THE CRITICAL FALL HARVEST PERIOD FOR ALFALFA IN INTERIOR BRITISH COLUMBIA

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Alfalfa (*Medicago sativa* L.) was grown under irrigation and harvested three times each year at Kamloops, British Columbia. The third cut was taken at five or six different times between 15 Aug. and 1 Nov. to identify the critical fall harvest period. Harvesting the third cut on 15 Aug. or 20 Aug. caused the most decrease in the yield of the first cut in the next year; thus the critical fall harvest period is from about 15 Aug. to 15 Sept. On average the total annual yield varied by only about 10% for the different times of third cut. When the third cutting was made on 15 Sept. or later, the average total yield varied by only about 6%. The winters of 3 of the 6 yr of the experiment were colder than normal. Thus, when yield is of prime concern, it is recommended that the timing of the third cut in interior B.C. be taken between 15 Sept. and 16 Oct.

Key words: Alfalfa, cutting management, winter injury, yield, fall harvest period, *Medicago sativa*

[Date critique de la récolte de la luzerne en automne dans le plateau intérieur de la Colombie-Britannique.]
Titre abrégé: Récolte de la luzerne en automne.
A Kamloops, Colombie-Britannique, des peuplements de luzerne irriguée (*Medicago sativa* L.) ont été exposés à un régime de trois coupes par an. La troisième coupe était prélevée à cinq ou six dates différentes entre le 15 août et le 1[er] novembre dans le but de cerner la période critique. Ce sont les coupes du 15 août et du 30 août qui ont occasionné la plus forte baisse de rendement à la première fauche de l'année suivante. La période critique pour la dernière coupe d'automne se situerait donc entre le 15 août et le 15 septembre. En moyenne, le rendement annuel total ne fluctuait que d'environ 10% selon les différentes dates de la troisième fauche. Quand celle-ci avait lieu le 5 septembre ou après, l'écart de variation se réduisait à 6% seulement. Trois des six hivers traversés par l'expérience étaient plus froids que la normale. Lorsque le rendement est l'objet premier recherché, il est conseillé de prévoir le prélèvement de la troisième coupe entre le 15 septembre et le 15 octobre.

Mots clés: Luzerne, régime de fauche, dommages causés par l'hiver, rendement, date de coupe en automne, *Medicago sativa*

Many experiments have shown that harvesting alfalfa (*Medicago sativa* L.) at certain times during the fall causes greater stand deterioration than harvesting at other times. Such experiments led to the concept of a critical fall cutting period that is 4–6 wk before the average date of the first killing frost in the fall (Smith 1981). Smith (1981) did not define a killing frost. The Atmospheric Environment Service defined a killing frost as $-2°C$ (Treidl 1979). McKenzie and McLean (1980) used this definition in their alfalfa studies, although in another study they found that leaves of alfalfa seedlings cold acclimate during the fall and survive to about −10°C (McKenzie and McLean 1982).

Many experiments do provide firm evidence for a critical fall (including August) cutting period. Of several cutting treatments between 1 Sept. and 15 Nov., at Madison, Wisconsin, the 15 Sept. treatment decreased the next year first cut yield the most (Smith 1981). Cutting treatments from 3 Sept. to 1 Oct. at three locations in Ontario indicated that the next year yield was least from cutting treatments on 10 Sept. and on 17 Sept. (Fulkerson 1970). At Beaverlodge, Alberta, cutting on 1 or 15 Aug. decreased the next year first cut yield more than cutting on 15 Sept. or 1 Oct. (McKenzie and McLean 1980). An alfalfa fall cutting study at Lacombe, Alberta indicated that cutting from 13 Aug. to 10 or 17 Sept. had a more detrimental effect than cutting between 10 and 17 Sept. to 8 Oct. (Folkins 1979). All these studies revealed that all cuttings within a 4- to 6-wk period are not equally detrimental.

Some experiments considered to reveal a critical fall harvest period are actually confounded by having different numbers of cuttings during the fall. Examples of this are provided by studies conducted at Madison, Wisconsin (Graber and Sprague 1938) and Guelph, Guelph, Ontario (Twamley 1960). Nevertheless, these studies do indicate that multiple cuttings in the fall decrease winter survival. In support of these early studies, McKenzie and McLean (1980) observed that Beaver alfalfa cut three times a year developed less cold hardiness in the fall than when cut only one or two times a year. In any case, the evidence for a critical fall cutting period is not as extensive as one might expect.

Harvesting during the critical fall period may interfere with carbohydrate storage and development of frost hardiness (Smith 1964; Graber and Sprague 1938), and decrease snow trapping (Graber and Sprague 1938). However, the detrimental effect of fall cutting may be related to factors other than those related to winter injury. For example, compared to an October harvest, a September harvest decreased the number of crown buds formed in the fall and the number of stems that developed the next spring (Silkett et al. 1937).

The studies reported here were conducted to define the critical fall harvest period at Kamloops, British Columbia and to assess the relevance, to producers, of a decrease in yield resulting from cutting during the critical fall harvest period.

MATERIALS AND METHODS

Study Site

Two experiments were conducted at the Kamloops, British Columbia Research Station (50° 42′ N lat., 120° 24′ W. long.). At Kamloops the average annual air temperature is 8.3°C. At a 10% risk the frost (0°C) free period is 129 d (12 May to 18 Sept.) and at a 25% risk the frost free period is 145 d (5 May to 26 Sept.) (Coligado et al. 1968b). A critical freeze of −2.2°C has occurred as early as 30 Sept. and as late as 15 Nov. There is a 10% chance of −2.2°C occurring by 2 Oct., a 25% chance of −2.2°C occurring by 11 Oct., and a 50% chance of −2.2°C occurring by 20 Oct.

The average annual precipitation is 25.6 cm with 9.1 cm occurring as snow. Since potential evaporation is 63 cm per year, alfalfa hay production requires irrigation. At the Research Station two irrigations (3–4 cm each) are usually applied before the first cut, and two or three irrigations are applied after the first and second cut. One or two irrigations are then applied after the third cut.

The soil has been classified to the family level: Orthic Humic Gleysol, fine loamy over coarse loamy, mixed, alkaline, modertely warm subarid (Canadian Soil Survey Committee 1978; A. L. van Ryswyk, pers. commun.). The soil has been cultivated for about 50 yr, and the plough layer contains 2.5–3.5% organic carbon.

Experiment 1

The study was set up as a 2 × 6 factorial experiment with two alfalfa cultivars (Beaver and Saranac) and six dates of harvest of the final cut (15 Aug., 30 Aug., 15 Sept., 30 Sept., 15 Oct.

and 1 Nov.). At Kamloops, Beaver is more persistent than Saranac (Stout 1985), and presumably has more cold hardiness. It was laid out in a randomized complete block design with 10 blocks. Plots (0.9 × 7.7 m) were seeded at a rate of 11 kg ha^{-1} on 18 May 1978 with a 15-cm row spacing, and were harvested once during the fall of 1978, but the yield was not recorded. Based on annual soil tests, boron fertilizer was broadcast onto the plots during the spring of 1979, 1980 and 1981 at 4.5 kg ha^{-1}; during the spring of 1982 at 2.2 kg ha^{-1} and during the spring of 1983 at 3.4 kg ha^{-1}. In addition, 224 kg ha^{-1} of P_2O_5 was broadcast onto plots in the springs of 1979, 1980 and 1981. Weeds were controlled by an annual spring application of Embutox (3.5 L ha^{-1}) or Sinbar (0.8 kg ha^{-1}). From 1979 to 1984 plots were harvested with a Mott flail-type harvester, which left a stubble height of about 10 cm. Dry weight yield was determined by drying a subsample to constant weight in a forced-air oven at 80°C. Measurements of first cut yields were repeated every year for 6 yr (1979, 1980, 1981, 1982, 1983 and 1984) and years were treated as a factor in a split plot when carrying out analysis of variance (ANOVA). Total yield was measured during the first 5 yr, and percent stand was evaluated in 4 yr. In 1979, 1981, 1982 and 1983 the first cut was harvested on 8 June, 1 June, 15 June and 1 June, respectively; the second cut was harvested on 16 July, 17 July, 19 July and 7 July, respectively; and the third and final cut was harvested between 15 Aug. and 1 Nov. In 1980 plots were cut four times rather than three, to add additional stress to the plants. The first cut was harvested on 13 May, the second cut was harvested on 12 June, and the third cut was harvested on 21 July. The fourth cut was taken according to the final cut schedule given above. In 1984 a first cut was harvested on 15 June. Percent stand for each plot was rated visually by two people on 22 Apr. 1980, 13 May 1982, 13 May 1983, and 21 Apr. 1984. The observers stood at the end of a plot and subjectively rated the plot as to its percent cover.

Percent stand was compared to first cut yield by ranking each treatment each of 3 yr (1982, 1983 and 1984, data from 1980 was not used since cutting treatments had not yet had an effect on percent stand). The mean value for each treatment was used for this ranking; each treatment was then assigned a value of 1 to 6 (1 = lowest value and 6 = highest value).

Experiment 2

This study was set up as a 3 × 5 factorial experiment with three alfalfa cultivars (Beaver, Anchor and Rambler) and five dates of harvest (15 Aug., 30 Aug., 15 Sept., 30 Sept. and 15 Oct.) for the third cut. At Kamloops, Beaver is more persistent than Anchor (Stout 1985). Rambler suffered less winter injury than Beaver at Swift Current, Saskatchewan when grown under dryland or irrigation (Heinrichs 1973). It was laid out in a randomized complete block design with six blocks. Plots (1.5 × 6.1 m) were seeded at a rate of 5.5 kg ha^{-1} on 17 May 1979, with a 30-cm row spacing. Plots were harvested on 16 Oct. 1979, but yield was not recorded. Based on annual soil tests, boron fertilizer was broadcast onto the plots during the spring of 1980 and 1981 at a rate of 4.5 kg ha^{-1}, during the spring of 1982 at a rate of 2.2 kg ha^{-1} and during the spring of 1983 at 3.4 kg ha^{-1}. In 1980 and 1981, 224 kg ha^{-1} of P_2O_5 was broadcast onto the plots in the spring. Weeds were controlled by an annual spring application of Embutox (3.5 L ha^{-1}) or Sinbar (0.8 kg ha^{-1}). From 1979 to 1984 plots were harvested with a Mott flail-type harvester and dry weight yield was determined. First cut yield measurements were repeated every year of 5 yr (1980, 1981, 1982, 1983 and 1984) and years were treated as a factor in a split plot when carrying out analysis of variance. Total yield was recorded during the first 4 yr, and percent stand was evaluated during 4 yr. The first cut was harvested 2 June 1980, 8 June 1981, 16 June 1982, 3 June 1983, and 15 June 1984. The second cut was harvested on 2 July 1980, 24 July 1981, 23 July 1982 and 13 July 1984. The third cut was harvested according to the schedule given earlier from 1979 to 1983. Percent stand for each plot was visually evaluated each spring by two observers on 22 Apr. 1980; 13 May 1982, 13 May 1983, and 21 Apr. 1984. Percent stand and first cut yields were compared by ranking each treatment as in exp. 1. On 10 Aug. 1983 the stand was evaluated by counting the number of plants in each plot. On 15 June and 22 July 1982, the number of plants in each plot showing visual symptoms of verticillium wilt (*Verticillium albo-atrum*) was counted.

RESULTS

In exp. 1 the total yield of Saranac decreased at a greater rate from 1979 to 1982 (Fig. 1) than did the total yield of Beaver (years × cultivars interaction significant $P<0.05$). From 1982 to 1983 the difference in yield between them remained constant. Both cultivars showed an increase in yield from 1982 to 1983. April, May and August were warmer in 1983 than in 1982 (Table 1), June was cooler in 1983 than in 1982, and July was about the same both years. During 5 yr, the average yield for Beaver was 9662 kg ha^{-1} vs. 8940 kg ha^{-1} for Saranac.

The relationship between total yield and date of third cut differed (significant year by date interaction $P\leq0.05$) from year to year (Fig. 2). Maximum total yields occurred with the 15 Sept. cutting treatment in 1979 and the 15 Oct. treatment in 1981 and 1983. There was no unique maximum in 1980 and 1982. Total yields tended to be low for 15 Aug. and 1 Nov. cutting treatments in all years.

In exp. 2 the total yield of Rambler decreased at a faster rate from 1980 to 1982 (Fig. 1) than did the total yield of Beaver or Anchor (years by cultivar interaction significant at $P\leq0.05$). The difference in yield between cultivars remained constant from 1982 to 1983. From 1980 to 1983, total

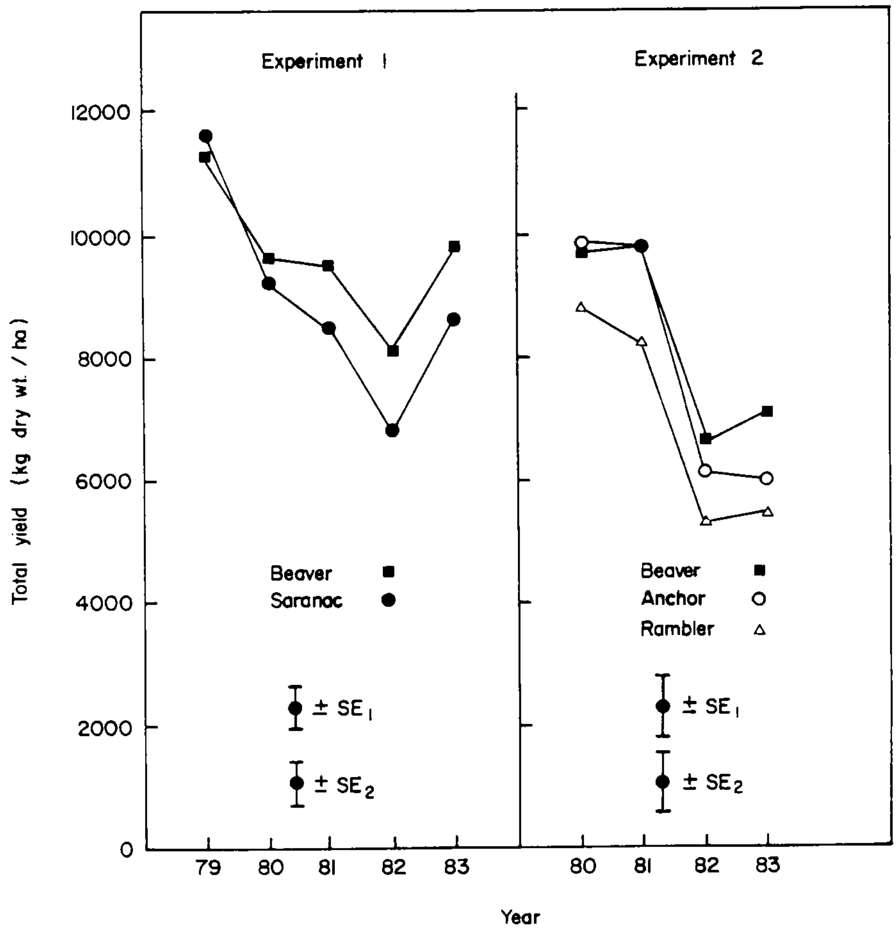

Fig. 1. Effect of stand age on total yield. Values are means for $n=60$ (exp. 1) or $n=30$ (exp. 2). SE_1 (standard error) is for comparing cultivars and SE_2 is for comparing years.

Table 1. Average mean temperature and snow fall at Kamloops airport†

Year	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Average mean temperature (°C)											
1978					12.9	19.1	22.3	17.8	14.1	8.4	−1.3	−6.4
1979	−13.8	−4.3	4.8	8.3	14.0	18.6	22.1	22.0	17.0	10.6	0.3	0.2
1980	−6.9	0.9	4.2	12.2	15.5	17.4	20.5	18.3	14.5	9.6	3.9	−0.4
1981	1.3	1.4	6.3	9.0	14.6	15.4	20.6	22.9	15.9	8.1	5.0	−3.0
1982	−8.1	−1.2	3.4	7.8	13.6	20.7	19.4	19.3	15.7	8.7	−0.7	−1.5
1983	0.9	3.4	6.1	9.6	15.4	17.9	19.3	21.3	13.2	8.7	4.9	−9.3
1984	−3.3	2.0	6.6	9.2	11.7	17.3	21.5					
Normal	−6.1	−1.3	3.5	9.1	14.1	18.0	20.8	19.8	14.9	8.4	1.6	−2.8
	Total snow fall (cm)											
1978	47.2	10.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	14.0
1979	29.9	10.5	1.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.6	10.7
1980	5.5	13.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	43.1
1981	1.4	5.4	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	38.8
1982	76.0	9.5	7.0	T‡	0.0	0.0	0.0	0.0	0.0	0.0	11.8	6.6
1983	13.2	1.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	29.3
1984	14.8	2.3	T	T	0.0	0.0	0.0					
Normal	32.0	12.7	4.5	0.3	0.0	0.0	0.0	0.0		0.4	11.6	30.0

† Data provided by Environment Canada. The normal value is a 30-yr average (1951–1980); Kamloops Airport is about 2 km south of the Kamloops Research Station.
‡ T = trace.

yield averaged 8288 kg ha^{-1} for Beaver, 7948 kg ha^{-1} for Anchor, and 6924 kg ha^{-1} for Rambler. As in exp. 1, the relationship between total yield and date of third cut differed (significant year × date interaction $P \leq 0.05$) from year to year (Fig. 2). Total yield in 1980 and 1981 was highest for the 15 Sept. harvest, and was lowest for the 15 Aug. harvest (Fig. 2). However in 1982 and 1983, the lowest total yield occurred for the 15 Aug. and 30 Aug. harvests; harvests from 15 Sept. to 15 Oct. had similar total yields.

For exp. 1, the average total yield on 15 Aug. was 92.6% of the average total yield on 15 Oct. (Table 2); on 15 Sept. the average total yield was 96.3% of the average total yield on 15 Oct. For exp. 2, the average total yield on 15 Aug. was 86.6% of the average total yield on 15 Sept. (Table 2). Thus, time of the final harvest did not have a consistent dramatic effect on total

Table 2. Average total dry matter yield as affected by third cut harvest date

Harvest date	Average yield† (kg dry wt ha^{-1} yr^{-1})	
	Exp. 1	Exp. 2
15 Aug.	8986*d*	7175*c*
30 Aug.	9245*bcd*	7300*c*
15 Sept.	9352*bc*	8288*a*
30 Sept.	9443*ab*	7890*b*
15 Oct.	9708*a*	7946*ab*
1 Nov.	9072*cd*	
SE	102	126

† Values are from 5 yr for exp. 1 and 4 yr for exp. 2.
a–d Different letters within a column indicate significant difference ($P \leq 0.05$) according to Duncan's multiple range test.

productivity of a stand.

As found for total yield, the first cut yield of Saranac decreased at a greater rate from 1979 to 1982 (Fig. 3) than did the first cut yield of Beaver (year × cultivars interaction $P \leq 0.05$). The difference in first cut yield between the two cultivars was similar in 1982 and 1983, but it decreased in 1984. The average first cut yield from 1979 to 1984 was 4046 kg ha^{-1} for Beaver and 3511 kg ha^{-1} for Saranac. First cut yield was affected by the date of third cut (significant date effect $P \leq 0.05$). This effect of cutting date was independent of years. The 15 Oct harvest resulted in a larger first cut yield than all other harvest dates (Fig. 4).

The results for first cut yields from exp. 2 were different than the results for first cut yields from exp. 1 in that the ANOVA indicated no significant interactions. However, cultivars, years, and third cut harvest date had a significant effect ($P \leq 0.05$). The average first cut yield was 4125 kg ha^{-1} for Beaver, 3698 kg ha^{-1} for Anchor, and 3521 kg ha^{-1} for Rambler. The first cut yield decreased dramatically from 1981 to 1982,

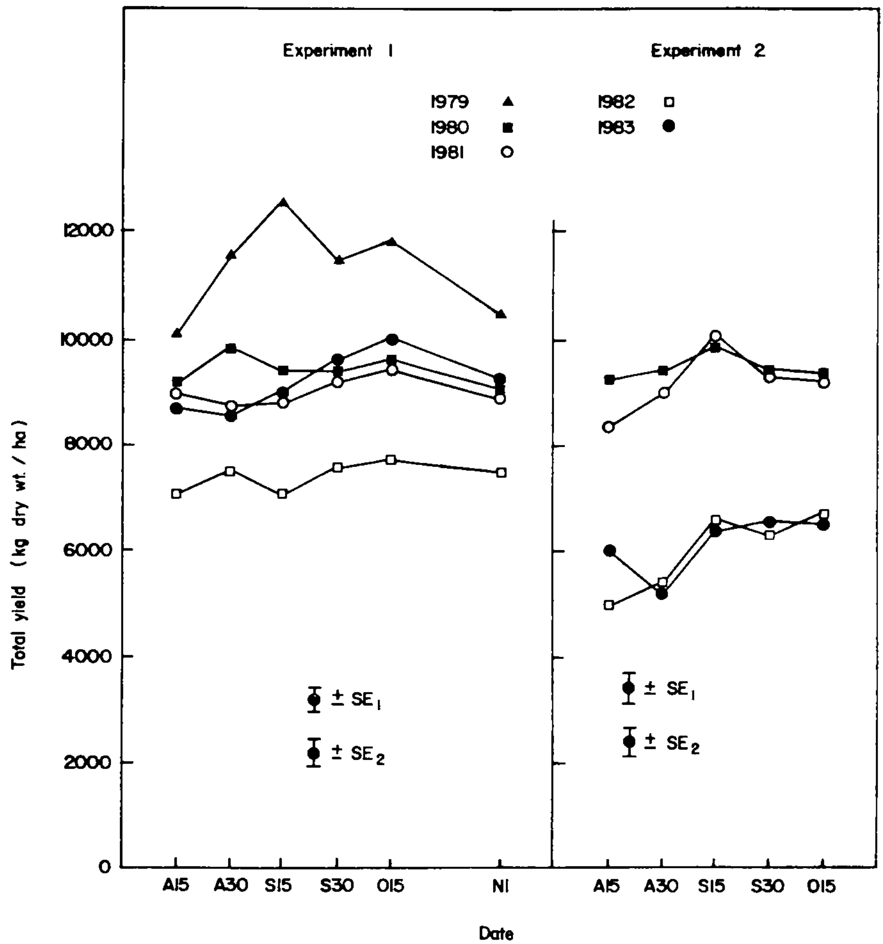

Fig. 2. Effect of fall harvest date on total yield. Values are means for $n = 20$ (exp. 1) and $n = 18$ (exp. 2). SE_1 is for comparing cutting dates, and SE_2 is for comparing years.

and then increased gradually from 1982 to 1984 (Fig. 3). The 15 Aug. and 30 Aug. third cut harvests decreased the first cut yield compared to the other three third cut harvests (Fig. 4).

The ANOVA results for percent stand were similar for both experiments. There was a significant effect ($P \leq 0.05$) of observers, cultivars, cultivars × observers, years × observers, cultivars × years, years, fall harvest date, and fall harvest date × years. In these experiments, no patches of winter killed plants were observed. Stand decrease resulted from a general thinning throughout the plots. The observer effect can be demonstrated by comparing the percent stand averaged for all years: for exp. 1 the average was 44% for observer 1 and 63% for observer 2; for exp. 2 the average was 34% for observer 1 and 54% for observer 2. In exp. 1 the average percent stand from 1980 to 1984 was 55% for Beaver and 43% for Saranac. In exp. 2 the average percent stand was 40% for Beaver, 45% for Anchor and 37% for Rambler. A large decrease in percent stand occurred between 1980 and 1982 for both experiments (Fig. 5). In exp. 2 especially, this stand decrease appears to coincide with a decrease in total yield (Fig. 1) and first cut yield (Fig. 3) between 1981 and 1982. From December to February the 1981–1982 winter was colder than other years (Table 1) and had some low extreme temperatures (Table 3). However,

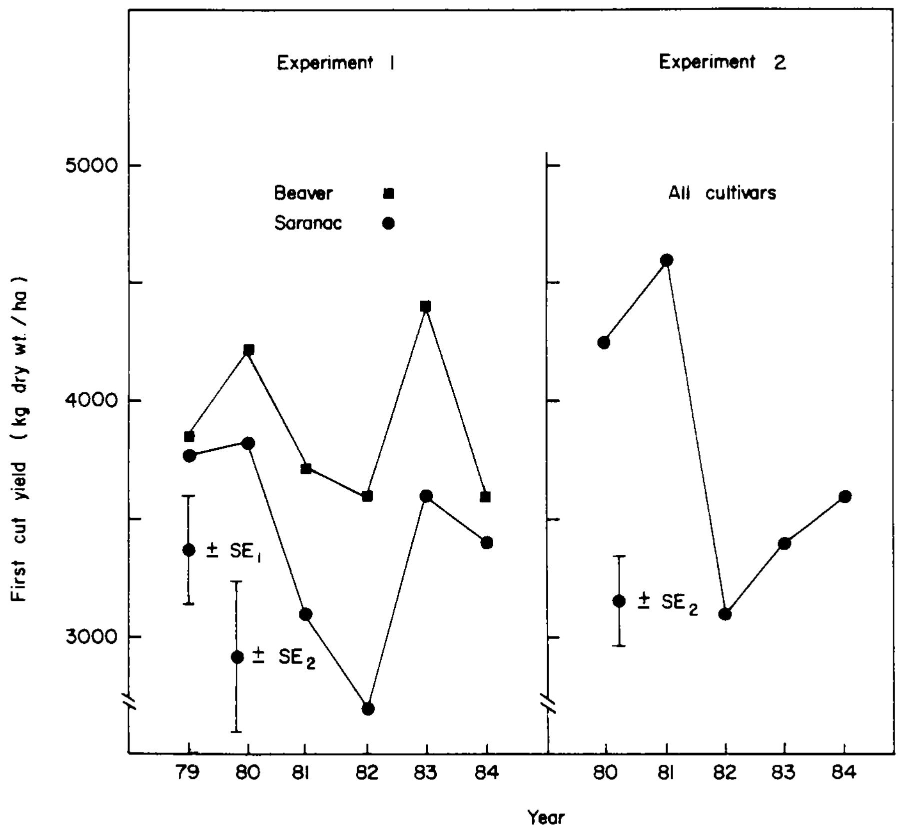

Fig. 3. Effect of stand age on first cut yields. Values are means for $n = 60$ (exp. 1) and $n = 90$ (exp. 2). SE_1 is for comparing cultivars, and SE_2 is for comparing years.

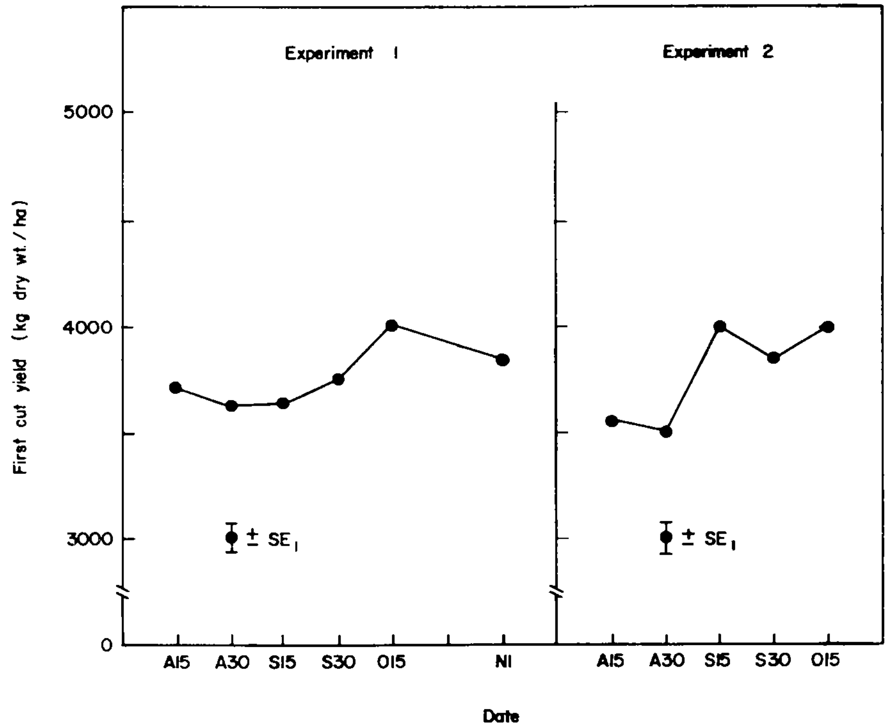

Fig. 4. Effect of fall harvest date on first cut yield. Values are means for $n = 120$ (exp. 1) and $n = 90$ (exp. 2). SE is for comparing fall cutting treatments.

Table 3. Minimum temperatures at Kamloops Airport†

	Month											
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Average minimum temperature (°C)											
1978									8.8	2.2	−4.7	−10.4
1979	−18.4	−9.3	−2.3	0.9	6.6	10.7	14.1	14.4	9.7	4.9	−4.1	−3.6
1980	−10.9	−2.1	−1.1	5.0	9.2	11.1	12.9	11.5	8.7	3.3	0.2	−6.3
1981	−1.3	−2.4	−0.5	2.0	8.5	9.0	13.7	14.3	9.2	2.8	0.8	−6.9
1982	−12.1	−5.1	−2.7	0.7	6.2	12.8	13.1	12.5	9.5	3.6	−4.4	−4.6
1983	−2.0	−0.1	0.4	2.6	7.3	11.7	12.3	13.6	6.8	2.7	1.7	−12.7
1984	−6.7	−1.8	1.0	3.3	5.4	11.1	13.3					
Normal‡	−9.8	−5.5	−2.1	2.0	6.7	10.7	12.8	12.1	7.8	2.9	−2.1	−6.2
	Extreme minimum air temperature (°C)											
1978	−20.3	−13.5	−9.3	−2.2	−0.6	4.8	9.0	6.5	1.7	−3.2	−17.6	−30.0
1979	−29.5	−21.6	−7.0	−6.2	2.3	5.5	7.5	10.4	3.4	−2.2	−9.6	−19.2
1980	−23.0	−11.0	−10.0	−4.4	0.4	7.9	8.3	5.2	4.0	−2.5	−6.7	−25.6
1981	−6.3	−17.1	−5.5	−3.7	1.6	5.3	7.7	8.4	1.4	−3.9	−5.9	−19.2
1982	−25.7	−20.0	−8.6	−5.9	−0.8	4.0	7.8	7.0	1.1	−4.9	−16.2	−10.9
1983	−7.1	−7.6	−6.1	3.2	1.8	7.2	8.0	7.6	−2.7	−3.8	−6.0	−26.8
1984	−19.2	−8.2	−4.2	−1.7	0.5	4.8	7.5					

† Data provided by Environment Canada. The airport is 2 km south of the Research Station.
‡ 30 yr average (1951–1980).

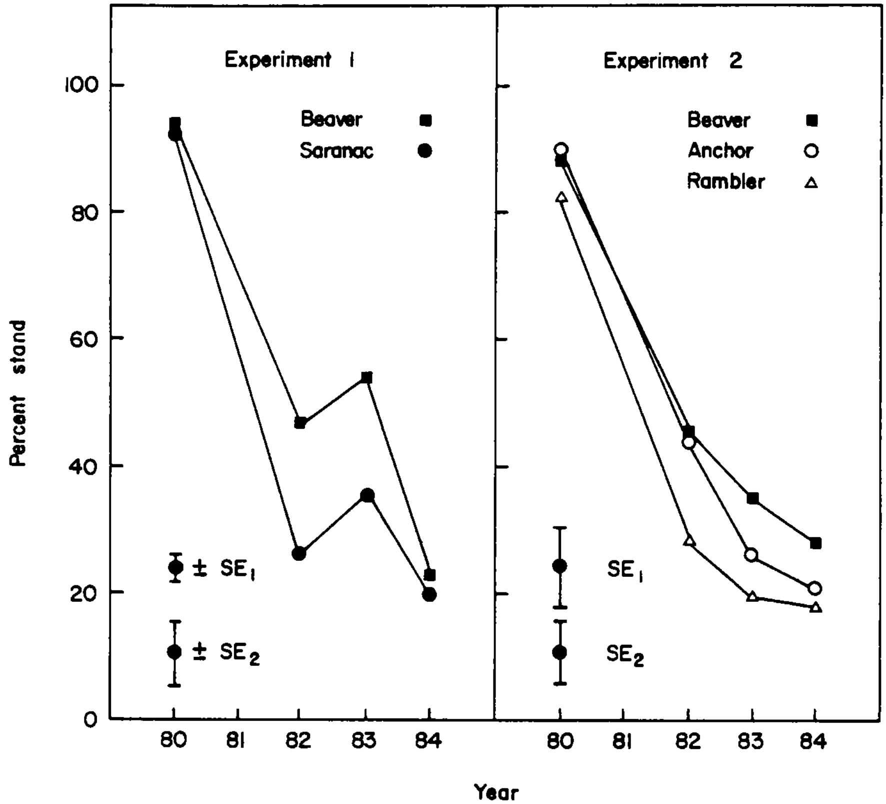

Fig. 5. Effect of stand age on visual ratings of percent stand in the spring. Values are means for $n=60$ (exp. 1) and $n=30$ (exp. 2).

the snow fall was also quite high during this cold period (Table 1) and so the soil temperature may have remained high. Percent stand decreased from 1980 to 1984 in both experiments. For exp. 1 the rate of stand decrease was on average greater for Saranac than for Beaver. For exp. 2 the ranking of cultivars according to rate of stand decrease was Rambler > Anchor > Beaver. However, the observer by year interaction and the apparent stand increase from 1982 to 1983 in exp. 1 indicates that comparing percent stand ratings from year to year should be done with caution.

In 1980, percent stand for exp. 1 was high and independent of fall cutting date (Fig. 6). Based on the high percent stand in 1980, no winter injury occurred during the first two winters of exp. 1 or the first winter of exp. 2. Following 1980, the trend for percent stand versus fall harvest date changed. For exp. 1, the 15 Sept. harvest appeared to decrease the stand more than other harvests; this observation, however, is not supported by total yield results (Fig. 2) or first cut yield results (Fig. 4). Percent stand results for 1983 from exp. 1, and for 1982 to 1984 for exp. 2 (Fig. 6) indicate that harvesting on either date in August decreased the stand more than harvesting on other dates; this result is supported by total yield (Fig. 2) and first cut yield (Fig. 4) data from exp. 2. In a given year percent stand ratings were correlated with the first cut yield (Fig. 7).

An evaluation of the stand in exp. 2 in

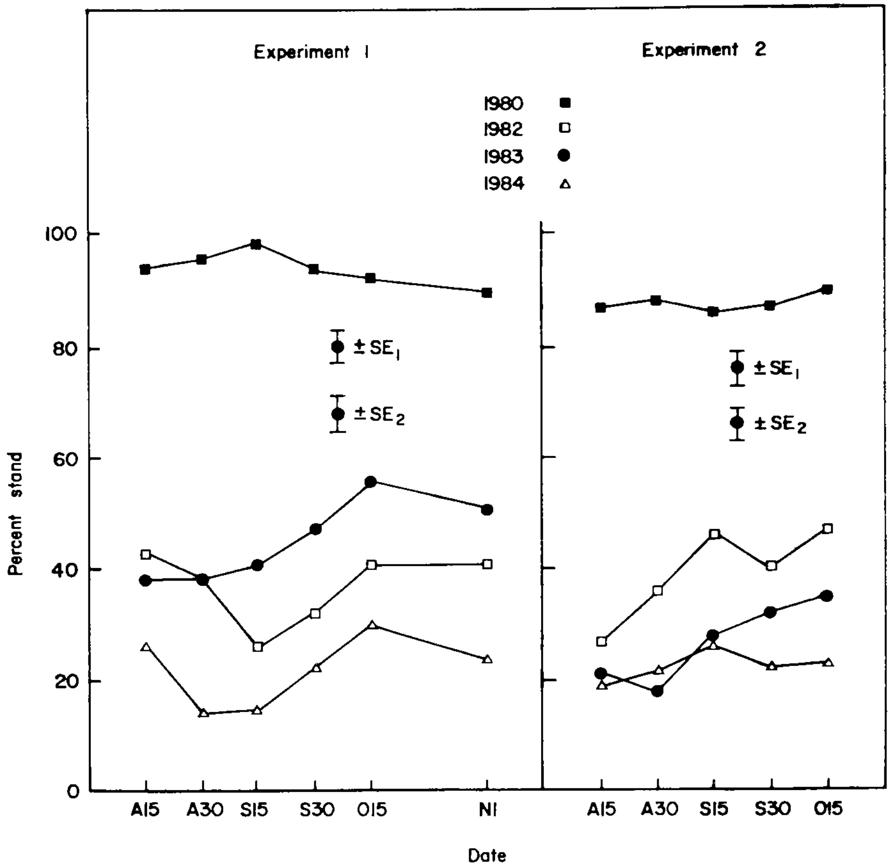

Fig. 6. Effect of fall harvest date on visual ratings of percent stand in the spring. Values are means for $n = 20$ (exp. 1) and $n = 18$ (exp. 2).

1983 by actually counting the number of plants per plot, revealed a cultivar difference, but no effect of fall harvest date (Table 4). These results partially support the cultivar difference detected in the spring by visual observations (Fig. 5), but do not support the effect of harvest date detected by visual observations earlier in the spring (Fig. 6).

Evaluation of plots of exp. 2 for visual

Table 4. Evaluation of plant number and height in exp. 2 on 10 Aug. 1983

	Measurement†	
Cultivar	Number of plants/plot	Plant height (cm)
Beaver	28.1	32
Anchor	23.9	36
Rambler	24.1	24
SE	0.7	1

† Values are averaged over six blocks and five harvest treatments per block. Fall harvest treatment had no effect ($P \leq 0.05$) on either variable.

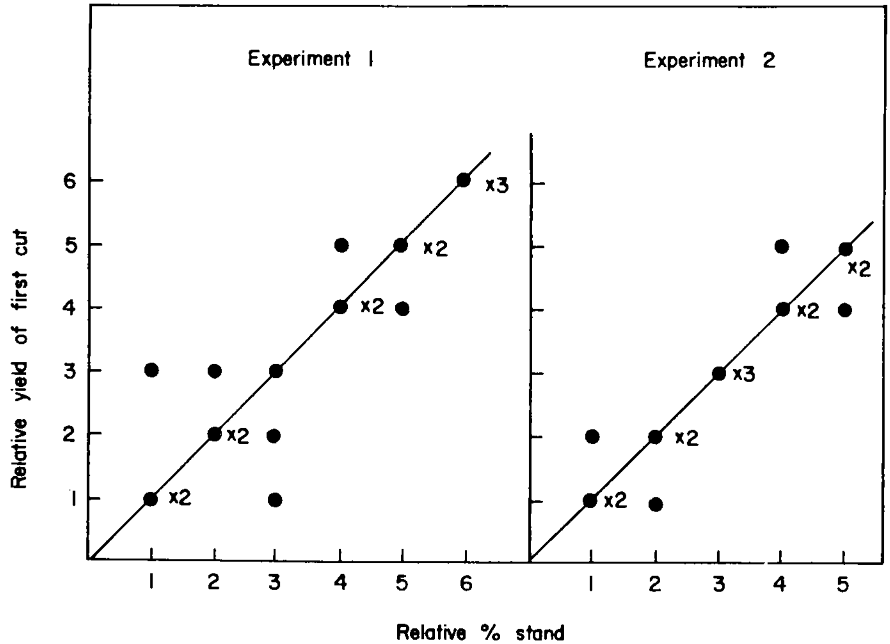

Fig. 7. Relationship between relative yield of the first cut and relative percent stand. A relative value of 1 indicates the lowest value and a relative value of 6 (exp. 1) or 5 (exp. 2) indicates the highest value.

symptoms of verticillium wilt revealed a cultivar difference on two dates in 1982 (Table 5). Anchor had more plants with visual symptoms of verticillium wilt on both dates. On 15 June, Rambler had more plants than Beaver, and on 22 July Beaver had more plants than Rambler.

Table 5. Number of plants per plot in exp. 2 showing visual symptoms of Verticillium wilt in 1982

Cultivar	Date counted† 15 June	22 July
Beaver	2.4	13.0
Anchor	4.3	19.8
Rambler	2.9	9.1
SE	0.1	1.1

† Values are averaged over six blocks and five harvest treatments. Effect of fall harvest treatment was not significant at $P \leq 0.05$.

DISCUSSION

Accepting the concept of a 4- to 6-wk critical period (Smith 1981) before a critical freeze of −2°C, Kamloops would have a critical period from early September or mid-September to mid-October. When first cut yield is used to compare harvest date, neither exp. 1 nor exp. 2 is consistent with this critical harvest period. It is interesting that August appears to be the most sensitive period at Kamloops (50° 42′N lat., 120° 24′W long.), Lacombe (52° 28′N lat., 113° 45′W long.), and Beaverlodge (55° 13′N lat., 119° 26′W long.). The average date of receiving a frost of −2.2°C or colder is 20 Oct. at Kamloops, 16 Sept. at Lacombe and 15 Sept. at Beaverlodge (Coligado et al. 1968a–c). Apparently the critical harvest period is not related to interference with cold acclimation and winter injury. In support of this, a recent study in Michigan concluded that fall cutting of alfalfa does not decrease stand persistence provided that moderately hardy and wilt-resistant cultivars are grown, and adequate fertilization is used (Tesar and Yager 1985).

Frost injury or low temperature injury to plants occurs only periodically when a "test" winter occurs. Thus it can be argued that a dramatic critical harvest period was not demonstrated in these experiments because a test winter did not occur. Although the stand deteriorated dramatically in these experiments, and there is reason to believe the injury occurred during the winter, there is not direct evidence that the injury resulted from low temperature. However, the low production of the first cut (Fig. 3) in 1982 compared to 1981 corresponded to a cold winter (Table 1). These experiments were conducted over a period that included both winters colder and winters warmer than the normal for this area. For example, of the six winters during which these experiments were conducted, 3 yr had a colder November, December and January than normal (Table 1). Four winters had less snow in December and five winters had less snow in January (Table 1). If a test winter requires temperatures lower than those that occurred during the period of these experiments, then a test winter is likely to be infrequent. For this reason it is recommended that fall cutting be practiced to maximize yield rather than to protect the stand from an infrequent test winter. The uncertainty as to whether or not the critical period is related to winter injury or some other factor adds further support to this conclusion.

The critical period may be related to the amount of plant development that occurs during the time between the second and third cut (Silkett 1937); when this period is short, tiller production can be inhibited by late August harvests. Inhibition of tiller production can explain why first cut yield is decreased (Fig. 4) but plant population is not (Table 4). Support for this is provided by the results of Folkins (1979). He observed that, under a two cut system, the detrimental effect of taking the second cut in August could be decreased by taking the first cut on 26 June rather than on 10 July. Leach (1969) observed that following "lenient" cutting of alfalfa, new shoot development occurred during the first week and again during the third or fourth week; however, following "severe" cutting, alfalfa plants only produced new shoots during the first week. Smith (1962) reported that uncut alfalfa develops three growths from the crown: the first in the early spring, the second during late June, and the third in early August. Buds giving rise to the next years top growth developed in late August or early September. McLeod et al. (1972) found that harvesting the first cut at prebud or early bud decreased stand persistence at Charlottetown, Prince Edward Island; thus cutting management can influence stand persistence even when not done during the traditional fall rest period. To conclude, interference with morphological development is as reasonable an explanation for the critical fall period as interference with cold acclimation and plant winter hardiness. This does not mean, however, that multiple defoliations in the fall do not exert their influence through effects on cold hardiness and winter survival.

In both experiments, the stand deteriorated from year to year. The deterioration may have been due to low temperature injury, to plant diseases, or to some other causes. In another study conducted between 1980 and 1984, it was concluded that stand deterioration at Kamloops resulted from plant death in the winter, although disease may have been an important factor (Stout 1985). Both stand deterioration with time and the incidence of verticillium wilt symptoms in 1982 showed a cultivar effect. Beaver deteriorated at a lower rate (Figs. 1 and 5) and showed fewer plants with wilt symptoms (Table 4). Therefore, plant disease may have been the primary cause of stand deterioration in these two experiments.

From an agronomic viewpoint, the main objective is to obtain the maximum yield over the life of the stand. Harvesting in August consistently resulted in the lowest total yields (Table 2) and stand densities (Figs. 4 and 6). Thus, to maximize yield August is not an appropriate time to take the third cut. In exp. 1 the 30 Sept. and 15 Oct. harvests gave the maximum total yield, and in exp. 2 the 15 Sept. harvest gave the maximum total yield (Table 2). To maximize yield, the third cut should be taken between 15 Sept. and 15 Oct. Harvesting between these dates resulted in only about a 6% variation in yield for both experiments. However, other important factors such as forage quality, lodging, or weather conditions for drying of the hay, may justify harvesting earlier than 15 Sept.

Visual ratings of percent stand in the spring are often used to evaluate winter injury to perennial forage crops. In principle, first cut yields are a more objective and quantitative measure of winter injury than the subjective visual ratings. Nevertheless, in a given year the relative ranking of treatments was similar when done using percent stand or first cut yield (Fig. 7). Therefore, percent stand is useful and valid for comparing treatments in a given year. On the other hand, percent stand is not useful for comparing stands from year to year. The presence of an observer-by-year interaction suggests that observer bias does not remain constant from year to year. Further, the percent stand cannot increase, yet the data from exp. 1 suggests an increase from 1982 to 1983. Of course, first cut yield also has a limited use for comparing years since environmental conditions during the growth period can vary from year to year. The relationship between first cut yield and third cut date (Fig. 4) was similar to the relationship between percent stand and third cut date for exp. 2 and for 1982 data from exp. 1. However, the agreement was not complete for 1983 and 1984 data from exp. 2. To conclude, rating percent stand is useful for comparing treatments in a given year, but in principle, the better and more objective method for comparing treatments is the first cut yield.

In conclusion, there is no evidence for a critical fall harvest period that results in increased winter injury. However, there is evidence for a critical harvest period in late August that decreases subsequent yield. A reasonable hypothesis, to explain this late August harvest period, is that it exerts its effect by interfering with tiller production.

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