Effect of basal frequency on phalaris (*Phalaris aquatica*) pasture production

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Abstract
A plot experiment was conducted to determine a critical phalaris basal frequency for pasture production. Small plots (0.84m^2) in an existing phalaris pasture were modified to a range of basal frequencies (40-50%, 30-39%, 20-29%, and 10-19%). Pasture dry matter and composition was assessed during the growing season. Phalaris production was reduced when basal frequency was below 20% but growth of annual grasses and subterranean clover resulted in no differences for total seasonal production. The addition of nitrogen increased total pasture production by 37% but reduced clover production by 45%. It is suggested that if basal frequency of phalaris is below 20% then management strategies need to be implemented to increase basal frequency or re-sowing the pasture should be considered.

Keywords
Perennial grass, grazing, regrowth.

Introduction
Phalaris (*Phalaris aquatic* L.) and subterranean clover (*Trifolium subterreanuem* L.) are the primary sown pasture species in the high rainfall zone of southern Australia due to the persistence and production of phalaris. However, Bowcher (2004) in a survey identified annual grasses to be the dominant species group throughout pastures in southern New South Wales. It was also identified that there were low incidences of perennial species and that subterranean clover was commonly present. This factor, combined with observations of low soil P availability, suggested low levels of pasture investment had occurred. Pasture establishment costs are high and there are no current benchmarks that can be used to determine the point at which a degraded perennial pasture requires re-establishment. Previous research has reported basal cover of phalaris pastures as a result of treatments imposed rather than as a primary driver for production. Manipulation of basal spacing experimentally will represent pasture degradation. The effect of degradation on pasture parameters can then be used to determine management thresholds for decision making regarding when to re-establish pastures.

Methods
The experimental site was located on at Bringenbrong (-36.157505 S, 148.050729 E; 920 mm average annual rainfall; elevation 286 m) in the South-West Slopes of NSW. The soil was characterised as a yellow Sodosol with a pH ($CaCl_2$) of 4.3 and an aluminium percentage of 14%. The experiment was conducted in a phalaris pasture (*Phalaris aquatica*, cv. Grazier, est 2011) with a high basal frequency between 40-50%. Grazier, developed by Upper Murray Seeds and soon to be released was derived from selection within the Uneta cultivar with selection emphasis on increased winter production and drought tolerance. Features of the cultivar include a prostrate growth habit, semi winter dormancy, high seed retention, and low summer dormancy.

A randomised complete block design was used with four basal frequency treatments, two nitrogen fertiliser treatments and four replicates. Each plot was 0.84 m^2, totalling a treatment area of 26.9 m^2. The entire experimental site was mown at a height of 4 cm on April 15 to remove senesced growth from the previous season. Basal frequency was measured twice (April 15 and May 10) at the beginning of the growing season by placing a 0.7 by 1.2 m quadrat of 0.1 by 0.1 m square mesh over the sampling area. Basal frequency was used as a simple and fast tool to assess phalaris density. Four basal frequency treatments were applied, 40-50%, 30-39%, 20-29% and 10-19% (assigned the letters A, B, C & D, respectively). In cases where plant density was too high for the allocated treatment, randomly selected 0.1 by 0.1 m grid squares had plant crowns removed by a mattock until the required density for each plot was obtained.

For each basal frequency treatment, there was a plus and minus nitrogen treatment. These N treatments allowed the influence of N at various basal spacings to be determined such that any contribution of clover to N fertility would not be a factor in the N treatments. The N fertiliser treatments were applied as urea (46% N) immediately before rainfall on April 19, June 17 and August 1 with 46 kg N/ha applied each date. After basal frequency treatment application on April 15, the site received a uniform application of single superphosphate (9% P, 11% S) at the rate of 25 kg P/ha. Subterranean clover (cv. Rosabrook) seed was sown on April 19 at a rate of 20 kg/ha (300 seeds/m^2) in the space between phalaris planting rows by hand which had been lightly cultivated. Due to the lack of rain in April, the experimental area was irrigated with 20 mm of water by watering can on April 19 to simulate a rainfall event and encourage autumn growth.

Dry matter was measured by harvesting the total plot to a height of 2.5 cm on five occasions at a six-week interval on: June 14, July 29, September 9, October 24 and December 6. The herbage was then sorted into four components: phalaris, clover, annual grasses and other broad leaf species. These components were then dried at 60°C for 48 hours and weighed.

Air temperatures were collected from the Khancoban weather station (BOM), approximately 10.5 km south-east (-36.23 S, 148.14 E; elevation 339m) from the experimental site. April was 3℃ warmer than the average maximum temperature, whereas May, June and July minimum temperature was 2-3℃ warmer than average. The annual rainfall at the site for 2016 was 1087 mm and growing season rainfall (Apr-Nov) was 849 mm.

All statistical analyses were conducted using the software package GenStat 17 (version 17, VSN International Ltd, UK). The data was analysed for normality before being analysed using analysis of variance (ANOVA) and Fisher's Least Significance Difference (LSD) with a P value of 0.05.

Results

After plot establishment on May 10, phalaris basal frequency treatments were assessed and all treatments were significantly different ($p < 0.05$). Treatment A, B, C and D had mean basal frequencies of 44%, 37%, 26% and 13%, respectively. There were no significant differences of clover establishment between plots with a mean of only 58 plants/m^2 established. Other species in the pasture during the season included winter grass (*Poa annua* L.), annual ryegrass (*Lolium rigidum* L.), capeweed (*Arctotheca calendula* L.), sorrel (*Rumex acetosella* L.) and wireweed (*Polygonum aviculare* L.).

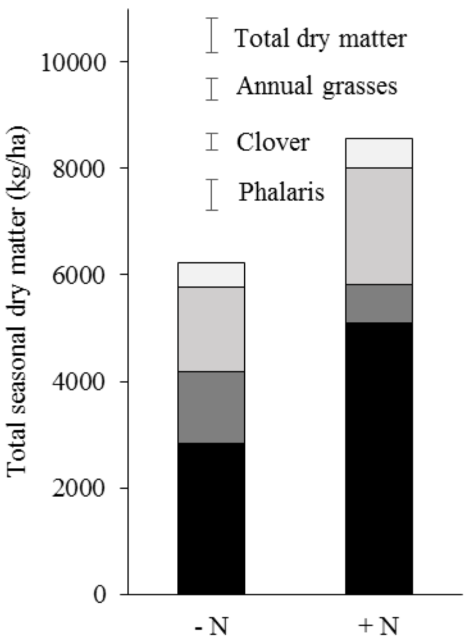

Figure 1. The effect of nitrogen application on total seasonal dry matter for different components (phalaris – black, clover – dark grey, annual grasses – light grey, broadleaf weeds – white) within the pasture for the season. Significant differences were found for phalaris ($p < 0.001$), clover ($p < 0.001$), annual grasses ($p < 0.005$) and the total dry matter ($p < 0.001$). Broad leaf weeds were not different between nitrogen treatments. Bars are LSD values at $p = 0.05$ level.

The application of nitrogen had the largest effect on dry matter production (Figure 1). Nitrogen increased phalaris production at all harvests with un-fertilised treatments accumulating 2846 kg/ha compared to the nitrogen fertilised plots of 5088 kg/ha ($p < 0.001$). Total annual grass production increased due to nitrogen application (1581 vs. 2200 kg/ha, $p < 0.005$) primarily driven by differences found on September 9 and October 24. Total clover production was reduced by nitrogen fertiliser (1344 vs. 733 kg/ha, $p < 0.001$). Differences found between nitrogen treatments for clover dry matter occurred on July 9, October 4 and December 6. Total seasonal pasture dry matter production increased over the sampling period due to nitrogen application from 6237 kg/ha un-fertilised to 8570 kg/ha fertilised ($p < 0.001$). The effect of nitrogen was consistently a main effect with only one instance of an interaction with phalaris basal frequency (noted below). The effects of basal frequency were independent of nitrogen fertility of the pasture.

At three sampling times phalaris dry matter for the lowest basal frequency was less than higher basal frequencies (Figure 2). On June 14 basal frequency D was less than treatments A and B ($p < 0.001$). On October 24 basal frequency D was less than all other treatments ($p < 0.001$) while on December 6 treatment D was marginally less than all other treatments ($p < 0.061$). There was no basal frequency main effect on July 29 or September 9.

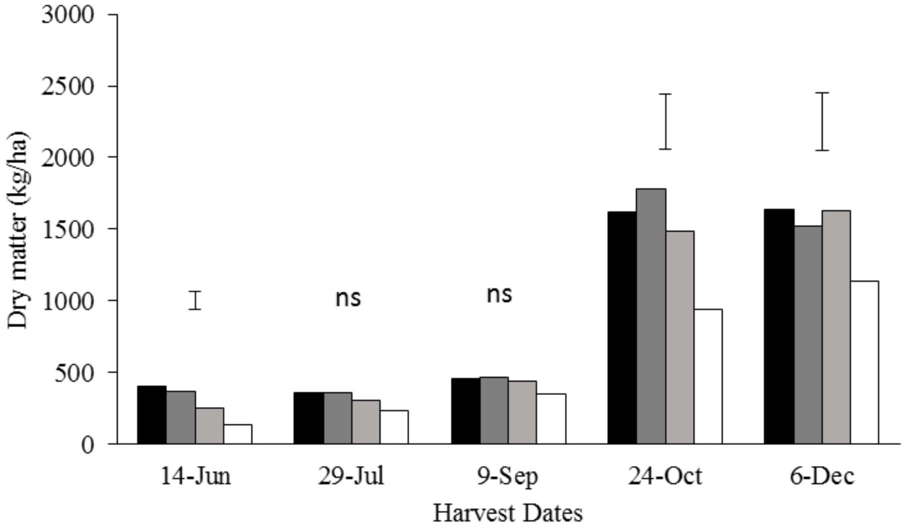

Figure 2. The effect of basal frequency (A – black, B – dark grey, C – light grey, D – white) on phalaris dry matter for five sampling dates. Significant differences found on 14 Jun ($p < 0.001$), 24 Oct ($p < 0.001$) and 6 Dec ($p < 0.061$). Bars are LSD values at $p = 0.05$ level.

Interestingly, September 9 was the only occurrence of an interaction between basal frequency and nitrogen. There was no difference between phalaris dry matter for minus nitrogen treatment between different basal frequencies whereas when nitrogen was applied, the three highest basal frequencies increased dry matter but treatment D was the same as a minus nitrogen treatment (Table 1). Presumably the cold weather prior to the July 29 sampling restricted growth whereas dry matter production in the period prior to September 9 could be increased by nitrogen application but only when basal frequency was higher than 20%. Total phalaris production increased from 2790 kg/ha in treatment D to an average of 4359 kg/ha for treatment A-C.

Table 1. Interaction of nitrogen treatment and basal frequency on September 9 on phalaris dry matter.

	Nitrogen treatment	
Basal frequency	-	+
A (40-50%)	208	714
B (30-39%)	220	707
C (20-29%)	141	731
D (10-19%)	282	425
p value	0.04	
LSD	227.2	

Phalaris basal frequency treatments were only associated with increased total pasture production at the June 14 sampling when treatments A and B were greater than treatment D. This occurred when the pasture composition was dominated by phalaris at an average of 99% of dry matter. For all other sampling periods, basal frequency had no effect on total pasture production. Total pasture production was determined by nitrogen application and the proportion of phalaris in the sward decreased as basal frequency decreased.

Discussion

Nitrogen treatment greatly increased pasture production primarily with increases in phalaris and annual grasses. The production of clover decreased in response to nitrogen application presumably through competition for light with the grasses. The effect of nitrogen on this pasture was not surprising but the addition of a nitrogen treatment was primarily to determine if there was an interaction between critical basal frequency and nitrogen fertility. Interestingly, there was only one result that indicated that nitrogen and basal frequency had an interaction. Importantly this means that responses to basal frequency are independent of nitrogen fertility. Clearly a reduction in basal frequency below 20% reduced phalaris production but does not necessarily reduce total pasture production. Culvenor et al. (1996) observed that a reduction in phalaris basal frequency in an established pasture resulted in a change in botanical composition with increases in both clover and annual grass production. Whether or not a pasture with low phalaris frequency is still productive will depend on the annual species that are present. In this study the annual grasses were primarily annual ryegrass and winter grass which at the vegetative stage are high in quality. If the annual species was vulpia (*Vulpia stipoides*) then there would be a reduction in quality whereas lower basal frequency of phalaris could improve the quality of the pasture if the annual grasses were replaced with subterranean clover as clover is able to maintain a higher herbage quality than grasses during late spring and summer. There would however be a trade-off due to a higher sub clover content, in that autumn production is reduced and the sub clover's prostrate growth habit whilst establishing presents difficulties for grazing (Smith et al. 1972) during a period of low feed availability on farm. Grazing management may provide a solution for increasing basal frequency. The study by Virgona and Bowcher (2000) suggested that the ability for phalaris to maintain basal cover increased with an increasing grazing interval although this was conducted on almost pure swards of the perennial species. Hill et al. (2004) found that lenient grazing regimes resulted in increases of phalaris basal area.

Conclusion

Phalaris basal frequency less than 20% will decrease phalaris production and is independent of nitrogen fertility. Total seasonal production was not affected by phalaris basal frequency as annual grasses and subterranean clover compensated for production. Nitrogen application increased phalaris and annual grass production which resulted in higher total production. Growth of subterranean clover was reduced by nitrogen application. Growers should utilise grazing management techniques to ensure that basal frequency remain greater than 20%.

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