

Production interactions between combinations of 4 perennial legumes and 5 perennial grasses, grown under high input management with and without applications of nitrogen

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Abstract

The value of legumes in high input pastures has come into question in recent years. High sowing rates of grasses (> 20 kg/ha) and the regular use of nitrogen fertilisers are contributing factors to the declining composition of legumes in pastures. However, legumes can be an important component of a mixed pasture sward, through their ability to fix atmospheric nitrogen and their high nutritive value. This study evaluated the dry matter (DM) contribution of legumes to irrigated mixed swards receiving either a nil nitrogen or a 40kg N/ha nitrogen treatment following each defoliation event. The experiment was sown with 29 pasture treatments consisting of mixed swards and monocultures of 5 grass species (perennial ryegrass cv. Base, tall fescue *Festuca arundinacea* cv. Quantum II MaxP, coloured brome *Bromus coloratus* cv. Exceltas, cocksfoot *Dactylis glomerata* cv. Megatas and phalaris *Phalaris* hybrid cv. Advanced AT) and 4 legume species (white clover cv. Bounty, red clover *Trifolium pratense* cv. Rubitas, strawberry clover *Trifolium fragiferum* cv. Palestine and Caucasian clover *Trifolium ambiguum* cv. Kuratas). The clover contribution (%) to production increased significantly ($P < 0.05$) in nil-nitrogen treatments compared with pasture mixes receiving nitrogen. The application of high rates of N fertilisers can inhibit significant contributions of legumes to overall production. White clover proved to be well adapted and the results of this study suggest it would difficult to justify the sole use of any alternative species tested.

Key words

Alternative pasture species, DM yield, perennial legumes, pasture composition, clover

Introduction

The majority of intensively managed pastures are characterised by grass dominant pastures requiring large inputs of nitrogen fertilisers to reach their potential productivity. However, legumes are promoted for inclusion in pastures because of their ability to fix nitrogen and improve nutritive value. The optimal proportion of legume in pastures is often quoted at around 30%. Recent studies by Suter *et al.* (2015) suggested that total nitrogen yield in mixed pastures increases with increased proportion of legumes up to one-third. However, McKenzie *et al.* (2003a) suggested that the amount of N fixation from white clover in mixed perennial ryegrass/white clover pastures was low and insufficient to maximise dry matter production and that strategic applications of inorganic N can assist maximise production. Further, the application of N fertilisers can result in a decrease in N fixation from legumes (Ledgard and Steele, 1992). Hence, the heavy use of synthetic nitrogen applications in pastures has brought into question the role of legumes in high input pastures. Although the feed nutritive value of forage is increased by incorporating legumes into pastures, there are other methods of increasing overall diet nutritive value such as supplementary feeding of grain in the dairy industry which may be a more efficient means of achieving this. The biggest challenge is retaining or promoting legumes in mixed swards without a penalty in overall dry matter (DM) yield. This study evaluated the persistence and contribution in terms of DM of legumes in a range of alternative mixed swards under high nitrogen and nil nitrogen inputs.

Methods

The experiment was established in 2014 at Cressy (41° 43'S, 147° 03'E) in Northern Tasmania where the mean annual rainfall is 628 mm and the elevation 147 m. The soil is a brown chromosol, and can be described as duplex with a heavy clay subsoil. The trial was sown in April 2014 with an Ojyard cone

seeder into a shallow cultivated seed bed, prepared over 12 months from a previously degraded pasture. The experiment was a randomised complete block design with four replicates. Pasture cultivars were sown as both monocultures and in mixed swards, using all the grass/clover combinations. Sowing rate for each cultivar was dependant on seed size and if sown as a monoculture or in a mix (Table 1). Growing season rainfall (November 2014 – April 2015) was 152.5 mm plus an additional 665 mm of irrigation applied to make the study fully irrigated. Plots received either nitrogen applied at 40 kg N/ha, or nil nitrogen following each harvest event. Maintenance levels of phosphorus and potassium were applied at 42 kg P/ha and 169 kg K/ha respectively. Weeds and pests were controlled as required, although in some plots volunteer grass, legume and broadleaf weeds became difficult to manage as a result of slow or poor establishment of the sown species.

Plots were cut twice during establishment in early spring, prior to dry matter evaluation at 6 harvest dates between November 2014 and April 2015. Dry matter (DM) yield was assessed at six defoliation events between November 2014 and April 2015. Defoliation interval was between 26 and 34 days depending on growth rates. Dry matter (DM) yield was assessed across all pasture treatment plots by quadrat cuts (2 per plot) when the perennial ryegrass plots had reached the three leaf regrowth stage. Plants were defoliated to 5mm using hand shears and following collection the residual plot area was mown to 5mm and the dry matter removed. Pasture samples were botanically separated into the individual cultivars planted, with weed and non-sown species removed. Samples were oven dried at 56 °C for 48 hours to determine DM yield. The yield data were analysed assuming a split plot design with the whole plot in a randomised complete block design using Proc Mixed in SAS v 9.3. Since the data from each plot were autoregressively correlated a repeated measures framework was used. After examining quantile-quantile plots of residuals the data an arc-sine square root transformation was selected. Predicted means are shown on the transformed scale.

Table 1: Sowing rates (kg/ha) of pasture cultivars in monoculture (mono) and mixed swards

<i>Grasses</i>	Mono	Mixed	<i>Legumes</i>	Mono	Mixed
Perennial ryegrass <i>cv. Base</i>	15	12	White clover <i>cv. Bounty</i>	6	3
Coloured brome <i>cv. Exceltas</i>	20	12	Red clover <i>cv. Rubitas</i>	6	4
Cocksfoot <i>cv. Megatas</i>	5	3	Strawberry clover <i>cv. Palestine</i>	6	3
Tall fescue <i>cv. Quantum II MaxP</i>	12	10	Caucasian clover <i>cv. Kuratas</i>	6	4
Phalaris <i>cv. Advanced AT</i>	5	3			

Results

There was a significant ($P<0.05$) nitrogen application effect on the dry matter production of all pasture treatments, with the exception of phalaris/white clover, phalaris/red clover and clover monocultures. The application of nitrogen had a significant ($P<0.05$) effect in suppressing the clover % of DM yields in mixed swards, with the exception of the coloured brome/Caucasian clover mixed sward. There was also a significant ($P<0.05$) harvest time effect on clover % of DM yields, except in perennial ryegrass/Caucasian clover, coloured brome/Caucasian clover and cocksfoot/Caucasian clover mixed swards. Significant ($P<0.05$) nitrogen*harvest time interactions were found in all mixed swards except perennial ryegrass/Caucasian clover and coloured brome/Caucasian clover. The contribution of all clovers to DM increased over time in both nil-nitrogen and nitrogen treated phalaris mixed swards (Figure 1).

Discussion

Overall production was higher in most pasture treatments receiving the nitrogen than the nil nitrogen. The non-significant effect in plots containing phalaris/white clover and phalaris red clover can be explained by the relatively low yields and growth habit of phalaris compared with other grasses, promoting the production of white and red clover. Further, the non-significant result in clover monocultures is due to their ability to fix their own nitrogen rather than rely on inorganic nitrogen being applied. The yields of Caucasian clover in all swards were significantly lower than other clovers. The April sowing time of this experiment is thought to have contributed to the relatively poor production of Caucasian clover in this instance, with spring sowing preferable for this relatively slower establishing species (Hall and Hurst, 2013). Further evaluation of Caucasian clover is required under are a more favourable sowing time as Caucasian clover has been shown to produce more N and more total dry matter in perennial ryegrass based mixed swards than white clover (Widdup *et al.* 2001).

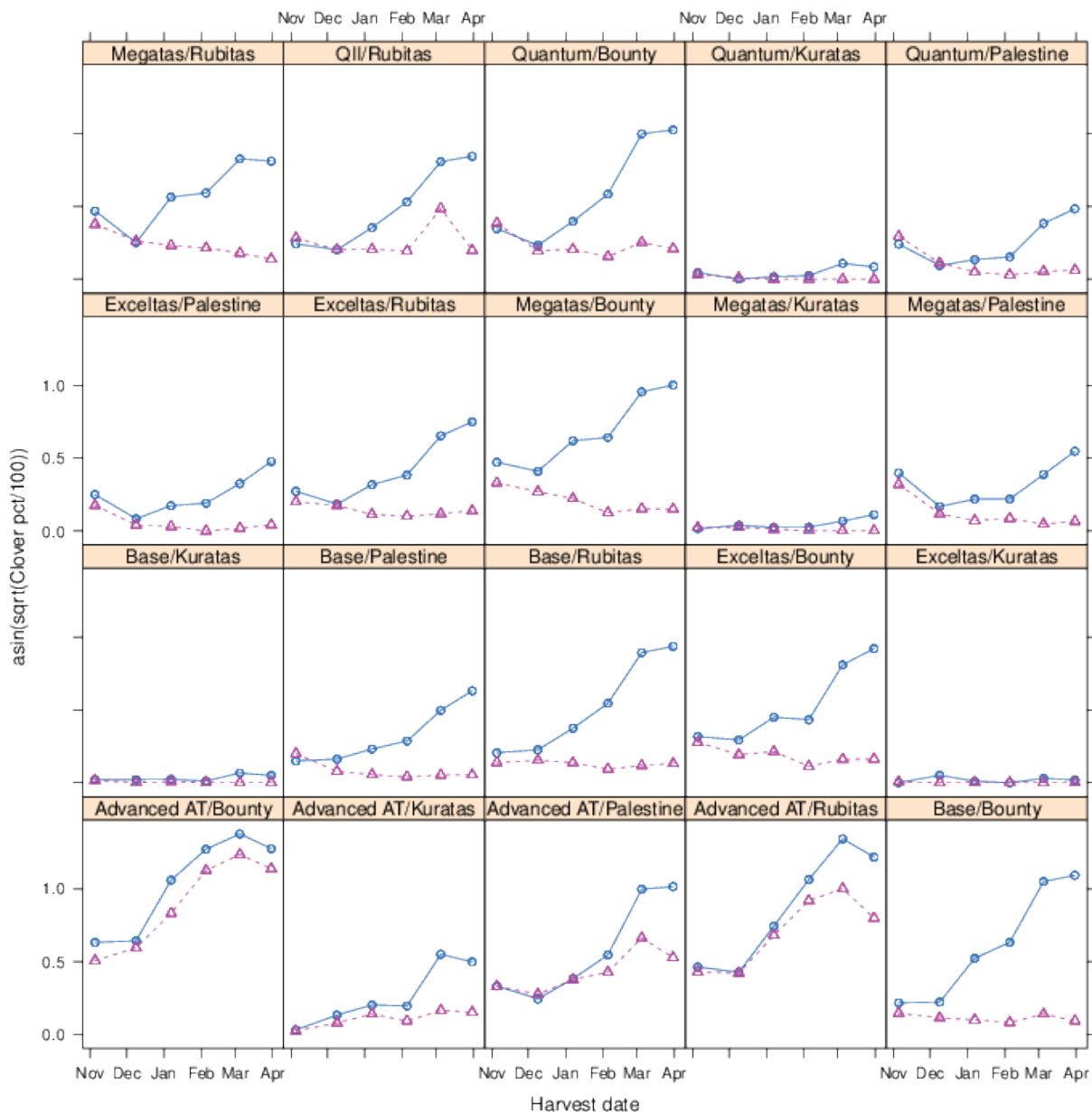


Figure 1: The contribution of dry matter (%) of clover in mixed pasture swards. Pasture treatments received either nil-nitrogen (blue circle) or 40 kg N/ha (pink triangle) following each harvest. Shown are the predicted means of clover contribution (%) on the transformed scale. The SE for each harvest dates are as follows; 0.04, 0.03, 0.04, 0.04, 0.06 and 0.04.

The application of nitrogen following each harvest suppressed the clover contribution (%) to the dry matter production. Clover contribution (%) to production remained low over time in plots receiving nitrogen. In contrast, the clover contribution (%) to production increased significantly in plots receiving nil nitrogen, with the exception of mixed swards with Caucasian clover. The increase in clover may be explained by the depletion of available nitrogen at each harvest date with the removal of dry matter and no nutrient return disadvantaging the DM production of grasses. It was observed that legumes became quite dominant in nil-nitrogen swards by the last harvest.

The contribution of legumes in fixing nitrogen was evident in some nil-nitrogen plots. It was observed that grass plants appeared healthier in nil-nitrogen mixed swards containing white clover and red clover was far superior to grasses in mixed swards with low amounts of Caucasian clover. This observation would affirm that N fixation is positively correlated with legume DM yield (Widdup *et al.*, 2001; Carlsson and Huss-Danell, 2003).

The observation that the clover contribution (%) to production increased in both nitrogen and nil-nitrogen phalaris plots over time is in contrast to plots based on perennial ryegrass, coloured brome and cocksfoot. The semi-erect growth habit and low level of summer dormancy (Culvenor, 2009) are likely to have promoted the growth of clovers; 1. Due to the reduced competition for light, the canopy was much more open; and 2. Lesser competition for nutrients. This observation provides a clue to how to maintain legumes in high input pastures. McKenzie *et al.* (2003b) showed that the composition of white clover in pastures can remain the same with increasing nitrogen applications, but the contribution to DM yields can be reduced. They cited that optimal grazing that maintains an open canopy is a possible reason for this.

The contribution (%) of the four legumes studied here to the production of mixed pastures receiving high rates of N fertilisers was low. White clover proved to be well adapted to the environment and the high input irrigation management used in this study and the results suggest it would be difficult to justify the sole use of any alternative species tested. Efforts may be better placed in determining a grazing management system that promotes the growth and persistence of clovers. However, the urgency to develop such management systems may be reliant on the price of inorganic N fertiliser.

Conclusion

This study has shown that the application of high rates of N fertilisers will inhibit significant contributions of legumes to overall production. Further experiments using a range of nitrogen rates is required to find the correct rate for optimising legume composition. In addition, further work is required to evaluate the contribution of these legumes in improving feed quality, as DM production is just one factor in animal production.

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