The effect of deferred grazing in spring and early summer pastures on pasture growth rate and feed quality

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Abstract

Maintaining pasture quality in late spring and early summer is a challenge in many hill country farming systems where pasture growth often exceeds animal demand. One possible management tool is to defer grazing on a portion of the farm to enable the desired grazing management and animal performance on the remainder. This study aimed to evaluate the effect of timing and duration of deferred grazing in mid-spring to early-summer on subsequent pasture accumulation rates, composition and quality, from mid-spring through to the following winter. A factorial design (3 durations x 3 closing times) in eight replicates compared withholding grazing (nil, 1 or 3 grazings), in three closing periods, mid spring, late spring, and early summer. Grazing pasture when covers reached 2500 - 3000 kg DM/ha to a residual of 1500 kg DM/ha was the standard grazing regimen used. Grazing after the exclusion period aimed to achieve the same residual as in the control treatment based on a feed budget. Short early closures resulted in little, or no change in pasture quality and quantity for the remainder of the season. Longer closure periods reduced pasture quality due to increases in the proportions of dead and reproductive stem. This effect was reduced with later closings. The control (nil deferred grazings) and mid-spring closings had a net loss of dead matter (-1000 and -420 kg DM/ha, respectively), while the late -spring and early-summer closings accumulated 60 and 180 kg DM/ha, respectively. These differences in dead matter were the major driver of the differences of net herbage accumulations ($P=0.018$), with net accumulations from 7990 kg DM/ha for the control (Nil) closings to 9660 kg DM/ha for the December (late) closings. Deferred grazing can be used to alter feed availability and utilisation while maintaining net pasture production over spring, summer and autumn.

Keywords: grazing management, pasture quality, deferred grazing, net pasture accumulation, dead matter, reproductive tillers, metabolisable energy

Introduction

The conversion of flat and rolling land to more

intensive farming enterprises such as dairying and dairy support, has reduced the area available for specialist sheep and beef finishing operations. This has resulted in increasing pressure on hill country farms, previously focused on breeding, to finish a higher proportion of stock. Profitable livestock finishing in hill country will require higher quality pasture than traditionally found in New Zealand hill country.

Typically, in most farming operations this presents pasture management challenges from mid-spring to early/mid-summer, when pasture growth rates are likely to exceed animal requirements. If the excess of pasture growth over animal requirements is not controlled or manipulated, the consequence is likely to be pastures of increasing mass, with a higher proportion of reproductive tillers and senescent material, with a subsequent loss in pasture quality (Sheath *et al.* 1984; Sheath *et al.* 1987).

On flat to easy country, land managers have the option of closing off a portion of the farm from grazing. This enables them to conserve surplus feed by producing hay or silage and match the feed grown on the remaining farm area to animal requirements. However, on most hill country farms there is an insufficient proportion of suitable land for this to be a viable option. Unless the farmer is able to acquire extra stock during periods of high pasture growth rates, the only practical tool available for managing the pasture growth is the timing and intensity of animal grazing.

Various spring and summer grazing management guidelines have been developed to inform hill country farmers of the influence of good pasture management on pasture quality and pasture accumulation (Smith & Dawson 1977; Sheath & Bircham 1983; Sheath *et al.* 1987).

Some of these have promoted the use of short periods of deferred grazing in mid-spring to early-summer to increase animal demand and keep control of pasture on the remainder of the farm. In practice this control is often not achieved.

To determine the costs and benefits of maintaining control of some areas at the expense of others (beyond the scope of this paper), it is necessary to determine the effect of the timing and duration of deferred grazing on

Figure 1 Weekly mean soil temperature and accumulative rainfall for the trial sites over the study period.

hill country pastures. Previous work in New Zealand sheep pastures has focused on the effects of deferred grazing on tiller dynamics (Matthew *et al.* 1991; Hernandez-Garay *et al.* 1993; Nie *et al.* 1997), although there has been some work on the impact of deferred grazing over a longer period (September to April/May) on pasture growth (e.g. Mackay *et al.* 1991).

Deferred grazing has been used in dryland Australian pastures to increase the perennial grass content of the pasture, decrease annual grass content and control broadleaf weeds such as thistles (Burton & Dowling, 2004; Nie *et al.* 2015). The impact of the deferral depends on the closing time and also on the starting botanical composition of the pasture. Burton & Dowling (2004) recommend a threshold of 20% perennial cover for deferred grazing to increase the content of desirable perennial species and reduce the content of weeds. If the content of perennial species is lower than this, annual weedy species may produce seed and result in a greater abundance of weeds in the pasture through seedling recruitment. For example, reduced spring grazing pressure on ripgut brome grass (*Bromus diandrus*) dominant high country pastures in New Zealand, was related to increased ripgut brome seed production, with implications for carcass contamination of sheep (Tozer *et al.* 2007).

This study was designed within the context of providing New Zealand farm managers with options to manage the feed supply and better maintain pasture quality across their whole farm. In contrast to the above studies, using deferred grazing as a tool to manipulate the botanical composition was not the focus. The focus of this trial was to evaluate the effect of timing

and duration of deferred grazing in mid-spring to early-summer on pasture accumulation rates and pasture quality from mid-spring through to the following winter.

Materials and methods
Field location

The study was conducted at the AgResearch Ballantrae Hill Country Research Station, Southern Hawke’s Bay, New Zealand (408180S, 1758500E). Ballantrae is typical of much of the North Island’s steep, pastoral hill country covering 3.5 million ha (28% of the total area of farmland in New Zealand),

and is located 125 to 350 m a.s.l. with an average air temperature of 12.8°C and annual rainfall of 1270 mm, distributed evenly throughout the year. Data from weather stations located at the site of each replicate were pooled, and the mean soil temperature and rainfall are represented in Figure 1.

Brown and Pallic Soils (Hewitt 1998) are present i.e. yellow-brown earths and intergrades to yellow-grey earths and related steepland soils, mainly formed from tertiary sandstone, siltstone and mudstone, but with some loess influence.

The pasture growth pattern on the research station is typical of summer moist hill country, with 38% occurring in spring, 33% in summer, 17% in autumn and 12% in winter (Lambert *et al.* 1983) The conventional management of sheep on this class of farm reflects the challenge of matching animal demand to pasture growth with, typically, a mean lambing date of mid- to late-September, with weaning occurring from early- to late-December.

Trial structure and treatments

A factorial design compared two deferred grazing treatments (miss one or miss three grazings), at three closing times, mid-spring (8 November), late-spring (28 November), and early-summer (17 December) (Table 1) to a control which was grazed at 3 to 4 week intervals throughout. Eight replicates were located on areas of low slope (<15°) but stratified across three areas of different soil fertility; low (2 replicates, average Olsen P of 8), medium (2 replicates, average Olsen P of 30) and high (4 replicates, average Olsen P of 56).

- Treatments:
- Control - no closure; graze at 3 - 4 week intervals provided pre-grazing pasture cover reached at least 2500 kg DM/ha
 - Mid-spring Short closure 1 - (miss 1 grazing at 1st rotation)
 - Mid-spring Long closure 3 - (miss 3 grazings starting from 1st rotation)
 - Late-spring 1 - Short closure (miss 1 grazing from 2nd rotation)
 - Late-spring 3 - Long closure (miss 3 grazings starting from 2nd rotation)
 - Early-summer 1 - Short closure (miss 1 grazing from 3rd rotation)
 - Early-summer 3 - Long closure (miss 3 grazing’s starting from 3rd rotation)

All plots (each 10 x 10 m), except those from which grazing was withheld, were grazed whenever the average pasture mass of the control plots had reached 2000-3000 kg DM/ha. Grazing management aimed to achieve a residual of 1500 kg DM/ha in 48 hours. An allowance of 1 kg DM/sheep/day was used, with the proviso that a minimum of three sheep were used at each grazing event. If there was insufficient pasture available to require 48 hour grazing by the minimum number of animals, grazing periods were shortened. After the exclusion period, grazing aimed to achieve the same residual as standard grazing events, based on the same allowance.

Measurements and analysis

Pasture measurements were conducted from immediately before the first grazing in mid-spring until after the final grazing in mid-June of the following winter.

Total pasture mass was estimated by rising plate meter (RPM) calibrated specifically at each grazing date for replicate at both pre- and post-grazing events

as described in Devantier (1998). When delayed grazing resulted in lodged pasture, or a pasture height greater than the height capacity of the RPM, pasture mass (kg DM/ha) was estimated from three randomly positioned 0.4 m² quadrats cut to ground level in each plot, with subsamples (200 g) oven dried (24 hours, 80°C temperature).

Pre-grazing pasture composition and quality was estimated from randomly clipped pasture samples (5 strips, 80 mm wide x 1 m long), cut to approximately 1 cm above ground level. The sample was chilled immediately and separated into 2 subsamples. One subsample was separated into grass leaf, grass stem, clover, weed, dead stem, and other dead material. Components were oven-dried for 24 hours at 60°C and weighed to estimate their contribution to total DM. The second subsample was used to estimate feed quality (metabolisable energy ME, and crude protein CP) which was assessed using near infrared reflectance spectroscopy (NIRS) (Corson *et al.* 1999), undertaken at a commercial laboratory. Post-grazing, subsamples were separated into live and dead fractions only.

For both pre- and post-grazing pasture dissections, dead matter was defined as completely dead (100% brown). In the event of a mixture of dead, senescing (yellow brown but still with moisture) and green in a single piece of plant material, the dead material was separated and consigned to dead vegetation and rest consigned to the appropriate dissection component.

Pasture mass accumulated for each rotation was calculated as the difference between post-grazing pasture mass at the end of one grazing and pre-grazing pasture mass for the following grazing. A feature of using this approach is that dead material decay can occur and result in a net loss of dead material. Total metabolisable energy (ME) was calculated as the energy density in pre-grazed pasture multiplied by the mass of pasture accumulated. Data were analysed comparing deferred grazing number and closing time to the control

Table 1 Trial treatments; time and length of closure (withheld from grazing).

Closed from grazing	Withholding grazing periods	Mid-spring (19 th Oct)	Mid-spring Early Nov (8 th)	Late-spring Late Nov (28 th)	Early-summer Dec (17 th)	Jan (10 th)	Feb (3 rd)	Feb/Mar (28 th Feb)	Final grazing June (21 st)
Control	Nil								
Mid-spring 1	1								
Mid-spring 3	3								
Late-spring 1	1								
Late-spring 3	3								
Early-summer 1	1								
Early-summer 3	3								

Legend: Grazed Not Grazed

(Mean dates of grazings)

as the fixed effects and replication as the random effect using the REML function of GenStat (17th Edition).

Results

Total pasture accumulated

There were no significant interactions ($P>0.05$), but for completeness, the data for all treatment combinations are presented.

Effect of length of closure

The accumulation of green pasture (Table 2) was significantly affected by length of closure ($P<0.01$), being lowest in the long closure (8130 kg DM/ha), intermediate in the control (8990 kg DM/ha) and highest in the short closure (9420 kg DM/ha). In contrast, there was a significantly greater accumulation of dead matter in the long closure (630 kg DM/ha, $P<0.001$), while in the short closure and control there was a net loss of dead matter (averaging 875 kg DM/ha).

Effect of closing date

Closing date significantly affected total and dead pasture accumulation (Table 2). There was a net loss of dead material in the control and in pastures closed in mid-

spring of 1000 and 420 kg dead DM/ha, respectively, but there was an accumulation of dead matter (60 and 180 kg DM/ha, respectively) when pastures were closed in late-spring and early-summer. These differences in dead matter ($P<0.001$) were the major driver of the differences in net pasture accumulation ($P=0.018$), with net accumulation ranging from 7990 kg DM/ha for the control (Nil closings) to 9660 kg DM/ha for early-summer closings. No effect of closing date on green pasture accumulation was detected.

Feed quality

Effect of the length of closure

The ME and CP concentration were higher in vegetation sampled in the control and short closure than the long closure (10.7 and 10.1 MJ ME/kg DM, 192 and 172 g CP/kg DM, respectively, $P<0.001$). However, there was no effect of length of closure on total metabolisable energy (GJ ME/ha) accumulated over the study period (Table 2).

Effect of closing time

Metabolisable energy accumulated over the study period (Table 2) was lowest in the control (84.7 GJ

ME/ha), intermediate in the mid-spring and late-spring closing (91.0 and 87.4 GJ ME/ha, respectively) and highest in the early-summer closing (100.3 GJ ME/ha, $P<0.05$). The effect of closing time on the energy and protein concentration in the accumulated pasture was similar for all three closing times, which were all lower than the control treatment ($P=0.046$). The energy content of the three closing times ranged from 10.2 to 10.3 MJ ME/kg DM whereas the energy content of the control was higher at 10.7 MJ ME/kg DM ($P<0.001$). A similar pattern occurred with the protein content of the three closings times ranging from 179 to 180 g CP/kg DM, which were all lower than the control (193 g CP/kg DM, $P<0.01$).

Some aspects of the variation in potential feed on offer compared to control

Total pasture mass

Figure 2 represents the potential amount of pasture on offer for the various closing time and durations chosen. The total pasture accumulated during a closure period was greater for the short closure than the control ranging from 1700 to 2500 kg DM/ha, depending on the closing date. After the closure period, pasture on offer was greater in the short closure than in the control (400-1000 kg DM/ha).

Pasture accumulation initially increased during the closure period in the long closure, after which the accumulation then depended on the closing date. Immediately after the closure period, pasture on offer was also greater in the long closure than in the control (1600-2900 kg DM/ha).

Figure 2 Pasture availability (feed-on-offer) in deferred grazing treatments (Control: solid line; LSD_{5%}=1382 kg DM/ha). Mid-spring closing from grazing (diamond); Late-spring closing (square); Early-summer closing (circle); Short closure (open symbols); Long closure (closed symbols).

Figure 3 Pattern of reproductive grass stem proportion of the sward of the deferred grazing treatments compared with the control (Control: solid line; LSD_{5%}=0.041). Mid-spring closing (diamond); Late-spring closing (square); Early-summer closing (circle); Short closure (open symbols); Long closure (closed symbols).

Pasture composition

Of note were the changes in dead material and seedhead accumulation over time. These are reported here. There were no significant variations in clover production and so they are not reported.

Reproductive stem

Figure 3 depicts the difference in reproductive stem development in the deferred treatments in comparison to the control. Closure date had no effect on the peak abundance or seasonal distribution of reproductive

Table 2 Accumulation of total, green and dead pasture mass, and energy content over late spring, summer and autumn when grazing was withheld in the short and long closure treatments, from either Mid-spring, Late-spring or Early-summer.

	Closing Time	Control	Short closure	Long closure	Mean	P value	LSD _{5%}
Total (kg DM/ha)	Control	7990			7990 b		
	Mid-spring		8114	8186	8150 b		
	Late-spring		8137	8545	8340 b		
	Early-Summer		9752	9562	9660 a	0.018	1132
	Mean	7990	8670	8760		0.835	997
Green (kg DM/ha)	Control	8990					
	Mid-spring		9013	8128	8570		
	Late-spring		8968	7589	8280		
	Early-summer		10265	8683	9470	0.126	1045
	Mean	8990 ab	9420 a	8130 b		0.004	920
Dead (kg DM/ha)	Control	-1000			-1000 c		
	Mid-spring		-899	59	-420 b		
	Late-spring		-831	955	60 ab		
	Early-summer		-512	878	180 a	<0.001	520
	Mean	-1000 b	-750 b	630 a		<0.001	460
Total energy (GJME/ha)	Control	84.7			84.7 b		
	Mid-spring		86.7	95.3	91.0 ab		
	Late-spring		86.2	88.5	87.4 b		
	Early-summer		103.0	97.6	100.3 a	0.046	11.4
	Mean	84.7	92.0	93.8		0.696	10.1

Subscripts are for comparisons within the column or within the row for 'Mean' data for each of Total, Green, Dead and Total energy

Figure 4 Contribution of dead material as a proportion of total sward dry matter of the deferred and control treatments (Control: solid line; $LSD_{5\%}=0.045$). Mid-spring closing (diamond); Late-spring closing (square); Early-summer closing (circle); Short closure (open symbols); Long closure (closed symbols).

stem in the short closure, whereas there were distinct differences between the closing dates in the long closure. The earliest closing date in mid-spring had the greatest difference from the control; the effect of this was evident in the first grazing after the closure period. In comparison, there was a smaller difference between late-spring and early-summer closing dates and the control in the proportion of reproductive stem, and there were no differences between these three treatments once grazing had resumed. Differences in seedhead accumulation before grazing had a carryover effect on pasture composition after the return to grazing, with more dead seedhead present with earlier closings.

Dead matter

Short closures (Figure 4) showed a similar pattern of increased dead leaf in the first growth period after the return to grazing with this returning to the same levels as the control by the second grazing after the closure period. In contrast, in the long closures, early closure increased the accumulation of dead leaf within the sward with each grazing until late-summer, while there was less dead leaf in the two later closing date treatments in mid-summer, followed by raised levels in the late-summer. There was no difference between any of the treatments and the control plots by mid-autumn.

Discussion

The data presented in this paper focuses on the influence of deferring grazing on pasture production and availability. Other effects such as consequences on the effects of pastoral fallow on the sward and soil (Mackay *et al.* 1991; Nie *et al.* 1997) are not considered

here. These factors include soil carbon, organic nitrogen levels and soil physical properties, root biomass, grass tiller densities, clover stolon growth, establishment success of natural re-seeding, and providing a suitable environment for the introduction of improved forage species.

Withholding a paddock from grazing changes seasonal herbage production, and also affects pasture quality by altering the botanical composition as discussed above (Burton & Dowling 2004, Nie *et al.* 1997) and accumulation of living and dead plant material. Often livestock

continuously graze during spring lactation. Therefore, the conversion of these results into grazing practice is related to the timing of the initial exclusion of the stock from the rotation, and the length of the exclusion. The length of exclusion was approximately 41 days for the short duration and 88 days for the long duration deferrals.

Early closures of short duration are likely to have no detectable effect on pasture production and quality. In these treatments, there was a gradual net loss of dead vegetation from the sward during regrowth and pastures remained green and of high quality. With respect to implications of this study for the whole farm, an early closure should enable pasture growth to be more easily maintained in other paddocks, with fewer negative implications for pasture quality over the following summer and autumn.

However, where pasture growth substantially exceeds demand, as can occur under optimal growing conditions in some spring and summers, a longer closure may be necessary to maintain pasture quality in other areas of the farm. While this strategy may increase total pasture production, there is a cost: a greater proportion of dead vegetation, more reproductive growth, and a reduction in pasture quality. These negative effects on pasture quality can be minimised by closing for grazing later in the season when a higher proportion of the potential reproductive growth has already occurred and vegetative growth harvested rather than lost to senescence.

Timing of closure is critical. In this study, spring closure occurred in mid-spring (early November). In other studies, earlier and longer closure increased

seedling recruitment, tillering and content of existing perennial plants and clovers, resulting in an improved pasture botanical composition and quality in the following seasons (Nie *et al.* 1996; Nie & Zollinger 2012; Nie *et al.* 2015).

However, early spring closing times can negatively influence feed supply at a critical time for animal performance if this occurs before pasture accumulation exceeds demand. When specifically targeting a developing feed surplus, withholding grazing on one area can help to better match feed supply and demand across the whole farm.

Restoring pasture condition from the lower quality, higher pasture mass under deferred grazing may compromise livestock performance in the short term (Sheath *et al.* 1987; Waghorn *et al.* 2007). However, this needs to be considered against the benefits of matching feed supply and demand, and maintaining pasture quality on the remainder of the farm. To achieve this, hill land managers will require an understanding of when pasture surpluses develop, and be able to monitor feed supply and demand. This will ensure animal production is optimised and enable priority control of pasture in areas where, once lost, pasture quality will not fully recover until the following winter (Sheath *et al.* 1984; Sheath *et al.* 1987).

Conclusions

Withholding grazing on a portion of the farm in mid spring to early summer may be a viable management option for controlling or manipulating feed quantity and quality on the remainder of the farm. The length and timing of the closure affects both the quantity and quality of pasture grown between mid-spring and the start of the following winter. Early closures of short duration (< 6 weeks) are likely to result in no or slight increases in net pasture accumulation with minimal loss of feed quality once standard grazing residuals are reinstated. As the length of the deferred grazing is increased, the total pasture accumulated will increase. However, this will be at the expense of pasture quality, although later closings reduce the decline. The option of early and short through to longer and later closures from grazing, allows flexibility when hill land managers develop strategies for managing season specific pasture surpluses. This information will be critical to determine the benefits and practicality of grazing strategies to control late-spring and early-summer pasture quality in New Zealand summer moist hill country.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Ministry of Business, Innovation and Employment, DairyNZ, Fonterra, Beef + Lamb New Zealand and DCANZ for funding through the P21 partnership programme.

The authors would also like to acknowledge the AgResearch Farm Systems and Farm field teams for technical support, in particular S. Brock and Y. Gray for their skill and diligence in botanical analysis.

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Estimation of ergovaline intake of cows from grazed perennial ryegrass containing NEA2 or standard endophyte

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Abstract

Ergovaline concentration was measured monthly from December 2015 to April 2016 in herbage of perennial ryegrass pastures containing NEA2 or standard endophyte (SE) in the Waikato, Manawatu and Canterbury. Ergovaline concentrations were then combined with estimated pasture intake, pasture botanical composition and cow liveweight data from experimental dairy farm systems in the Waikato and Canterbury to estimate dairy cow ergovaline intake (mg/kg LW^{0.75}/day). For the diploid ryegrass 'Trojan' with NEA2 estimated ergovaline intake ranged from 0.01 to 0.029 mg/kg LW^{0.75}/day, levels at which no significant animal production effects have been reported. Ergovaline intake of tetraploid ryegrass 'Bealey NEA2' was at least an order of magnitude lower than this. For the diploid ryegrass, 'Bronsyn' with SE, ergovaline intake was 0.016 to 0.056 mg/kg LW^{0.75}/day, which at the highest level carried a ~20% risk of causing animal production effects for 15% of the samples. AR1 and AR37 pastures, used as controls, contained nil or trace amounts of ergovaline.

Keywords: alkaloid, *Epichloë festucae* var. *lolii*, *Lolium*

Introduction

The perennial ryegrass endophyte *Epichloë festucae* var. *lolii* provides the plant protection against insect attack by producing alkaloids, mainly lolitrem B, peramine, ergovaline and epoxy-janthitrems (Popay & Hume 2011). These compounds, apart from peramine, can be associated with detrimental effects on animals at particular levels of intake. Lolitrem B is a neuro-toxin associated with the neuromuscular disorder 'ryegrass staggers' in grazing animals (di Menna *et al.* 2012). Some strains of *Epichloë festucae* var. *lolii* endophyte including AR1 (Fletcher 1999a), AR37 (Hunt & Newman 2005) and NEA2 (Tian *et al.* 2013) produce little or no lolitrem B and are commercially marketed in perennial ryegrass as offering insect protection with reduced likelihood of animal health and production issues.

NEA2 and AR37 produce the alkaloids ergovaline and epoxy-janthitrems, respectively, that can have

detrimental animal affects above certain intake levels. Epoxy-janthitrems are tremorgenic compounds (Finch *et al.* 2012) and AR37 is marketed with the caveat that it can cause ryegrass staggers (<https://www.agricom.co.nz/rd/endophyte-information/ar37>).

Ergovaline plays a role in producing physiological effects in animals similar to those of fescue toxicosis, with a review by Klotz & Nicol (2016) concluding the effects of ergovaline are dose related. Reduced serum prolactin concentration and increased respiration rate have been reported at low ergovaline intake (0.02-0.04 mg/kg LW^{0.75}/day), increased core temperature at moderate intake (0.04-0.06 mg/kg LW^{0.75}/day), and economically important symptoms of reduced DM intake, milk production or liveweight gain usually associated with ergovaline intake above 0.07 mg/kg LW^{0.75}/day. The review concluded that "quantitative data on the ergovaline profiles of novel endophytes in both the grazed and residual portions of the pasture are needed".

This study aimed to measure ergovaline concentration in the grazed component of several perennial ryegrass cultivars containing novel or SE, including the diploid commercially sold as 'Trojan NEA2' and the tetraploid cultivar sold as 'Bealey NEA2'. Ryegrass stubble, below a simulated grazing height (4-5 cm), could not be tested in this study as the National Forage Variety Trial (NFVT) protocol stipulates that grass plots cannot be cut to ground level.

When NEA2 was released it was believed to be a single endophyte strain, but subsequent genotyping showed it is a mix of several endophytes. 'Trojan NEA2', as sold and used in this study, contains two biochemically distinct endophytes (NEA2 and NEA6, both protected by Plant Variety Rights) and each representing approximately 50% of the endophyte content (breeding lines are tested before multiplication). Recently, through the use of additional molecular markers, NEA6 in 'Trojan' has been shown to be two separate endophyte strains (Fletcher *et al.* 2017), however, alkaloid analysis has shown that their profiles are similar (unpublished data). 'Bealey NEA2', as sold, contains two endophytes, approximately 85% of strain NEA2 and 15% NEA6.

Three locations within the two New Zealand mega-