INFLUENCE OF FALL CUTTING MANAGEMENT AND N FERTILIZATION ON WINTER SURVIVAL OF LOLIUM PERENNE L.

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ABSTRACT
Two perennial ryegrass cultivars known to differ in winter hardiness were subjected to six fall managements comprising two N rates and three fall cutting treatments. Water-soluble carbohydrate changes, winter survival and freezing tolerance were measured as well as subsequent spring production. Fall cutting treatments had strong effects on winter survival as cuts taken late in the fall reduced survival to a greater extent than earlier cuts. Nitrogen fertilization had no preponderant effect on the acquisition of cold tolerance at least under the N levels applied in this study, but was related to more vigorous spring growth. The superior winter survival of the more freezing tolerant cv. seemed to be related to its ability to maintain high levels of HMW fructans throughout the season. Water-soluble carbohydrate levels were generally not affected by N fertilization.

KEYWORDS
Ryegrass, N fertilization, winter survival, cutting management

INTRODUCTION
Attempts made to introduce perennial ryegrass (*Lolium perenne* L.) in eastern Canada have met with limited success because severe winterkill often occurs. Preliminary observations indicated that winter survival was greatly influenced by fall cutting management and application of N fertilizer late in the fall. These observations confirmed previous findings by Thompson (1974), Hunt et al. (1976), and Hides (1978) for different studies conducted in UK. The objectives of this study were to determine the effects of different levels of N and cutting treatments in the fall on levels of key biochemical compounds, winter survival and freezing tolerance as well as on subsequent spring production of two contrasting ryegrass cultivars.

MATERIALS AND METHODS
Two ryegrass cultivars, differing in their overall winter hardiness (Riika: hardy; Friend: semi-hardy) were field-grown at a site near Quebec, QC. A split-split plot experimental design in four replicates was used: two N rates comprised whole plots, three cutting treatments, sub-plots, and two perennial ryegrass cultivars sub-sub-plots giving 48 experimental units. Ryegrass was seeded with a Brillion type seeder at a rate of 25 kg ha^{-1} in May 1993 and fertilized with 400 kg ha^{-1} of 8-16-16 at the time of establishment. All plots were cut on Aug. 15, 1993 and fertilized with N at a rate of 60 kg ha^{-1}. Thereafter, one third of the plots were cut on Sept. 15, a second third on Oct. 1 and the last one on Oct. 15. Nitrogen fertilizer (60 kg ha^{-1}) was applied to half of the plots immediately after cutting and the other half did not receive any N during fall. Five field samplings were made from mid-October to April. Field survival, freezing tolerance, and the levels of starch, mono and disaccharides were measured in the crowns as previously described (Castonguay et al., 1995). Spring regrowth was estimated by yields from the first cut made on June 1994. Fructans were extracted by homogenization of the tissues in hot water. High molecular weight (HMW) fructans were analyzed on a KS-804 (Shodex) column (HPLC grade H_2O, 1 ml min^{-1}) and low molecular weight fructans (LMW) on a HPX-42A (Bio-Rad) column (H_2O, 0.5 ml min^{-1}) using refractometry for quantitation.

RESULTS AND DISCUSSION
Soil froze at the end of the first week of November and remained frozen until mid-April, reaching the lowest temperature of -6°C in mid-January. Field survival of the cvs. showed striking differences (Fig.1). The survival of cv. Riika was 100 % through the end of February for all treatments. In April, a small decrease in plant survival was observed for some treatments, with a minimal value of 80 % for the Sept. 15 cutting, N- treatment. The cv. Friend showed a very different response, with marked reduction in plant survival for some of the treatments as early as December and very severe damage for all treatments in April. Plants cut on Sept. 15 (N+ and N) showed the highest survival at all sampling dates. A maximal value for TL_{50} (-20 to -22°C) was obtained in December for Riika and did not seem to be related to the treatments. A value of -16 to -18°C was reached in cv. Friend; however, the determinations were no longer feasible in February and April due to excessive winterkill. Determination of the levels of individual sugars showed that sucrose increased from ~50 mg g^{-1} DW in September to reach ~160 mg g^{-1} DW in mid-February. Sucrose levels were consistently higher in cv. Riika than in cv. Friend in February and in April. Glucose and fructose levels were low (~20-30 mg g^{-1} DW) and showed little variations between cvs. or treatments. HMW fructans accumulated in all cultivars and treatments with a degree of polymerization (DP) varying from 10 to 100 and an average value of 30 (1DP=180 daltons). There was no variation in the pattern of distribution of DP all through winter and no effect of N fertilization was observed. For the Sept. 15 cutting, fall levels of HMW fructans (Fig. 2) were substantially higher in cv. Riika than in cv. Friend whereas spring levels were similar. Low molecular weight (LMW) fructans (DP3-DP10) showed a similar pattern for both cvs and treatments. First cut yields obtained in June 1994 (Table 1) illustrate clearly the winter hardiness potential of the cultivars studied. The highest yield of cv. Friend ranked below the lowest value obtained for cv. Riika. The greater winter survival for cv. Riika as compared with cv. Friend may be due to higher fall dormancy for Riika, this cultivar producing less growth in the previous fall (data not presented). A clear effect of date of cutting as well as N fertilization was evident for cv. Riika. Earlier dates of cutting, combined with N fall fertilization were conducive to higher yields at the first cut. However, it is obvious that Sept. 15 cutting (N+) provided the highest first cut yield and should be privileged in a management system. Our study showed the existence of variability in ryegrass for winter survival and its dependence on cold tolerance. Fall cutting regimes had a strong influence on winter survival of ryegrass as cuts taken late in fall reduced survival to a greater extent than earlier cuts. Nitrogen fertilization had no preponderant effect on the acquisition of cold tolerance at least under the N levels applied in this study. We observed that a high level of sucrose reflected an increased tolerance to cold. The superior winter survival and freezing tolerance of cv. Riika seemed related to its ability to maintain high levels of HMW fructans throughout the season. Water-soluble carbohydrate levels were generally not affected by N fertilization. Even if N fertilization was not conducive to a higher degree of winter survival, it is likely to be related to a more vigorous spring regrowth. Growing ryegrass as a fodder crop under Quebec conditions remains risky as the cvs. actually available lack sufficient winter survival capacity. The development of hardier cvs. is required to allow an extensive use of this species under rigorous winter. Furthermore, an adapted management system must be developed to allow the optimal use of this species under cold climate conditions.

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Table 1
DM production on the first cut in June 1994 for different levels of N and fall cutting management in the fall of 1993

Cultivar	Cutting and N regimes		Yield kg ha^{-1}	
Riika	Sept. 15	N+	5995	a
Riika	Oct. 1	N+	3784	ab
Riika	Oct. 15	N+	3519	ab
Riika	Sept.15	N-	3423	bc
Riika	Oct. 1	N-	2831	bcd
Riika	Oct. 15	N-	2578	bcd
Friend	Sept. 15	N-	2297	bcd
Friend	Sept. 15	N+	1222	bcd
Friend	Oct. 1	N-	896	cd
Friend	Oct. 15	N-	747	d
Friend	Oct. 15	N+	562	d
Friend	Oct. 1	N+	—	

a-d Values followed by the same letter are not significantly different by Duncan multiple range test at P - 0.05.

Figure 1
Percent of survival of ryegrass cvs. Friend and Riika after cuttings made on Sept. 15, Oct. 1 and Oct. 15; samples were taken through fall and winter; N+ and N- refer to the presence or absence of N fertilization after fall cutting.

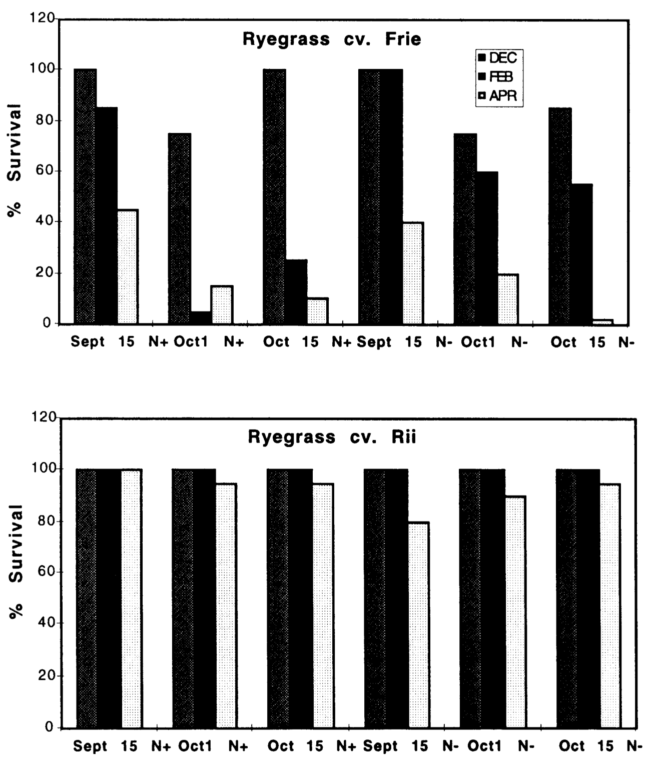

Figure 2
Comparison of the levels of HMW fructans in ryegrass cvs. Friend and Riika for plants cut on Sept. 15, 1993 and sampled on Oct 20, 1993 and April 18, 1994. N fertilization was applied after fall cutting