Removing early spring emerged reproductive growing points enhances seed yield of Italian ryegrass

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Abstract

Early spring closing (last grazing) usually occurs in ryegrass seed crops at the first sign of stem elongation, as removal of reproductive growing points has been considered to be detrimental to seed yield. In eight closing date trials Italian ryegrass (*Lolium multiflorum* Lam.) seed yields were increased by an average of 55% if closing dates were delayed two or three weeks later than traditionally used. The seed yield increase occurred even though the closing date defoliation removed 10 to 90% of reproductive tillers present at defoliation. These results suggest that the optimum closing date for most Italian ryegrass cultivars in the Canterbury region is between the 18 and 30 October; rather than the traditional practice of closing in late September or the first week of October. Extra grazing in October from later closing dates will be valuable on mixed cropped farms when feed supplies are limited.

Additional keywords: annual ryegrass, closing date, defoliation, *Lolium multiflorum*

Introduction

Italian ryegrass (*Lolium multiflorum* Lam.) seed crops are commonly grazed during late winter and early spring. The last day of grazing or defoliation is known as the "closing date". The recommended closing date for Italian ryegrass is early October (Hampton and Rowarth, 1998) when reproductive tillers are beginning to elongate. Closing later than this is thought to reduce seed yield because of the removal of reproductive heads. This guideline is based on perennial ryegrass closing date studies of Hill (1971). Optimum seed yield requires the production of a minimum number of seed heads (Hampton and Fairey 1997), commonly around 1100-1800 m^{-2} for Italian ryegrass and 1800-2400 m^{-2} for perennial ryegrass (FAR, unpublished data). Above the minimum required, seed yields plateau unless greater numbers of seeds per spikelet can be produced. Therefore the first aim of producers is to ensure the minimum number of seed heads is obtained. Trials were undertaken in farmers' fields comparing the farmers' closing date with delayed closing achieved by mowing (simulated grazing) to determine whether later closing dates, and the subsequent removal of reproductive growing points were detrimental to seed yield.

Methods

A total of eight trials over four seasons were undertaken in farmers' fields in central Canterbury to determine optimum closing dates for Italian ryegrass seed crops. Six trials examined a range of closing dates and

the trial location and cultivars are shown in Table 1. Two other trials compared two closing dates and five plant growth regulator rates of trinexapac-ethyl, 0 to 800 g TE ha^{-1} (Table 6). Trinexpac-ethyl is a straw-shortening plant growth regulator. In all trials the crops were grazed in late winter -early spring with sheep and the first closing date was when the farmer stopped grazing. Subsequent closings were imposed with a mower cutting at 50 to 75 mm. A hand-cut sample was taken to assess the number of reproductive tillers removed (node removed) and to assess dry matter removed. The closing treatment for a specific date and all future closing dates were cut at each closing date mowing (i.e. late closed treatments were cut approximately every 10 days). In contrast, when defoliation as a single silage cut was investigated, future closing dates remained uncut (Trial 6). The farmer's normal management was applied for nitrogen and fungicide. In the Irwell N trial, the herbage removed was replaced with N at 3% of the dry matter removed; in other trials a standard N rate was used for all treatments. The TE was applied at 300 g ha^{-1} at Zadoks (Zadoks *et al*., 1974) growth stage 32 for each closing date in Trials 1 to 6, and 0 to 800 g ha^{-1} in Trials 7 and 8. All closing treatments were replicated 4 times in a randomised block design. Plots were 3.2 m x 10 m.

The trials were cut with a plot windrower at 40-42% seed moisture content (SMC) and machine harvested with a plot combine at about 12 to 14% seed moisture content. The harvest was usually split into two windrow dates with 7 to 10 days between the first group and second group. The field dressed seed was machine dressed to a First Generation Seed Certification standard (98+% purity) (AgriQuality, 2006) and the machine dressed seed yield (kg ha^{-1}) was calculated. The seed yield and least significant difference (LSD 5%) was calculated by analysis of variance for each trial. To compare trials seed yield was expressed as relative seed yield (RSY) with the seed yield of the earliest closing date in a trial equal to 100.

Results

Seed yield increased when closing was delayed to after the 10 October, compared with the 20 September to 4 October (Table 1). There was variation between trials but on average the highest seed yield was from closing in the period 18 October to 3 November (Table 1). Delaying closing to the period 1-3 November resulted in a significantly lower seed yield in 2 out 4 trials. The average seed yield increase for crops closed between the 26 and 31 October; was 55% (range 12 to 87%) from 1300 to 1985 kg ha^{-1} compared with closing before 5 October (Table 1). Of the eight trials, detailed data from five are included.

Table 1: Relative seed yields (RSY) from six trials with different cultivars and sites and over three seasons, actual first closing date and actual seed yield (SY) for the < 5 October closing treatment.

	1.Irwell	2.Irwell N	3.Irwell	4.Chertsey	5.Leeston	6.Irwell	
Closing Date	04-05	05-06	05-06	05-06	06-07	06-07	Average
Cultivar (1^{st} closing)	Feast (1 Oct)	Feast (20 Sept)	Feast (20 Sept)	Feast (1 Oct)	Tabu (1 Oct)	Sonik (1 Oct)	
< 5 Oct	100c	100c	100c	100b	100c	100b	100c
10-13 Oct	102c	136b	--	--	161ab	145a	135b
18-23 Oct	151a	120b	134b	122a	150b	147a	138ab
26-31 Oct	--	156a	169a	112b	187a	152a	155a
1-3 Nov	128b	170a	158a	100b	--	--	139ab
SY < 5 Oct (kg ha^{-1})	1720	1210	1200	1500	1070	990	1300

Means followed by the same letter are not significantly different LSD 5%.
-- No closing date in this period.

Trial 1 Irwell 2004-2005

There was a large seed yield response to the closing date treatments, with the highest seed yield occurring from the 22 October closing with an increase of 750 kg ha^{-1} compared to 20 September closing (Table 2). The first three closing dates had similar seed yields and were approximately 33% lower than the highest seed yield (Table 2). Accumulated forage dry matter (DM) increased with each delay in closing date, with an average daily gain of 85 kg ha^{-1}. In this trial only a low percentage (4 to 14%) of defoliated tillers had nodes (Table 2)

Table 2: Seed yield, dry matter (DM) accumulated at closing and accumulated percentage of reproductive tillers removed at 75 mm for five closing dates (Trial 1 Irwell 2004-05).

Closing date	Seed yield (kg ha^{-1})	DM (kg ha^{-1})	Accumulated tiller removal (%)
20 Sep	1850c	0	0
1 Oct	1720c	660	0
11 Oct	1760c	1540	1
22 Oct	2600a	2720	4
1 Nov	2200b	3760	14
LSD 5%	250		

Means followed by the same letter are not significantly different LSD 5%.

Trial 2 Irwell 2005-06

Seed yields increased significantly with delayed closing, with the highest seed yield with closing on either 26 October or 3 November closing with an increase of 740 to 780 kg ha^{-1} compared to 20 September closing (Table 3). At the first closing there were 2240±102 vegetative tillers m^{-2}. The latter closing dates removed 67 and 94% of all elongating reproductive tillers but had little effect on the final reproductive head number which averaged 1030 m^{-2}. Accumulated forage DM increased with each delay in closing date, with an average

daily gain of 128 kg ha^{-1}. Harvest mass declined with delayed closing resulting in an increased harvest index with delayed closing (Table 3).

Table 3: Seed yield, dry matter (DM) accumulated (±SE standard error of mean) and accumulated percentage of reproductive tillers removed at 50 mm for five closing dates, reproductive head density, harvest mass dry matter and harvest index (HI) (Trial 3 Irwell N 2005-06).

Date	Seed yield (kg ha^{-1})	Closing DM (±SE) (kg ha^{-1})	Tillers removed (%)	Head (m^{-2})	Harvest mass (T ha^{-1})	HI (%)
20 Sep	1210c	0	0	1280	18.7a	6.1
10 Oct	1650c	2840 ±175	7	1110	16.6b	9.0
18 Oct	1510b	3530 ±293	21	900	12.0c	10.7
26 Oct	1950a	4700 ±428	67	1140	12.4c	13.3
3 Nov	1990a	5660 ±463	94	990	10.2d	16.7
LSD 5%	239			220	2.2	

Means followed by the same letter are not significantly different LSD 5%.

Trial 6 Irwell 2006-07

Delayed closing increased seed yield by between 340 and 550 kg ha^{-1} (Table 4) with no difference between closing with simulated grazing compared with silage removal with closing to 23 October. Accumulated forage increased with each delay in closing date, with an average daily gain of 64 kg DM ha^{-1} (grazed) and 100 kg DM ha^{-1} (silage). Seed head numbers averaged 1210 heads m^{-2} and were no difference between treatments (Table 4). At the closing on the 13 and 23 October between 76 and 98% of all nodes were removed (Table 5).

Table 4: Seed yield (SY), dry matter (DM) accumulated and head density for closing dates and closing method (Trial 6 Irwell 2006-07).

Closing Date	Closing Method	SY (kg ha^{-1})	DM (kg ha^{-1})	Heads (m^{2})
1 Oct	graze/mow	990	0	1280
13 Oct	graze/mow	1440	630	1260
23 Oct	graze/mow	1460	1170	1540
31 Oct	graze/mow	1500	1920	1260
13 Oct	Silage 7.5cm	1510	1430	1060
13 Oct	Silage 15cm	1540	980	1120
23 Oct	Silage 7.5cm	1430	2380	1040
23 Oct	Silage 15cm	1330	1640	1110
	LSD 5%	213		NS

Table 5: Percentage of tillers with nil, one, two or three nodes in silage plots at two closing dates and two cutting heights (Trial 6 Irwell 2006-07).

	Cut height	Nodes removed (%)				
Date	(cm)	0	1	2	3	Total
13 October	7.5	2	32	55	11	98
	15	14	55	31	0	76
23 October	7.5	3	15	58	24	97
	15	2	32	55	11	98

Trials 7 and 8

In the two closing date x TE rate trials a large seed yield responses of 1270 kg ha^{-1} (60%) and 830 kg ha^{-1} (33%) at Wakanui and Milford respectively occurred when closing date was delayed 10 to 12 days from early-mid October to mid-late October (Table 6). The detailed components of yield and related yield factors show the increased yield was achieved differently with the two trials. In Archie the driver of seed yield was more seeds spikelet^{-1} compared with Crusader where more reproductive tillers (seed heads) was the driver. Delayed closing decreased harvest index, reduced stem length and reduced lodging in both cultivars (Table 6).

Table 6: Seed yield**,** components of yield and other parameters for two trials each with two closing dates. Data are means of 5 rates of trinexapac-ethyl (Moddus) for Trials 7 and 8 (2009-10).

Cultivar	Archie				Crusader			
Location	Wakanui		LSD 5%	F prob	Milford		LSD 5%	F prob
Close Date	10 Oct	20 Oct			18 Oct	30 Oct		
Seed yield (kg ha^{-1})	2100	3370	153	<0.001	2540	3370	124	<0.001
Seed heads (m^2)	970	1030	110	NS	1620	2020	260	0.003
Spikelets head^{-1}	25.0	23.7	0.9	0.006	24.9	22.6	1.0	<0.001
TSW (g)	4.57	4.57	0.2	NS	2.84	2.74	0.06	<0.001
Seeds head^{-1}	51	74	9	<0.001	60	64	10	NS
Seeds spiklet^{-1}	2.0	3.1	0.4	<0.001	2.5	2.8	0.5	NS
Seed yield head^{-1} (mg)	227	332	36	<0.001	171	176	28	NS
Harvest mass (T ha^{-1})	15.9	12.9	1.1	<0.001	16.4	17.2	2.2	NS
Harvest Index (%)	11.8	20.8	1.4	<0.001	14.1	16.7	2	<0.001
Stem length (cm)	101	80	4	<0.001	108	92	8	<0.001
Lodging (%)	79	27	6	<0.001	60	31	8	<0.001

Discussion

Delaying closing of Italian ryegrass by two to three weeks from traditional dates of late September to early October resulted in large seed yield increases (average 55%) of between 340 and 750 kg ha^{-1} more seed. Extra herbage harvested with delayed closing was between 1170 and 4700 kg ha^{-1} for the different trials closed in the last 10 days of October. Mixed cropping farms are often limited for feed during October and thus extra grazing has considerable value;

worth $ 0.15 to 0.20 kg DM^{-1}. Not all farms have livestock and the Irwell 2006-07 data (Table 4) suggest that closing by cutting for silage is also an option.

Delaying closing resulted in a small delay in harvest date; a three week delay in closing delaying harvest maturity about 7 days; and effect that can be explained in terms of the difference in thermal time between October versus December-January.

The higher seed yields from delayed closing are associated with the removal of early emerged reproductive tillers. In the case of Trial 6, > 90% of the tillers removed had nodes (Table 4). In Trial 2 (Table 2) the highest seed yields were associated with the cutting of between 31 and 46% of reproductive tillers. Even though reproductive tillers were removed at closing, the number of seed heads at harvest was similar among treatments (Table 2 and 3) and in cv 'Tabu' and 'Crusader' (Trial 5 and 7) the later closed and higher yielding treatments had more heads. Hill (1971) showed that delayed closing (after 29 September) in perennial ryegrass reduced seed yield. The assumption that the perennial ryegrass data applied to Italian ryegrass is not supported by this data

Our observations were that later closed plots (Table 1) had less lodging, and in the TE trial later closing gave significantly less lodging (Table 6) and this may contribute to the higher seed yield through an increase in seeds $spikelet^{-1}$ and improved photo synthetically active radiation (PAR) at the flag leaf as has been shown in perennial ryegrass (Rolston *et al*., 2007). It is probable that delayed closing results in a more uniform flowering and therefore less seed loss at harvest. Other components of yield when measured, either declined e.g. $spikelets\ head^{-1}$ or were similar e.g. TSW (Table 6).

Conclusion

In Canterbury, New Zealand the optimum closing date for Italian ryegrass seed crops occurs after stem elongation has begun. Even when a high proportion of reproductive growing points are removed seed yield is higher than when no growing points are removed. For the cultivars evaluated the recommend closing date, based on this research, is mid- to late October.

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