Virginia Cooperative Extension
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Publication DASC-93P

Comparative Nutritional Quality of Winter Crops for Silage

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Cover crops are planted to increase the health and fertility of soils and to benefit the surrounding environment (SARE 2007). By covering the soil surface, cover crops reduce soil erosion caused by rainfall events, water runoff, wind, or their combinations. The mulchlike cover provided by cover crops also limits the access of light, thereby inhibiting or slowing the growth of weeds. Another benefit of cover crops is that the root system increases pore formation, which increases water infiltration and soil aeration and reduces soil compaction.

Adding legumes to annual crops can increase nitrogen capture from the atmosphere. This process, known as "nitrogen fixation," occurs through a symbiotic relationship between legume plants and bacteria in the soil. When left as cover or mulch, the biomass of the winter crop can provide additional residual nitrogen for the following crop.

In dairy farming systems, the use of annual crops for forage is typically oriented to winter annual grasses, although interest in using more diverse mixtures has increased over recent years. As part of the Conservation Innovation Grants program and in collaboration with the U.S. Department of Agriculture Natural Resources Conservation Service, research performed at Virginia Tech evaluated the yield and nutritional quality of diverse mixtures of winter crops for grazing or silage use.

United States Department of Agriculture
Natural Resources Conservation Service

Specific Objectives

1. Determine how cropping grasses with legumes as winter crops affects yields and nutritional composition of winter crops for forage.

2. Determine how cropping grasses with legumes as winter crops affects yields and nutritional composition of the following corn or sorghum silage crop.

Experimental Approach

This study was performed at three Virginia Tech experiment stations located in Blacksburg, Orange, and Blackstone, Virginia (fig. 1). For this study, five grasses — barley, rye, ryegrass, triticale, and wheat — were planted alone or in combination with each of two legumes (crimson clover or hairy vetch). Planting densities for treatments were selected following guidelines from the "Agronomy Handbook" (Brann, Holshouser, and Mullins 2009; table 1). Four replicates of each of the 15 treatments were planted at each location. Plots were planted during fall 2014 and harvested during spring 2015.

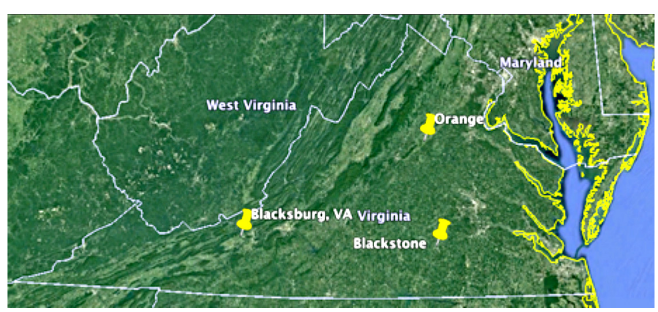

Figure 1. The study was performed at three experimental stations located in Blacksburg, Blackstone, and Orange, Virginia.

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Tech, 2017

VT/0117/DASC-93P

Table 1. Planting densities of winter crops (lb/acre).

Grass	Grass in monoculture	Grass + crimson clover	Grass + hairy vetch
Barley	96	48 + 10	48 + 10
Rye	25	13 + 10	13 + 10
Ryegrass	112	56 + 10	56 + 10
Triticale	112	56 + 10	56 + 10
Wheat	120	60 + 10	60 + 10

After harvesting, a fraction of the sample of each plot was processed to determine the nutritional composition of the fresh forage. Given that winter crops are typically ensiled in dairy farming systems, a second fraction of the samples of each plot was wilted, chopped, and ensiled for 60 days in the Dairy Nutrition Laboratory within the Department of Dairy Science at Virginia Tech (fig. 2), where all samples were analyzed. Chemical analyses of the samples (wet chemistry procedures) included ash, crude protein, fiber, sugars, and starch. In addition, samples were analyzed for in vitro dry matter digestibility and in vitro fiber digestibility (tables 2 and 3).

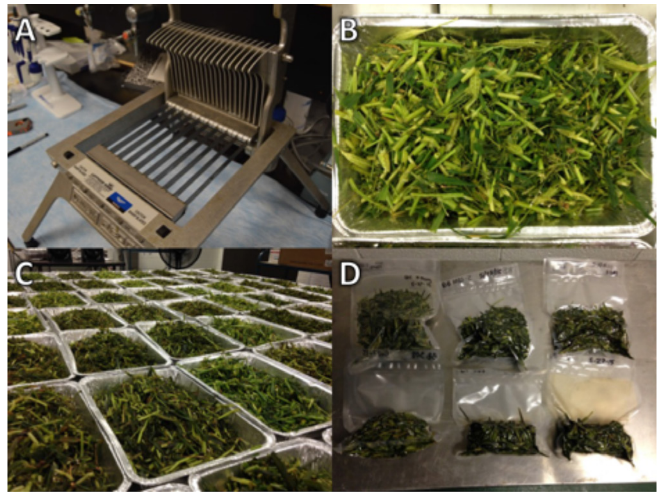

Figure 2. Sample processing and ensiling. Winter crop samples were cut at 0.75 inch using a lettuce cutter (A and B). After a 24-hour wilting process in the lab (C), samples were ensiled in plastic pouches (D) and stored for 60 days before analysis.

After harvesting of winter crops, plots were split equally in halves, with corn and forage sorghum planted in each subplot. Planting density was set to 28,000 plants per acre for corn and 90,000 plants per acre for forage sorghum.

Table 2. Yield and nutritional quality of fresh winter crops grown in Virginia.

Winter crop	DM[1] Yield (tons/acre)	Ash (% DM)	CP[2] (% DM)	NDF[3] (% DM)	ADF[4] (% DM)	Lignin (% DM)	Sugars (% DM)	Starch (% DM)	IVTDMD[5] (% DM)	IVNDFD[6] (% NDF)
Barley	1.35	8.7	11.7	57.4	32.1	2.3	12.1	2.8	83.9	72.2
Rye	1.05	8.6	14.4	52.8	31.2	2.3	14.1	3.5	85.8	73.3
Ryegrass	1.08	9.2	12.0	43.2	25.3	2.1	11.2	2.8	90.6	78.1
Triticale	0.94	8.9	14.0	49.2	28.5	2.4	15.0	3.4	88.6	76.9
Wheat	0.93	8.5	12.8	45.8	25.7	2.6	18.8	3.7	90.0	78.1
Barley + crimson clover	1.52	8.6	14.6	52.8	31.4	2.5	10.8	3.2	84.1	70.6
Rye + crimson clover	1.23	8.9	15.6	48.5	29.7	2.5	14.6	3.8	86.9	74.0
Ryegrass + crimson clover	1.17	9.1	15.0	43.2	27.3	2.7	9.8	2.6	88.2	73.1
Triticale + crimson clover	1.11	8.2	16.2	44.1	27.6	2.6	14.1	3.8	87.6	71.6
Wheat + crimson clover	1.32	9.1	16.0	43.5	27.4	3.0	16.4	4.6	88.2	73.6
Barley + hairy vetch	1.28	9.2	16.2	51.9	32.0	3.1	9.5	3.0	85.1	71.3
Rye + hairy vetch	1.06	8.9	18.3	48.3	30.7	2.6	10.9	3.4	87.0	73.0
Ryegrass + hairy vetch	1.04	9.3	15.6	43.6	28.1	2.9	8.8	2.6	88.2	73.2
Triticale + hairy vetch	0.92	9.1	18.2	44.6	27.4	2.7	11.1	3.3	88.3	73.8
Wheat + hairy vetch	1.18	8.8	18.3	44.2	27.4	3.4	12.5	3.6	88.3	73.2

[1]*DM: dry matter.*
[2]*CP: crude protein.*
[3]*NDF: neutral detergent fiber.*
[4]*ADF: acid detergent fiber.*
[5]*IVTDMD: in vitro true dry matter digestibility.*
[6]*IVNDFD: in vitro neutral detergent fiber digestibility.*

Yield and Nutritional Composition

Forage dry matter yield tended to increase when grasses were grown in combination with crimson clover but not when grown in combination with hairy vetch. Adding legumes increased the protein concentration of the forages. Protein concentrations of the fresh forages were 13.0 percent for grasses in monoculture, 15.5 percent for mixtures including crimson clover, and 17.3 percent for mixtures including hairy vetch (table 2). Protein concentrations of the silages were 14.2 percent for grasses in monoculture, 16.6 percent for mixtures including crimson clover, and 18.3 percent for mixtures including hairy vetch (table 3).

Adding legumes reduced the fiber concentration of the forages. Neutral detergent fiber concentrations of the fresh forages were 49.7 percent for grasses in monoculture and 46.5 percent for mixtures including legumes (table 2). Similarly, neutral detergent fiber concentrations of the silages were 53.2 percent for grass silages and 50.0 percent for silages including legumes with grasses (table 3). Typically, grasses contain greater concentrations of fiber than legumes, and this was the case for our data set. These data indicate that adding legumes to grasses can increase the energy concentration of winter crop forages.

The concentration of sugars of fresh forages decreased from 14.3 percent to 10.5 percent when grasses were grown in combination with hairy vetch (table 2), but it was not affected when grasses were grown in combination with crimson clover (13.2 percent sugars). Because sugars are the substrate for lactic acid bacteria during the ensiling process, sugar concentrations decreased substantially for all silages after the ensiling process (table 3). Sugar concentrations of ensiled samples followed the same trend observed in fresh samples, as including legumes in the winter crop mixture reduced sugar concentrations in the silage. However, the magnitude of this difference has minimum nutritional implications.

Table 3. Nutritional quality of ensiled winter crops grown in Virginia.

Winter crop	pH	Ash (% DM[1])	CP[2] (% DM)	NDF[3] (% DM)	ADF[4] (% DM)	Lignin (% DM)	Sugars (% DM)	Starch (% DM)	IVTDMD[5] (% DM)	IVNDFD[6] (% NDF)
Barley	4.25	8.2	13.1	63.9	30.2	3.4	2.4	N/A	80.9	70.1
Rye	4.17	8.7	15.1	55.5	31.7	2.7	2.5	N/A	85.5	72.0
Ryegrass	4.10	10.0	13.3	44.8	31.9	2.9	4.3	N/A	89.8	77.3
Triticale	4.15	9.6	15.2	53.5	30.9	2.5	2.6	N/A	87.4	76.4
Wheat	4.00	8.7	14.3	48.6	32.4	3.2	3.6	N/A	88.7	76.1
Barley + crimson clover	4.35	9.5	15.5	55.7	29.8	3.0	2.3	N/A	82.9	69.2
Rye + crimson clover	4.20	9.9	16.6	52.6	30.7	3.7	2.5	N/A	85.1	71.7
Ryegrass + crimson clover	4.14	10.8	16.4	44.1	28.4	3.9	4.0	N/A	87.4	71.6
Triticale + crimson clover	4.27	10.5	17.2	49.1	30.4	3.2	3.0	N/A	85.5	70.1
Wheat + crimson clover	4.02	10.1	17.1	45.1	31.5	3.8	3.4	N/A	87.2	71.4
Barley + hairy vetch	4.56	10.0	16.7	57.6	28.4	3.5	1.8	N/A	81.4	67.7
Rye + hairy vetch	4.48	10.0	17.8	55.9	27.2	3.4	1.8	N/A	83.5	70.4
Ryegrass + hairy vetch	4.27	11.1	17.6	47.3	30.3	3.9	2.2	N/A	86.2	73.2
Triticale + hairy vetch	4.47	10.9	19.5	46.3	28.5	3.6	2.1	N/A	86.7	71.1
Wheat + hairy vetch	4.32	9.8	19.6	46.5	31.3	5.0	2.1	N/A	87.0	72.0

[1]*DM: dry matter.*
[2]*CP: crude protein.*
[3]*NDF: neutral detergent fiber.*
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Silage pH is a good indicator of the quality of the fermentation and ensiling process, with a lower pH indicating a better ensiling process. In this study, including legumes increased pH of the silages relative to silages of grass monocultures (table 3). In the case of hairy vetch, silage pH increased from 4.13 to 4.42, whereas for crimson clover, silage pH increased from 4.10 to 4.20. Differences in pH relate to differences in sugar concentrations, differences in buffer capacities of the forages, or a combination of both. Our data show that pH was much more dependent on sugar concentrations for mixtures containing hairy vetch than for grasses in monoculture or for mixtures containing crimson clover (fig. 3). Because silage fermentation and conservation can be more challenging if hairy vetch is included in winter crop mixtures, the use of inoculants should be strongly considered.

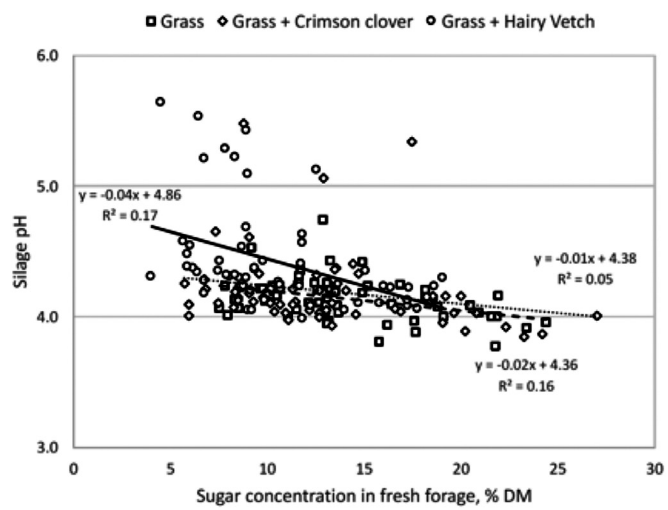

Figure 3. Relationship between silage pH and sugar concentration in winter crops. Grasses in monoculture are represented by the dashed line, grasses with crimson clover are represented by the dotted line, and grasses with hairy vetch are represented by the solid line.

Digestibility

In fresh materials (table 2), in vitro dry matter digestibility was lowest for barley (83.9 percent) and greatest for rye grass (90.6 percent). The in vitro digestibility of the fiber was also lowest for the barley (72.2 percent) and greatest for the ryegrass (78.1 percent). The addition of legumes to the winter crop tended to decrease in vitro fiber digestibility (70.9 percent for barley and 73.1 percent for ryegrass), although the magnitude of this decrease has minimal nutritional implications.

Similar to fresh samples, in vitro dry matter digestibility was lowest for barley silage (80.9 percent) and greatest for ryegrass silage (89.8 percent; table 3). The in vitro digestibility of the fiber was also lowest for the barley silage (70.1 percent) and greatest for the ryegrass silage (77.3 percent). The addition of legumes decreased in vitro digestibility of the fiber (68.4 percent for barley silage and 72.4 percent for ryegrass silage). Again, the magnitude of this decrease has minimal nutritional implications.

The small impact of adding legumes on digestibility makes sense. First, fiber digestibility of legumes is typically lower than fiber digestibility of grasses. Secondly, fiber concentration is typically lower in legumes than in grasses. In this study, even though the digestibility of the fiber was reduced with the addition of legumes, the concentration of highly digestible, nonfibrous components (i.e., cell contents) was increased in barley, rye, triticale, and wheat silages. Because the nonfibrous components of these silages are completely and uniformly digestible, the nutritional composition was actually enhanced by adding legumes.

The Following Crop

Regarding yield of the following crop, adding legumes to the winter crop did not affect yields of corn or sorghum for silage. Plots containing ryegrass, either in monoculture or in combination with legumes, tended to reduce corn yields when compared to other grasses. These observations were attributed to the regrowth of ryegrass after corn emergence, which put high weed pressure on the early growth of corn. Despite these differences at early vegetative stages, the nutritional composition of the corn and sorghum plants was unaffected by winter crops, as reflected by the similar fiber concentrations of the harvested corn and sorghum fresh and ensiled samples (table 4).

Take-Home Messages

- Cropping legumes with grasses increases crude protein concentration in the resultant forage. Because crude protein is an expensive component of diets, adding legumes to mixtures could lower feeding costs. Also, higher concentrations of crude protein indicate that cropping legumes with grasses increases the extraction of nitrogen from the soil and atmosphere.

Table 4. Yield and nutritional composition of corn and forage sorghum grown after harvesting winter crops for silage in Virginia.

	DM[1] Yield (tons DM/acre)	pH	Ash (% DM)	CP[2] (% DM)	NDF[3] (% DM)	IVTDMD[4] (% DM)	IVNDFD[5] (% NDF)
Fresh corn	7.62	—	3.5	10.0	42.8	74.0	39.9
Fresh sorghum	7.63	—	5.1	11.1	52.0	74.0	44.4
Corn silage	—	3.65	3.5	10.2	41.3	75.2	42.6
Sorghum silage	—	3.78	5.4	10.7	49.3	73.8	45.9

[1]*DM: dry matter.*
[2]*CP: crude protein.*
[3]*NDF: neutral detergent fiber.*
[4]*IVTDMD: in vitro true dry matter digestibility.*
[5]*IVNDFD: in vitro neutral detergent fiber digestibility.*

- Cropping legumes with grasses decreases fiber concentration in the resultant forage. This can result in higher energy concentrations in the feed because fiber has lower digestion rates than nonfibrous components.
- Cropping legumes with grasses decreases sugar concentration in the resultant forage. A lower concentration of sugar can make the fermentation more difficult during the ensiling process. This is particularly important for hairy vetch.
- In this study, cropping legumes with grasses had no positive or negative effects on crop yield or nutritional quality of the following summer crop (corn or forage sorghum in this case).

Acknowledgements

The authors are thankful to Steve Gulick, Northern Piedmont Agricultural Research and Extension Center, and Beth Hokanson, Virginia Tech Department of Crop and Soil Environmental Sciences, for their help planting the plots. We are also thankful to Yang Yang and Christy L. Teets of the Virginia Tech Department of Dairy Science for their help harvesting and processing samples.

The authors thank Laura Siegle, Virginia Cooperative Extension agent, Amelia County; Kevin Spurlin, VCE agent, Grayson County; Thomas Wilson, Virginia Tech Department of Animal and Poultry Sciences; and Kristy Daniels, Virginia Tech Department of Dairy Science, for reviewing this article.

This project was supported by the USDA Natural Resources Conservation Service as part of the 2014 Conservation Innovation Grants program.

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