Nutritive Value Change during the Fall of Late-Summer-Planted Oats, Radishes, and Turnips

Mary E. Lenz, Jordan L. Cox-O’Neill, Kristin E. Hales, and Mary E. Drewnoski*

Abstract
The change in nutritive value of late-summer-planted oats (Avena sativa L.) and brassicas (Brassica spp.) during the fall in the Midwestern US is not well documented. A mixture of ‘Jerry’ oats, ‘daikon’ oilseed radish (Raphanus sativus L.), and ‘purple top’ turnip (Brassica rapa ssp. rapa L.) was drill-seeded in late August/early September in southcentral Nebraska over two years. Forage was collected in early November, early December, and mid-January. The mean in vitro organic matter digestibility (IVOMD) of radish (86%) and turnip (87%) tops were high and were greater than oats (75%). Within forage type, IVOMD did not decline from November to December, but due to a decline in total ethanol soluble carbohydrates in January, IVOMD decreased 10 percentage units for oats and 5 percentage units for brassica tops from December to January. However, these forages would still be considered high energy even in January. In both years, crude protein (CP) of all forages was high, with oats (16% CP) being less than both radish (27%) and turnip (24%) tops. Little change in CP occurred over the sampling period. Sulfur content of the brassicas was high in November (0.8–0.9% S) and remained above 0.5% S through January, suggesting that the potential for sulfur toxicity, if grazed alone, persists. Delayed grazing of these cool-season forage mixtures late into the fall and early winter is an option for cattle producers in the Midwestern US, as nutritive value remains appropriate for growing cattle or lactating beef cows.

Small grains and brassicas are two forage types that can be planted in mid- to late summer and grown through the fall in the Midwest. Coblenz and Walgenbach (2010b) compared fall-grown oat, winter wheat, and spring triticale forage yields over two years and observed a range of 1,312 to 5,933 lb/acre produced by the final harvest date in November, with oats consistently yielding the highest (2,439 to 5,933 lb/acre) and wheat the lowest (Coblentz and Walgenbach, 2010b). Brassicas can attain similar or greater yields as small grains (Lauriault et al., 2009). For example, turnips and radishes grown in northern Colorado yielded between 2,300 and 6,360 lb/acre with planting date being the main factor influencing biomass production (Villalobos and Brummer, 2017).

Mid- to late-summer-planted, winter-sensitive small grains and brassicas have been shown to be highly digestible (65 to 90% in vitro true digestibility) and have moderate crude protein (15 to 20% crude protein) content in early fall (Coblentz and Walgenbach, 2010b; Villalobos and Brummer, 2015; Villalobos and Brummer, 2017). Compared with spring-planted oats, oats grown during the fall...
Table A. Useful conversions.

<table>
<thead>
<tr>
<th>To convert Column 1 to Column 2, multiply by</th>
<th>Column 1 Suggested Unit</th>
<th>Column 2 SI Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/9 (°F – 32)</td>
<td>Fahrenheit, °F</td>
<td>Celsius, °C</td>
</tr>
<tr>
<td>25.4</td>
<td>inch</td>
<td>millimeter, mm</td>
</tr>
<tr>
<td>10</td>
<td>percent, %</td>
<td>gram per kilogram, g/kg</td>
</tr>
</tbody>
</table>

have been observed to have greater digestibility and contain more water-soluble carbohydrates (Coblentz and Walgenbach, 2010a). Due to their yield potential and high nutritive value, small grains and brassicas can be cost effective for feeding growing calves in the fall or extending the grazing season of cows and reducing feed costs (Drewnoski et al., 2018).

Initiating grazing later may allow for increased forage yields. However, delaying grazing will typically result in increased forage maturity and decreased digestibility. Previous research suggests that brassica forage digestibility is not affected by maturity as much as grass forage (Smith and Collins, 2003; Villalobos and Brummer, 2015; Wiedenhoeft and Barton, 1994). Relatively stable neutral detergent fiber (aNDF) and crude protein (CP) were noted by Wiedenhoeft and Barton (1994) in Maine when these measures were taken on brassicas planted early, mid, and late summer and then harvested through early December. Villalobos and Brummer (2015) evaluated the effect of harvest date (mid-October or mid-November) in Fort Collins, CO, on mid-summer-planted brassicas and found only minor differences in nutritive value due to maturity in the fall. However, the extent to which nutritive values of these forages change during the late fall has not been well established, and thus, the feasibility of their use as stockpiled forages has yet to be fully evaluated. Therefore, the objective of this study was to evaluate the nutritive value of oats, turnips, and radishes during fall in the Midwest US.

Management and Sampling of Forages

A 124-acre (Year 1) and a 131-acre (Year 2) irrigated corn silage pivot located at the US Meat Animal Research Center near Clay Center, NE was utilized to evaluate the forage nutritive value of a mixture of 84 lb/acre of ‘Jerry’ oats (Avena sativa), 2.0 lb/acre of ‘daikon’ radishes (Raphanus sativus), and 1.5 lb/acre of ‘purple top’ turnips (Brassica rapa ssp. rapa) planted on 9 Sept. 2014 and 25 Aug. 2015 using an 8-inch row spacing. Nitrogen was split-applied via pivot using two equal applications a week apart totaling 48 lb N/acre (Year 1) and 40 lb N/acre (Year 2). The pivots were split into quarters (North, South, East, and West).

Samples for nutrient analysis were collected in early November, early December, and the middle of January in both years. The radishes and turnips were pulled up so that root biomass could be collected. Oats were clipped at ground level. Each species (oats, radish, and turnip) was collected at random within each quarter and put into separate bags according to species type. They were kept in a portable cooler with ice for transport to the lab. Once at the lab, brassicas were separated into tops (leaves + stem) and roots, and all samples were stored frozen at 25°F. In Year 1, there was not enough brassica root sample collected to conduct analysis of nutritive value. In Year 2, sample size was increased to allow analysis of brassica roots.

Laboratory Analysis

Samples were freeze-dried (Virtis FreezeMobile 25ES, Life Scientific Inc., St. Louis, MO) and ground through a 1/26th inch (1-mm) screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ). Freeze-dried samples were analyzed for corrected dry matter (DM; 212°F), organic matter (OM), S, CP, aNDF, acid detergent fiber (ADF), total ethanol soluble carbohydrates (TESC), and in vitro organic matter digestibility (IVOMD).

Organic matter was determined by placing samples in a muffle furnace for 6 h at 1112°F (AOAC, 1999; method 4.1.10). Sulfur and CP analysis was determined using a combustion chamber (TruSpec N Determinatr, Leco Corporation, St. Joseph, MO; AOAC, 1999; method 990.03). Neutral detergent fiber and ADF were analyzed sequentially (Ankom 200, ANKOM Technology Corp., Macedon, NY) with heat-resistant alpha-amylase added for aNDF (Van Soest et al., 1991). Ethanol soluble carbohydrate analysis was conducted using the procedure described by DuBois et al. (1956) with a modification from Hall et al. (1999). In vitro organic matter digestibility was determined within 48 h using the method described by Tilley and Terry (1963), modified by adding urea to the McDougall’s buffer (McDougall, 1948) at a rate of 0.13 oz urea/gal (1 g urea/L) of buffer solution to ensure adequate N was available for microbes in the rumen fluid (Weiss, 1994). After incubation, samples were filtered using Whatman 541 filter paper and dried at 212°F to determine DM disappearance. Samples were then placed in crucibles and heated in a muffle furnace for 6 h at 1112°F to determine OM disappearance (AOAC, 1999; method 4.1.10). Blanks were included in the in vitro run to adjust for any feed particles that might have come from the inoculum. Five grass hay standards with known in vivo (total tract) digestibility (51–60% range) were used to adjust IVOMD values (Stalker et al., 2013). These adjustment values resulted in 4.2 and 4.6 percentage units added to IVOMD in Year 1 and 2, respectively.
**Statistical Analysis**

Forage nutritive value was analyzed using the GLIMMIX procedure of SAS 9.3 (SAS Inst. Inc., Cary, NC). When evaluating the quality of oats and brassica tops over both years, pivot quarter nested within year was the experimental unit. The model included fixed effects of species, date, year, and their interactions. A random residual statement with species by quarter nested within year as the subject and a covariance structure of ANTE(1) was used [best fit determined by Akaike information criterion corrected (AICC)]. Table 1 provides a summary of the analysis of variance. The three-way interaction was only significant ($P < 0.01$) for TESC, and there was a tendency for a three-way interaction for ADF ($P < 0.10$). The two-way interaction of date by species was significant ($P < 0.01$) for TESC, ADF, IVOMD, and S, and there was a tendency for ($P = 0.07$) a two-way interaction for aNDF. The two-way interaction of harvest date by year was significant for TESC, ADF, aNDF, CP, and S. The two-way interaction of year by species was significant ($P < 0.01$) for aNDF, ADF, IVOMD, CP, and S.

When comparing brassica roots and tops in Year 2, the model included the fixed effect of date and sample type (species and plant part). There was a plant part by date interaction ($P < 0.01$) for TESC, ADF, aNDF, CP, and S. For all analysis, effects were considered significant at $P \leq 0.05$ and a tendency when $P$ is greater than 0.05 but less than or equal to 0.10.

**Weather**

The temperature and precipitation during the later-summer and fall of both years are reported in Table 2.

**Forage Quality**

**Total Ethanol Soluble Carbohydrate Content**

Total ethanol soluble carbohydrates (Fig. 1) of oats, radish tops, and turnip tops peaked during December in Year 1, ranging from 17 to 22%, and decreased ($P < 0.01$) to 5 to 6% in January. In Year 2, this trend was the same for oats and turnip tops ($P < 0.01$) with TESC peaking in December. However, radish tops did not differ ($P = 0.78$) in TESC from November (10.6%) to December (10.2%). Like Year 1, TESC in Year 2 of oats, radish tops, and turnip tops decreased ($P < 0.01$) from December to January.

In Year 2, TESC content of radish (32.4%) and turnip (50.0%) roots were significantly greater ($P < 0.01$) than the aboveground plant parts (7.8 and 13.8% for radish tops and turnip tops, respectively) across all dates with TESC content of radish roots being less ($P < 0.01$) than turnip roots (Table 3). Additionally, turnip roots maintained TESC content better than radish roots. Radish roots TESC decreased from 43.6% in December to 17.4% in January, whereas turnip roots in December and January did not differ ($P = 0.24$; 52.5 vs. 50.8%).

In both years, these data suggest that following initial frost, photosynthesis continued to occur, and soluble carbohydrates continued to increase through the month of November. Then due to weathering during the month of December, much of the soluble carbohydrates were lost in the oats, radish tops, turnip tops, and radish roots. However, turnip roots maintained high TESC content into early January.

**Digestibility**

In all months, radish and turnip tops were more ($P < 0.01$) digestible than oats. Radish and turnip tops did not differ ($P \geq 0.12$) in digestibility in November and December. In January, the digestibility of radish tops tended ($P = 0.09$) to be less than turnip tops (Table 4). Within species, the digestibility in November and December did not differ ($P \geq 0.17$) but decreased ($P < 0.01$) from December to January. The

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**Table 1. Analysis of variance for nutrient content of oats (Avena sativa) and brassica tops (daikon radishes (Raphanus sativus) and purple top turnips (Brassica rapa)] sampled in early November, early December, and mid-January over a 2-year period.**

<table>
<thead>
<tr>
<th></th>
<th>TESC</th>
<th>aNDF</th>
<th>ADF</th>
<th>IVOMD</th>
<th>CP</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Date</strong></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Date × year</strong></td>
<td>*</td>
<td>*</td>
<td>NS†</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td><strong>Date × species</strong></td>
<td>NS‡</td>
<td>NS‡</td>
<td>NS‡</td>
<td>NS‡</td>
<td>NS</td>
<td>NS‡</td>
</tr>
<tr>
<td><strong>Date × year × species</strong></td>
<td>*</td>
<td>NS‡</td>
<td>**</td>
<td>NS‡</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

* $P \leq 0.05$.  
** $0.05 < P \leq 0.10$.  
† Total ethanol soluble carbohydrates (TESC), neutral detergent fiber (aNDF), acid detergent fiber (ADF), crude protein (CP), and sulfur (S) were analyzed on a dry matter basis. In vitro organic matter digestibility (IVOMD) was analyzed on an organic matter basis.  
‡ NS, not significant.

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**Table 2. Weather during late-summer, post-planting of forage and during the fall sample collection period.**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th></th>
<th></th>
<th></th>
<th>Year 2</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean high temperature, °F</td>
<td>75.5</td>
<td>69.1</td>
<td>47.6</td>
<td>38.1</td>
<td>35.8</td>
<td>83.6</td>
<td>69.5</td>
<td>53.7</td>
</tr>
<tr>
<td>Mean low temperature, °F</td>
<td>51.4</td>
<td>42.3</td>
<td>22.1</td>
<td>22.9</td>
<td>17.7</td>
<td>60.1</td>
<td>45.4</td>
<td>33.2</td>
</tr>
<tr>
<td>Mean monthly temperature, °F</td>
<td>63.5</td>
<td>55.7</td>
<td>34.4</td>
<td>30.5</td>
<td>26.8</td>
<td>71.9</td>
<td>57.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Total monthly precipitation, inches</td>
<td>1.88</td>
<td>1.00</td>
<td>0.23</td>
<td>0.54</td>
<td>0.15</td>
<td>1.12</td>
<td>1.53</td>
<td>2.01</td>
</tr>
</tbody>
</table>

† In Year 1, the forage was planted on 8 September; thus, monthly mean does not include 1–8 September. In Year 2, forages were planted on 25 August; thus, September includes the 5 days (26–31 August post-planting that were in August.
digestibility of oats appeared to decline more (10 percentage unit decline) than radish and turnip tops (5 percentage unit decrease); however, the digestibility of oats in January was still high (67% IVOMD).

The digestibility of oats was less in Year 2 than Year 1 (69 vs. 80% IVOMD, respectively) when the forage was planted earlier in the summer, but digestibility of radish and turnip tops (85–87% IVOMD) did not differ (P ≥ 0.25) between years within species. A decrease in oat forage digestibility due to increased maturity in the fall has been observed by others (Coblentz and Walgenbach, 2010b) as has the lack of decrease in digestibility with maturity in brassicas (Villalobos and Brummer, 2015).

In Year 2, the sample by date interaction was not significant (P = 0.12) when comparing radish and turnip tops and roots (Table 3). Across all dates, radish roots (91.6% IVOMD) and turnip roots (95.1% IVOMD) were more digestible (P < 0.01) than radish tops (86.0% IVOMD) and turnip tops (87.6% IVOMD). Radish roots were (P < 0.01) less digestible than turnip roots, and radish tops were less digestible (P = 0.03) than turnip tops. There was a significant date effect (P < 0.01) with digestibility in November and December (91.5% IVOMD) not differing (P = 0.87) but decreasing (P < 0.01) 4 percentage units in January (87.1% IVOMD).

The high digestibility of brassica roots has been reported by others. Koch et al. (2002) planted brassicas from mid-July to mid-October over four years. Turnip roots ranged from 85.7 to 89.1% in vitro DM digestibility when harvested in October and 82.8 to 86.5% when harvested in November in Powell, WY. Not only do the brassicas appear to have greater digestibility and thus greater energy content than oats in early fall, they seem to retain this advantage post freezing. It appears that as the oats lose TESC, a corresponding decline in digestibility is observed. Brassica tops also lose much of their TESC, but the corresponding decline in digestibility is not as large. Therefore, producers may consider using brassicas to help decrease loss of energy value that occurs in the fall after freezing. The differences in changes in TESC and digestibility of radish and turnip roots may suggest turnips are better suited for fall stockpiled grazing than radishes. If cattle are not strip-grazed, it appears they tend to consume the oats and brassica tops first, with the roots of the brassicas being consumed last. In this situation, it appears the purple

Table 3. Nutrient content of daikon radishes (Raphanus sativus) and purple top turnips (Brassica rapa) sampled in early November, early December, and mid-January in Year 2.

<table>
<thead>
<tr>
<th>Nutrient†</th>
<th>Tops</th>
<th>Roots</th>
<th>Tops</th>
<th>Roots</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TESC,%</td>
<td>10.6bc</td>
<td>10.2d</td>
<td>36.1b</td>
<td>42.6b</td>
<td>17.4b</td>
</tr>
<tr>
<td>aNDF,%</td>
<td>30.5c</td>
<td>28.1c</td>
<td>19.9b</td>
<td>16.8de</td>
<td>28.1c</td>
</tr>
<tr>
<td>ADF,%</td>
<td>22.7bc</td>
<td>20.5c</td>
<td>13.1ef</td>
<td>24.3b</td>
<td>16.9d</td>
</tr>
<tr>
<td>IVOMD,%</td>
<td>88.8</td>
<td>87.0</td>
<td>92.5</td>
<td>88.5</td>
<td>89.6</td>
</tr>
<tr>
<td>CP,%</td>
<td>25.7b</td>
<td>24.9a</td>
<td>15.8de</td>
<td>15.9d</td>
<td>21.3ab</td>
</tr>
<tr>
<td>S,%</td>
<td>1.10bc</td>
<td>0.98cd</td>
<td>1.03bc</td>
<td>0.89de</td>
<td>0.96ed</td>
</tr>
</tbody>
</table>

†Total ethanol soluble carbohydrates (TESC), neutral detergent fiber (aNDF), acid detergent fiber (ADF), crude protein (CP), and sulfur are reported on a dry matter basis. In vitro organic matter digestibility (IVOMD) is reported on an organic matter basis.  
‡Values within row without the same superscript differ (P ≤ 0.05).
Table 4. Two-year mean nutrient content of oats (Avena sativa) and brassica tops [daikon radishes (Raphanus sativus) and purple top turnips (Brassica rapa)] sampled in early November, early December, and mid-January.

<table>
<thead>
<tr>
<th>Nutrient†</th>
<th>Oats</th>
<th>Radishes</th>
<th>Turnips</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CP,%</strong></td>
<td>17.9</td>
<td>13.8</td>
<td>15.8</td>
</tr>
<tr>
<td><strong>IVOMD,%</strong></td>
<td>79.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>67.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>aNDF,%</strong></td>
<td>48.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>ADF,%</strong></td>
<td>27.1</td>
<td>25.7</td>
<td>38.2</td>
</tr>
<tr>
<td><strong>Sulfur,%</strong></td>
<td>0.303&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.286&lt;sup&gt;de&lt;/sup&gt;</td>
<td>0.246&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

†Neutral detergent fiber (aNDF), acid detergent fiber (ADF), crude protein (CP), and sulfur are reported on a dry matter basis. In vitro organic matter digestibility (IVOMD) is reported on an organic matter basis.

‡ Values within row without the same superscript differ (P ≤ 0.05).

Top turnips may be better suited to stockpiled grazing than the daikon radish as they retain their energy value better. However, it is important to note that the brassica roots were only about 18% of the total brassica DM production.

Crude Protein

The CP of oats, radish tops, and turnip tops was less (P < 0.01) in Year 2 when the forage was planted earlier than in Year 1. The CP content of oats (21 and 10%, for year 1 and 2, respectively) was lower (P < 0.01) than radish and turnip tops in both years (Table 3). The CP of the radish (29%) and turnip (28%) tops did not differ (P = 0.27) in Year 1, but in Year 2, the CP of radish tops (24%) was greater (P < 0.01) than turnip tops (20%).

In November of Year 2, the CP content of radish and turnip tops did not differ (P = 0.12) and were greater (P < 0.01) than radish and turnip roots, with radish roots being greater than the turnip roots (Table 3). From November to December, there was less CP decline in the radish tops than in turnip tops resulting in radish tops being greater (P < 0.01) than turnip tops. There was an increase in CP of turnip roots in December, resulting in CP of radish roots and turnip roots not differing (P = 0.84) but still being less (P < 0.02) than the tops. From December to January, the CP content of the tops declined while the roots remained unchanged. The decline in the CP content of the tops resulted in turnip tops not differing (P ≥ 0.14) from both radish and turnip roots. However, radish tops were still greater (P < 0.05) than turnip tops as well as radish and turnip roots. As seen in the previous month, radish and turnip roots did not differ (P = 0.13) from each other.

Given the effects of maturity (planting date) on both the digestibility and CP content of oats, it appears that adding brassicas into late-summer-planted oats can be a way to buffer the reduced nutritional value that would result from earlier planting while getting the benefit of increased forage yield.

Fiber Content

Over the fall, aNDF and ADF of oats were greater (P < 0.01) than both radish and turnip tops (Table 4). The aNDF and ADF of both radish and turnip tops in November and December were quite low, being similar to high fiber concentrates such as citrus pulp, corn gluten feed, and distillers grains (NASEM, 2016). In both years, the aNDF and ADF content of all species increased (P < 0.01) in January, which was likely a concentrating effect due to the loss of TESC.

The brassica roots had extremely low fiber content. In Year 2, the aNDF and ADF content of radish and turnip roots was significantly less (P < 0.01) than the aboveground plant parts (tops) at all dates (Table 3). In November, aNDF of radish and turnip roots did not differ (P ≥ 0.33). In December, aNDF and ADF of radish and turnip roots decreased due to the gain in TESC, but radish roots had greater (P ≤ 0.05) aNDF and ADF than turnip roots. In January, radish roots had a large increase in aNDF and ADF due to a loss of TESC whereas turnip roots remained unchanged (P ≥ 0.49), resulting in radish roots having significantly more (P < 0.01) aNDF and ADF than turnip roots.

Westwood and Mulcock (2012) suggested that 27 to 30% NDF is the minimum concentration for optimal rumen function. Radish and turnip tops and roots were below this threshold in November and December although radish tops were close to the minimum. The increase in NDF content of the brassica tops as well as the radish roots in January resulted in them being above the threshold suggested by Westwood and Mulcock (2012). However, the turnip roots remained below the threshold.

Sulfur Content

Across all dates, the S content of oats was less (P < 0.01) than that of radish and turnip tops (Table 4). The S content of oats did not differ (P = 0.62) between November (0.30%) and December (0.29%) nor did it differ (P = 0.23) between December and January (0.25%; Table 4). For both radish and turnip tops, the S content did not differ (P ≥ 0.30) between November (0.92% and 0.81%, respectively) and December (0.90 and 0.78%, respectively) but decreased (P < 0.01) from December to January (0.63 and 0.60%, respectively). When comparing the S content, radish tops were greater (P < 0.01) than turnip tops in November and December but did not differ (P = 0.26) in January.
In November and December of Year 2, the S content of radish tops and roots did not differ ($P \geq 0.12$) and were greater ($P < 0.01$) than turnip tops, which were greater ($P < 0.01$) than turnip roots (Table 3). In January, radish roots were greater ($P \leq 0.02$) than radish tops, turnip tops, and turnip roots, which did not differ ($P \geq 0.13$).

The high S content of the brassica tops and roots in this study agree with previous research. In New Zealand, reported S concentrations were high as kale had 0.85% S, rapeseed 0.61% S, and turnips 0.69% S of DM (Sun et al., 2012). The recommended maximum tolerable level of S is suggested to be 0.5% when cattle are consuming a high-fiber diet; thus, intake of brassicas alone could potentially cause polioencephalomalacia (Drewnoski et al., 2014). This is consistent with previous case studies that observed polioencephalomalacia when grazing Brassicaceae family forages (Gould, 2000). Although there was a decrease in S over the fall in the present study, brassicas in January still contained extremely high levels of S (tops and roots greater than 0.5%). Given the much lower concentrations of S and higher aNDF in oats (greater levels of aNDF in the diet have been shown to decrease risk of toxicity; Drewnoski et al., 2014), including a grass in mixtures with brassicas for grazing would be recommended. Therefore, despite the advantages brassicas have over oats from an energy and protein standpoint, their lower fiber and higher S content make monocultures of brassicas for fall stockpiled grazing less desirable than using them as a supplement to improve the energy and protein content of stockpiled oats forage.

Conclusions and Recommendations

Digestibility and CP content of brassicas are greater than oats when planted in late summer, although oats were still high in nutritive value, with the brassicas retaining their energy value better than oats. Minimal changes in CP content of both oats and brassicas were observed over the fall. Radish and turnip tops are more comparable to a high fiber concentrate than roughage given that they have aNDF of 25 to 30% of DM and an OM digestibility of 80 to 88%. This coupled with their high S content suggests they should not be grazed in monoculture but can be a good compliment to mix with late-summer-planted oats. The digestibility of all species decreased over the fall with the largest decrease occurring during the month of December. However, all forages were still highly digestible in early January. Thus, even though the forage changes color from green to brown after hard frosts, the brown forage still has good feed value and could be used for growing weaned calves or grazing lactating beef cows.

References