Nitrogen supply and the establishment and productivity of chicory (*Cichcrium intybus* L.) based pastures

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ABSTRACT

The effects of alternative legume and nitrogen fertiliser strategies on the establishment, early growth and productivity of chicory and chicory / legume mixtures were evaluated. Nitrogen did not have asignificant effect on chicory or legume germination or establishment. On the other hand, both nitrogen and companion legumes had positive effect on chicory dry matter yield. While companion legumes did not affect the establishment of chicory, chicory and nitrogen had asignificant negative effect on legume establishment and dry matter yield. Therefore applying nitrogen at the time of sowing, to spring sown chicory and legumes did not have a beneficial effect. It was concluded that to establish a well-balanced chicory / legume pasture and prevent weeds from out-competing legumes, the application of nitrogen fertiliser should be delayed as long as possible. However, care should be taken to prevent pasture run-down.

KEY WORDS

Cichcrium intybus, Chicory, pasture, establishment, legume.

INTRODUCTION

Nitrogen ranks with phosphorus as one of the major nutrient deficiencies in Australian soils (9). The role of legumes in increasing dry matter yield of grass / legume pastures by providing symbiotically fixed nitrogen is well documented (*e.*g. 8, 14). The extent to which legumes supply the nitrogen required by a grass / legume pasture is a subject of continuing study. Wilman and Fisher (15) reported that the legume component (white clover) of grass / clover pastures was able to supply all the nitrogen of the mixed pastures. Others (*e.g.* 13) argued that fixed nitrogen is adequate only during the active growth period of legumes requiring strategic application of small amounts of nitrogen when they are dormant.

In this study the effects of alternative legume and nitrogen fertiliser strategies on the establishment, early growth, competitiveness and productivity of chicory and chicory / legume mixtures were evaluated. Emphasis was placed on early growth as it is anticipated that chicory will probably be used more as special purpose forage where producers require reliable establishment and quick production. The objective was then to examine competition between chicory and legume species and to see which species establish successfully. This was then used to quantify the nitrogen requirement of chicory and how much of this requirement could be supplied from companion legumes.

MATERIAL AND METHODS

The experiment was a randomised complete block with 13 treatments, replicated 4 times. Treatments were factorial combinations of chicory alone or with subterranean clover *(Trifolium subterraneum* cv Goulburn), white clover (*Trifolium repens* cv Haifa) or lucerne (*Medicago sativa* cv Aurora), all ? nitrogen at 30 kg/ha applied soon after establishment. In addition, there were extra nitrogen treatments applied to the chicory (60 and 120 kg/ha/year). Plots were sown into a well-prepared seedbed by hand broadcasting and then raking. The sowing rates (5 kg/ha) were intended to give initial densities of 60 plants/m^2 of chicory; this was around the optimum density (Alemseged *et al*. 2000). The legumes were sown at their recommended rate for monoculture (7, 3, and 3 kg/ha respectively for sub clover, lucerne and white clover).

The proportion of each component in the sward was measured using two techniques. Each fortnight plant density counts and height were measured using permanent (30 cm * 30 cm) quadrats. Every six weeks, starting 14 weeks after sowing, dry matter ranking on 9 quadrats in each plot was estimated using the Botanal? procedure (12). The ranks were calibrated by cutting herbage from a randomly selected quadrat and sorting samples into species and dry and green parts. The samples were then dried at 60 ^{0}C for 24 hrs to determine dry matter yield.

The differences between treatments in seedling number and height were analysed using ANOVA in the MGLH (least squares) procedure of SYSTAT (14). The differences between treatments for dry matter yield were examined by analysis of variance of a randomised block design using GENSTAT 5 (10). A least significant difference test (LSD=0.05) was used to separate mean effects when the F-test was statistically significant at $P<0.05$.

RESULTS

Establishment of chicory four weeks after sowing was high with an average of 480 plants/m^2 or about 75% of the viable seeds sown. At the end of 16 weeks from sowing the average plant population was 68 plants/m^2 (Table 1) or about 14% of the population that was present at week four. Neither nitrogen fertilisation or companion legume had any significant effects on chicory density in the first year from sowing.

Table 1. Chicory plant density (plants/m^2) four and sixteen weeks after sowing and dry matter yield.

Treatment	Plant density		
	4 weeks	16 weeks	DM (kg/ha)
Monoculture chicory + 0 kg/ha Nitrogen	430	60	2900
Monoculture chicory + 30 kg/ha Nitrogen	450	60	3400
Monoculture chicory + 60 kg/ha Nitrogen	500	83	3800
Monoculture chicory + 120 kg/ha Nitrogen	440	65	3700
Chicory + Sub clover + 0 kg/ha Nitrogen	470	73	2700
Chicory + Sub clover + 30 kg/ha Nitrogen	530	73	3000
Chicory + White clover + 0 kg/ha Nitrogen	430	53	2860
Chicory + White clover + 30 kg/ha Nitrogen	510	75	2900
Chicory + Lucerne + 0 kg/ha Nitrogen	520	75	2600

Chicory + Lucerne + 30 kg/ha Nitrogen	520	61	2750
Lsd (0.05)	118	30	255

In monoculture, the white clover population was highest of the three legumes, followed by lucerne and sub clover when measured after eight weeks of growth (Table 2). Nitrogen application did not significantly affect the legume plant population but density of the three legumes were higher ($P<0.05$) in monoculture than when sown with chicory.

Nitrogen application significantly ($P<0.05$) increased chicory dry matter yield (Table 1). White clover dry matter yields was significantly ($P<0.001$) reduced by fertilisation. Sub clover yield was also reduced and lucerne dry matter yield increased by N fertilisation, although these were not statistically significant. White clover, lucerne and sub clover yields were all significantly ($P<0.001$) higher in monoculture than in mixtures either with or without nitrogen, indicating the strong level of competition from chicory (Table 2).

Table 2. Legume density (plants/m^2) eight weeks after sowing and dry matter yield (kg/ha).

Treatment	Density (Plants/m2)	DM (kg/ha)
Chicory + Sub clover + 0 kg/ha Nitrogen	20	95
Chicory + Sub clover + 30 kg/ha Nitrogen	18	42
Chicory + White clover + 0 kg/ha Nitrogen	108	834
Chicory + White clover + 30 kg/ha Nitrogen	85	415
Chicory + Lucerne + 0 kg/ha Nitrogen	54	208
Chicory + Lucerne + 30 kg/ha Nitrogen	58	278
Monoculture Sub clover + 0 kg/ha Nitrogen	46	296
Monoculture White clover + 0 kg/ha Nitrogen	170	1460
Monoculture Lucerne + 0 kg/ha Nitrogen	86	820
Lsd (0.05)	24	205

The legume contribution to sown species production (chicory + legumes) was generally low in the first six months of growth. When no nitrogen was applied, white clover made a greater contribution to dry matter yield (25 %) than either lucerne (6 %) or sub clover (4 %). The contribution of each species when nitrogen was applied was 12%, 2% and 9% respectively.

DISCUSSION

Early establishment and growth is essential to enable pasture species to compete successfully with other undesirable species and to develop a productive pasture (3). Chicory germination in this experiment was rapid and even. The final chicory population in this experiment was only 14% of the initial population. This suggests that the sowing rate could be reduced without risk, as the population decline was attributed to self-thinning. This agrees with the results reported by (7) in which a 30-fold difference in seeding rate did not have an effect on the plant population and plant weight of *Lolium perenne* after 20 weeks of growth. However, the high initial plant population might have enabled chicory to dominate the weeds and companion legumes.

The establishment of white clover was also successful. White clover is one of the few perennial pasture species with the ability to establish when either surface sown or direct drilled into native perennial grasses pastures (3). The higher white clover seedling numbers in monoculture than in mixtures (170-plants/m^2 vs 105 plants/m^2), however, demonstrates the strong competition from chicory during establishment. The lucerne density of 80 plants/m^2 obtained (in both monoculture and mixture) in this experiment was substantially lower than the optimum of 240 plants/m^2 suggested by (11) in the first year from US studies. However, the expected optimum density in the field in Australia is 100 – 120 plants/m^2 under irrigation (Gordon King pers. com.). Similarly, the density of sub clover achieved (40 plants/m^2) was lower than those reported by (2) for productive pastures of other varieties (85 to 115 plants/m^2). Spring sowing may explain in part the establishment failure of the winter growing sub clover. Spring sowing was chosen because current knowledge suggested that this would be the most appropriate season for sowing chicory. This experiment then tested the ability of sub clover to be successfully sown at the same time as chicory in a companion crop. This study suggests that sub clover was unable to successfully establish in a spring sowing of chicory, and it is therefore recommended that sub clover should be oversown in the following autumn. Observations on commercial paddocks suggest that sub clover is compatible with chicory.

Data on the effect of fertiliser on population dynamics is limited. The lack of response of germination and establishment rates to nitrogen application in this experiment is similar to results reported by (4) in which no improvement in germination rate was found with nitrogen application. However, once established there are many reports of the effect of fertiliser on growth and botanical composition of pastures (e.g. 4, 5, 6). Almost all studies reported that the application of nitrogen fertiliser impairs the growth of legumes in mixture with grasses.

CONCLUSION

The main reason for the higher productivity of chicory / white clover mixture (when nitrogen was not applied) could relate to the higher establishment of white clover. From the practical viewpoint the results from this experiment indicate that applying nitrogen at the time of sowing or shortly after to spring sown chicory and legumes does not have a beneficial effect, especially if the soil fertility is high. Therefore, to establish a well-balanced chicory / legume pasture and prevent grass weeds from out-competing legumes, the application of nitrogen fertiliser should be delayed as long as possible. However, care should be taken to prevent pasture rundown as the accumulated available nitrogen declines with time.

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