Suitability of cover crop monocultures for late-season forage in South Dakota

Matthew J. Hansen, Vance N. Owens, Dwayne Beck, and Peter Sexton

Plant Science Department, South Dakota State University, NPB 248B, Box 2140-C, 1110 Rotunda Lane North, Brookings, SD 57007, USA (e-mail: mjhansen2159@jacks.sdstate.edu).

Received 25 April 2012, accepted 5 March 2013.

Hansen, M. J., Owens, V. N., Beck, D. and Sexton, P. 2013. Suitability of cover crop monocultures for late-season forage in South Dakota. Can. J. Plant Sci. 93: 589–597. Cover crops provide many agronomic benefits and can produce large amounts of forage that is suitable for grazing. The objectives of this study were to determine (1) suitable cover crop forages based on yield and nutrient values; and (2) changes in feed value and yield of these crops through the late fall. Five cover crop monocultures consisting of lentil (Lens culinaris Medikus), cowpea (Vigna unguiculata L.), forage radish (Raphanus sativus L.), and a mixture of these crops were planted after winter wheat (Triticum aestivum L.) harvest in 2010 and 2011 in central and southeastern South Dakota. Forage data were collected on approximately Oct. 01, Nov. 01, and Dec. 01 each year. Yields increased after the first harvest date at both sites, both years. Oats, radish, and the cover crop mixture all yielded >4000 kg of dry matter per hectare on the second harvest date in 2011 in central South Dakota and radish and oats yielded >4000 kg ha⁻¹ in southeastern South Dakota on the second and third harvest dates, respectively. Forage quality tended to decrease after each harvest date. Radish in central South Dakota in 2010 had the highest protein values for the study (194–313 g kg⁻¹) whereas oats in southeastern South Dakota had the lowest protein concentrations (63–108 g kg⁻¹), both years. All cover crops except cowpea were viable forages through the late fall when they had good establishment with the potential need for protein supplementation with oats, foxtail millet, and the cover crop mixture, depending on animal requirements.

Key words: Forage quality, forage yield, cover crops, legumes, grasses

Hansen, M. J., Owens, V. N., Beck, D. and Sexton, P. 2013. Convenance des cultures-bris pour l'affouragement de fin de saison dans le Dakota du Sud. Can. J. Plant Sci. 93: 589–597. Les cultures-bris présentent maints avantages agronomiques et peuvent produire une grande quantité de fourrage pour les animaux en paissance. L’étude devait établir (1) la quantité convenable de fourrage fournie par la culture-abi en fonction de son rendement et de sa valeur nutritive et (2) la variation de la valeur nutritive et du rendement des mêmes cultures à la fin de l’automne. Cinq cultures-bris ont été semées après la récolte du blé d’hiver (Triticum aestivum L.) en 2010 et 2011, dans le centre et le sud-est du Dakota : lentille (Lens culinaris Medikus), dolique (Vigna unguiculata L.), millet des oiseaux (Setaria italica L.), avoine (Avena sativa L.), radis fourrager (Raphans sativus L.) et un mélange des mêmes cultures. Les données sur le fourrage ont été recueillies approximativement les 1er octobre, novembre et décembre chaque année. Le rendement s’est accru après la première date de récolte aux deux endroits, les deux années. L’avoine, le radis et le mélange ont produit plus de 4000 kg de matière sèche par hectare à la deuxième date, en 2011, dans le centre du DS, tandis que le radis et l’avoine en ont donné plus de 4000 kg par hectare dans le sud-est du DS à la deuxième et à la troisième date, respectivement. La qualité du fourrage a tendance à diminuer après chaque récolte. Le radis a enregistré la plus forte teneur en protéines de l’étude (194–313 g par kg) dans le centre du DS en 2010, alors que l’avoine s’est caractérisé par la concentration la plus faible (63–108 g par kg), les deux années, dans le sud-est du DS. Toutes les cultures-bris sauf la dolique constituent des fourrages viables à la fin de l’automne, pourvu qu’elles se soient bien implantées, mais on pourrait devoir fournir un supplément de protéines avec l’avoine, le millet des oiseaux et le mélange, selon les besoins des animaux.

Mots clés: Qualité du fourrage, rendement fourrager, cultures-bris, légumineuses, graminées

Cover crops are known to provide many agronomic benefits in annual cash cropping systems. One of the most important advantages of cover crops is erosion and runoff control. The increased root structure anchors the soil (Reicosky and Forcella 1998), the above-ground residue reduces erosion, and when combined with no-till practices, erosion can be significantly decreased (McGregor et al. 1975; Karlen et al. 1994) and water quality can be improved (Uri 2000). Cover crops increase soil organic carbon (C), which improves several soil physical properties including structure, aeration, water infiltration (Reicosky and Forcella 1998), improve soil productivity and increase crop yields (Blackwell et al. 1990). The increased ground cover from the cover crops also provides shade, thus decreasing weed populations (Fisk et al. 2001).

Producers have several factors to consider when selecting the appropriate cover crops or cover crop monocultures. The increased ground cover from the cover crops or cover crop monocultures can improve soil productivity and increase crop yields. The increased ground cover from the cover crops also provides shade, thus decreasing weed populations. Producers have several factors to consider when selecting the appropriate cover crops or cover crop monocultures.
mixtures. One of the most important factors is the crop that will be following the cover crop. Cover crops such as oats (Avena sativa L.), rye (Secale cereale L.), and other grasses will sequester inorganic nitrogen (N) (Wagger et al. 1998), making it unavailable to the subsequent crop due to their high C:N ratio. Leguminous crops, such as chickling vetch (Lathyrus sativus L.), add fixed atmospheric N to the soil, reducing N fertilizer costs for the subsequent cash crop, and their low C:N ratios make N stored in their residue available for the following year’s crop (Holderbaum et al. 1990). The availability of N the following year is a major yield factor for most crops. This is why grass crops or higher C:N ratio mixtures are planted ahead of legumes and legumes or low C:N ratio mixtures are planted ahead of grass crops. The effects of cover crops on the following crop can vary widely. Various cover crops have had positive (Hively and Cox 2001; Lotter et al. 2003), negative (Hively and Cox 2001), and no effect (Fae et al. 2009) on corn (Zea mays L.) yields the following year. Some negative corn yields from cover crops may occur due allelopathic effects of the cover crop (Weston 1996) and these should be researched to prevent problems before they occur.

One major opportunity for cover crops is using them as forages late in the fall. Feeding beef cattle in the winter is expensive and can account for half the production costs in the Midwest (Schoonmaker et al. 2003). These high feed costs create an opportunity for cover crops to become a valuable asset where livestock are produced. The current major late-season option for producers in the upper Midwest is dead corn stalks. Dead corn stalks are low in crude protein (CP), but with proper supplementation they can provide a quality diet for livestock in the winter (Adams et al. 1996).

Selection criteria for late-season forage crops needs to be based on yield, production timing, and nutrient values. Cold-sensitive crops tend to grow quickly but are sensitive to low temperatures, while winter hardy crops grow slower, but keep producing more after frost (Maloney et al. 1999). Cold-sensitive grasses tend to have low CP and high neutral detergent fiber (NDF) while winter hardy forbs and legumes have higher CP and lower NDF values (Maloney et al. 1999). Legumes tend to have better forage value and can fix N, but the higher seed costs (Roberts and Swinton 1996) when compared with other crops need to be considered before planting. Species selected in this study are commonly used C_3 and C_4 grasses, legumes, and broadleaves used as cover crops.

Our study focused on different cover crop species and their ability to provide forage during the late fall forage deficit period. The objectives of this study were to determine (1) suitable cover crop forages based on yield and nutrient values; and (2) changes in feed value and yield of these crops through the late fall. Our hypothesis was that the cool-season crops (lentil, oat, and radish) would have the highest yields and the broadleaf crops would have the highest feed quality in this study with forage quality decreasing as it gets later in the season.

**MATERIALS AND METHODS**

**Study Sites**

This study was set up as a 2-yr trial with locations at the Dakota Lakes Research Farm (DLRF) in central South Dakota (lat. 44°17′33″N, long. 99°59′44″W) and the Southeast Research Station (SERS) in southeast South Dakota (lat. 43°02′40″N, long. 96°54′11″W). The main soil type the DLRF is a Millboro silty clay loam (fine, montmorillonitic, mesic Vertic Argiustolls). The main soil type at the SERS is Egan-Clarno-Tetonka Complex (fine-silty, mixed, mesic Udic Haplustolls). Additional soil characteristics are presented in Table 1. Irrigation was not used at either location with the DLRF being managed with completely no-till practices since 1990, while the SERS chisel plowed corn and wheat (Triticum aestivum L.) ground in the fall and worked 85–90% of all crop ground in the spring with a field cultivator when this experiment took place. The fields at the DLRF have been in a winter wheat–corn–cool-season broadleaf rotation since 1990. Cover crops have been planted after winter wheat during the past several years. Fields at the SERS were in a winter wheat–corn–soybean (Glycine max (L.) Merr.] rotation.

**Planting**

At the DLRF glyphosate (N-(phosphonomethyl)glycine) was applied at 1.15 kg a.i. ha⁻¹ prior to cover crop seeding on 2010 Jul. 26 and glyphosate at 1.25 kg a.i. ha⁻¹ and bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) at 0.21 kg a.i. ha⁻¹ were applied before seeding on 2011 Jul. 30. At the SERS glyphosate was applied at 1.15 kg a.i. ha⁻¹ prior to planting each year. Six different cover crops were direct-seeded into winter wheat stubble in 2010 and 2011 along with unplanted control plots. Wheat was harvested with a stripper head at the DLRF and a cutter head at the SERS. The cover crop treatments utilized were lentil (Lens culinaris Medikus), cowpea (Vigna unguiculata L.), foxtail millet (Setaria italica L.), oats (Avena sativa L.), forage radish (Raphanus sativus L.), and a mixture of these crops. Leguminous crops were inoculated with the appropriate rhizobium species to allow for N fixation. Seeding rates, cultivars, and seeding depths are listed in Table 2. Seeding rates...
were based on local planting rates. At the DLRF 7.6 × 12.2 m (25 × 40 ft) plots were seeded with a John Deere 750 drill in 2010 and an AVEC drill in 2011. At the SERS 6.1 × 36.6 m (20 × 120 ft) plots were seeded with a John Deere 750 drill. Crops were planted on Aug. 21 and Aug. 04 at DLRF and Aug. 30 and Aug. 09 at SERS in 2010 and 2011, respectively. Crops were planted later in 2010 due to abnormally cool and wet summer conditions. No fertilizer was applied to the cover crop treatments at planting or during the growing season. There were four replications at the DLRF in 2010 and 2011 with three replications utilized at SERS both years. Four replications were planted at the SERS in 2010 but the fourth was not utilized in the analysis due to wet conditions and poor crop emergence.

**Forage Analysis**

At the DLRF 1.0 m² and at the SERS 0.56 m² (6 ft²) were hand harvested from each plot at approximately 1-mo intervals beginning on Oct. 01 with three harvest dates total. Samples were harvested at approximately 3 cm above ground level. Harvested biomass was weighed wet and a subsample was taken from the harvested portion. The subsample was dried in a forced air oven at 60°C for 48 h and reweighed to calculated yield on a dry matter basis. The dried subsample was ground to pass a 2-mm screen in a Wiley No. 4 Laboratory Mill (Thomas Scientific, Swedesboro, NJ). Concentrations of acid detergent fiber (ADF), NDF, and CP were analyzed to determine changes in forage quality. Neutral detergent fiber measures the total fiber in the forage, ADF measures the indigestible fiber in the forage, and CP is a measure of N in the forage available to the animal. Acid detergent fiber and NDF concentrations were determined using an Ankom Fiber Analyzer (ANKOM Technology Corp., Fairport, NY). Total N was determined with a Vario Max CNS Elemental analyzer (Elementar Instrument, Mt. Laurel, NJ). Total N was multiplied by 6.25 to calculate CP concentration.

**Statistical Analysis**

Statistical analysis was performed on yield and quality data using PROC MIXED in SAS software (SAS Institute, Inc. 1996). This experiment was set up as a split-plot arrangement of a randomized complete block design with cover crop as the whole plot and harvest date as the sub-plot for the forage yield and forage quality. Replication was considered as random and cover crop and harvest date were considered fixed in all analyses. All three harvest dates were compared within each site and harvest years were analyzed separately due to weather and planting date differences. A least significant difference (LSD) was used to separate mean effects when an F test was significant (P = 0.05).

**RESULTS**

**Climate Data**

Climate data were collected from automated weather stations on both sites in 2010 and 2011 (Table 3). Precipitation at the DLRF was 34 mm below the 30-yr average in 2010 with no major monthly variation from the average. In 2011 it was 33 mm below average, but there was 203 mm precipitation in June and of this, 85 and 53 mm fell consecutively on Jun. 20 and 21, respectively. June and July of 2011 were abnormally wet, but from August to November only 44 mm of precipitation was received, whereas 146 mm is the average for this time period. Temperature was close to normal for both years although the average temperature in July 2011 was above normal.

The SERS was extremely wet in 2010 with June, July, and September receiving from 70 to 96 mm more precipitation than average. However, annual precipitation in 2011 was 127 mm below average. Most of the difference in 2011 occurred from September to November, when precipitation was 105 mm less than average. Temperatures were similar both years and were close to the 30-yr average.

**Crop Maturation**

Lentil remained in the vegetative stage at both sites throughout the study both years. Foxtail millet at the DLRF was in the vegetative stage in 2010 at the first harvest date and reached the late flowering/early grain fill stage before a killing frost between the first and second harvest dates. In 2011, it reached the flowering stage before the first harvest date and the seed had filled before a killing frost between the first and second harvest dates. Oats at both sites in 2010 remained in the vegetative stage for the first two harvest dates and reached the flowering stage by the third harvest date. In 2011 it reached the flowering stage by the second harvest date; however, no seed production was found by
Forage Yield

Foxtail millet had poor emergence both years at SERS and was left out of those analyses. Due to low production, cowpea was not planted at SERS in 2011 and was left out of all forage analyses. Radish had poor emergence at DLRF in 2010 and bolted without vernalization in 2011. The final design of the experiment contained five treatments at the DLRF and four at the SERS. There was a significant effect of cover crop, harvest date, and cover crop × harvest date interaction for yield at DLRF in 2010 and 2011. Table 4 shows cover crop yields for each harvest date. Yield of foxtail millet, radish, and the cover crop mixture in 2010 and foxtail millet in 2011 did not change significantly at any harvest date. In the other cover crop mixture in 2010 and foxtail millet in 2011 did not change significantly at any harvest date. In the other cover crop-year combinations, yield generally increased between the first and second harvest dates. Radish yield in 2011 decreased between the second (4948 kg ha⁻¹) and third (3432 kg ha⁻¹) harvest dates. Foxtail millet (2943 kg ha⁻¹) and lentil (2413 kg ha⁻¹) had similar yields both years while the other cover crops produced >2000 kg ha⁻¹ in 2011 (3432 kg ha⁻¹) compared with 2010 (1150 kg ha⁻¹). Foxtail millet (2943 kg ha⁻¹) and lentil (2413 kg ha⁻¹) had the highest yields in 2010, while oats (3499 kg ha⁻¹), radish (3359 kg ha⁻¹), and the cover crop mixture (3437 kg ha⁻¹) had the highest yields in 2011.

Yields at SERS were affected by cover crop and harvest date in 2010 and 2011. The cover crop × harvest date interaction was not significant (P = 0.1567) in 2010, but was in 2011 (P = 0.0028). Cover crop yields by harvest date are shown in Table 4. All cover crop yields increased after the first harvest date in 2010 with radish and oats yielding >4000 kg ha⁻¹ at the second and third harvest dates, respectively. Oats, lentil, and the cover crop mixture yields increased significantly after the first harvest date in 2011 while radish did not. Oats, lentil, and the cover crop mixture production was similar in both years. On the other hand, average radish yield differed by approximately 2500 kg ha⁻¹ in 2010 and 2011, likely due to differences in precipitation. Oats (3240 and 3407 kg ha⁻¹) produced the highest yields at the SERS both years.

Forage Quality

Acid detergent fiber increased for the cover crop mixture, radish, and lentil (114, 34, and 68 g kg⁻¹) after the first harvest date at the DLRF (Table 5) in 2010 and decreased for oats, lentil, and radish (55, 47, and 42 g kg⁻¹) from the second to third harvest date. Foxtail millet (310 and 274 g kg⁻¹) did not change significantly through the season in either year. In 2011 there was a significant cover crop × harvest date interaction (P = 0.0147), but radish was the only crop to significantly change with harvest date. The ADF concentration was similar both years for all species, except for the radish, which was higher in ADF in 2011 (262 g kg⁻¹) compared with 2010 (159 g kg⁻¹). There was a significant cover crop × harvest date interaction for NDF in 2010 (P < 0.0001), but not in 2011 (P = 0.0583). Neutral detergent fiber concentrations increased for lentil, radish, and the cover crop mixture (89, 102 and 153 g kg⁻¹) between the first and second harvest dates in 2010 and decreased between the second and third harvest dates for oats and radish (64 and 62 g kg⁻¹). Cover crop and harvest date effects were significant for ADF and NDF in both years (Table 5). Foxtail millet (310 and 274 g kg⁻¹) had the highest ADF concentrations both years while radish was significantly low in 2010 (159 g kg⁻¹).

There was a significant cover crop × harvest date interaction for ADF at the SERS in 2010 (P = 0.0030) but not in 2011 (P = 0.2089). The concentrations of ADF generally increased in radish and the cover crop mixture in 2010, while it remained unchanged in lentil,
and decreased at the second harvest date in oats (Table 6). All crops had higher ADF values in 2010 than in 2011 (7–82 g kg⁻¹). Neutral detergent fiber results were similar to the ADF results except the concentration of NDF in lentils increased significantly (243, 314, and 369 g kg⁻¹) with each harvest date (Table 6) in 2010. Cover crop and harvest date affected ADF and NDF both years at the SERS.

Crude protein concentrations at the DLRF were significantly affected by cover crop, harvest date, and a cover crop × harvest date interaction in both 2010 and 2011. Although not always significantly higher, peak CP concentrations (224 and 164 g kg⁻¹) were at the first harvest date for all crops in both years (Table 7). Crude protein levels were lower for all crops in 2011 compared with 2010, except for foxtail millet. Radish had the highest CP concentrations in 2010 (194–313 g kg⁻¹) but was much lower in 2011 (95–161 g kg⁻¹) because many of the plants bolted, thus reducing leaf mass. Lower levels for the other species can be explained by the earlier planting date in 2011 (Table 2).

Crude protein concentrations at the SERS were significantly affected by cover crop and cover crop × harvest date interaction in both years. Harvest date was significant in 2011 (P < 0.0001) but not in 2010 (P = 0.1597). Crude protein concentrations were highest at the first harvest date for all cover crops both years (138 and 156 g kg⁻¹) except for lentil in 2010, which increased from 173 to 241 g kg⁻¹ from the first to third harvest dates (Table 7). Lentil in 2010 was the only crop in which the CP concentration did not decrease after the first harvest date. Crude protein concentrations were very similar in values and trends for the crops both years, except lentil. Lentil (215 and 196 g kg⁻¹) had the highest CP concentrations both years, while oats (81 and 78 g kg⁻¹) had the lowest.

**DISCUSSION**

**Forage Yield and Utilization**

Yields varied across locations but were similar within each location across years, except for when emergence problems were present. One major difference was the
crop in a dryland cropping system as a fallow replace-
mint option and achieved yields of 1725 g kg⁻¹.

May et al. (2007) planted ‘Golden German’ foxtail millet and had yields of 2500–13,000 kg ha⁻¹ at several sites when planted on May 15 and Jun. 10. Oat yields in the same study ranged from 2600 to 9900 kg ha⁻¹. Kunelius et al. (1987) studied the effect of different planting dates on several Brassica sp. and forage radish in eastern Canada in a single crop system. Yields for forage radish decreased as planting date increased. In plots planted Jul. 25 and harvested Sep. 20 and Nov. 01 yields were around 4000 kg ha⁻¹ while plots planted on May 23 reached >8000 kg ha⁻¹.

The utilization method of the forages used in this experiment is an important factor[HI] when it comes to maximizing economic returns. Traditional continuous grazing is the most common grazing practice and typically utilizes 25–50% of the available forage while rotational grazing improves utilization to 50–75% with increased labor requirements (Smith et al. 2011). Swath grazing is another popular grazing technique that is common in Canada (Entz et al. 2002; Aasen et al. 2004; May et al. 2007). Utilization from this process has been shown to be 66–76% for calves and higher for full-grown beef cattle (Volesky et al. 2002). A more traditional
option that producers may select is baling. Baling utilizes 57–95% of the packaged forage with losses due to bale packaging, shattering during baling, feed refusal, or trampling (Smith et al. 1974; Kallenbach 2000; Volesky et al. 2002). Two disadvantages of baling are the removal of nutrients from the field that are important to the following year’s crop that would otherwise be deposited back onto the field as manure by grazing animals. Grazing also allows animals to return to previously grazed plants that have regrown late in the fall, whereas baling would remove the biomass once and any regrowth could not be utilized by the livestock.

Forage Quality

Crude protein requirements for beef cattle change depending on gestation stage, but range from 69 to 120 g kg⁻¹ of dry matter for a 550-kg cow with higher concentrations needed for milk production (Jurgens 1997). Oats (81 and 78 g kg⁻¹) at the SERS had the lowest CP concentration both years and was below the amount required to maintain cattle in late gestation or producing milk. Foxtail millet at the DLRF in 2010 and 2011, and oats at the DLRF in 2010 had similar CP concentrations (approximately 100 g kg⁻¹) and may require supplementation as well. The grass species tended to have lower CP concentrations (78–173 g kg⁻¹) than the broadleaf and legume species (123–267 g kg⁻¹) and is similar to results of others (Maloney et al. 1999).

The grass crops, particularly foxtail millet, and the cover crop mixture had the highest ADF (165–310 g kg⁻¹) and NDF (323–595 g kg⁻¹) concentrations at both locations. Radish had very low ADF (139–221 g kg⁻¹) and NDF (183–292 g kg⁻¹) concentrations both years at the SERS and in 2010 at the DLRF(142–183 and 186–288 g kg⁻¹). Values this low may cause nutritional problems and a grass cereal crop should be planted with the radish to increase the NDF concentration of the forage above 300 g kg⁻¹ to improve rumen function (McCormick et al. 2006). Lentil also had low NDF concentrations (243–389 g kg⁻¹) and may require a grass species to be planted with it to ensure livestock health.

### Table 6. Acid detergent fiber and neutral detergent fiber concentrations for the Southeast Research Station in 2010 and 2011 across three harvest dates with Fisher’s Protected LSDₐ₀.₀₅ values for significant effects

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<th>Oct. 06</th>
<th>Nov. 04</th>
<th>Nov. 23</th>
<th>Mean²</th>
<th>Oct. 07</th>
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<td>214b</td>
<td>235ab</td>
<td>233.4</td>
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<td>168</td>
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<td>224a</td>
<td>209B</td>
<td>200</td>
<td>184</td>
<td>165</td>
<td>183</td>
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<td>161b</td>
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<td>174C</td>
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<td>268a</td>
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<td>214B</td>
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<td></td>
<td></td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Harvest date</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Cover crop × harvest date³</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NS²</td>
<td></td>
</tr>
</tbody>
</table>

¹Uppercase letters can be used to separate crop and harvest date mean values.
²Lowercase letters can be used to separate differences within a crop across harvest dates.
³Values can be used to separate differences within a crop across harvest dates.
⁴NS, not significant at the 0.05 level of probability.
Crude protein tended to decrease and NDF and ADF increase as harvest dates progressed. These changes are expected when warm-season crops are killed by frost late in the year and when cool-season crops mature (Adams et al. 1996; Maloney et al. 1999). Crops in this trial were all left standing, but swathing the crops during the season may slow the deterioration of these crops and help maintain higher feed values later in the year. Aasen et al. (2004) and May et al. (2007) found that weathering in the windrow did not significantly decrease feed value of fall swathed crops. Fiber concentrations tend to increase while in the windrow, but not always significantly, and normally remain fairly stable (Volesky et al. 2002; Aasen et al. 2004; May et al. 2007). Fiber concentrations increased for all the crops used in this study at least once between harvest dates, and that increase may be slowed using swath grazing for those crops with inherently high NDF and ADF concentrations, such as foxtail millet. Lentil had acceptable feed value through the harvest dates with Fisher’s Protected LSD0.05 values for significant effects.

All the cover crops used in this study demonstrated late-season forage potential, except for cowpea. Yields varied depending on rainfall at the two sites, with foxtail millet at SERS being most negatively affected by excess rain in 2010 and dry conditions in 2011. Oats at the SERS both years and at the DLRF in 2011 performed as expected and were the highest-yielding crop. The grasses had the lowest CP levels, which supported our hypothesis that the broadleaf crops would provide higher-quality forage than the grasses. Some protein or fiber supplementation would be needed for the monocultures and a cover crop mixture may provide these needs without adding to labor requirements.

ACKNOWLEDGMENTS

We would like to thank the South Dakota State University Soil Chemistry Laboratory for analyzing soil and forage samples for this study. We would also like to thank the staffs at Dakota Lakes and Southeast Research Stations for their help with planting and harvesting.


