# Swath grazing potential of spring cereals, field pea and mixtures with other species

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[1]*Alberta Agriculture Food and Rural Development;* [2]*Lacombe Research Centre, Agriculture and Agri-Food Canada, 6000 C&E Trail, Lacombe, Alberta, Canada T4L 1W1. Contribution no. 1028,*
*received 18 August 2003, accepted 12 April 2004.*

Aasen, A., Baron, V. S., Clayton, G. W., Dick, A. C. and McCartney, D. H. 2004. **Swath grazing potential of spring cereals, field pea and mixtures with other species**. Can. J. Plant Sci. **84**: 1051–1058. There is little information on the relative suitability of cereal species and field pea or their mixtures for winter swath grazing. The objective of this study was to compare the swath grazing potential of small-grain cereal and field pea (*Pisum sativa* L.) monocultures, their mixtures, and mixtures with other species, by evaluating forage yield in the fall and changes in nutritive value due to weathering from fall until spring. The monocultures and mixtures were seeded in early summer and swathed in late September with conventional farm equipment for 3 yr. Dry matter yield was measured by harvesting a subplot (1.22 × 3.62 m) across each plot prior to swathing. A cross-section sample of swath was taken for quality determination immediately after swathing, in late November and April. In vitro digestible organic matter (IVDOM), protein, and neutral (NDF) and acid detergent fiber (ADF) concentrations were measured for each sampling time. Generally, barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.) and field pea monocrops produced similar yields, and mixtures did not out-yield monocrops. Yield of the barley/oat mixture was more stable from year to year than the respective monocrops. Addition of field pea to cereals in mixtures increased crude protein slightly and reduced NDF over cereal monocrops, but field pea mixtures did not improve nutritive value compared with the field pea monocrop. In one year with severe weathering conditions, field pea and field pea mixtures lost nutritive value faster than cereal monocrops initially, but had nutritive value similar to the cereal monocrops by April. Mixtures and monocrops lost nutritive value at a similar rate due to weathering. Added costs of growing mixtures rather than monocrops were not offset by superior yield, nutritive value, or resistance to weathering.

**Key words**: Winter swath grazing, cereal and field pea mixtures, weathering, nutritive value

Aasen, A., Baron, V. S., Clayton, G. W., Dick, A. C. et McCartney, D. H. 2004. **Potentiel des céréales de printemps, du pois de grande culture et des mélanges comprenant d'autres espèces pour la pâture sur andains**. Can. J. Plant Sci. **84**: 1051–1058. On ne sait pas grand-chose de l'utilité relative des céréales, du pois de grande culture et de leurs mélanges pour la pâture hivernale sur andains. L'étude devait comparer le potentiel des petites céréales et du pois de plein champ (*Pisum sativum* L.), de leur combinaison et de leurs mélanges avec d'autres espèces en la matière par évaluation du rendement fourrager à l'automne et par analyse des variations de la valeur nutritive attribuables à l'altération sur pied entre l'automne et le printemps. Trois années durant, monocultures et mélanges ont été semés au début de l'été puis mis en andains à la fin de septembre avec du matériel agricole ordinaire. On a mesuré le rendement en matière sèche en récoltant une partie (1,22 × 3,62 m) de la parcelle avant l'andainage. Pour évaluer la qualité du foin après cette opération, on a prélevé un échantillon transversal des andains à la fin de novembre et en avril. La concentration de matière organique digestible in vitro, des protéines ainsi que des fibres au détergent neutre (FDN) et acide (FDA) a été établie à chaque date d'échantillonnage. Dans l'ensemble, l'orge (*Hordeum vulgare* L.), l'avoine (*Avena sativa* L.) et le pois de plein champ donnent un rendement équivalent lorsqu'ils sont cultivés seuls; le rendement des mélanges ne dépasse pas celui des monocultures. Le mélange orge/avoine a un rendement plus stable que les monocultures correspondantes d'une année à l'autre. L'addition du pois aux céréales accroît légèrement la concentration de protéines brutes et diminue celle de FDN comparativement à la monoculture de céréales, mais la valeur nutritive des mélanges incluant le pois ne dépasse pas celle du pois cultivé seul. Lors d'une année où les conditions climatiques étaient difficiles, la valeur nutritive du pois de grande cultures et des mélanges le comprenant a diminué plus vite que celle des monocultures de céréales au départ, mais en avril, les différentes cultures avaient une valeur nutritive équivalente. L'altération sur pied réduit la valeur nutritive des mélanges et des monocultures au même rythme. Comparativement aux monocultures, le coût plus élevé de la culture d'un mélange n'est pas compensé par une amélioration du rendement, de la valeur nutritive et de la résistance à l'altération sur pied.

**Mots clés**: Pâture hivernale sur andains, mélanges de céréales et de pois, altération sur pied, valeur nutritive

Swath grazing whole-plant small-grain species is used to extend the grazing season for beef cows on the Canadian prairies (Anonymous 1998; Entz et al. 2002). Windrowing stockpiled perennial grass for grazing has been studied elsewhere (Volesky et al. 2002). Swath grazing is similar to stockpile-grazing standing perennials during fall and winter when conventional pastures cannot meet the nutritional demands of ruminants. Producers can reduce winter feed costs by extending the grazing season with stockpiled forages because of savings achieved through elimination of mechanical harvesting, handling, feeding and manure removal associated with conserved forage systems (Johnson

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**Abbreviations**: **ADF**, acid detergent fiber; **IVDOM**, in vitro digestible organic matter; **NDF**, neutral detergent fiber and Wand 1999). Volesky et al. (2002) observed that costs for bale-fed weaned calves were 37% greater than those in a windrowed perennial grass grazing system due to the costs associated with baling and handling of hay.

Small grains have been used as emergency sources of forage during dry years (Kilcher and Heinrichs 1961). Swathed cereals provide a flexible grazing system, while cereals left standing have shown reduced grazing efficiency (Entz et al. 2002). Swathing consolidates standing cereals, making them more easily apprehended by cows grazing through snow. Accessibility of standing perennial grass may be reduced by snow in western Canada (Lawrence and Heinrichs 1974), although Riesterer et al. (2000) indicated that cows could graze standing perennials through 0.5 m of snow if sufficient biomass was available. Accessibility may critically limit energy intake in cold weather (–15°C and lower) when cow nutritional requirements for digestible dry matter increase by at least 16% or more (National Research Council 1996). Grazing time and dry matter intake decreased on native range during cold periods in winter (Adams et al. 1986).

There are indications (Anonymous 1998) that the nutritive value of swathed small grains meet minimum beef cow requirements under thermo-neutral conditions during mid gestation (NRC 1996). However, there is limited information on nutritive value variability of swathed small grain dry matter from year to year and throughout the winter. Mixtures of small grains with other species have been used to increase nutritive value in silage and hay systems over small grains grown alone (Berkenkamp and Meeres 1987; Baron et al. 1992b; Thompson et al. 1992). Species that are effective for improving nutritive value in mixtures do so by adding leaf material to the small grain crop, which is usually between the heading and dough stages of development when harvested (Baron et al. 1992a; Entz et al. 2002).

Swathing should make the use of mixtures containing species such as field pea feasible for grazing. The higher nutritive value of such mixtures should increase the number of livestock classes that could be supported by the swathed system.

Almost no information exists on loss of dry matter yield and nutrients due to weathering of swathed forage materials during fall, winter and the following spring. The nutritive value of perennial grasses tends to decline during winter due to leaf aging and senescence, freezing, rainfall, and then leaching of cell solubles (Burns and Chamblee 2000a, b). Legumes are not generally used for stockpiling because they lose their leaves due to disease and maturation during stockpiling in summer, and due to frost during fall (Matches and Burns 1995). However, no information exists on the susceptibility of annual legumes such as field pea to loss of whole-plant nutritive value after swathing and over- winter weathering.

Our hypothesis was that mixtures of small grains and other species should improve the nutritive value of swathed material for grazing in fall, but mixtures would suffer greater winter weathering losses than pure stands due to loss of green leaves. The objective of this study was to determine the swath grazing potential of cereal and field pea monocrops, their mixtures, and mixtures with other species by evaluating and comparing forage yield in the fall, and changes in nutritive value from fall until spring.

## MATERIALS AND METHODS

The study was initiated in the spring of 1998 at Lacombe, Alberta, Canada (52°28′N; 113°45′W; 847 m). The trial was seeded in a randomized complete block design on Orthic Black Chernozemic Ponoka clay loam soil. Three crops were used: AC Lacombe barley, AC Belmont oat in 1998 and AC Mustang oat in 1999 and 2000, and Swing field pea. They were grown as monocrops and in mixtures with each other, and also in mixtures with Prima fall rye (*Secale cereale* L.) or Maris Ledger Italian ryegrass (*Lolium multiflorum* Lam.). Recommended seeding rates (300 and 75 seeds $m^{-2}$ for cereals and field pea, respectively (Anonymous 1998)) were used for the pure stands and 75% of recommended rates for cereal mixtures. Field pea mixtures with spring cereals used a full seeding rate of field pea and 25% of full rate for cereals. Italian ryegrass was seeded at 560 seeds $m^{-2}$. Each component of a mixture was seeded in a separate pass. Monocrops and mixtures of spring cereals received 42 kg N $ha^{-1}$, mixtures with field pea received 24 kg N $ha^{-1}$ and field pea monocultures received 6 kg N $ha^{-1}$. All plots received 25 kg $ha^{-1}$ of phosphorus. The field pea and field pea mixtures were seeded with 5.6 kg $ha^{-1}$ of a peat-based granular rhizobial inoculant for field pea (NITRAGIN Inc., Brookfield, WI). Plots were seeded into canola (*Brassica napus)* stubble with a 3.66-m-wide Conserva Pak no-till seed drill (Conserva Pak, Indian Head, SK) with 12 rows 30 cm apart. Each plot was 15.25 m long. The plots were seeded 1998 Jul. 13 (late due to rain), 1999 Jun. 28 and 2000 Jun. 20. All plots were sprayed prior to planting with 720 g a.i. $ha^{-1}$ of glyphosate [*N*-(phosphonomethyl)glycine] and 49 g a.i. $ha^{-1}$ of imazethapyr [2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-5-ethyl-3-pyridinecarboxylic acid]. Bentazon [3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] was applied at 1.06 kg a.i. $ha^{-1}$ post-emergence to control broadleaf weeds and volunteer Roundup Ready™ canola.

Yields were determined in late September from a 4.46-$m^2$ area by cutting across each plot using a 1.22-m-wide sickle-type plot harvester (Swift Machine & Welding Ltd, Swift Current, SK). Soon after the initial harvest, plots were individually cut longitudinally with a conventional 4.6-m-wide field swather equipped with a draper header. Swathing occurred on Sep. 28, 23 and 20 in 1998, 1999, 2000, respectively. In 1998, crops were swathed when spring cereals were at heading stage and field pea was flowering with immature pods. In 1999, swathing occurred when the spring cereals were at the milk to early dough stage and field pea was flowering, but the bottom pods were full. In 2000, the spring cereals were in the early to mid dough stage and field pea had finished flowering with the top pods filling at the time of swathing. Dry matter losses and dry matter yield were not determined after the initial harvest.

Samples were taken to determine nutritive value at initial harvest, 2 mo later, and again in April. The sampling dates were Sep. 28, Nov. 27, and Apr. 28 in 1998; Sep. 23, Nov. 23, and Apr. 24 in 1999; and Sep. 20, Nov. 20, and Apr. 09 in 2000. Sampling sites were randomly chosen within each plot prior to the initial harvest. A hedge clipper was used to cut a 10-cm-wide section through the swath profile. All of the forage from each sample was collected and weighed fresh. A subsample of approximately 500 g was taken for moisture determination and for chemical analysis. Subsamples were dried at 50°C for 72 h to determine dry matter concentration. They were then ground, first through a Wiley mill (Model no. 4; Arthur H. Thomas Co., Philadelphia, PA) equipped with a 2-mm screen and then through a Cyclone mill (Model MS; UD Corporation, Boulder, CO) using a 1.0-mm screen, prior to quality determinations. Total nitrogen was measured with a Leco carbon and nitrogen determinator (Model CN 2000, Leco Corp., St. Joseph, MI). Crude protein was determined by multiplying N-content by 6.25. In vitro digestible organic matter concentration (IVDOM) was measured with direct acidification during a 24-h second-stage pepsin digestion (Marten and Barnes 1980). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and permanganate lignin concentrations were determined sequentially (Van Soest and Robertson 1980).

The potential for treatment forages to meet cow minimum daily energy intake requirements (NRC 1996) was estimated qualitatively from ADF and NDF concentrations. Forage energy concentration was estimated from ADF and potential dry matter intake was estimated from NDF concentration (NRC 1996). Cow physiological stages used to determine energy requirements (NRC 1996) were comparable to those observed in central Alberta in September, late November and April. Cows bred in late June and July would be at mid pregnancy during September and November and late pregnancy or lactation in April. The requirement at each stage was adjusted using factors associated with mean daily temperatures for September, November-early December and April (NRC 1996). Temperature ranges associated with late September were 5 to 15°C, late November –5 to –15°C, and April –5 to 5°C, respectively. Cow requirements were deemed satisfied when estimated dry matter intake provided energy to supply maintenance requirements at the stages and temperature ranges provided above (not analyzed statistically).

Data were analyzed with the PROC MIXED procedure of SAS software (Littel et al. 1996) in accordance to the split-plot experimental design, with blocks as a random effect, years, treatments (main plot) and sampling dates (sub-plot) as fixed effects. Treatment effects were declared significant at $P < 0.05$, and when ANOVA indicated significant effects means were compared using a Least Significant Difference test (at $P \leq 0.05$).

## RESULTS AND DISCUSSION

### Dry Matter Yield

Dry matter yield at the initial harvest in September was affected ($P \leq 0.05$) by the year × species/mixture interaction. Rainfall and temperature patterns during 1998 and 1999 resulted in periods of crop stress and limited crop production, but conditions during 2000 were adequate (Table 1). As a consequence, mean dry matter yields for September 2000 were 3.4 and 2.7 times higher than 1998 and 1999, respectively (Table 2). In 1998, precipitation in June was 148% of normal and the wet soil conditions led to delayed planting. Coincidentally, temperatures during July and August were higher than normal for the year. This, accompanied by below-normal precipitation in July and September, put the crops under stress. The late planting placed cereals at the heading stage in late September, when the crops had to be swathed to avoid a hard frost. This is much earlier than the 4 wk after heading required for maximizing whole-plant barley yield (Baron et al. 1992a). Seeding occurred earlier in 1999, but July precipitation was almost excessive and temperatures (with the exception of August) were below normal from June until September (Table 1) causing low forage production.

The dry matter yield ranking of monocrops and mixtures varied from year to year (Table 2), but there were some important trends. In 1998, dry matter yield was similar among the monocrops. In 1999, barley was lower ($P < 0.05$) than oat and field pea, which were similar to each other while in 2000, oat was lower ($P < 0.05$) than field pea and barley, which were similar to each other. From a yield perspective, mixtures did not offer an advantage over monocrop field pea or cereals. The barley/oat mixture provided yield stability, with yields similar to the higher of either monocrop each year (Table 2).

Mixtures of fall rye and ryegrass with barley and oat yielded generally similar to the oat and barley monocrops as was observed earlier Baron et al. (1994). Thompson et al. (1992) reported similar results when Italian ryegrass/barley mixtures were compared with monocrop barley for a single cut. However, when they included ryegrass regrowth, the dry matter yield of the mixture exceeded that of monocrop barley.

Field pea mixtures with barley and oat produced yields similar to the cereal monocrops, except in 2000 when the barley monocrop was higher than the mixture. The field pea mixtures with fall rye and ryegrass had lower ($P \leq 0.05$) dry matter yields than the field pea monocrop in 1998 and 2000, but were similar in 1999. Berkenkamp and Meeres (1987) observed that field pea-oat and field pea-barley mixtures did not out-yield oat or barley monocrops, but out-yielded field pea monocrops occasionally. Field pea crops are not as competitive with weeds as oat or barley and may be slightly more sensitive to intercrop competition in forage mixtures than cereals. From a survey of farmers' fields in central Alberta, Harker (2001) concluded that yield losses due to weed competition occurred 67 and 27% of the time for field pea and barley respectively.

### Nutritive Value

Variables that influence nutritive value (i.e. IVDOM, protein, NDF and ADF) were affected ($P < 0.05$) by the year × monocrop/mixture interaction. Factors that contributed to this interaction may have been year-to-year climatic variation, growth stage at cutting in September, loss in nutritive value due to over-winter weathering, and possibly variations in the species composition of the mixtures (not measured).

### Initial Nutritive Value

Year effects on quality of monocrops at swathing were variable. Concentrations of IVDOM (Table 3) were lower in 1999 than in the other 2 yr, but barley IVDOM was similar

**Table 1. Monthly total and long-term average precipitation and monthly mean and long-term average temperature at Lacombe, AB, during 1998/1999, 1999/2000 and 2000/2001**

| | Monthly precipitation | | | | Monthly mean temperature | | | |
|---|---|---|---|---|---|---|---|---|
| Month | 1998–1999 | 1999–2000 | 2000–2001 | Avg.[z] | 1998–1999 | 1999–2000 | 2000–2001 | Avg. |
| | (mm) | | | | (°C) | | | |
| April | 19.8 | 31.7 | 17.0 | 26.2 | 6.1 | 4.9 | 3.4 | 3.7 |
| May | 57.2 | 51.2 | 50.2 | 50.7 | 13.1 | 8.6 | 8.7 | 9.9 |
| June | 121.6 | 60.8 | 101.2 | 82.4 | 13.2 | 12.5 | 12.8 | 13.6 |
| July | 61.2 | 184.4 | 148.2 | 80.7 | 18.0 | 13.9 | 16.3 | 16.1 |
| August | 76.2 | 69.6 | 66.8 | 65.0 | 17.4 | 15.4 | 14.4 | 14.9 |
| September | 15.6 | 4.0 | 28.4 | 41.9 | 11.7 | 9.9 | 9.5 | 11.9 |
| October | 83.2 | 16.4 | 7.4 | 20.2 | 5.7 | 4.6 | 4.2 | 4.5 |
| November | 19.6 | 12.5 | 18.3 | 16.4 | –4.8 | –2.0 | –4.6 | –4.5 |
| December | 25.4 | 7.1 | 9.5 | 15.9 | –11.4 | –3.2 | –12.9 | –10.8 |
| January | 31.8 | 21.4 | 2.7 | 2.7 | –13.0 | –13.2 | –4.0 | –13.8 |
| February | 8.5 | 8.9 | 6.7 | 6.7 | –7.1 | –9.6 | –11.6 | –10.5 |
| March | 19.1 | 20.8 | 12.8 | 12.8 | –4.9 | –2.5 | –1.0 | –1.4 |
| Total | 539.2 | 488.8 | 449.0 | 492.3 | | | | |

[z]Average of 93 yr at Lacombe.

**Table 2. Dry matter yield in September for 12 cereal and field pea forage monocrops and mixtures grown at Lacombe, AB, during 1998, 1999 and 2000**

| | Dry matter yield | | |
|---|---|---|---|
| Crop treatment[z] | 1998 | 1999 | 2000 |
| | (kg ha$^{-1}$) | | |
| Barley | 4170 | 5350 | 13570 |
| Barley/fall rye | 3740 | 4720 | 12070 |
| Barley/oat | 5240 | 8220 | 12930 |
| Barley/ryegrass | 4010 | 5740 | 13130 |
| Oat | 5050 | 7620 | 10390 |
| Oat/fall rye | 3760 | 6660 | 8970 |
| Oat/ryegrass | 4240 | 6720 | 11960 |
| Field pea | 5630 | 7300 | 13210 |
| Field pea/barley | 4270 | 6650 | 11190 |
| Field pea/fall rye | 2830 | 5690 | 7390 |
| Field pea/oat | 3840 | 6570 | 11400 |
| Field pea/ryegrass | 3370 | 6120 | 10610 |
| $LSD_{0.05}$[y] | | 1740 | |

[z]Variety names and planting rates are provided in the materials and methods section.
[y]LSD to compare any two year-by-treatment means.

in 1998 and 2000 while oat was higher in 1998 than in 2000 and pea was higher in 2000 than in 1998 and 1999. For barley, NDF (Table 4) concentration at harvest was higher in 1999 than in the other 2 yr, which were similar to each other. Oat NDF concentrations were similar for 1999 and 2000 and both were higher than 1998 levels. Field pea had similar NDF concentrations for 1998 and 1999; both higher than 2000. Year response for barley and oat ADF concentrations showed 2000 > 1999 > 1998 (Table 5). Field pea ADF concentrations were similar among years. Initial crude protein concentration (Table 6) was similar among years within monocrops.

The earlier growth stage at cutting in 1998 compared to 1999 and 2000 likely had an influence on nutritive value among cereal monocrops. As crops mature, cereal-IVDOM and protein concentrations decrease, while NDF and ADF concentration increase (Cherney and Marten 1982). In the present study, barley ADF and oat IVDOM, NDF, and ADF followed this pattern at swathing. These parameters do not vary as much with maturity for field pea as for cereals (Brundage and Klebesadel 1969). Therefore, less variation was expected in IVDOM, protein and fiber levels of the field pea monocrop compared with the cereal monocrops, and cereal-field pea mixtures were expected to maintain their nutritive value over a growing season. This study confirmed the earlier study with regard to the field pea ADF concentration, but IVDOM and NDF concentrations were variable over years and did not appear to be related to maturity.

Generally the nutritive value of the field pea monocrops was higher in September than the cereals. Field pea monocrops had higher IVDOM (Table 3) and lower NDF (Table 4) concentrations than cereal counterparts in September, November and April for 1999 and 2000, and lower NDF than barley in September 1998. All monocrops had similar IVDOM concentrations in September 1998 (Table 3), but not for NDF concentrations (Table 4). Protein concentration of field pea monocrop was always significantly ($P < 0.05$) higher than the cereal counterparts in September, ranging from 164 to 193 g kg$^{-1}$ compared to 111 to 136 g kg$^{-1}$ over years for the cereal monocrops (Table 6).

Nutritive value of the barley/oat mixture was generally similar to both monocrop counterparts for each September harvest; the exception was 1999 when barley ADF (Table 5) was lower than the mixture. The cereal mixtures with Italian ryegrass and fall rye were not significantly better than the barley and oat monocrops in September, and field pea mixture with fall rye was only better than the field pea monocrop in 1999 (Table 5). Field pea mixtures with cereals improved IVDOM concentration and reduced NDF over cereal monocrops in 2 of 3 and 3 of 3 yr, respectively, but did not reduce ADF significantly compared to barley and oat monocrops. The mixtures had higher crude protein in 1 yr but were similar to the monocrops in the other 2 yr. Mixing field pea with cereals did not improve nutritive value above the field pea monocrop. These results are in general agreement with those of Chapko et al. (1991) who found that protein concentrations were significantly increased, NDF concentrations decreased and ADF concen-

**Table 3. In vitro digestible organic matter concentration of 12 cereal and field pea forage monocrops and mixtures swathed and allowed to weather from September until the following April at Lacombe, AB, 1998–2001**

| | Year and sampling date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998/1999 | | | 1999/2000 | | | 2000/2001 | | |
| Crop treatment[z] | Sep. 28 | Nov. 27 | Apr. 28 | Sep. 23 | Nov. 23 | Apr. 24 | Sep. 20 | 20 Nov | 9 Apr |
| | ($kg\ ha^{-1}$) | | | | | | | | |
| Barley | 637 | 585 | 476 | 522 | 551 | 479 | 624 | 621 | 643 |
| Barley/fall rye | 654 | 584 | 501 | 612 | 578 | 526 | 657 | 630 | 623 |
| Barley/oat | 658 | 583 | 461 | 525 | 562 | 545 | 619 | 642 | 653 |
| Barley/ryegrass | 655 | 596 | 511 | 628 | 586 | 543 | 648 | 621 | 623 |
| Oat | 684 | 619 | 506 | 547 | 569 | 566 | 626 | 592 | 641 |
| Oat/fall rye | 732 | 615 | 537 | 596 | 589 | 571 | 667 | 624 | 637 |
| Oat/ryegrass | 692 | 622 | 498 | 575 | 548 | 568 | 667 | 628 | 651 |
| Field pea | 678 | 556 | 483 | 628 | 672 | 617 | 754 | 760 | 725 |
| Field pea/barley | 678 | 671 | 512 | 590 | 625 | 591 | 675 | 631 | 663 |
| Field pea/fall rye | 728 | 629 | 518 | 707 | 690 | 638 | 782 | 712 | 684 |
| Field pea/oat | 695 | 611 | 494 | 631 | 659 | 595 | 679 | 655 | 653 |
| Field pea/ryegrass | 685 | 577 | 491 | 709 | 662 | 662 | 802 | 736 | 728 |
| $LSD_{0.05}$[y] | 51 | | | | | | | | |

[z]Variety names are shown in Materials and Methods section.
[y]LSD to compare any two year × sampling date × treatment means.

**Table 4. Neutral detergent fiber concentration of 12 cereal and field pea forage monocrops and mixtures swathed and allowed to weather from September until the following April at Lacombe, AB, 1998–2001**

| | Year and sampling date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998/1999 | | | 1999/2000 | | | 2000/2001 | | |
| Crop treatment[z] | Sep. 28 | Nov. 27 | Apr. 28 | Sep. 23 | Nov. 23 | Apr. 24 | Sep. 20 | Nov. 20 | Apr. 09 |
| | ($g\ kg^{-1}$) | | | | | | | | |
| Barley | 564 | 680 | 829 | 634 | 573 | 655 | 576 | 584 | 608 |
| Barley/fall rye | 569 | 649 | 693 | 586 | 573 | 640 | 566 | 584 | 616 |
| Barley/oat | 548 | 643 | 802 | 618 | 621 | 683 | 579 | 578 | 613 |
| Barley/ryegrass | 567 | 662 | 750 | 535 | 564 | 667 | 571 | 578 | 628 |
| Oat | 500 | 631 | 785 | 580 | 649 | 672 | 574 | 613 | 660 |
| Oat/fall rye | 461 | 641 | 744 | 607 | 632 | 676 | 560 | 606 | 660 |
| Oat/ryegrass | 509 | 635 | 781 | 578 | 644 | 630 | 565 | 603 | 629 |
| Field pea | 445 | 637 | 631 | 484 | 430 | 519 | 376 | 388 | 469 |
| Field pea/barley | 490 | 651 | 681 | 538 | 505 | 599 | 507 | 561 | 602 |
| Field pea/fall rye | 406 | 616 | 638 | 416 | 455 | 567 | 409 | 447 | 534 |
| Field pea/oat | 440 | 592 | 683 | 529 | 489 | 639 | 531 | 580 | 657 |
| Field pea/ryegrass | 425 | 618 | 619 | 469 | 498 | 564 | 369 | 406 | 450 |
| Mean | 494 | 638 | 720 | 548 | 553 | 626 | 515 | 544 | 594 |
| $LSD_{0.05}$[y] | 66 | | | | | | | | |

[z]Variety names are given in Materials and Methods section.
[y]LSD to compare any two year × sampling date × treatment means.

trations were unaffected when comparing barley and oat monocrops with cereal-field pea mixtures. On the contrary, others have found that mixtures of spring planted winter cereals (Baron et al. 1992b) and Italian ryegrass (Thompson et al. 1992) improved nutritive value to some extent over barley or oat monocrops.

## Effect of Weathering on Nutritive Value

In the current study the swathed forages showed evidence of substantial weathering losses between September and April of 1998/1999, while the other years had much smaller losses for nutritive value. The reason for the difference among years was likely due to the greater precipitation that occurred from October to April of 1998/1999 compared to the other years. More than four times the normal rainfall occurred during October of 1998 (Table 1), with another 136 mm in melted snow equivalent and rain occurring between November 1998 and April 1999. Precipitation amounts for November to April of 1999/2000 and 2000/2001 were 88 and 56 mm, respectively, considerably lower than the long-term mean precipitation of 112 mm for the duration.

In 1998/1999, monocrops of all species had significant decreases in IVDOM (Table 3) from September to November and from November to April. The decrease was relatively larger for field pea than cereal monocrops so that by November, the ranking of barley and pea monocrop mean IVDOM were reversed compared to the September ranking. By contrast, when weathering was not as severe in the other years, IVDOM concentration in November and April was significantly higher for field pea than barley and oat monocrop; the cereals were generally similar.

**Table 5. Acid detergent fiber concentration of 12 cereal and field pea forage monocrops and mixtures swathed and allowed to weather from September until the following April at Lacombe, AB, 1998–2001**

| | Year and sampling date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998/1999 | | | 1999/2000 | | | 2000/2001 | | |
| Crop treatment[z] | Sep. 28 | Nov. 27 | Apr. 28 | Sep. 23 | Nov. 23 | Apr. 24 | Sep. 20 | Nov. 20 | Apr. 09 |
| | (g kg$^{-1}$) | | | | | | | | |
| Barley | 293 | 327 | 376 | 328 | 312 | 364 | 363 | 360 | 373 |
| Barley/fall rye | 291 | 325 | 366 | 287 | 298 | 342 | 368 | 379 | 394 |
| Barley/oat | 294 | 314 | 396 | 367 | 326 | 364 | 376 | 364 | 386 |
| Barley/ryegrass | 290 | 330 | 385 | 292 | 295 | 344 | 369 | 353 | 402 |
| Oat | 282 | 328 | 402 | 343 | 345 | 379 | 381 | 392 | 412 |
| Oats/fall rye | 253 | 332 | 373 | 345 | 347 | 358 | 367 | 391 | 419 |
| Oats/ryegrass | 290 | 336 | 413 | 339 | 366 | 376 | 369 | 393 | 399 |
| Field pea | 312 | 408 | 366 | 296 | 308 | 325 | 302 | 284 | 373 |
| Field pea/barley | 322 | 387 | 386 | 308 | 323 | 381 | 337 | 352 | 366 |
| Field pea/fall rye | 283 | 344 | 361 | 255 | 297 | 340 | 296 | 334 | 395 |
| Field pea/oat | 296 | 361 | 400 | 321 | 300 | 387 | 368 | 374 | 400 |
| Field pea/ryegrass | 308 | 391 | 377 | 287 | 303 | 363 | 252 | 304 | 333 |
| LSD $_{0.05}$[y] | 37 | | | | | | | | |

[z]Variety names are given in Materials and Methods section.
[y]LSD to compare any two year × sampling date × treatment means.

**Table 6. Crude protein concentration of 12 cereal and field pea forage monocrops and mixtures swathed and allowed to weather from September until the following April at Lacombe, AB, 1998–2001**

| | Year and sampling date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998/1999 | | | 1999/2000 | | | 2000/2001 | | |
| Crop treatment[z] | Sep. 28 | Nov. 27 | Apr. 28 | Sep. 23 | Nov. 23 | Apr. 24 | Sep. 28 | Nov. 27 | Apr. 15 |
| | (g kg$^{-1}$) | | | | | | | | |
| Barley | 133 | 128 | 105 | 124 | 132 | 133 | 133 | 142 | 141 |
| Barley/fall rye | 129 | 125 | 110 | 155 | 131 | 139 | 133 | 94 | 104 |
| Barley/oat | 116 | 123 | 103 | 114 | 117 | 122 | 110 | 140 | 120 |
| Barley/ryegrass | 145 | 125 | 110 | 158 | 135 | 146 | 112 | 121 | 115 |
| Oat | 127 | 132 | 106 | 111 | 106 | 125 | 136 | 145 | 104 |
| Oat/fall rye | 147 | 125 | 124 | 136 | 114 | 121 | 138 | 152 | 127 |
| Oat/ryegrass | 120 | 121 | 105 | 118 | 96 | 124 | 131 | 141 | 126 |
| Field pea | 181 | 158 | 181 | 164 | 187 | 222 | 193 | 173 | 188 |
| Field pea/barley | 160 | 145 | 155 | 154 | 171 | 184 | 150 | 158 | 140 |
| Field pea/fall rye | 178 | 185 | 166 | 206 | 198 | 210 | 197 | 189 | 177 |
| Field pea/oat | 149 | 166 | 145 | 145 | 170 | 161 | 142 | 144 | 129 |
| Field pea/ryegrass | 177 | 160 | 152 | 196 | 186 | 212 | 180 | 164 | 198 |
| LSD $_{0.05}$[y] | 27 | | | | | | | | |

[z]Variety names are provided in the Materials and Methods section.
[y]LSD to compare any two year × sampling date × treatment means.

Neutral detergent fiber concentration showed an increasing trend from September to April in all years with the rate of increase more rapid in 1998/1999 (Table 4). Except for November 1998/1999, field pea had significantly lower NDF concentration than cereal monocrops at all times. The increase in ADF concentration was more obscure than for NDF. Oat tended to have the highest, field pea the lowest and barley intermediate ADF values in November and April. Rain and snow melt after frost leach cell solubles from leaves, reducing nutritive value as well as yield (Matches and Burns 1995; Burns and Chamblee 2000b). This explains the relatively large increases observed for NDF (cell wall) from September to November and then November to April for most species/mixtures in 1998/1999.

Crude protein content was least affected (Table 6) by weathering, causing only relatively small changes among the monocrops within years compared to IVDOM. Both increasing and decreasing trends appeared in crude protein content within years and monocrops from September to April, but the differences were not always significant. The trend for crude protein content remaining constant over winter is in agreement with others working with stockpiled perennial grasses (Ocumpaugh and Matches 1977; Burns and Chamblee 2000b).

Mixtures provided no consistent improvement over monocrops in nutritive value parameters in November and April of any year. Thus, further in-depth analyses of weathering effects beyond that given for monocrops was not considered necessary.

Compared to perennial stockpiled species, swathed cereals and field pea had similar or lower losses in nutritive value over winter. Averaged over the same years (1998/1999 to 2000/2001) at Lacombe, Alberta, IVDOM concentration of standing stockpiled perennial grasses decreased from 608 to 435 g kg$^{-1}$ during the September to April period (Baron et al. 2002). In the same study, protein

**Table 7. Ability of 12 cereal and field pea forage monocrops and mixtures swathed and allowed to weather from September to April in 1998–2001 at Lacombe, AB, to meet the nutritional requirements of beef cows at three physiological stages[z] and environmental conditions[y] typical of the sampling periods**

| | 1998/1999 | | | 1999/2000 | | | 2000/2001 | | |
|---|---|---|---|---|---|---|---|---|---|
| Crop treatment[x] | Sep. 28 | Nov. 27 | Apr. 28 | Sep. 23 | Nov. 23 | Apr. 24 | Sep. 20 | Nov. 20 | Apr. 09 |
| Barley | +++ | +++ | + | +++ | +++ | +++ | +++ | +++ | +++ |
| Barley/fall rye | +++ | +++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ |
| Barley/oat | +++ | +++ | + | +++ | +++ | +++ | +++ | +++ | +++ |
| Barley/ryegrass | +++ | +++ | + | +++ | +++ | +++ | +++ | +++ | ++ |
| Oat | +++ | +++ | + | +++ | +++ | ++ | +++ | ++ | + |
| Oat/fall rye | +++ | +++ | ++ | +++ | +++ | ++ | +++ | ++ | + |
| Oats/ryegrass | +++ | +++ | NS | +++ | ++ | +++ | +++ | ++ | ++ |
| Field pea | +++ | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| Field pea/barley | +++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ |
| Field pea/fall rye | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| Field pea/oat | +++ | +++ | ++ | +++ | +++ | ++ | +++ | +++ | ++ |
| Field pea/ryegrass | +++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

[z]+, ++ and +++ indicate that energy requirements of grazing beef cows (NRC 1996) would be met if, in mid-pregnancy, late-pregnancy and early lactation, respectively. +++ implies all three requirements are met; ++ implies the first two requirements are met and + implies only the first is met. NS is not sufficient to sustain energy requirements for any of the defined stages and periods.
[y]Average daily mean temperatures at Lacombe for late September, late November and mid April fall within the ranges of 5 to 15, –5 to –15 and –5 to 5°C, respectively.
[x]Variety names are provided in the Materials and Methods section.

concentration deceased from 109 to 99 g $kg^{-1}$ and NDF concentration increased from 580 to 729 g $kg^{-1}$. In Nebraska, windrowed and standing perennial grass NDF concentration increased from 650 g $kg^{-1}$ to 730 g $kg^{-1}$, while ADF concentration increased from 390 to 450 g $kg^{-1}$ from September to February, averaged over 2 yr (Volesky et al. 2002). In that study, windrowed perennial grass protein remained constant at approximately 110 g $kg^{-1}$, while standing perennial grass protein decreased from 110 to 57 g $kg^{-1}$ due to weathering.

## Suitability for Beef Cows

Gestating cows generally graze on cereal swaths during fall and winter and occasionally during spring. Crude protein levels of cereal monocrops and mixtures were well within the 70 to 90 g $kg^{-1}$ concentrations required by cows in mid to late gestation from September to April. Field peas provide protein concentrations suitable for lactating cows even into April (NRC 1996). Energy intake requirements by cows are affected by factors such as stage of pregnancy or lactation, and ambient temperature (NRC 1996). Cows in central Alberta are generally in mid pregnancy during September and November and in late stages of pregnancy or early lactation by mid April. Table 7 provides a qualitative assessment of the ability of monocrops and mixtures to provide minimum energy intake requirements for cows at different physiological stages and at ambient temperatures normally associated with these specific times of the year. Assessments are based on equations provided by NRC (1996) and on NDF and ADF concentrations (Tables 5 and 6) from the current study. Generally, all swathed treatments would provide minimum requirements during fall and early winter for cows that are in late stages of pregnancy or are lactating. However, by spring 1998/1999 (above average weathering) only mixtures or monocrops involving field pea or fall rye would provide minimum energy intakes needed to support cows at late stages of pregnancy, and only the field pea monocrop or field pea mixtures with ryegrass or fall rye would support lactating cows. In April of other years (less weathering) mixtures containing oat were unlikely to meet the higher requirements for late pregnancy and lactation, but all treatments would support minimum energy intake requirements of mid pregnancy.

## Economic Suitability

Comparison of total variable production costs including seed, seeding, fertilizer and herbicide inputs, based on 1998 input costs indicate barley, oat and field pea monocrop production costs would be \$140, \$145 and \$159 $ha^{-1}$, respectively. Costs for barley mixtures (excluding field pea) ranged from \$162 to \$165 $ha^{-1}$, oat mixtures (excluding field pea) from \$165 to \$167 $ha^{-1}$ and field pea mixtures (including cereals) from \$190 to \$202 $ha^{-1}$. Given the relative cost comparisons and small improvements in nutritive value offered by the mixtures it would appear there would be little advantage in utilizing them over monocrops. From a cost versus potential to meet minimum requirements viewpoint, the best choices would be field pea monocrop, cereal monocrops and barley mixed with fall rye. Yield and grazing losses were not determined in November and April, so it is not possible to comment further on the economic suitability of the various treatments.

## SUMMARY AND CONCLUSIONS

All monocrops and mixtures in the current study have the potential to provide minimum energy and protein requirements to support cows from mid pregnancy through to lactation during fall and early winter (Table 7). However, weathering caused by late fall and winter precipitation, in conjunction with snowmelt, reduced nutritive value of swathed material substantially. Under severe weathering conditions field pea and mixtures containing field pea lost nutritive value rapidly, yet could still support requirements of beef cows as well as cereals, especially oat. Field pea and the addition of field pea to cereals in mixtures increased crude protein slightly (Table 6) and decreased NDF (Table 4) concentration over the cereal monocrops. This enabled field pea to meet energy intake requirements of cows better than cereal monocrops, even after severe weathering. Mixtures did not lose nutritive value more rapidly than monocrops, although mixtures including field pea were more similar to field pea than the cereal component.

Mixtures of field pea with cereals did not increase dry matter yield (Table 2) over field pea or cereal monocrops. The barley/oat mixture was advantageous in that yield was more stable over years than either cereal monocrop.

Field pea monocrop yielded as much as cereal monocrops and field pea mixtures. Field pea mixtures did not provide substantial improvements in nutritive value over the field pea monocrop. Field pea mixtures with any other species cost substantially more to grow than the field pea monocrop, cereal monocrops or cereal mixtures with fall rye and Italian ryegrass, because of higher seed (field pea plus other species) and herbicide costs. It appears that the field pea monocrop is economically feasible but field pea mixtures are not. Measurement of grazing and dry matter losses throughout winter would provide more definitive conclusions about costs of digestible dry matter produced, disappeared, and cost per cow grazing day for these agronomic treatments.

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