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Performance by dairy cows grazing two perennial ryegrass cultivars

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ABSTRACT

The effects of two high-endophyte perennial ryegrass cultivars ('Aries HD' or 'Yatsyn 1') on the performance of lactating dairy cows were investigated during a two-year trial. Spring calved cows (Year 1, n = 359; Year 2, n = 570) were allocated to one of two herds. Herds grazed the cultivars as part of each grazing rotation from November to May for the 1997/98 and 1998/99 seasons. Milksolids production was higher ($P < 0.001$) from the Aries HD herd compared with the Yatsyn 1 herd (228 vs. 202 kg MS/herd/day, Year 1; 340 vs. 294 kg MS/herd/day, Year 2, Aries HD and Yatsyn 1 herds, respectively) ($P < 0.001$). Milk fat % and protein % did not differ significantly ($P > 0.1$) between herds. Significantly ($P < 0.001$) more body condition (+0.8 of one body condition score) and more live weight (+17 kg) was gained by cows grazing Aries HD during Year 2. Interval from start of mating to predicted conception tended to be longer for cows grazing Yatsyn 1 (+6 days) during Year 1 ($P = 0.06$). Significantly different cow performance from ryegrass cultivars that produce similar yields of dry matter may be due partly to differences in forage quality and endophyte toxins. Aries HD tended to be more digestible than Yatsyn 1 and was associated with lower concentrations of ergovaline, an alkaloid produced by *Neotyphodium* endophytes that has been associated previously with reduced animal performance.

Keywords: Ryegrass; dairy cow; feed quality; milk production.

INTRODUCTION

Continued selection for milk production has increased the genetic potential of dairy cows to produce milk. However, increased production of milk is associated with greater nutritional requirements, providing a challenge for New Zealand dairy farmers to fully feed cows from a predominantly pasture-based system. Seasonal variation in the quantity and quality of temperate pastures can prevent the attainment of genetic production potential by cows of high genetic merit.

Significant potential exists to improve the nutritional value of pasture through plant breeding programs. Traditionally, forage breeding programs have focused on selection indices including herbage yield, agronomic performance and resistance to pests and disease, with limited consideration of the nutrient requirements of the grazing animal. A New Zealand forage breeding program uses selection criteria such as reduced concentrations of specific *Lolium perenne* endophyte alkaloids and increased digestibility in addition to traditional criteria. Live weight gains by lambs grazing perennial ryegrass cultivars selected from this program have exceeded those grazing 'Grasslands Nui' by up to 60% (Westwood and Norriss, 1999). Potential benefits for lactating dairy cows associated with the same cultivars relationships between and the performance of lactating dairy cows require further elucidation.

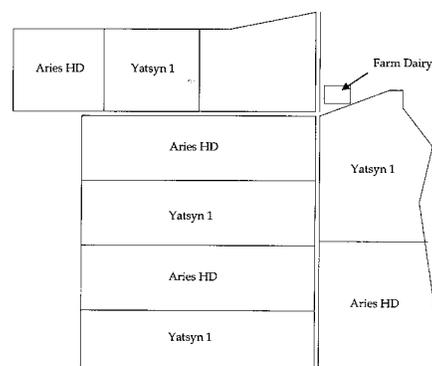
The objectives of this study were to 1) investigate milk production by dairy cows grazing pastures containing either Aries HD, a high-endophyte perennial ryegrass cultivar selected for improved digestibility, or Yatsyn 1 high-endophyte perennial ryegrass, a cultivar used widely in the New Zealand dairy industry; 2) evaluate the body condition score, live weight and reproductive performance of cows grazing Aries HD compared with Yatsyn 1.

MATERIALS AND METHODS

The study was conducted on an irrigated dairy farm in

the Central Hawkes Bay region of New Zealand which had been converted recently from a beef and cropping farm. Sixty three hectares of high-endophyte diploid perennial ryegrass (31.5 ha 'Aries HD' and 31.5 ha 'Yatsyn 1') were sown at 25 kg/ha, together with 3 kg/ha Grasslands Challenge white clover, 3 kg/ha Grasslands Kopu white clover and 1 kg/ha Pawera red clover per hectare during Autumn 1997. All seed was Superstrike, coated and the ryegrass verified as high endophyte (>90% infected). Level of endophyte infection was confirmed by microscopic examination of tillers collected in October 1998. Cultivars were alternated across the study area to minimise any possible effects of differences in soils within the area (Figure 1). The balance of the 170 ha farm (107 ha) was sown in a commercial ryegrass mix (Embassy high-endophyte perennial ryegrass, 12 kg/ha; Banks high-endophyte perennial ryegrass, 8 kg/ha; Maverick Gold hybrid ryegrass, 4 kg/ha; Kopu white clover 4 kg/ha; Colenso red clover 2 kg/ha; Saborto cocksfoot 1.5 kg/ha)

FIGURE 1: Arrangement of study cultivars within the 63 hectare area allocated for study involvement.



Soil tests were collected across study paddocks once during Year 1 and once during Year 2. Multiple core samples were collected and pooled for each paddock. Year 1 results ranged between pH, 5.6-5.8; Olsen P, 19-31; sulphate S, 4-5; K, 5-13. Year 2 results ranged between pH, 5.8-6.2; Olsen P, 23-38; sulphate S 15-43; K, 5-12. Applications of nitrogen and fertiliser were identical across all study paddocks and were based on the lowest soil test results.

Three hundred and fifty nine spring-calving Jersey/Friesian/Ayrshire mixed-breed dairy cows were allocated to one of two herds (179 cows, Aries HD and 180 cows, Yatsyn 1) in October 1997, balanced for calving date, milk production and age. In October 1998, 570 cows were re-randomised and re-allocated to herds using calving date, milk production, age, previous herd allocation, body condition score and live weight. Cow numbers remained even across herds during both years as maintained by the sharemilker and monitored by the study consultant. Following purchase of additional cows, cow numbers peaked at 214 per herd (December grazing period, Year 1, both herds) and 316 (Yatsyn 1; December, January and February, Year 2) vs. 315 (Aries HD; December, January and February, Year 2).

One herd grazed Aries HD pastures on consecutive days for up to 10 days (Year 1), and 14 days (Year 2) (minimum 5 days) of each grazing rotation while the other herd grazed Yatsyn 1 pastures concurrently. At the end of each grazing period, herds remained separate and grazed the non-study areas of the farm. Seven grazing periods were recorded between November 1997 and May 1998 ('Year 1'), mean duration = 8 days. Milk measurements did not commence until November due to resource constraints associated with the significant labour and time commitment required to run this study being unavailable during busy calving and mating periods. At the completion of Year 1 (May 1998), cows were dried off and recombined as one herd. Seven grazing periods were recorded between November 1998 and May 1999 ('Year 2'), mean duration = 11 days. Neither pre-grazing nor post-grazing residuals were objectively quantified during either year of the study, however, dry matter covers were subjectively assessed by the sharemilker and consultant during both years and considered to be very similar for both cultivars.

Morning and afternoon total milk production (litres) were recorded for each herd during each grazing period using an electronic flow meter (Signet 525 Metalex Flow Sensor). Milk production data were not recorded until herds had grazed cultivars for a minimum of 48 hours. Morning and afternoon milk samples from each herd were collected using a tap in the milk line set to drip into a stainless steel bucket throughout the milking, to collect on average 5 L of milk. A representative sub-sample was collected from each herd at each milking and submitted for analysis of milk fat % and milk protein % by a commercial dairy laboratory.

In addition in Year 2, milk yields and composition for individual cows were measured by herd test by the Livestock Improvement Corporation on four occasions. Cows had been grazing study cultivars for at least 48 hours before, and at the time of, herd test. Herd testing recorded p.m. and a.m. litres, milk fat % and protein %, and somatic

cell count for each cow. Cows were also herd tested during Year 1, however cows were not grazing study cultivars at the time of test, therefore data were not analysed.

All cows were weighed and scored for body condition, using the 1-10 New Zealand scale, at the commencement (October 1998) and end (May 1999) of Year 2 only.

Interval from start of mating to predicted conception was assessed using calving date to start of mating interval as a covariate. Predicted conception dates were obtained from Livestock Improvement Corporation records. Year 2 data were not available for analysis at the time of preparation of this paper.

Blood samples were collected for prolactin (PRL) assay from 30 randomly selected cows from each herd in December 1998. The same cows were re-sampled in February 1999. Cows had grazed the cultivars for a minimum of 48 hours before collection of blood samples. Blood was placed on ice before being centrifuged and plasma decanted and frozen. Bovine PRL was assayed using ovine PRL (NIDDK-oPRL-1-2) for standards and radioiodination, and ovine PRL antiserum (NIDDK-anti-oPRL-2). Prolactin was iodinated by the lactoperoxidase method, using [¹²⁵I] iodide (New England Nuclear NEZ0033A). The assay method is essentially as prescribed for the NIDDK reagents. Separation of antibody – bound label from free label was by second antibody precipitation using an excess of sheep anti-rabbit serum (generated at the Ruakura Research Centre, Hamilton, New Zealand). Sensitivity was 0.6 ng/ml. Inter-assay and intra-assay coefficients of variation at 25 ng/ml were 2.5 % and 4.0 % respectively.

Pastures samples consisting of mixed ryegrass/white clover were collected on four occasions during Year 2 from each study paddock. Samples were harvested to "post-grazing residual" height, individual paddock samples were bulked according to cultivar, and a pooled sample from each cultivar was dried overnight at 60°C before submission to a commercial feed testing facility. Samples were assessed for organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), digestible dry matter in organic matter (DOMD) and megajoules of metabolisable energy (MJME) per kg DM. Dry matter was assessed by oven drying at 95°C, OM by combustion at 550°C for 8 hours and CP by the Kjeldahl technique as reported in Tecator Kjeltex 1035 analyser (Sweden) manual. Digestibility was assessed using a cellulase pepsin technique, and MJME calculated using MJME = DOMD x 0.16. Duplicate samples, bulked from each paddock of each cultivar were placed immediately on ice following collection and submitted for endophyte alkaloid profile analysis.

Pastures were scored for clover content on four occasions during Year 2, with clover expressed as a percent of total sward. Scoring was by an Agriculture New Zealand consultant using the 'gumboot method', where a point on a boot is marked, and pasture species touching the mark noted while walking through each paddock. Paddocks were averaged to give a score for each cultivar. Presence of other non-study grass or weed species was not quantified.

An ANOVA was performed (Genstat Version 5.0) using each grazing period as a replicate to assess potential differences in milksolids production between each herds.

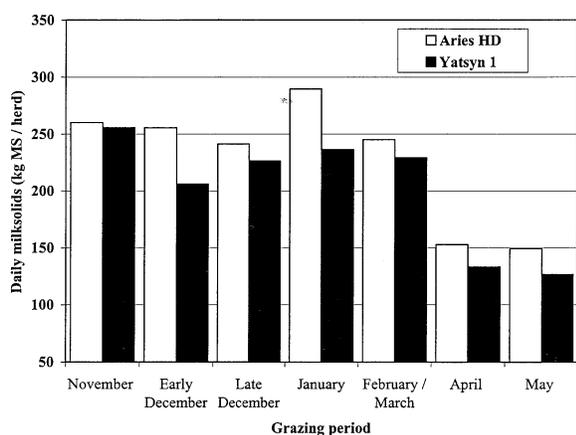
Grazing period means were adjusted for missing values. Auto-correlation within and between sampling periods was assessed at less than 10%. This method of analysis assumes paddock-to-paddock and animal-to-animal variation was minimal. Herd test data was analysed using Genstat ANOVA. Differences in time from mating to predicted conception date were assessed using survival analysis. The influence of controlling for the effects of interval from calving to start of mating on herd survival function were examined using Cox's proportional hazards model (BMDP Dynamic, 2L).

RESULTS

Milksolids production: Significantly more milksolids (fat plus protein) were produced by the Aries HD herd than the Yatsyn 1 herd during both years of the study (Figure 2 and Figure 3; $P < 0.001$; combined analysis across years).

Cows that grazed Aries HD also produced significantly ($P < 0.001$) more MS than cows grazing Yatsyn 1 according to the herd test information collected during Year 2 (Figure 4).

FIGURE 2: Daily milksolids production by the herds grazing Aries HD or Yatsyn 1 during Year 1. (Cow numbers per herd per period; November, 175; Early December, 175; Late December, 175; January 187; February / March, 214; April, 195; May 195)



Milk fat percent and milk protein percent: Milk fat % and milk protein % did not differ significantly between herds for bulk milk samples during either year of the study ($P > 0.1$, combined analysis). Similarly milk fat % and milk protein % did not differ significantly ($P > 0.1$) for the herd test samples in Year 2. Following \log_{10} transformation of herd test data, somatic cell counts did not differ significantly ($P > 0.1$) between cows grazing the two cultivars.

Live weight and body condition score: Cows that grazed Aries HD gained significantly ($P < 0.001$) more live weight and body condition between October 1998 and May 1999 than cows grazing Yatsyn 1. Aries HD cows gained, on average, 46 kg live weight (416 kg vs. 462 kg, October and May, respectively) compared with Yatsyn 1 cows with an average gain of 29 kg (420 kg vs. 449 kg, October and May, respectively). Aries HD cows gained, on average, 0.8 of one condition score (4.3, October vs. 5.1, May) compared with Yatsyn 1 with an average gain of 0.3 of one condition score (4.3, October vs. 4.6, May) during the same

FIGURE 3: Daily milksolids production by the herds grazing Aries HD or Yatsyn 1 during Year 2. (Cow numbers per herd per period; November, 288 Yatsyn 1, 287 Aries HD; December, 316 Yatsyn 1; 315 Aries HD; January, 316 Yatsyn 1; 315 Aries HD; February, 316 Yatsyn 1; 315 Aries HD; March, 295 both herds; April 295 both herds; May 230 both herds)

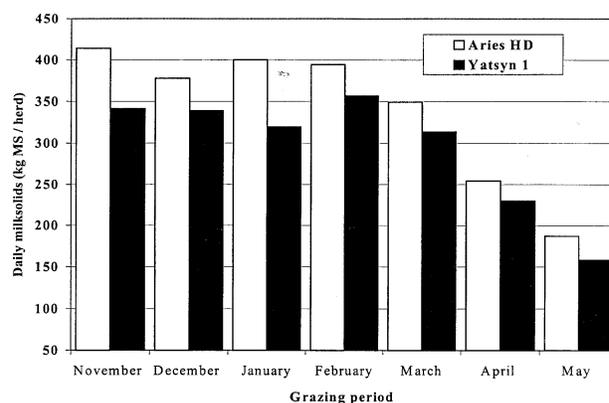


FIGURE 4: Daily milksolids production by cows grazing Aries HD or Yatsyn during Year 2 (herd test data).

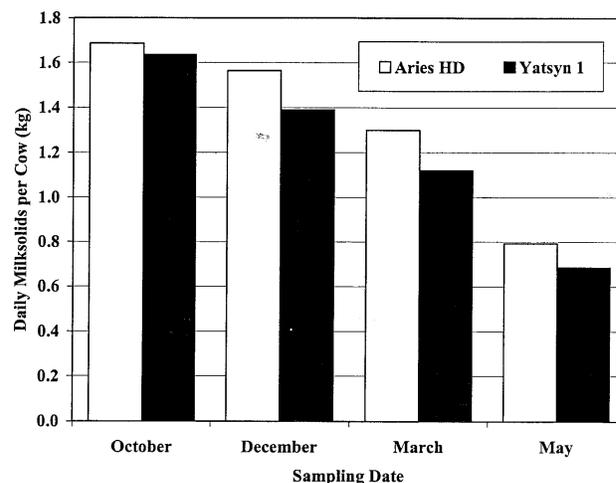


FIGURE 5: Cumulative proportion of cows conceiving for herds grazing Aries HD or Yatsyn 1. Day one of mating was 28th October 1997. Data includes only cows in herds at time of herd split in October 1997.

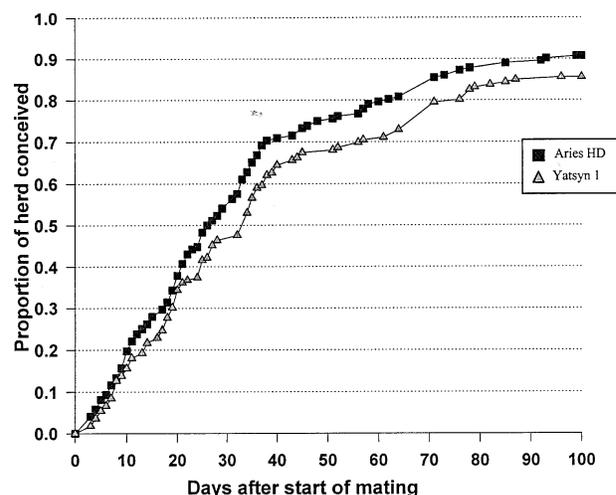


TABLE 1: Mean values for Dry matter, Organic matter, Crude Protein, Neutral Detergent Fibre, Organic Matter Digestibility of Dry Matter, Megajoules of Metabolisable Energy, and clover expressed as percent of total herbage for Aries HD and Yatsyn 1 high endophyte perennial ryegrass/white clover collected on four occasions during Year 2

	Dry Matter % As % of fresh matter	Organic Matter ¹	Crude Protein ¹	NDF ^{1,2}	DOMD ^{1,3}	MJME/kg DM	Clover ⁴
Aries HD							
20 October 1998	18.1	91.1	26.7	33.8	74.8	12.0	60
4 December 1998	16.5	88.5	28.0	49.5	70.8	11.3	ND
1 February 1999	13.8	89.2	28.8	46.4	67.0	10.7	30
25 March 1999	15.8	88.6	30.5	61.2	67.3	10.8	30
Yatsyn 1							
20 October 1998	19.4	90.7	28.7	32.1	75.7	12.1	40
4 December 1998	14.9	88.2	28.0	50.7	71.4	11.4	ND
1 February 1999	14.2	88.6	26.2	48.4	63.2	10.1	40
25 March 1999	16.8	87.9	29.0	58.8	64.7	10.3	35

¹ Expressed as a percent of dry matter

² NDF = Neutral Detergent Fibre

³ DOMD = Organic Matter Digestibility of Dry Matter

⁴ Expressed as a percent of total herbage

ND = Not done

period.

Interval from start of mating to conception: Cows grazing Yatsyn 1 tended ($P = 0.06$) to have a longer interval from the start of mating to predicted conception during Year 1 (36 days vs. 42 days for cows grazing Aries HD and Yatsyn 1, respectively; Figure 5).

Nutritive value and clover content: In February and March 1999, *in vitro* DOMD content and MJME values were higher for Aries HD than for Yatsyn 1 (Table 1), however, lack of replication does not permit statistical evaluation of these data. Clover content was variable across the sampling occasions.

Endophyte alkaloid concentrations: Concentrations of peramine were lower for the Aries HD samples than the Yatsyn 1 samples, however, levels are considered adequate to ensure persistence of perennial ryegrass. Concentrations of lolitrem B were similar for both cultivars on 2 out of 3 sampling occasions (Table 2), however, concentrations of ergovaline were lower for the Aries HD samples than for Yatsyn 1 on all 3 occasions. Incidence of ryegrass staggers was low for cows grazing both cultivars during both years, and subjective assessment indicated no apparent difference between cultivars.

TABLE 2: Concentrations of endophyte-associated alkaloids (ppm) for Aries HD and Yatsyn 1 cultivars collected during Year 2.

	Lolitrem B (ppm)	Ergovaline (plus ergovalinine) (ppm)	Peramine (ppm)
Aries HD			
4 December 1998	0.4	< 0.1	14.1
1 February 1999	1.1	< 0.1	14.6
25 March 1999	1.0	0.1	23.1
Yatsyn 1			
4 December 1998	0.5	0.3	17.2
1 February 1999	1.7	0.5	20.6
25 March 1999	1.0	0.5	35.3

Plasma Prolactin: The effects of cultivar on concentrations of plasma prolactin were inconsistent (Table 3).

TABLE 3: Plasma prolactin (ng/mL) collected from 30 cows in each herd on two occasions during Year 2, mean and standard deviation (SD).

	Plasma Prolactin (ng/mL)			
	December 1998		February 1999	
	Mean	SD	Mean	SD
Aries HD	29.6	10.0	14.5	6.8
Yatsyn 1	22.5	6.9	21.7	9.5

DISCUSSION

The findings of significantly improved performance by dairy cows grazing Aries HD is in agreement with previous work with lambs (Bluett *et al.*, 1997; Bluett *et al.* 1999a; Westwood and Norriss, 1999) and cows (Westwood and Lean, unpublished). The mechanisms by which Aries HD improves the performance of grazing ruminants are not fully understood, however current knowledge surrounding some characteristics of this cultivar could, in part, explain observed outcomes.

Aftermath heading: Aftermath heading (AMH) describes the development of stem and seedhead subsequent to removal of the initial spring seedhead flush, a phenomena that contributes to loss of feed quality experienced on many NZ dairy farms during the summer. Aries HD is characterised by reduced AMH, as demonstrated by the National Forage Variety Trials (NFVT) at Palmerston North (approximately 90 km from the study site) where replicated plots of Aries HD were scored at 8.0 and Yatsyn 1 at 7.5, $LSD_{0.05} = 0.6$ (where 1 = most and 9 = least aftermath heading; NFVT trial code P396PAL, unpublished). Reduced AMH probably contributed in part to significantly improved performance by cows grazing Aries HD, possibly through effects on digestibility of the ryegrass plant.

Digestibility: On two of four sampling occasions during Year 2, non-replicated Aries HD pasture samples showed greater digestibility and higher MJME/kg DM values than Yatsyn 1. These results are in agreement with previous work in which five trials conducted from 1994 – 1997 under rotational grazing during summer demonstrated Aries HD to be between 0.9% and 3.5% higher in digestibility than Yatsyn 1 (Norriss, unpublished).

Selection strategies include methods by which the rapid decline in pasture quality during summer may be addressed.

Increased digestibility values reported for Aries HD may be associated with selection for reduced AMH or may reflect improved digestibility traits inherent to the cultivar. Higher digestibility can improve animal performance because a greater proportion of feed eaten is available for use by the animal, with a lesser proportion lost as faecal energy, therefore efficiency of feed conversion is improved (Thompson and Poppi, 1990). Further, increased digestibility has been positively associated with herbage intake (Troelsen and Campbell, 1969).

Dry Matter Intake (DMI): Dry matter intakes were not quantified, therefore we cannot speculate on possible associations between Aries HD and DMI in this study. Previous studies under controlled experimental conditions have found increased DMI by animals eating Aries HD compared with Yatsyn 1 (Bluett *et al.*, 1999a; Westwood and Lean, unpublished). Increased DMI by animals grazing Aries HD reported for previous studies may be associated with greater digestibility or reduced concentrations of the endophyte alkaloid, ergovaline. Presence of endophyte alkaloids has been linked with reduced DMI through lower palatability or reduced appetite (Fletcher, 1993).

While AMH and digestibility may have contributed in part to significantly improved performance by cows grazing Aries HD, it is unlikely that these factors alone were responsible for production differences between herds. Metabolisable energy differed between Aries HD and Yatsyn 1 by less than 0.6 MJME/kg DM during February and March 1999. Assuming that a cow in late lactation was eating 15 kg DM / day, and that additional ME was partitioned entirely towards the production of milk, up to 1.4 kg of milk at 5.25 % milk fat and 3.70 % milk protein, could be attributed to the additional intake of ME (AFRC, 1995). Given that a cow in mid to late lactation is unlikely to partition additional energy entirely towards the production of milk, it is unlikely that differences in production of milk between the Aries HD and the Yatsyn 1 herds can be attributed entirely to differences in digestibility.

Endophyte alkaloids: Aries HD and Yatsyn 1 were sown as high-endophyte lines to ensure persistence, a requirement typical for most North Island dairy farms. Persistency of high-endophyte perennial ryegrasses is conferred by peramine, a pyrrolopyrazine alkaloid produced by the endophyte that offers some protection against insect attack. At least two other endophyte-associated alkaloids that may negatively influence the productivity of grazing animals have been isolated from high-endophyte perennial ryegrasses. Lolitrem B, a tremorgen, has been associated with ryegrass staggers while ergovaline, a dopamine agonist has been associated with increased incidence of heat stress and reduced concentrations of plasma prolactin (Fletcher *et al.*, 1999).

While concentrations of lolitrem B were similar for Aries HD and Yatsyn 1 in ryegrass samples collected during Year 2, concentrations of ergovaline associated with Aries HD were less than half those of Yatsyn 1, in agreement with previous reports (Bluett *et al.*, 1997; Bluett *et al.*, 1999b; Norriss, unpublished). While Fletcher (1998) suggested a threshold of >0.5 ppm for suppression of prolactin in lambs, the potential threshold at which dairy performance may be impaired remains unclear. We cannot,

therefore, discount the possibility that greater concentrations of ergovaline associated with Yatsyn 1 samples contributed to reduced milk production and live weight gain by cows grazing that cultivar for part of each grazing rotation.

Associations between *Lolium perenne* endophyte and dairy cow productivity are poorly understood, with some (Valentine *et al.*, 1993; Clark *et al.*, 1996; Thom *et al.*, 1997; Blackwell and Keogh, 1999), but not all, studies reporting negative associations between endophyte and cow performance. Inconsistencies between studies most likely reflect limitations of study design and grazing management, interactions between intake of alkaloids by grazing cows and environment, (principally ambient temperature and humidity), genetic variation in animal or herd tolerance to alkaloids, animal adaptation to the effects of alkaloids, and different profiles of endophyte alkaloids associated with different ryegrass cultivars.

White clover content: White clover content of mixed swards is an important modifier of dairy farm productivity because white clover content is positively associated with animal performance. Differences in clover content were variable during Year 2, however, we acknowledge that the 'gumboot' method provides a relatively imprecise measure of clover content. Clover content was not quantified during Year 1, however, subjective assessment by the farmer and the consultant responsible for overview of the study indicated that differences were minimal. In a National Forage Variety Trial undertaken at Palmerston North, Yatsyn 1 was associated with a significantly greater yield of clover than Aries HD (2274kg/ha/year vs. 1871kg/ha/year, LSD @5%=308, NFVT P396PAL).

The mechanisms by which interval from start of mating to predicted conception was extended for cows grazing Yatsyn 1 remain unclear. The data do not permit us to adequately determine if this effect was due to delayed submission rate, decreased conception rate or a combination of both. Fletcher (1998) speculated that ergovaline may negatively influence conception in dairy cows through heat stress and elevated body temperatures, both of which have been associated with reduced conception rates and increased incidence of early embryonic death.

Under traditional forage evaluation methods, dry matter yields of ryegrass by Aries HD and Yatsyn 1 were not significantly different in either of two 3-year trials run at Palmerston North, (National Forage Variety Trials P294PAL and P396PAL). However, milksolids yields differed by more than 10% for cows grazing Aries HD and Yatsyn 1 in the current study. Previous studies have shown improved performance by lambs grazing Aries HD compared with those grazing Yatsyn 1, despite similar yields of dry matter by each cultivar. Similarly, live weight gains by lambs differed by up to 60% when lambs grazed different high endophyte perennial ryegrass cultivars with potential dry matter yields that differed by less than 10%. The apparent absence of a positive association between dry matter yield and animal performance indicates that the use of animal grazing studies for the evaluation of new cultivars remains preferable to dry matter evaluation alone. This approach will ensure that the continued genetic improvement of forages results in improved animal production.

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