Different combinations of perennial ryegrass and white clover phenotypes do not affect mixture yield under cutting management during establishment

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Abstract
A field experiment was conducted for 12 months under irrigation and cutting management to determine if interactions between perennial ryegrass and white clover cultivars of different phenotypes could affect pasture yield and botanical composition during establishment. Four ryegrass and four clover cultivars, differing in leaf and tiller/stolon traits, were grown in all combinations (n=16), along with monocultures of each (n=8), as sub-plots under two nitrogen fertiliser levels (100 or 325 kg N/ha/year). Dry matter yield and botanical composition were measured on nine occasions and ryegrass and clover population densities were determined four times. Total annual yield was similar for all mixture combinations due to substitution between the sward components. While there were significant yield differences among ryegrass or clover cultivar monocultures, these seldom explained differences in mixture yields. Mixtures yielded more DM than ryegrass monocultures under both N treatments (+1.3 to +3.9 t DM/ha/year).

Keywords: perennial ryegrass, white clover, dairy, dry matter yield, nitrogen fertiliser, phenotype, competition

Introduction
Perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) are the main components of pastures in New Zealand. Generally, when ryegrass and clover cultivars of different phenotypes are grown in a mixture the total annual dry matter (DM) yield of the pasture is similar, although differences in botanical composition can occur (Reid 1961; Connolly 1968; Camlin 1981; Rhodes & Harris 1979; Widdup & Turner 1983; Ledgard et al. 1990). More ryegrass and clover cultivars of different phenotypes are grown in a mixture to provide more productive pastures. This study addresses this question and examines how grass and clover characteristics may affect their competitive ability. Another objective was to quantify the effect of the inclusion of clover on pasture dry matter (DM) yield and its implications for ryegrass cultivar performance. The working hypothesis was that the DM production of the sward will not differ when modern perennial ryegrass and white clover cultivars with different phenotypes are grown in mixtures. All combinations of four perennial ryegrass and four white clover cultivars grown in binary mixtures at different nitrogen (N) fertiliser levels were compared. The perennial ryegrass cultivar by white clover cultivar interaction term was considered the critical test of the hypothesis. Monocultures of all cultivars were also included to help separate the effects on mixture yields of variation among cultivars in yielding ability *per se* from phenotypic factors such as tiller or stolon density and leaf morphology.

Methodology and analysis
The experiment was sown in November 2013 at the Lincoln University Research Dairy Farm, Lincoln, Canterbury, New Zealand (latitude 43°38'10.26"S; longitude 172°27'42.91"E; altitude 12 m a.s.l.) and measurements were made from 1 June 2014 to 31 May 2015. Soils at the site were Paparua sandy loam and Wakanui sandy loam, typic immature pallic soils and mottled immature pallic soils, respectively, (New Zealand soil classification, Hewitt 2010). Total rainfall during the experiment (376 mm) was 223 mm lower than the 30 year average (1981 to 2010) of 599 mm. Mean temperature for the period (12.3°C) was 0.7°C higher than the historic average (National Institute of Water and Atmospheric Research 2015).

The experimental design was a split-plot with four replicate blocks. Main plots were two N levels (100 and 325 kg N/ha/year), randomised within blocks. Subplots were the pasture types (24), made up of a 4 × 4 factorial of four perennial ryegrass cultivars and four white clover cultivars (16 subplots), plus monocultures of each cultivar (8 subplots), randomised within main plots. Subplots were 3 x 1.8 m; from within that area, the 10 central drill lines (1.5 m width) were harvested, resulting in a measurement area of 4.5 m².
perennial ryegrass cultivars were compared providing a range from fine to broader leaved and from open to dense plant habits. The cultivars were Abermagic AR1 (a dense, fine-leaved, diploid), Arrow AR1 (a dense, medium to broad-leaved, diploid), Prospect AR37 (a dense, medium to wide-leaved, diploid) and Bealey NEA2 (an open, medium-leaved, tetraploid). The four white clover cultivars evaluated represented a range in leaf size: Nomad (small-leaved), Bounty (medium-leaved). Tribut (medium-large-leaved) and Kopu II (large-leaved). Sowing rates were 20 kg/ha of seed for the diploid ryegrasses and 28 kg/ha for the tetraploid to account for differences in seed weight between the two species. White clover was sown at a rate of 4 kg/ha of bare seed (correction of this sowing rate was made to account for seed coating).

Defoliation was by cutting, to avoid confounding animal effects; irrigation was applied from October 2014 to March 2015 (400 mm). N fertiliser was applied manually as urea (46-0-0). In the Low N (100 kg N/ha) treatment, urea was applied at rates of 25 kg N/ha on four occasions. In the High N (325 kg N/ha) treatment, it was applied at a rate of 35.2 kg N/ha on six occasions and at a rate of 57 kg N/ha for the last two applications.

CMax™ (30 g/L amipyrine) at 60 mL/10 L water was applied on 3rd January 2015, with a knapsack sprayer, to the perennial ryegrass monocultures to control white clover and other legumes. The same day Gallant™ Ultra (520 g/L haloxyfop-P) at 12 mL/10 L water with Uptake™ spraying oil (582 g/L paraffinic oil and 240 g/L alkoxylated alcohol non-ionic surfactants) at 15 mL/10 L water were applied with a knapsack sprayer to the white clover monocultures to control white clover and other grasses.

Total DM yield was estimated on nine occasions (the last one on 12 May 2015) by harvesting the entire 4.5 m² measurement area to 5.5 cm above ground level, using a Haldrup forage harvester (Haldrup F-55, Denmark). Botanical composition was determined by dissecting a 15 g (fresh weight) subsample into: live perennial ryegrass, live white clover, live other species and dead material of all species. Components were dried for 72 hours at 65°C. Perennial ryegrass and white clover population densities were measured during June 2014, November 2014, January 2015 and May 2015; a 5 x 20 cm (100 cm²) frame was randomly positioned at three locations in each subplot and the number of perennial ryegrass tillers and white clover growing points within each frame were counted.

Statistical analyses were conducted for mixtures, monocultures of perennial ryegrass and monocultures of white clover, using ANOVA in GenStat 17 (VSN International 2014). Repeated measurements analyses were conducted on the total DM yield using the AREPMEASURE procedure in GenStat 17 (VSN International 2014).

Results

No interactions between perennial ryegrass and white clover cultivars on DM yield of the mixtures were observed, with one exception (Table 1). In November 2014, there was an interaction between N treatment, perennial ryegrass cultivar and white clover cultivar (P=0.045). Mixtures containing Abermagic AR1 and Kopu II grown under the High N treatment yielded less than the same mixtures under the Low N treatment. Mixtures containing Abermagic AR1 were the highest yielding irrespective of the N treatment and white clover cultivar included.

The effect of perennial ryegrass cultivar on the DM yield of the mixture was significant in six of the nine harvests. In November 2014, there was an interaction between N treatment, perennial ryegrass cultivar and white clover cultivar (P=0.001). Mixtures with low N application rate yielded 30.6% more DM/year than perennial ryegrass monocultures with the same level of N (+ 3.9 t DM/ha), while mixed pastures yielded only 6.8% more than perennial ryegrass monocultures (+1.3 t DM/ha) with high N application (Table 2).

Mixed pastures yielded 16.4% more than perennial ryegrass monocultures (+ 2.6 t DM/ha, average of both N treatments); however, the increment due to inclusion of clover varied when the pastures were grown under the different N treatments (N × white clover presence interaction, P<0.001). Mixtures with low N application rate yielded 30.6% more DM/year than perennial ryegrass monocultures with the same level of N (+ 3.9 t DM/ha), while mixed pastures yielded only 6.8% more than perennial ryegrass monocultures (+1.3 t DM/ha) with high N application (Table 2).
The effect of perennial ryegrass cultivar on clover content was greater in spring (August 2014, P<0.001; October 2014, P=0.003) and autumn (May 2015, P=0.001) whilst the effect of white clover cultivar occurred during most of the year (Figure 1). However, clover content was affected by the interaction between perennial ryegrass and white clover cultivar only once (May 2015, P=0.005).

Discussion

Mixture yields: interactions between grass and clover cultivars

Except for one date, no interactions between perennial ryegrass and white clover cultivars on DM yield of the mixtures occurred (November 2014). Thus, the hypothesis proposed is supported and breeding of both perennial ryegrass and white clover over recent decades has not altered the conclusion previously drawn, that interactions between perennial ryegrass and white clover cultivars do not affect the total yield of mixtures. This study found that monocultures of perennial ryegrass and white clover grew at similar rates from May 2015, and May 2015 (P=0.001), but not in November 2014 or January 2015 (P=0.220 and 0.334, respectively). Significant interaction between grass and clover cultivar on tiller density was detected only in November 2014 (P=0.023).

Different combinations of perennial ryegrass and white clover phenotypes... (L. Rossi, D.F. Chapman and G.R. Edwards)
Reducing nitrogen fertiliser alters dairy shed effluent quality

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Abstract
Dairy farmers using low rates of nitrogen fertiliser observed reduced odour in milking sheds, and a smaller growth response of pasture to effluent application. Effluent samples from four conventional (>100 kg N/ha/year, “high-fert”) and three low-nitrogen (N) fertiliser (<50 kg N/ha/year, “low-fert”) properties were collected in January 2017 and analysed for total N concentration, N form, mineral nutrient concentration and pH. Total effluent N concentration was comparable between both classes of farm. However, low-fert properties had a higher proportion of N in organic forms as opposed to ammoniacal-N than high-fert properties (mean 75% and 59% organic on low- and high-fert properties, respectively, P<0.01). Low-fert effluent also had a lower pH, higher P concentration, and nearer optimal N:P ratio than effluent from high-fert properties. It was hypothesised that reducing N fertiliser may result in more nutritionally-balanced effluent (N:P ratio), causing microbes to multiply more rapidly (lowering pH), storing N in microbial biomass, reducing ammonia emissions and odour, and reducing the risk of N leaching from effluent applied to pasture.

Keywords: dairy shed effluent, nitrogen fertiliser, ammonia, organic N, environmental loss

Introduction
Dairy shed effluent is a valuable source of nutrients for pasture plants on dairy farms (DairyNZ 2015). However, it is also a potential source of nutrient loss predominately via the following pathways: ammonia volatilisation (Li et al. 2014), nitrate leaching, and phosphorus runoff. Effluent is highly variable, and the characteristics of effluent will alter the quantity of nutrients available for loss via each pathway, and therefore the potential for environmental losses (Houlbrooke et al. 2011).

Nitrogen (N) exists in effluent in both inorganic (ammonium (NH₄⁺) and nitrate (NO₃⁻)) and organic forms. Inorganic N is susceptible to gaseous loss as ammonia (NH₃) and leaching as nitrate. Although dissolved organic nitrogen can leach as a general rule, organic nitrogen is unlikely to be lost unless it is first converted to inorganic forms (Houlbrooke et al. 2011).

Inorganic nitrogen is available to plants and can be rapidly used for growth. Therefore, effluent rich in ammonia and/or nitrate is likely to result in an immediate plant growth response. However, organic nitrogen (other than urea) is slowly released for plant use, and slow-release nutrients may result in a higher long-term pasture growth response per unit of N applied than soluble nutrient applications (Zaman et al. 2009).

Farm staff on properties in the study group using low rates of N fertiliser noticed a reduced odour in the milking shed, and also a reduction in the immediate visible pasture response to effluent application, compared with their expectations from past experience under conventional management (A. Lapping pers. comm.). This paper describes the results from a farmer-funded effluent analysis study designed to determine whether these observations were due to actual differences in the characteristics of effluent between farms using low or high rates of synthetic N fertiliser.

Methodology and analysis
Seven dairy farms were chosen for this study. All were located on free-draining alluvial soil and annual rainfall was supplemented with irrigation. All farms were located between Greendale and Dunsandel, in Canterbury, New Zealand. On most farms herd size was 300-800 cows (one “low-fert” farm had 300 and one “high-fert” farm had 1500). All used twice-a-day milking at the time of sampling, most farms used a daily acid wash and two alkali washes per week (one high-fert farm used only one alkali wash per week). Insufficient data were available on wash-down water use to determine whether dilution differed between farms. Three farms applied low total rates of N fertiliser (30-43 kgN/ha/year, as both organic and synthetic forms), and four applied moderate to high rates (100-350 kgN/ha/year, primarily as urea). These two categories were referred to as low-fert and high-fert farms, where “fert” refers solely to nitrogen. Supplementary feed practices were comparable, with cows receiving a grain or PKE supplementary feed on most properties, although two low-fert and one high-fert property also fed seaweed and/or fish hydrolysate as an animal nutritional supplement.

Eleven effluent samples were collected on two dates in January 2017. Four farms (two low-fert, two high-fert) were sampled on 16 January. All seven farms were sampled on 30 January. Samples were