# The effects of grass species and nitrogen fertilizer on white clover growth and mixture yield in a northern maritime environment

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## ABSTRACT

The impact of four contrasting companion grasses on white clover was studied in a field experiment at Korpa Experimental Station, Iceland, over a four year period. Smooth meadow grass (*Poa pratensis* L. cv. Fylking), timothy (*Phleum pratense* L. cv. Adda), perennial ryegrass (*Lolium perenne* L. cv. Svea) and meadow fescue (*Festuca pratensis* Huds. cv. Salten) were sown in binary mixtures with white clover (*Trifolium repens* L. cv. Norstar). The fertilizer treatments were 0 kg N (N1), 20 kg N in the spring (N2) and 20 kg N ha$^{-1}$ in the spring and after each harvest (N3) applied for three years after the establishment year. Detailed morphological measurements of the white clover and the different companion grasses were made every autumn and spring during the course of the experiment and herbage yield was measured for three years. The results showed that population size of white clover and dry matter production was greatly influenced by the growth habit of the companion grass. Perennial ryegrass caused the greatest suppression to clover growth, mainly because of high shoot yields and the large leaf canopy as early as in the establishment year. In contrast, smooth meadow grass was the least competitive companion grass. Its low dry matter production per tiller and rhizomatous growth habit led to an open sward, which favoured clover growth. No interaction was found between grass companion and fertilizer treatment.

**Key words:** compatibility, companion grass, herbage production, morphology, white clover

## YFIRLIT

*Áhrif mismunandi svarðarnauta á vöxt hvítsmára og uppskeru smárablöndu á norðurslóð*

Fylgst var með samspili fjögurra ólíkra grastegunda við hvítsmára í tilraun á Tilraunastöðinni á Korpu í fjögur ár. Norstar hvítsmára var ýmist sáð í blöndu með Fylkingu vallarsveifgrasi, Öddu vallarfoxgrasi, Svea vallarrýgresi eða Salten hávingli. Áburðarliðir voru 0 kg N (N1), 20 kg N að vori (N2) og 20 kg N ha$^{-1}$ að vori og eftir hvern slátt (N3). Ítarlegar mælingar voru gerðar á hvítsmáranum og grasinu haust og vor ár hvert sem tilraunin stóð og þurrefnisuppskera var mæld í þrjú sumur. Niðurstöður sýndu að stofnstærð hvítsmára og uppskera hans ræðst að talsverðu leyti af vaxtarlagi svarðarnautarins. Vallarrýgresi dró mest úr vexti smárans, aðallega vegna mikils blaðvaxtar og uppskeru strax fyrsta haustið. Vallarsveifgras reyndist hins vegar besti svarðarnauturinn því hver grassproti myndar tiltölulega litla þurrefnisuppskeru og saman mynda þeir opna grasþekju sem gefur hvítsmáranum meira rými til vaxtar. Ekkert samspil fannst á milli áburðarliða og svarðarnauta.

## INTRODUCTION

In recent years there has been an increased emphasis in Europe on developing agricultural systems that minimise environmental degradation, maintain agricultural productivity and promote economic viability. The sustainability of such production systems relies, to a large extent, on the cultivation of forage legumes primarily due to their ability to fix atmospheric nitrogen and improve the feeding value of the herbage (Frame et al. 1998). However, the legume content in the sward needs to be sufficient to optimise the benefits of $N_2$ fixation and make use of the superior feeding value of the legumes in the forage (e.g. Rhodes et al. 1994).

There is considerable interest in introducing the benefits of forage legumes into agricultural systems in northern, marginal areas, such as in Iceland, where their use has been very limited. The conditions for herbage production in these areas are characterised by a short and cool growing season and long and unstable winters (e.g. Helgadóttir 1989). Such conditions cause difficulties in the survival of sown herbage species and sustainability of the production. This has been particularly true for both white and red clover (Lunnan 1989, Helgadóttir 1996). However, white clover cultivars that combine winter hardiness and acceptable production potential are now available on the market and give promise for utilisation of white clover in practical agriculture.

White clover is always grown in a mixture with companion grasses. Perennial ryegrass is the most common companion and it has been found to be most compatible in mixtures with white clover (Chestnutt & Lowe 1970). However, ryegrass is not sufficiently persistent under northern, marginal conditions to give sustainable production. It is therefore important to choose the appropriate companion grass for white clover to utilize its full potential. Plant establishment is generally slow in the north and the condition of the clover plant in autumn is decisive for its subsequent survival during the long and harsh winter (Dalmannsdóttir et al. 2001). Competitive effects of the companion grass will both influence clover growth during establishment (Collins et al. 1996) and subsequent herbage production (Collins & Rhodes 1989). Further, the grass canopy may also influence the winter survival of white clover and its long-term persistence in the sward. Both growth form and seasonal growth pattern of the grass play a role in the competitive interactions between the two components and the management of the sward further influences the results. It has been shown that competitive suppression of clover is positively related to both leaf length and tiller density of the companion grass (Rhodes & Harris 1979). It has also been found that grass companions with lax or prostrate leaves produce greater suppression of clover growth than more erect types of similar leaf length. However, grasses with an upright growth habit and long, erect leaves may be more damaging to clover under severe winter conditions than prostrate types (Rhodes 1981).

It is well known that competition for available soil N is crucial in determining the balance between grasses and clovers in mixtures (Donald 1963). The application of nitrogen usually increases the competitive ability of the grass component for light, water and nutrients, resulting in the suppression of clover growth (Vallis 1978, Snaydon & Baines 1981). However, nitrogen fixation is restricted by low temperatures in the north (Schulman et al. 1988, Nesheim & Boller 1991) and the addition of artificial N fertilizer may be necessary to obtain acceptable yield levels.

The aim of the current experiment was to study relationships between tiller number and biomass production of four contrasting companion grasses and the growth of white clover (as measured by stolon, root and leaf production and bud number) in autumn and spring and subsequent effects on survival of white clover and herbage production. In addition, the effects of different amounts of fertilizer N on herbage yield were investigated.

## MATERIALS AND METHODS

### *Experimental setup*

The Norwegian white clover (*Trifolium repens* L.) cultivar Norstar was sown with four different companion grasses on 16 June 1999 at Korpa Experimental Station, Iceland (64°09'). The grass species were smooth meadow grass (*Poa pratensis* L.), cv. Fylking from Sweden, timothy (*Phleum pratense* L.), cv. Adda from Iceland, perennial ryegrass (*Lolium perenne* L.), cv. Svea from Sweden, and meadow fescue (*Festuca pratensis* Huds.), cv. Salten from Norway. Seed was strip seeded with an Øyjord plot seed drill at the rate of 6.7 kg $ha^{-1}$ for white clover, 12.5 kg $ha^{-1}$ for timothy and meadow fescue, 15 kg $ha^{-1}$ for smooth meadow grass and 17 kg $ha^{-1}$ for perennial ryegrass. The fertilizer rates at sowing were 50 kg N, 35 kg P and 65 kg K $ha^{-1}$. The experimental design was a split plot with three replicates. Grass companions made up the main plots and three different N fertilizer treatments were on subplots: 0 kg N (N1), 20 kg N in the spring (N2) and 20 kg N $ha^{-1}$ in the spring and after each harvest except the final harvest in the season (N3). All plots received the equivalent of 30 kg P and 50 kg K in spring. Individual plot size was 1.8 x 8 $m^2$.

### *Management*

A cleaning cut was taken in early August in the establishment year in order to control weeds but dry matter yields were not measured. In the first two harvest years, instead of harvesting on predetermined dates, plots were harvested at a fixed sward height in order to counteract different phenological development of the companion grasses. An average height of approximately 20 cm was used as this is common practice in experiments containing white clover swards and simulates grazing (e.g. Wachendorf et al. 2001). Consequently, in the first harvest year (Yr1) plots with perennial ryegrass and meadow fescue were harvested four times (21 June, 20 July, 2 August and 21 August) and plots with smooth meadow grass and timothy were harvested three times (27 June, 25 July and 24 August). In the second harvest year (Yr2) plots with perennial ryegrass and meadow fescue were harvested on 20 June, 19 July and 9 August, whereas plots with smooth meadow grass and timothy were harvested on 27 June, 24 July and 17 August. In the third and final harvest year (Yr3) all plots were harvested at the same dates twice over the growing season, on 26 June and 6 August.

### *Measurements*

The plots were harvested using an Agria cutting machine. At each harvest total dry matter yield was determined and a sub-sample of the herbage was separated into sown grass, sown clover and other species, and dry matter yield determined for each fraction.

Detailed morphological measurements of the white clover and the different companion grasses were made every autumn and spring on the following dates: 18-20 October 1999 (Yr0), 23-25 May and 24-26 October 2000 (Yr1), 28-31 May and 29-31 October 2001 (Yr2) and 28-31 May 2002 (Yr3). On these dates one soil core of 12 cm diameter was taken at random from each plot to a depth of approximately 10 cm. Soil was carefully washed off in order to retain as much root material as possible. The samples from each treatment were then combined over replicates and separated into grass and clover plants. Grass tillers were counted to provide an estimate of tiller number $m^{-2}$ and their dry weight measured. For the clover plants values were obtained for the number of taproots, growing points and leaves, length of stolon and dry matter of each component. The number of taproots from the first sampling date, taken four months after the sowing, gave an estimate of seedling density per unit area.

**Table 1.** Tiller number and shoot dry matter yields of smooth meadow grass, timothy, perennial ryegrass and meadow fescue grown with white clover every autumn and spring 1999-2002 (Yr0-Yr3).

| | Yr0 | Yr1 | | Yr2 | | Yr3 |
|---|---|---|---|---|---|---|
| | Autumn | Spring | Autumn | Spring | Autumn | Spring |
| **Grass tillers, no. m$^{-2}$** | | | | | | |
| Meadow grass | 6430 | 6625 | 5927 | 2995 | 3863 | 3122 |
| Timothy | 8463 | 5701 | 3892 | 911 | 3666 | 1022 |
| Perennial ryegrass | 8266 | 8188 | 5760 | 986 | 4109 | 72 |
| Meadow fescue | 2546 | 3578 | 5662 | 1219 | 3873 | 852 |
| Mean | 6426 | 6023 | 5310 | 1528 | 3878 | 1267 |
| s.e.d.[1] | 1345 | 491 | 788 | 234 | 618 | 75 |
| Sig.[2] | * | *** | * | *** | NS | *** |
| **Shoot DM, gm$^{-2}$** | | | | | | |
| Meadow grass | 57 | 51 | 48 | 22 | 44 | 29 |
| Timothy | 174 | 127 | 83 | 23 | 110 | 26 |
| Perennial ryegrass | 221 | 131 | 75 | 10 | 87 | 3 |
| Meadow fescue | 37 | 48 | 71 | 18 | 75 | 17 |
| Mean | 122 | 89 | 69 | 18 | 79 | 19 |
| s.e.d.[1] | 27 | 10 | 17 | 2 | 11 | 2 |
| Sig.[2] | *** | *** | * | ** | ** | *** |

[1] Standard error of difference (s.e.d.) for comparing means within each year (n =12).
[2] NS = Non-significant, * P<0.05, ** P < 0.01, *** P < 0.001

*Statistical analyses*
The results for yield were analysed for each year separately using the standard split-plot model for ANOVA (n=36) in Genstat Version 7.1 (Laws Agricultural Trust 2003). The morphological data were analysed as one-way ANOVA, using fertilizer treatments as replicates (n=12).

## RESULTS

*Establishment*
Plots sown with meadow fescue had significantly (P<0.05) fewer grass tillers in the autumn of the establishment year (Yr0) than plots sown with the other grass species whereas the shoot DM yield was significantly lower (P<0.001) for meadow fescue and smooth meadow grass than for timothy and perennial ryegrass (Table 1). Significantly fewer clover plants had established in plots with timothy compared to the other companions, judging from the density of taproots in autumn (Table 2). However, the production of neither growing points nor stolons differed from that in plots with perennial ryegrass and meadow fescue (Table 2). Clover growing in plots with smooth meadow grass produced significantly more stolons m$^{-2}$ than in plots with the other three grasses and similarly had more growing points than clover growing with timothy and perennial ryegrass.

*Persistence of companion grasses*
The botanical composition of the herbage shows that other species than those originally sown made up an insignificant proportion of the total herbage, except in Yr3, where they contributed 12% in plots sown with meadow fescue (Table 3). However, as early as Yr2 visual observations in spring indicated that perennial ryegrass and meadow fescue had suf-

**Table 2.** The effects of smooth meadow grass, timothy, perennial ryegrass and meadow fescue on growing point no. and stolon production of white clover every autumn and spring 1999-2002 (Yr0-Yr3).

| | Yr0 | Yr1 | | Yr2 | | Yr3 |
|---|---|---|---|---|---|---|
| | Autumn | Spring | Autumn | Spring | Autumn | Spring |
| **Growing points, no. m$^{-2}$** | | | | | | |
| Meadow grass | 8719 | 7254 | 12552 | 455 | 5278 | 803 |
| Timothy | 5328 | 4276 | 9593 | 436 | 4983 | 1330 |
| Perennial ryegrass | 4295 | 4561 | 9780 | 695 | 3539 | 1166 |
| Meadow fescue | 7746 | 6271 | 9043 | 449 | 2919 | 1114 |
| Mean | 6522 | 5590 | 10242 | 509 | 4180 | 1103 |
| s.e.d.1 | 1254 | 573 | 1336 | 199 | 1463 | 220 |
| Sig.2 | * | ** | * | NS | * | * |
| **Stolon production, m m$^{-2}$** | | | | | | |
| Meadow grass | 54 | 54 | 277 | 9 | 85 | 23 |
| Timothy | 26 | 29 | 207 | 9 | 71 | 26 |
| Perennial ryegrass | 17 | 19 | 214 | 14 | 79 | 19 |
| Meadow fescue | 30 | 29 | 218 | 11 | 55 | 18 |
| Mean | 32 | 33 | 229 | 11 | 72 | 21 |
| s.e.d.[1] | 9 | 7 | 15 | 4 | 29 | 4 |
| Sig.[2] | * | ** | * | NS | NS | * |
| **Taproots, no. m$^{-2}$** | | | | | | |
| Meadow grass | 1199 | 1180 | 796 | 105 | 10 | 0 |
| Timothy | 737 | 845 | 531 | 79 | 59 | 0 |
| Perennial ryegrass | 1101 | 865 | 678 | 98 | 79 | 0 |
| Meadow fescue | 1278 | 1022 | 609 | 92 | 89 | 0 |
| Mean | 1079 | 978 | 654 | 93 | 59 | 0 |
| s.e.d.1 | 196 | 182 | 120 | 31 | 19 | 0 |
| Sig.2 | * | * | * | NS | * | |

[1] Standard error of difference (s.e.d.) for comparing means within each year (n =12).
[2] NS = Non-significant, * P<0.05, ** P < 0.01, *** P < 0.001

fered winter damage resulting in a number of open patches in the sward. Plots with timothy and smooth meadow grass, on the other hand, had a complete vegetative cover of the sown species.

*Dry matter yields*

The mean total yields varied substantially between the three harvest years, averaging 6.1, 3.5 and 4.7 t DM ha$^{-1}$ respectively (Table 4) and in all years there was a significant (P<0.001) difference between grass species, both in total and clover yields. Plots with perennial ryegrass were highest yielding in Yr1 but lowest in Yr3. Plots with meadow fescue were lowest yielding in Yr1 and Yr2 and plots with smooth meadow grass gave highest yields in Yr3. The ranking of clover yield with the different companions was smooth meadow grass>timothy>meadow fescue>perennial ryegrass in Yr1, whereas in

**Table 3.** Botanical composition (%) of total herbage, divided into sown grass (G), sown clover (C) and other species (O), for a mixture of white clover and smooth meadow grass, timothy, perennial ryegrass and meadow fescue, averaged over fertilizer treatments, harvested for three consecutive years (Yr1-Yr3).

| | Smooth meadow grass | | | Timothy | | | Perennial ryegrass | | | Meadow fescue | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | C | O | G | C | O | G | C | O | G | C | O |
| Yr 1 | 57 | 43 | 0 | 65 | 35 | 0 | 79 | 21 | 0 | 69 | 30 | 1 |
| Yr 2 | 73 | 26 | 1 | 76 | 22 | 2 | 78 | 21 | 1 | 82 | 15 | 3 |
| Yr 3 | 63 | 32 | 5 | 64 | 34 | 2 | 59 | 38 | 3 | 59 | 29 | 12 |

**Table 4.** The mean total yields, averaged over fertilizer treatments, and yields of white clover (DM t ha$^{-1}$) in a mixture with smooth meadow grass, timothy, perennial ryegrass and meadow fescue in all three harvest years (Yr1-Yr3).

| | Yr1 | | Yr2 | | Yr3 | |
|---|---|---|---|---|---|---|
| **Companion** | **Mixture** | **Clover** | **Mixture** | **Clover** | **Mixture** | **Clover** |
| Meadow grass | 5.84 | 2.45 | 3.57 | 0.89 | 5.15 | 1.79 |
| Timothy | 6.08 | 2.06 | 3.49 | 0.71 | 4.82 | 1.68 |
| Perennial ryegrass | 6.87 | 1.39 | 3.85 | 0.76 | 3.84 | 1.65 |
| Meadow fescue | 5.52 | 1.66 | 3.08 | 0.44 | 4.88 | 0.94 |
| Mean | 6.08 | 1.89 | 3.50 | 0.70 | 4.67 | 1.51 |
| s.e.d.[1] | 0.25 | 0.11 | 0.15 | 0.05 | 0.20 | 0.10 |
| Sig.[2] | *** | *** | *** | *** | *** | *** |

[1] Standard error of difference (s.e.d.) for comparing means within each year (n =9).
[2] NS = Non-significant, * P<0.05, ** P < 0.01, *** P < 0.001

Yr2 and Yr3 clover yield was lowest in plots with meadow fescue. The differences in clover yield partly reflected the proportion of clover in the herbage (Table 3).

There were significant differences (P<0.001) between fertilizer treatments for total yield in all years. In general, N1 gave the lowest yields and N3 the highest yields (Table 5). Exactly the opposite was the case for clover yields when, both in Yr1 and Yr3, N1 yielded significantly more than N3.

No significant interactions were found between grass companions and fertilizer treatments.

*Morphological measurements*

In general, there was a small change in population size for both clover and grass from autumn in the establishment year to the following spring for both grass and clover (Table 1 and Table 2). The total number of growing points and the amount of stolon produced by the white clover per unit area increased rapidly over the summer but fell dramatically during subsequent winters (Table 2). Similarly there was a great reduction in grass tiller number and shoot dry matter yields from autumn to spring after Yr0 (Table 1).

There were significant differences between grass companions for most of the morpho-

**Table 5.** The mean total yields, averaged over grass companions, and yields of white clover (DM t ha$^{-1}$) subjected to three different fertilizer treatments, 0 N (N1), 20 N in spring (N2) and 20 kg N ha$^{-1}$ in spring and after each harvest (N3) in all three harvest years (Yr1-Yr3).

| | Yr1 | | Yr2 | | Yr3 | |
|---|---|---|---|---|---|---|
| **N-treatment** | **Mixture** | **Clover** | **Mixture** | **Clover** | **Mixture** | **Clover** |
| N1 | 5.34 | 2.21 | 2.66 | 0.74 | 4.14 | 1.62 |
| N2 | 6.23 | 1.96 | 3.56 | 0.72 | 4.80 | 1.56 |
| N3 | 6.65 | 1.49 | 4.27 | 0.64 | 5.06 | 1.36 |
| Mean | 6.08 | 1.89 | 3.50 | 0.70 | 4.67 | 1.51 |
| s.e.d.[1] | 0.18 | 0.10 | 0.13 | 0.05 | 0.17 | 0.09 |
| Sig.[2] | *** | *** | *** | NS | *** | ** |

[1] Standard error of difference (s.e.d.) for comparing means within each year (n =12).
[2] NS = Non-significant, * P<0.05, ** P < 0.01, *** P < 0.001

logical measurements but the pattern differed between sampling dates. Thus, for number of grass tillers in spring of Yr1 the ranking was as follows (Table 1): perennial ryegrass>smooth meadow grass>timothy>meadow fescue. In the autumn of Yr1 only timothy had significantly fewer tillers than the other companions. In the spring of Yr2 smooth meadow grass had significantly more tillers than the other species, whereas in the autumn there was no difference between species. By the spring of Yr3 perennial ryegrass had virtually disappeared whereas smooth meadow grass had the most tillers. Timothy had a higher shoot DM than smooth meadow grass at all sampling dates, except in the spring of Yr2 and Yr3. Both growing point number and stolon production in white clover was, in general, highest in the plots with smooth meadow grass, especially in the autumn (Table 2). Taproot density fell dramatically during the course of the experiment, as the clover plants started to develop stolons, with none present in the spring of Yr3.

## DISCUSSION

### *Effects of companion grasses during establishment*

White clover and its grass companion compete for light, growing space, water and nutrients if any of these factors are in short supply, both during the establishment phase and in mature swards. Successful establishment of productive mixed white clover swards therefore requires both adequate plant numbers of white clover and rapid development after sowing (Haggar et al. 1985). The present experiment investigated the effects of different grass companions on the establishment of white clover under northern conditions. Results showed that, on average, the density of clover was 1079 plants m$^{-2}$ as measured by the number of taproots present in the sward in the autumn of the establishment year (Table 2). However, significantly fewer plants were found in plots with timothy compared with the other grass companions. It is possible that high seed rates of timothy in the mixture together with rapid shoot development had negatively affected clover establishment since the effects on clover development, measured by stolon production and growing point number, were not as severe. Shoot dry matter of the grass companion in the autumn of Yr0 was negatively correlated with growing point number ($r = -0.74$; $P<0.001$; $n=12$) and is thus a decisive factor for clover development. Smooth meadow grass, for example, was slow to establish, it had a low biomass in autumn and thus favoured clover development. Perennial ryegrass, on the other hand, had produced high shoot dry matter and suppressed development.

*Companion grasses and subsequent growth*

The effects of Yr0 were clearly carried over to Yr1. The mixture with perennial ryegrass thus gave the highest total yields and the smallest contribution from the clover component (Table 4). The mixture with smooth meadow grass, on the other hand, was low yielding but with the highest contribution from the clover. This difference in competitive ability of the two grass companions was reflected in the population size of the clover in Yr1 as clover in plots with smooth meadow grass had more growing points and stolons per unit area than clover growing with other companions (Table 2). During the second winter of the experiment ryegrass suffered severe winterkill. At the time of sampling in the spring of Yr2 it had very few tillers and low shoot dry matter yields per unit area, thus causing less suppression to the clover than in the previous year. The yield of the ryegrass mixture was particularly low in Yr3, demonstrating that the clover component could not make up for the yield loss of the grass component. The meadow fescue mixture was generally both low yielding and contained small amounts of clover, especially in Yr2.

A number of studies have demonstrated that grass companions differ in their compatibility with white clover. It is generally assumed that non-aggressive meadow fescue is highly compatible while timothy is intermediate (Frame et al. 1998). However, compatibility depends on both the growth habit and the seasonality of the grass component as demonstrated by studies comparing the complementary growth patterns of white clover and different ryegrass cultivars. Thus, Collins & Rhodes (1990) found that ryegrass cultivars with an erect growth habit were more compatible with clover while others have not found such a relationship (Piano & Annicchiarico 1995, Elgersma et al. 1998). Tetraploid ryegrass cultivars are generally less aggressive towards white clover than diploid forms (Fothergill & Davies 1993, Elgersma & Schlepers 1997). This is attributed to their growth habit, which is generally more open than that of diploids, thus allowing more space and better light penetration through the canopy (Frame et al. 1998). Similarly, late flowering ryegrass cultivars suppress clover presence compared to early flowering cultivars (Davies & Fothergill 1990), an effect attributable to increasing tiller density (Frame et al. 1998). Finally, it has been noted that, within perennial ryegrasses, the least productive and least persistent cultivars permit the best performance of companion white clover (Camlin 1981). Even though different species are being compared in the current study the results obtained generally comply with the findings for perennial cultivars expressing different growth habit. Thus, smooth meadow grass is early flowering, it has an open prostrate growth habit and low dry matter yields for individual tillers, and it is the most compatible companion with white clover of those tested in the current experiment. Unfortunately, these same characteristics make it inherently low yielding, but a higher proportion of clover will probably result in more stable yields in the long run.

*Effects of nitrogen*

The results obtained for nitrogen fertilisation were in line with common knowledge that increasing annual rates of fertilizer N, applied throughout the season, increase total herbage production but decrease the white clover contribution (Frame et al. 1998). If the aim is to balance the clover contribution of the herbage around 30% (Rhodes et al. 1994), it seems that applying 20 kg N $ha^{-1}$ in spring gave the desired results for this particular experiment. The effects of nitrogen, however, need to be studied in much more detail, particularly in early spring when N may be limited. This is currently being undertaken in a field experiment at Korpa Experimental Station.

## CONCLUSION

The results obtained in the current study demonstrate that population size of white clover and dry matter production is greatly influenced by the growth habit of the companion grass.

Perennial ryegrass caused the greatest suppression to clover growth, mainly because of high shoot yields and large leaf canopy already in the establishment year. Consequently the white clover plants were small and weak at the onset of winter resulting in low yields the following summer. In contrast, smooth meadow grass was the least competitive companion grass. Its low dry matter production per tiller and rhizomatous growth habit led to an open sward, which favoured clover growth.

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