Effect of chicory sowing rate on first year production in pasture mixtures

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Abstract

The first year performance of pastures sown with chicory (cv. Grasslands Puna) at seeding rates of 0.75, 1.5, 3 and 6 kg seed/ha in pure stands, and in mixtures with each of two clovers (cv. Grasslands Pawera red clover or Grasslands Kopu white clover) and with white clover plus each of two winter active perennial grasses (cv. Grasslands Matua prairie grass or cv. Grasslands Maru phalaris) was investigated in a field experiment. Three replicates of 25 seeding treatments were sown in late November 1992 into a fertile Wakanui silt loam. From four harvests, total yields from chicory sown alone ranged from 920 DM/m^2 at 0.75 kg seed/ha to 1480 g DM/m^2 at 3 kg/ha. Dry matter yields of companion species and weeds decreased as chicory populations increased. The large seeded species, Matua prairie grass and Pawera red clover, were more competitive with chicory than the slower establishing small seeded species, Maru phalaris and Kopu white clover. Clover yield was inversely proportional to chicory yield. When mixed with Pawera red clover which yielded from 380 to 140 g/m^2/yr, chicory yielded from 780 to 1270 g/m^2/yr. Chicory yielded 830 to 1280 g/m^2/yr when mixed with Kopu white clover (250 to 45 g DM/m^2/yr). Matua prairie grass produced well (120-70 g/m^2) in winter but more work is required to determine its potential as a companion winter grass in chicory swards. Maru phalaris had low productivity in the first winter. Chicory taproot dry matter showed an inverse relationship with the number of plants in pure stands. Individual taproots weighed from 7 to 2 g at 0.75 to 6 kg seed/ha, when plant number varied from 50 to 135 chicory plants/m^2. For pure chicory stands we recommend sowing rates between 1.5 to 3 kg seed/ha. When mixed with clovers and winter active grasses, chicory should be sown at rates lower than 1.5 kg/ha because it was very competitive in the establishment year.

Additional key words: Cichorium intybus *L., competition, herbage mass, mixed swards, plant population, taproot yield*

Introduction

Chicory cv. Grasslands Puna (Rumball, 1986) is grown in New Zealand to provide high quality forage for livestock during spring, summer and autumn. It may be grown either in pure stands or in pasture mixtures. There is little definitive information on chicory seeding rates for use in pasture mixtures and there are few reports on the sociability of chicory with legumes and grasses during the establishment year. Legumes will maintain nitrogen fertility, and winter active grasses such as prairie grass (Rumball, 1974) and phalaris (Rumball, 1980) could exploit the winter period when chicory is dormant.

The limited data available from studies which used only one sowing rate of chicory indicate that chicory can be very competitive in mixtures with legumes and grasses. Sowing rates have varied widely in these studies, from 1 to 7 kg/ha for stands sown with clover and 0.5 to 10 kg/ha when sown in pasture mixtures (Lancashire and Brock, 1983; Kise *et al.*, 1987; Casey, 1992; Fraser *et al.*, 1988; MacFarlane, 1990). Results from these experiments did not provide strong evidence for sowing rate recommendations, but it was clear that spring and early summer sowings were preferable to autumn sowing time.

A field trial was established to investigate the response of chicory when sown at 0, 0.75, 1.5 and 6 kg/ha in pure swards, or mixed with companion species.

Materials and Methods

Treatments and site characteristics

Chicory (*Cichorium intybus* L.) cv. Grasslands Puna was sown on 30 November 1992 at 0, 0.75, 1.5, 3 or 6 kg/ha in 1) 'pure' stands but without weed control, 2) mixtures with either 6 kg/ha red clover (*Trifolium pratense* L.) cv. Grasslands Pawera or 2 kg/ha white clover (*Trifolium repens* L.) cv. Grasslands Kopu and 3) mixtures with 2 kg/ha Kopu white clover plus either 10 kg/ha prairie grass (*Bromus wildenowii* Kunth.) cv. Grasslands Matua or 2 kg/ha phalaris (*Phalaris aquatica* L.) cv. Grasslands Maru. Three replicates of the 25 seeding combinations were broadcast and raked into a firm fine seed bed. The treatments were thus: one unsown treatment of weeds only; six single species stands of each of the two clovers plus each of the four chicory sowing rates; ten binary mixtures (chicory at each of the four sowing rates plus either white clover or red clover, and white clover with each of the two grasses); and eight three-species mixtures (chicory at each of the four sowing rates mixed with white clover plus either prairie grass or phalaris). Plots were 2 x 1.5 m. The soil was a Wakanui silt loam of high fertility (pH=5.1; P=30; S=4; K=8; MAF Quick Test, 1992) at Lincoln, Canterbury (43° 38' S Lat., 172° 28' E Long.). The climate at Lincoln is typically cool in winter (6°C), warm (16°C) and drought prone in summer, with a mean annual rainfall of 695 mm. The climate for the duration of this field experiment was wetter than average with high rainfalls in May, September and November 1993. However October 1993 was drier than normal.

Field measurements and botanical analysis

The number of plants/m^2 and the dry matter yields of chicory, companion species and weeds were determined. Plants of sown species were counted in three randomly placed 0.023 m^2 quadrats per plot on 15 December, 16 January, 18 August 1993 and chicory only on 16 December 1993. Forage production was measured by cutting one 0.2 m^2 quadrat from each plot on 24-28 February, 15-20 May, 16-17 August and 15-19 November 1993. Fresh samples were separated on their botanical characteristics into weeds, clovers (white or red clover), sown grasses (prairie grass or phalaris) and chicory. Once separated, the samples were dried at 70°C for 24 hours and weighed. Taproots from three plants from within the pure chicory plots were dug to a depth of 150 mm on 16 December 1993. Taproots were washed and then dried at 70°C for seven days.

Statistical analysis

The MINITAB software package was used to analyse data from the randomised complete block (RCB) design which had three replicates and twenty five treatments. The separate data sets from each harvest were treated as a RCB with split plots in time. The main plots were the sowing treatments and the sub-plots the sampling time. Where significant differences are indicated the level of probability was $P < 0.05$.

Results

Plant population

The four sowing rates resulted in pure chicory populations of 50, 70, 90 and 135 plants/m^2 after one year (Fig. 1). When compared with the potential population from viable seeds sown, the proportion of seedlings surviving the first 16 days was greatest at low sowing rates. Delayed emergence resulted in seedling number increases at the January count.

Dry matter production

Chicory stands: There were significant differences between sowing rates in chicory dry matter yield from all harvests; the 0.75 kg/ha sowing rate tended to produce least and the 3 kg/ha rate the most (Fig. 2). Three

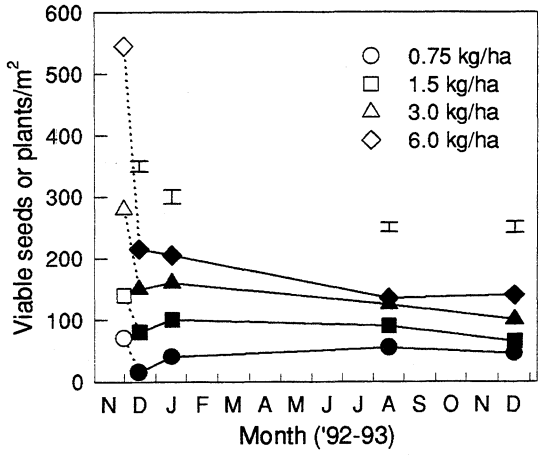

Figure 1. Number of viable chicory seeds sown on 30 November, 1992 (open symbols), and subsequent plant populations (closed symbols) in the pure chicory plots at the four sowing rates. Error bars = SEM.

months after sowing, pure chicory yields ranged from 120 to 200 g DM/m^2 but in winter, production was only 40 g DM/m^2. Chicory produced the most DM in spring (November harvest); the 0.75 kg/ha sowing rate produced 570 g DM/m^2 which was significantly less than the 910 g DM/m^2 produced by the 3 kg/ha sowing rates.

Total weed production for the first year from the weeds only plot was 420 g DM/m^2. Chicory, at the lowest sowing rate and annual production 920 g DM/m^2, suppressed weed yield to 180 g DM/m^2. The greatest chicory annual yield of 1480 g DM/m^2 came from the 3 kg/ha sowing rate where weed production was 202 g DM/m^2.

Binary mixtures: Clovers had similar seasonal trends in mixtures to chicory. Pawera red clover had higher yields than Kopu white clover in mixtures with chicory; Pawera had low yields in August, but in spring produced 150 and 110 g DM/m^2 in the 0.75 and 1.5 kg/ha sowing rates, respectively. Kopu white clover sown with either of the grasses or with chicory had very low production in all four harvests; this was especially so at chicory sowing rates above 1.5 kg/ha.

Total dry matter yields of Pawera red clover and weeds declined with increasing chicory sowing rates (Fig. 3). The chicory yield from the 0.75 kg/ha sowing rate of 795 g DM/m^2 was associated with 370 g DM/m^2 of Pawera red clover, but an increase in chicory yield to 1230 g DM/m^2 resulted in only 130 g DM/m^2 of red clover at the 6 kg/ha sowing rate.

Three-species mixtures: When Kopu white clover and Matua prairie grass were sown with chicory, total annual dry matter yield (1650 g DM/m^2) was greatest at the 3 kg/ha sowing rate, but there were no significant differences among all four sowing rates (Fig. 4). Matua prairie grass production declined with successive increases in chicory sowing rate, from 1190 g DM/m^2 without chicory down to 320 g DM/m^2 at the highest sowing rate. August yield of Matua prairie grass was about 110 g DM/m^2 for all of the chicory sowing rates and for the Matua plus white clover without chicory. Kopu white clover total yields were low, with less than 100 g DM/m^2 at all chicory sowing rates and only 195 g DM/m^2 when mixed with prairie grass and no chicory.

Maru phalaris was slow to establish and it made little contribution to total yields in the presence of chicory (Fig. 5). Maru phalaris produced 395 g DM/m^2 and Kopu white clover 520 g DM/m^2 in the absence of chicory. Both Kopu white clover and Maru phalaris performed poorly in three-species mixtures with chicory.

Uneven establishment with low mean plant populations may have been the reason for low yields from Maru phalaris where mean population was only 40 plants per m^2 in January 1993 but white clover populations exceeded 100 plants/m^2 in all treatments.

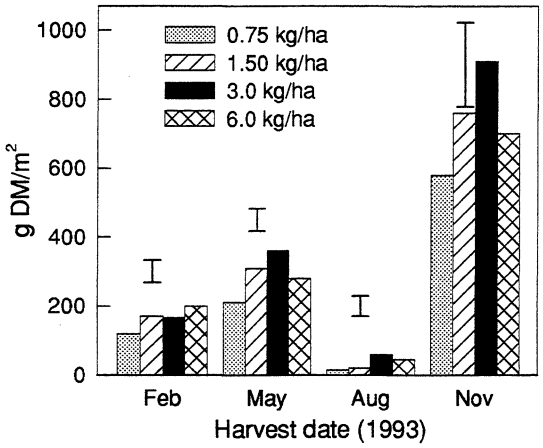

Figure 2. Chicory dry matter yields at three-month intervals from the pure chicory plots at the four sowing rates. Error bars = SEM.

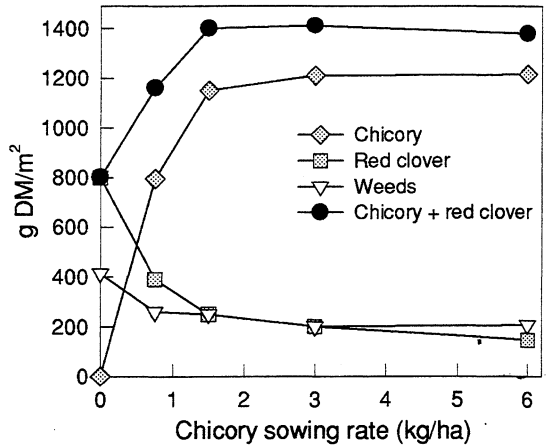

Figure 3. First year dry matter yields of the component species of the chicory - red clover mixture at five chicory sowing rates.

Taproot yields

Dry weight per taproot was highest at low sowing rates (Fig. 6). No significant differences were found between the two highest sowing rates (3 and 6 kg/ha). Taproot weight showed an inverse relationship with chicory plant population. Chicory taproot DM yields one year after sowing were 350 g/m^2 at 0.75 and 1.5 kg seed/ha and 270-260 g/m^2 at 3 and 6 kg seed/ha.

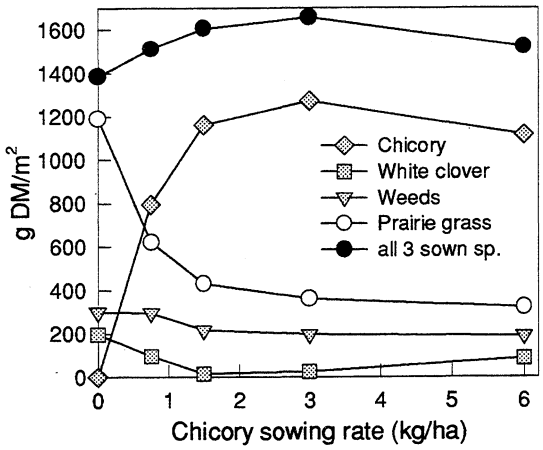

Figure 4. First year dry matter yields of the component species of the chicory - white clover - prairie grass mixture at five chicory sowing rates.

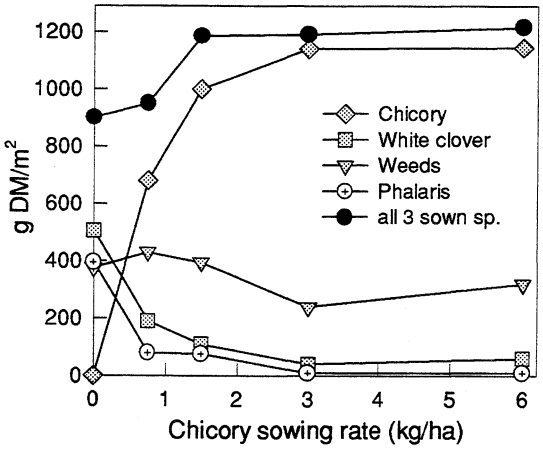

Figure 5. First year dry matter yields of the component species of the chicory -white clover - phalaris mixture at five chicory sowing rates.

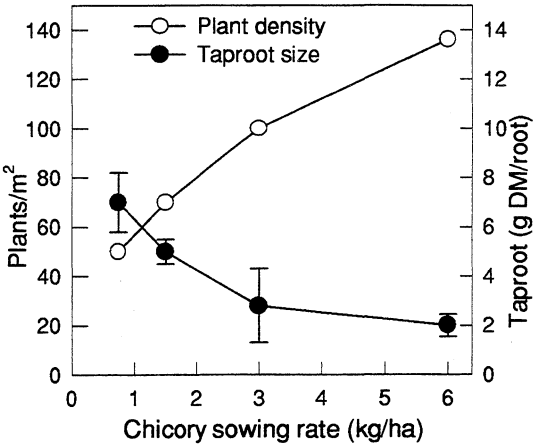

Figure 6. Chicory taproot dry weight and chicory plant population at four sowing rates one year after sowing. Error bars = SEM.

Discussion

Establishment phase

The initial populations and seedling vigour of pasture species sown with chicory will influence the botanical composition of the established pasture. Chicory sowing rates of 3 kg/ha or higher smothered small seeded, slower establishing species such as white clover and phalaris (Fig. 5), while larger seeded species with vigorous seedlings such as prairie grass survived the dense chicory competition (Fig. 4). Dense weed populations also influenced the outcome of pasture mixtures containing chicory. High chicory sowing rates reduced weed yields in this study, but in three-species mixtures, the combined effects of competition from weeds and high chicory sowing rates suppressed other pasture species in this soil with high weed seed content.

The initially high populations of chicory declined rapidly, in a similar manner to other rosette-forming plants with deep taproots such as red clover and lucerne. Chicory tended towards an equilibrium population of 50

to 135 plants/m^2 in its first year (Arias-Carbajal, 1994). If average chicory plants during vigorous vegetative growth are from 10 to 15 cm in diameter, then there is room for a maximum of about 100 plants in a square metre and very little space for any other species to express their growth potential.

Herbage production in the establishment year

February yields were low because of the relatively late sowing date. Earlier sowing in September would have resulted in greater summer production. Autumn and winter production from the May and August cuts was influenced by the cooler temperatures of those seasons. Spring yields of up to 910 g DM/m^2 demonstrated the ability of chicory dominant pastures to accumulate very high pasture mass when the chicory was about 1 m in height at the early reproductive stage. Mean production rates over the 90 days from 16-17 August to 15-19 November were up to 10 g DM/m^2/d. Given the slow production rates likely during the cool days in August and September, the mean production during the later part of the spring growth period would have exceeded 20 g DM/m^2/d.

The management of the spring growth period in this study may be challenged on the grounds that plots should have been cut when pasture mass reached about 400 g DM/m^2. This would have better simulated defoliation management of chicory pastures on farms. More frequent defoliation at lower pasture mass may have been advantageous to shorter growing pasture species. White clover and the slow establishing phalaris in particular may have produced more in spring if shading had been less intense under more frequent defoliation. This needs to be demonstrated.

Given the sensitivity of chicory to frequent defoliation, farmers should be able to manipulate the botanical composition of pastures containing chicory by adjusting spelling times. During periods of rapid chicory growth, the recommended spelling times of three to five weeks (Matthews *et al.*, 1990) would provide an opportunity for this manipulation. With five week spells there would be considerable shading of associated species in pastures containing high populations of chicory. Shorter spelling times of about three weeks should encourage white clover and most grasses (Arias-Carbajal, 1994).

The two grasses had contrasting success when sown with chicory and Kopu white clover. Maru phalaris was not a successful companion species in its first winter because it had a low and unevenly distributed plant population. Maru phalaris only performed well in spring (270 g DM/m^2) in a binary mixture with white clover. Matua prairie grass produced more DM in winter than Maru phalaris in the first year, but it was in spring when its DM production was greatest (300 and 200 g DM/m^2 in the 0.75 and 1.5 kg/ha chicory sowing rates, respectively). Clearly, early spring (September) grazing is likely to be important to utilize winter grass production and avoid grass suppression of chicory.

Chicory taproots

Chicory taproot dry weights were low at sowing rates of 3 and 6 kg/ha because of intraspecific competition. High sowing rates also resulted in a reduction in the total DM yield of taproots and, at the 6 kg/ha sowing rate, a possible reduction in shoot yield. Low taproot biomass at high chicory populations could result in slower recovery from defoliation and may explain why chicory populations decline rapidly to more moderate populations of larger plants in mature stands.

Conclusions

Chicory sowing rates higher than 3 kg/ha caused intense intraspecific competition, and chicory populations declined to about 100 plants/m^2. For mixtures including other species such as prairie grass which had vigorous seedlings, 1.5 kg/ha chicory sowing rate was adequate.

For the establishment of pure stands of chicory in a prepared seedbed on fertile lowland sites, sowing rates should not exceed 3 kg/ha. In mixtures containing slow establishing species, chicory sowing rate should be restricted to a maximum of 1.5 kg/ha, and early grazing management should aim to favour the associated species if the chicory appears to be too competitive.

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