Endophyte toxins and performance of spring-calving dairy cows in Northland

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Abstract

An on-farm trial was carried out at Te Hana, in Northland, to measure milk production responses in 2 groups of 16 spring-calving, 3-year-old Holstein-Friesian cows maintained throughout the trial on pastures with or without the ryegrass endophyte toxins, ergovaline and lolitrem B. The trial began in October 1997, with second calving cows balanced for calving date and production worth. Milk volumes of all cows were recorded for 10 consecutive days each month followed by a herd test in which milk volume, protein, fat and lactose contents were determined from milk samples. There were no differences in milk volume or milk solids production in the October and November measurement periods. In December, the group grazing toxin-free (–Ev) pastures produced 24% more milk than the group grazing toxin-containing (+Ev) pastures. These differences increased progressively as the trial proceeded, until terminated in mid-April. Throughout the trial period the –Ev group produced 23% and 19% more milk and milk solids, respectively, than the +Ev group. A rise in levels of the endophyte toxins in ryegrass coincided with the start of differences in milking performance. A toxin-free maize based supplement was fed to both groups during the January to March period to maintain the trial when pasture growth was insufficient. A negative correlation was found between milk production of the +Ev group in January and the prevailing temperature and humidity conditions during the night.

Keywords: endophyte toxins, ergovaline, lolitrem B, milk production, *Neotyphodium*, Northland, ryegrass

Introduction

Milk production in Northland from spring-calving herds is lower than that obtained from the other major dairying regions of New Zealand (LIC Ltd 1998). Lactation peaks in September–October and usually starts to decline from mid-October onwards before any marked decline occurs in the feeding value of the pasture.

As in other regions, dairy pastures in Northland are predominantly perennial ryegrass-based and mostly contain high levels of endophyte (*Neotyphodium lolii*). The perennial ryegrass (*Lolium perenne* L.) in such pastures contains the endophyte alkaloids lolitrem B and ergovaline (Easton *et al.* 1995), and these alkaloids are higher in ryegrass flowering stems and in leaf sheaths than in leaf blades (Lane *et al.* 1997; Keogh *et al.* 1996).

Decreased performance of dairy cows consuming endophyte-infected tall fescue (Strahan *et al.* 1987) and endophyte-infected ryegrass (Valentine *et al.* 1993) have been reported. Trials in New Zealand (Thom *et al.* 1997; Clark *et al.* 1999) have shown only small and inconsistent effects on milk production. These trials were, however, of short duration and any cumulative and longer-term effects would not have been expressed. Decreases in milk production have occurred in herds in Northland in which heat stress has been evident during some periods in summer (Blackwell 1999). As impaired heat regulation is one of the physiological effects attributed to ergopeptine alkaloids (Oliver *et al.* 1997), the possible involvement of the endophyte alkaloids, and ergovaline in particular, in the milking performance of Northland herds was suspected.

This paper outlines an on-farm trial in which milk production was measured throughout the 1997/1998 season. Herds grazed pastures with or without ergovaline and lolitrem B. Some of the results from this trial have been presented elsewhere (Keogh *et al.* 1999), however, this paper contains additional information on milk solids production, serum prolactin levels and cow condition scores.

Methods

Pastures, animals and their management, and measurements were as previously described (Keogh *et al.* 1999).

Pastures

Existing 3- and 4-year-old high endophyte ryegrass pastures were used for one group (+Ev). Three year old tall fescue pastures, a 2-year-old low endophyte ryegrass pasture, plus autumn and spring sown ryegrass pastures with selected endophyte that did not produce either lolitrem B or ergovaline were used for the other group (–Ev).

Animals and management

Two groups of 16 second calving Holstein-Friesian cows, balanced for calving date and production worth (a measure of a cow's ability to convert feed into profit through her lifetime production) were allocated to the respective pastures in early October 1997 and were maintained on the trial continuously until mid-April 1998. Each group was given similar pasture allowances daily.

Stocking rates for both groups were kept at similar levels throughout. The group grazing pastures without ergovaline and lolitrem B (–Ev) was initially stocked at 2.9 cows/ha, reduced to 2.05 cows/ha from February onwards when the spring-sown paddock was grazed during the non-measurement phase. The group grazing pastures containing ergovaline and lolitrem B (+Ev) was stocked at 2.76 cows/ha reducing to 2 cows/ha from February when an additional paddock was included.

During the dry January–March period 120 kg/cow of maize-based meal (ergovaline-free) was fed to both groups to sustain the trial. Meal feeding started after the January measurement period.

During the 10 day measurement periods the –Ev group grazed only the 2-year-old ryegrass pasture or the autumn sown pasture.

Measurements

Milk volumes for all trial cows were measured with milk meters at each milking for 10 consecutive days each month before a herd test. Blood samples were taken, body temperatures recorded, and cow condition was assessed after afternoon milkings before each herd test. Cow condition was visually assessed by Mark Blackwell using a well established scoring system. Daily maximum and minimum temperatures and relative humidities were recorded on-farm from January to April 1998. Pasture samples were taken monthly to monitor herbage mass before and after grazing, botanical composition, endophyte status, lolitrem B and ergovaline concentrations, and nutritional value.

Results

Milk production

From monthly Herd Test records during the 6 month trial period, the –Ev group produced 40 kg milksolids more than the +Ev control group (Table 1). Milk solids production (Figure 1) and milk volume (Figure 2) followed similar patterns over the trial period. The higher milk solids production translates into an additional revenue of at least $260/ha.

Milk production was similar for both groups during October and November, and for the remainder of the trial period the –Ev group produced significantly more milk than the +Ev group. The –Ev group exceeded

Table 1 Milk solids production (kg/cow) and value ($/cow) for the trial period and seasonal production.

	Season Total	Milk Solids¶ (kg/cow)	Milk value† $/cow
–Ev – 16 cows average	335	251	828
+Ev – 16 cows average	295	211	696
Difference	40	40	132
% Difference		+ 19%	+ 19%

¶ Milk solids produced between 1 October 1997 and 29 April 1998

† Calculated using $3.30/kg MS

Table 2 Mean ergovaline and lolitrem B concentrations (ppm) in leaf blade and leaf sheath components of +Ev pastures.

	--- Ergovaline ---		--- Lolitrem B ---	
	Blade	Sheath	Blade	Sheath
Oct–Nov	0.15	0.3	0.5	1.5
Dec–Jan	0.27	0.8	2.0	4.0
Feb–Mar	0.40	1.3	2.1	6.5
Apr	0.25	0.4	2.0	10.2

Figure 1 Milk solids production from Te Hana herd test data for –Ev and +Ev groups, 1997/98 (2 mobs of 16 cows).

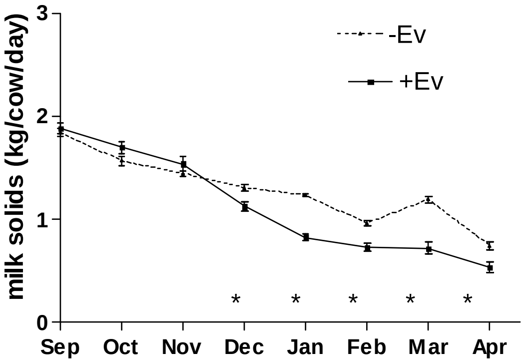


Figure 2 Mean milk volumes over 10-day measurement periods each month in 1997/98 (* indicates treatment means are significantly different p<0.05).

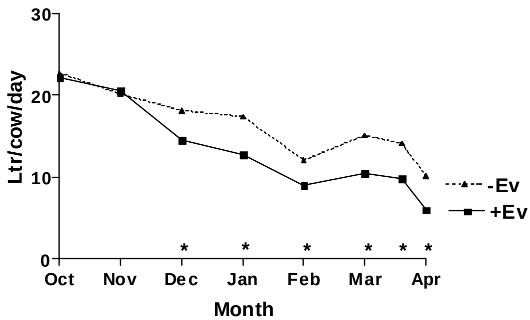


Figure 3 Relationships between milk production and a temperature-relative humidity index for –Ev and +Ev groups during January 1998 measurement period. The index was the product of minimum daily temperature and maximum %RH. Dotted lines are 95% confidence limits.

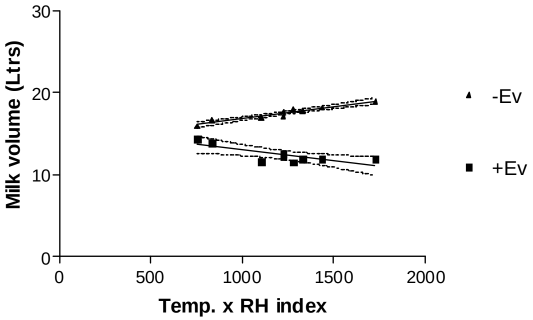


Figure 4 Prolactin levels for –Ev and +Ev groups from October 1997 to April 1998.

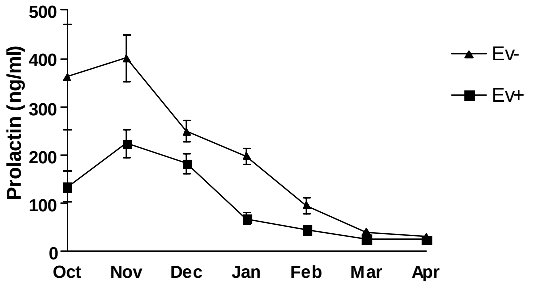
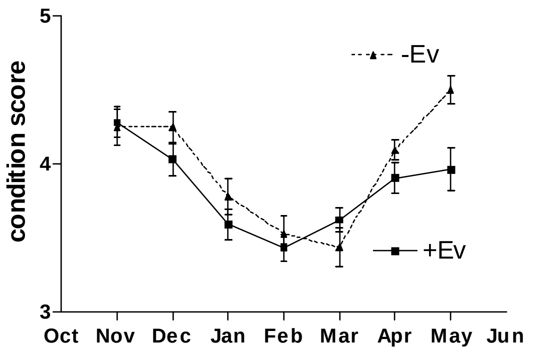


Figure 5 Mean cow condition scores from November 1997 to May 1998.



production by the +Ev group by 24% in December, 35% in January and February, 44% in March and early April, and by 70% in mid-April. The overall difference in milk production throughout the trial period was 23%.

Effects of environmental factors and milk production

There was a positive relationship ($R^2 = 0.942$) between milk production and minimum daily temperatures and maximum daily relative humidity (% RH) for the –Ev group, but a negative relationship ($R^2 = 0.603$) for the +Ev group for the same parameters (Figure 3). There was no relationship between daily maximum temperatures and milk production.

Prolactin

The +Ev group had significantly lower prolactin levels in the October to January period (Figure 4).

Ryegrass toxins

Samples from pastures grazed by the –Ev group were all free of ergovaline and lolitrem B, except for one sample in December. Both ergovaline and lolitrem B were present in pastures grazed by the +Ev groups. These alkaloids were higher for leaf sheath than for leaf blade, and higher in summer and in autumn than in spring samples of ryegrass from +Ev group pastures.

Animal health

Ryegrass staggers occurred in the +Ev group but not in the –Ev group. No heat stress was observed in either group or in the main herd that summer. No elevated body temperatures were recorded in 1997/98 from measurements made during afternoon milkings. Two +Ev cows were replaced with same age cows in March due to clinical facial eczema. There were elevated gamma glutamyl transpeptidase (GGT) levels in 6 cows in each group, but analysis showed that milk production was not affected (Keogh *et al*. 1999). The +Ev cows developed a rough coat appearance during the autumn.

Condition score

Average condition score of the two mobs followed the same trend as the milk production differences, remaining higher for the –Ev cows into the drought, and recovering more rapidly after the grass recovered in March and through into May.

Discussion

Treatment differences

This trial has focused attention on what may be a major limitation to performance of spring calving cows in Northland. The differences in milk and milk solids production over the trial period were 23% and 19% respectively. Differences did not develop, however, until after the 10-day measurement period which ended on 12 November. The ryegrass alkaloid levels increased throughout the trial period on the +Ev group pastures, and significantly lower prolactin (Figure 4) and higher lysergol (Keogh *et al*. 1999) levels are indicators that +Ev group cows were also ingesting increasing levels of toxins as the season progressed. The evidence suggests the presence and intake of ryegrass endophyte toxins was affecting milk production of cows in the +Ev group, but the possibility that other factors may also have contributed to the differences in milking performance needs to be considered.

Other factors

The aim of management was to ensure that both groups of cows had access to similar amounts of pasture after each milking to ensure that differences in feed availability were not affecting performance. Differences in pasture quality parameters that might have contributed to the differences in performance were not found. Indeed, on one occasion in December when the clover content of one –Ev group pasture was markedly higher than that present in the +Ev group pasture, grazing was deferred until after the clover content was reduced by a group of calves. Clover growth was very poor from January due to dry conditions and differences in clover content of the pastures were small as a consequence. As a consequence of poorer pasture growth during the warm, dry conditions that prevailed from mid-January to mid-March an extra paddock was made available to each group, and a maize-based supplement was also fed to enable the trial to continue. The use of the supplement would have reduced any impact of endophyte toxins on +Ev group performance at this time. Despite the use of the supplement, however, the difference in performance between the groups continued to increase.

In February clinical FE occurred in two +Ev group cows and these were replaced with two other second calving cows from the main herd. This prompted the use of zinc in the water supply and on the supplement to reduce further the risk of FE. Serum GGT levels were monitored and 4 cows in each group had GGT levels >100 ppm in February. Analysis showed that milk production by the affected cows was not adversely affected (Keogh *et al.* 1999).

Although cows in the +Ev group were affected with ryegrass staggers (RGS) at times from January onwards, it is not considered to have adversely affected performance as previous studies (Keogh unpublished data) indicated that grazing performance is unaffected even in animals with severe RGS.

Body condition of the –Ev cows was marginally better than that of the +Ev cows for most of the trial period, and increased faster at the end of the season. If this benefit is repeatable it would extend the potential lactation length, and allow carryover effects into the next calving and lactation.

Environmental influences

Daily maximum and minimum temperatures and % RH were recorded from January until the end of the trial. The January measurement period was the only one in which intake was solely from pasture and during this time significant positive and negative relationships were obtained between milk production and daily minimum temperatures and maximum % RH (conditions occurring at night) for –Ev and +Ev groups respectively. There was no relationship between daily maximum temperatures and minimum % RH, conditions occurring during the day, and milk production. These results indicate that night conditions were associated with a marked difference in performance of the two groups.

Brody *et al.* (1955) reported that cattle were able to tolerate high ambient temperatures without performance or feed intake being affected as long as the minimum diurnal temperature was low enough to allow dissipation of accumulated heat. The suggested lower critical temperature to which ambient temperature needed to decline so that cattle could achieve measurable loss of accumulated heat was 21°C. The rate of heat loss is also influenced by relative humidity and air movement. During the January measurement period maximum and minimum ambient temperatures ranged from 22.8 to 30.8°C and from 10.3 to 19.4°C respectively. Maximum relative humidities ranged from 73% to 92%. Records taken in the 1998/99 season show that diurnal air movement is at a minimum between 10 pm and 6 am. It is suggested that this combination of night-time conditions was not conducive to heat loss and that the +Ev cows were likely to have suffered from heat stress, especially on those days when reductions in milk production occurred.

Changes in feed intake are the most likely reason causing differences in milk production. Neither feed intake nor grazing time was monitored in this on-farm trial. However, when cattle were grazed on tall fescue pastures differing in endophyte status (60% infection cf. <1% infection), reductions in grazing time and intake were noted for cattle on the high endophyte pastures during periods of thermal stress (Howard *et al.* 1992). These authors derived a temperature-humidity index (THI) and showed that grazing time on high endophyte pastures decreased in response to increasing THI, whereas cattle grazing the low endophyte pastures were not affected by THI. Our results for the +Ev group show a similar response (decreased milk production) to an increasing index derived from night conditions.

The reason(s) for increased milk production by the –Ev group in response to the same conditions is not readily apparent, but the results are not incompatible with those obtained for the grazing time of cattle on low endophyte tall fescue in response to increasing THI (Howard *et al.* 1992).

Implications

The economics of replacing +Ev ryegrass-based pastures with –Ev ryegrass-based pastures needs to be evaluated. Factors to take into account are the cost of pasture replacement, the repeatability of production responses in different seasons, and the risk of endophytic ryegrass contamination and reversion back to a toxin producing pasture over time.

What was achieved at Te Hana was made possible in part by the survival of one paddock of endophyte-free ryegrass sown in 1996. This appears to be due to the 1991 release of the Argentine stem weevil parasitoid in this area. Although this parasitoid gives a measure of protection against Argentine stem weevil, other pests such as black beetle may threaten endophyte-free ryegrass survival in the future.

Conclusion

This trial has shown that +Ev pastures have seriously limited milk production at times during summer and autumn in the 1997/98 season. To what extent such a limitation may occur in other seasons and other regions remains to be determined.

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