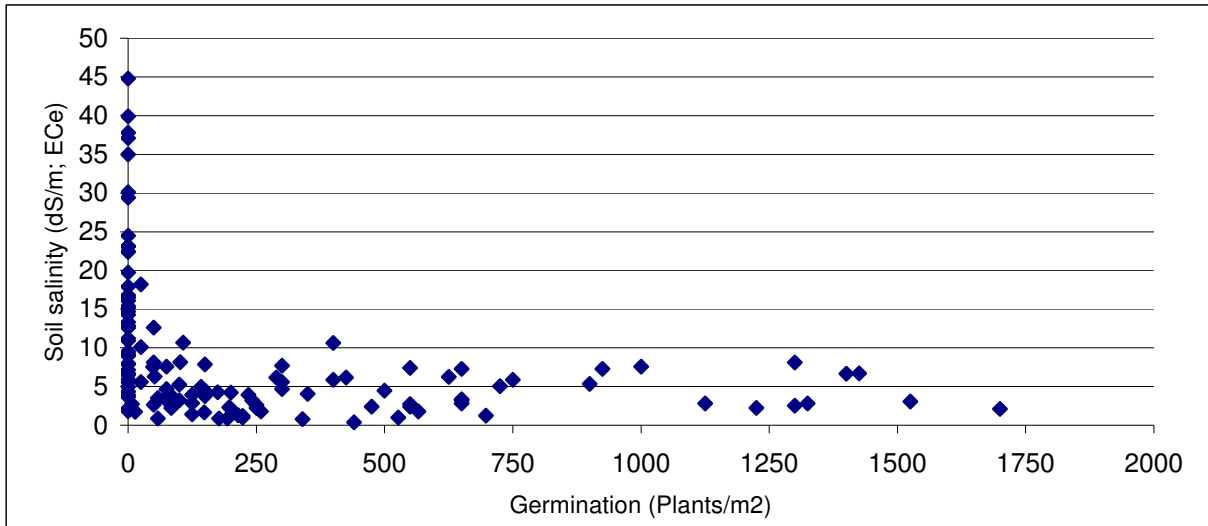


Figure 20: Germination of balansa clover by soil salinity in the top 10cm in the Upper South East of SA.

Sustainability/Biodiversity results: There are three indexes for Landscape Functional Analysis - stability, infiltration and nutrients. Figure 21 indicates that each of these indices has increased as we move up the scale of vegetation type from a bare scald to remnant vegetation, with the range of improved pastures sitting between these two extremes. In simplistic terms this indicates that improved pastures are somewhere mid-way between a bare scalded area and a patch of remnant vegetation in terms of landscape function – i.e. we have not degraded the land by improving the pasture.

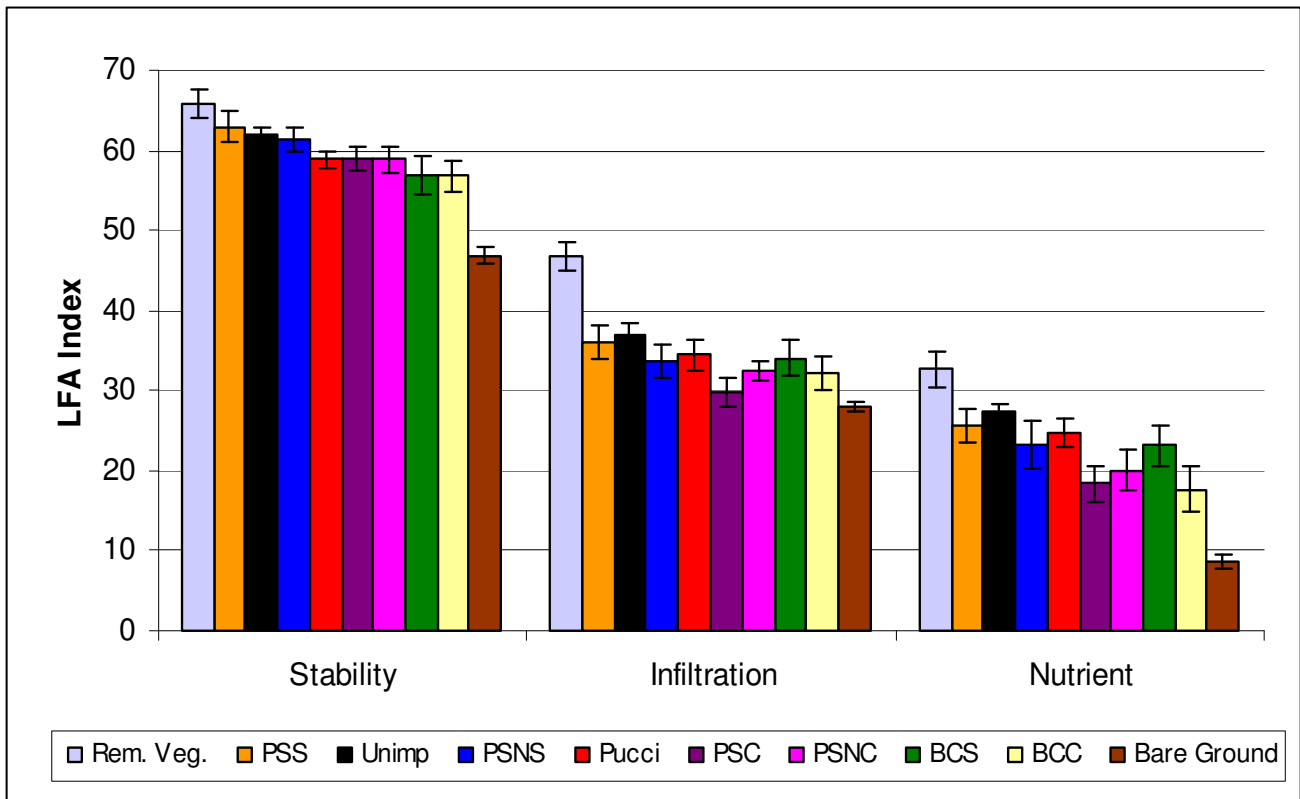
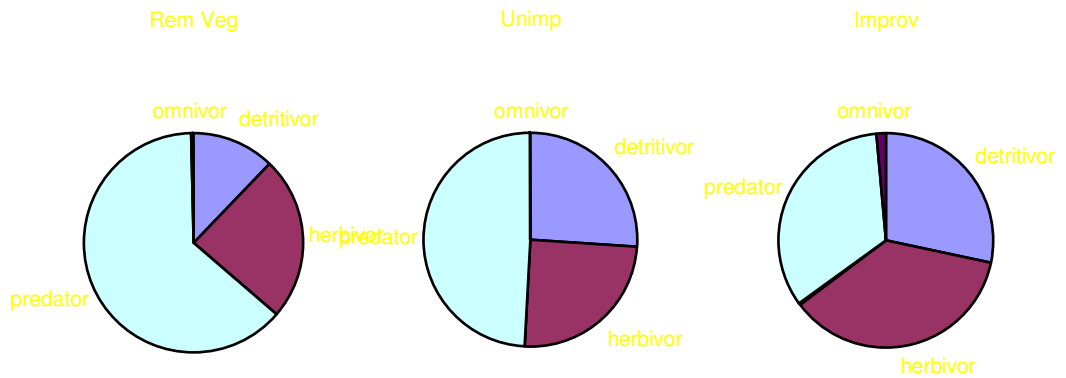


Figure 21: Landscape Functional Analysis (LFA) of the different pasture types as well as an adjacent are of remnant vegetation and bare salt scalds at “Erelma Downs”, Mt Charles.

A more difficult piece of data to interpret is that presented in Figure 22, which presents the proportions and breakdown of soil surface invertebrates discovered in the remnant vegetation area, unimproved pastures and improved pastures. Again, a simplistic summary is that there was an increase in the number of predators collected at each of the sites, which is apparently unusual but what does it mean? Perhaps this question will be answered in the Biodiversity Theme report!

Oct 04



May 05

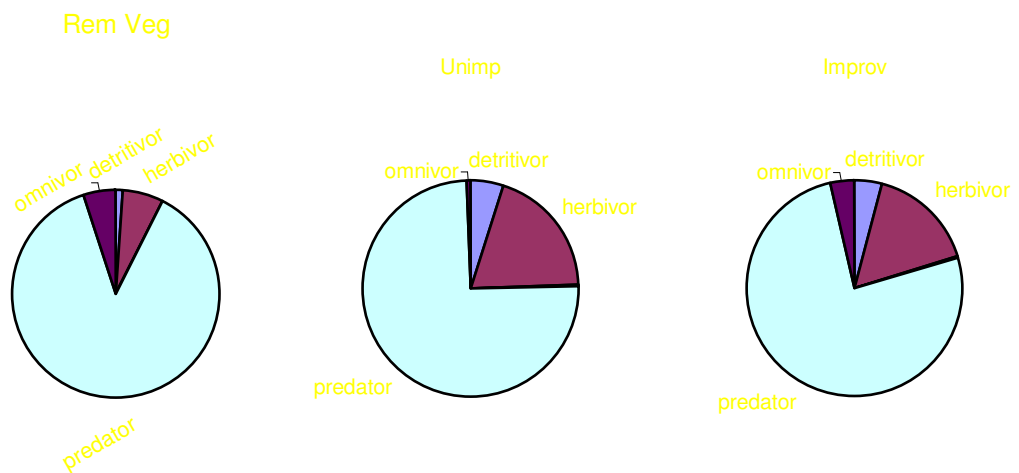


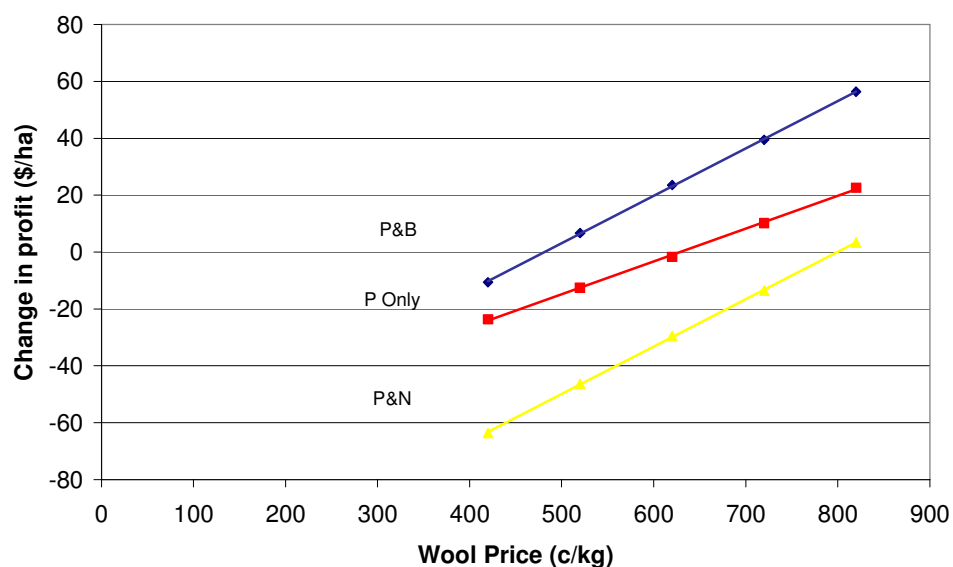
Figure 22: Soil Surface invertebrates collected from the Remnant Vegetation, Unimproved and Improved pasture areas in October 2004 and May 2005 and sorted and classified in terms of functional groups.

Economic analyses: The most profitable treatment compared to the Unimproved pasture when run through the MIDAS farm optimisation model was Puccinellia + Balansa Clover. This treatment produced the best animal growth rate and wool quality at a relatively low cost. For the standard assumptions used in the model, profit was increased by around \$40 per hectare per annum, compared with around \$10 per hectare for the Puccinellia only treatment and a \$17 per

hectare loss for Puccinellia with annual topdressing of nitrogenous fertiliser (equivalent to Puccinellia + Super + Nitrogen treatment). This loss was brought about primarily due to the high cost of applied nitrogen, compared to the cost of re-seeding balansa clover every 5 years in the Balansa Clover treatment.

The results showed that the change in profit resulting from each of the treatments was not influenced by the structure of the sheep flock. This is contrary to other analyses conducted for the SGSL Program for experimental sites in Victoria and Western Australia. The most profitable flock structure for most conditions was the merino prime lamb (MPL) flock, although the value of more productive pastures on the shallow duplex soil was the same for the MPL and Wool flocks.

Other factors had a marked influence on the change in profit resulting from increased pasture growth and quality. Figure 23 shows the effect of wool price on the profitability of 3 treatments relative to the unimproved pasture. Puccinellia oversown with balansa clover is profitable for all but the lowest of wool prices used in the analysis.



P&B – Treatment 4, Puccinellia and balansa
P Only – Treatment 2, Puccinellia only
P&N – Treatment 3, Puccinellia with annual top dressing of nitrogen fertiliser

Figure 23: Change in profit for each treatment relative to the unimproved pasture at different wool prices

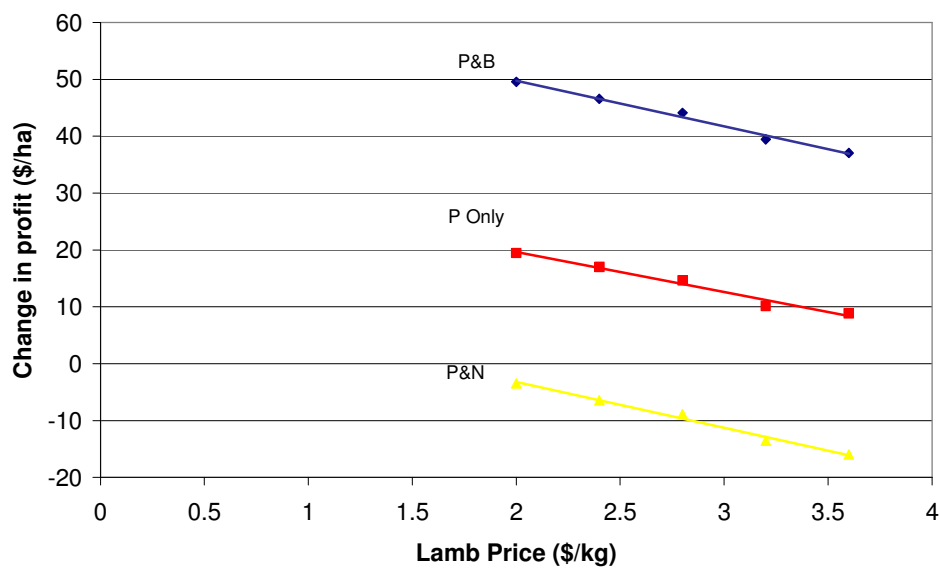
At the low wool prices the cost of establishing and maintaining the puccinellia/balansa clover mix is higher than the gross returns to the additional production achieved on this treatment, as estimated by the model. It was assumed that balansa clover would need to be re-sown into the puccinellia-dominant sward every five years, as seasonal conditions and grazing strategy are likely to lead to reduced density over time, however further analysis indicated minimal reduction in profit if this lifespan was reduced to 3 years (~\$2/ha/year reduction).

The puccinellia-only treatment was substantially less profitable than the puccinellia + balansa clover mix, with the main difference between these treatments, apart from the cost of re-sowing balansa clover, being the pasture quality. Over the growing season the quality of the pasture without balansa clover was assumed to be two percentage points lower in digestible dry matter

(DDM). During the drier months the quality was assumed to be one percentage point lower. The difference in profitability therefore is due mainly to the additional production that can be achieved with better quality of pasture.

Puccinellia with annual applications of nitrogenous fertiliser was profitable only at any the highest wool prices used in the analysis. While the figure shows a positive return at 800c per kg the net return is unlikely to be sufficient to induce widespread adoption. The main factor influencing this result is the relatively high cost of topdressing with nitrogen fertiliser. The results of the trial indicated that there was no production (or quality) advantage over the balansa clover pasture mix, which is supported by the experimental results earlier.

Figure 24 shows the influence of prime lamb price on the change in average profit per hectare of the treatments assessed. Treatments 2 and 4 were profitable at all prices used in the analysis. Treatment 3 however was not profitable at any lamb price.



P&B – Treatment 4, Puccinellia and balansa
P Only – Treatment 2, Puccinella only
P&N – Treatment 3, Puccinellia with annual top dressing of nitrogen fertiliser

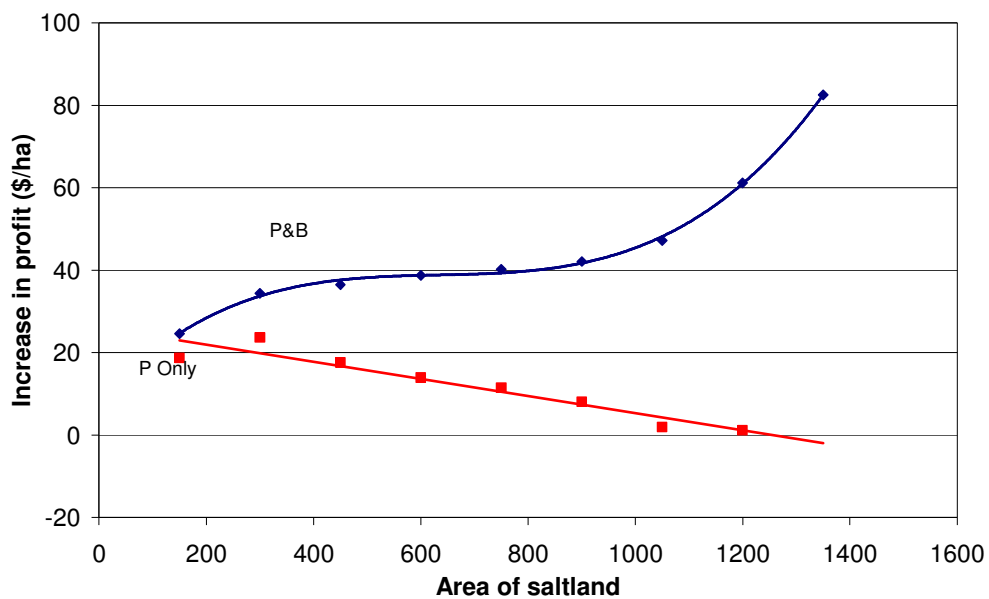
Figure 24: Change in profit for each treatment relative to the unimproved pasture at different prime lamb prices

Contrary to expectations the change in average profit per hectare resulting from all treatments is lower at the highest lamb prices. That is, farmers that have larger areas of saline land in this region will improve farm profitability by adopting puccinellia over unimproved pasture, however the gains per hectare are less than farmers that have smaller areas of saline land in this region. This result is largely influenced by the cost of supplementary feeding of grain, as represented in the model. It is assumed that the price of grain would increase as the amount fed increases, which occurs for two reasons. Firstly it is likely that the cost of transporting grain to the farm will be higher as larger volumes are purchased, as grain would need to be sought further from the farm. While this may not be true should an individual farmer increase the demand for grain, it is likely to be true if a large proportion of farmers in a region increased the quantity of grain demanded. Secondly, farmers would likely expect a higher return from additional grain feeding as increased requirement for labour reduces leisure time. That is, the

implied cost of the farmer's labour would increase as more labour is required to feed grain to livestock.

To take advantage of the higher prices farmers would need to increase production by increasing stocking rate. This would require higher levels of grain feeding because, despite puccinellia providing improved pasture growth, there is insufficient production in some periods to carry additional stock over the break of the season. So whilst this is a profitable strategy when lamb prices increase, the requirement for additional grain reduces the increase in average profit per hectare that would result from imposing the treatments used in the trial.

Figure 25 shows the affect of area of saline land in the Upper South of South Australia on farm profit for two for the treatments applied in the main grazing experiment. The results show that the increase in profit per hectare was highest for larger areas of saline land where Puccinellia oversown with balansa clover was applied. However, the increase in per hectare profit declined with area of saline land for puccinellia-only saline systems.



P&B – Treatment 4, Puccinellea and balansa
P Only – Treatment 2, Puccinella only

Figure 25: Increase in profit per hectare resulting from Treatments 2 & 4 at different areas if shallow duplex soil, which is susceptible to waterlogging and salt encroachment

The change in profit resulting from the puccinellia-only system declined for similar reasons outlined above for the downward sloping curves in Figure 24. That is, the increase in production from puccinellia-only saltland could only be capitalised upon if supplementary feeding also increased. The increasing cost of supplementary feeding with quantity fed meant that the average increase in profit per hectare was lower as the area of salinity in this environment increased.

Additional supplementary feed is required to utilise the additional pasture provided by the more productive pasture treatments in the trial.

Conclusion

Pasture production: Significant increases in pasture production for Puccinellia + Super + Nitrogen and Puccinellia + Super + Balansa Clover over all other pasture treatments.

Botanical composition: Achieved a significant increase in percentage of balansa clover (up to 27% of dry matter) and a significant decrease in sea barley grass (down to 12%); thereby increasing the quality of the pasture sward.

Animal production: Significant increase in animal production per hectare by adopting a Puccinellia + Super + Balansa Clover pasture treatment; Unimproved pastures had the poorest production.

Probably no difference between continuous and strategic grazing regimes, but seems to be somewhat confounded by poor lucerne quality in 2004.

Similar effects on wool production (greasy and clean fleece weight/ha), with clean fleece weight highest in Puccinellia + Super + Balansa Clover treatment, followed by Pucci + Super + Nitrogen > Pucci only & Pucci + Super > Unimproved

Economics: The 'best-bet' pasture treatment of improving existing puccinellis-dominant pastures by oversowing with balansa clover is the most profitable of the pasture systems considered when analysed on a whole farm basis.

Two of the three puccinellea pasture treatments assessed for saline soils in the Upper South East improved farm profitability. The increase in profit was highest when balansa clover was sown into existing puccinellia-dominant pasture, as it improved quality of the feed at relatively low cost.

The increase in profit was substantial under a range of price conditions, and likely to provide sufficient incentive to encourage reasonable levels of adoption in the region. The average per hectare value of puccinellia pasture is highest when the area is small, however large areas of puccinellia will increase whole farm profit but the average per hectare value will be lower.