J. Dairy Sci. 101:1–11
https://doi.org/10.3168/jds.2017-13260

Nutritional composition and in vitro digestibility of grass and legume winter (cover) crops

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ABSTRACT

In dairy farming systems, growing winter crops for forage is frequently limited to annual grasses grown in monoculture. The objectives of this study were to determine how cropping grasses alone or in mixtures with legumes affects the yield, nutritional composition, and in vitro digestibility of fresh and ensiled winter crops and the yield, nutritional composition, and in vitro digestibility of the subsequent summer crops. Experimental plots were planted with 15 different winter crops at 3 locations in Virginia. At each site, 4 plots of each treatment were planted in a randomized complete block design. The 15 treatments included 5 winter annual grasses (barley [BA], ryegrass [RG], rye [RY], triticale [TR], and wheat [WT]) in monoculture (i.e., no legumes [NO]) or with 1 of 2 winter annual legumes (crimson clover [CC] and hairy vetch [HV]). After harvesting the winter crops, corn and forage sorghum were planted within the same plots perpendicular to the winter crop plantings. The nutritional composition and the in vitro digestibility of winter and summer crops were determined for fresh and ensiled samples. Growing grasses in mixtures with CC increased forage dry matter (DM) yield (2.84 Mg/ha), but the yield of mixtures with HV (2.47 Mg/ha) was similar to that of grasses grown in monoculture (2.40 Mg/ha). Growing grasses in mixtures with legumes increased the crude protein concentration of the fresh forage from 13.0% to 15.5% for CC and to 17.3% for HV. For neutral detergent fiber (NDF) concentrations, the interaction between grasses and legumes was significant for both fresh and ensiled forages. Growing BA, RY, and TR in mixtures with legumes decreased NDF concentrations, whereas growing RG and WT with legumes did not affect the NDF concentrations of either the fresh or the ensiled forages. Growing grasses in mixtures with legumes decreased the concentration of sugars of fresh forages relative to grasses grown in monoculture. Primarily, this decrease can be attributed to low concentrations of sugars of mixtures with HV (10.5%). Growing grasses in mixtures with legumes reduced the fiber digestibility of both winter crops (75.7% to 72.8% NDF). Growing grasses in mixtures with legumes did not affect estimated DM yield, nutritional composition, or digestibility of the succeeding summer crops. In conclusion, growing grasses in mixtures with legumes as winter forage crops can increase forage estimated DM yields and its nutritional quality in dairy farming sytems.
Key words: cover crop, small grain, legume, silage, digestibility

INTRODUCTION

Cover crops are planted to increase the health and fertility of soils, to control weeds, and to benefit the environment (SARE, 2007; Myers and Watts, 2015). By covering the soil surface, the vegetative portion of the crops protects the soil from wind and rain erosion. In addition, the roots of the cover crops hold the soil in place, reducing soil erosion from wind and rain. For a corn and soybean rotation, Villamil et al. (2006) observed that soil aggregate stability was increased by 9 to 17% when cover crops were grown between crops compared with when the ground was left fallow and no cover crops were used during the rotation. Also, growing cover crops decreased bulk density and penetration resistance of the soil and increased total porosity and soil water retention (Villamil et al., 2006).

Different plant species are grown for cover crops. Grass species, such as rye (*Secale cereale*), annual ryegrass (*Lolium multiflorum*), or oats (*Avena sativa*), are the species grown most frequently (Myers and Watts, 2015). The legume species hairy vetch (*Vicia villosa*) or crimson clover (*Trifolium incarnatum*) are also used frequently for this purpose (Shipley et al., 1992). Grass species have an extensive and fine fibrous root system, whereas legumes have a tap root system (Stokes et al.,

Received May 30, 2017.
Accepted November 5, 2017.
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2009; De Baets et al., 2011; Vannoppen et al., 2015). As fibrous root systems reduce soil erosion more than tap root systems (De Baets et al., 2011), grass species are often recommended for cover crops. Also, as they scavenge more residual soil N than legume species, growing grass species is advisable to reduce soil nitrate leaching (SARE, 2007; Ketterings et al., 2015). Alternatively, legume species can fix N from the atmosphere through a symbiotic relationship between legume plants and bacteria in the soil (Hartwig and Ammon, 2002; Plaza-Bonilla et al., 2015). When left as a cover or mulch, the biomass of the cover crop can provide additional residual N for the following crop (Shipley et al., 1992). However, in dairy farming systems, where winter crops are harvested and ensiled for feed, this benefit could be marginal or nonexistent. Still, cover crops can contribute to below-ground biomass development (i.e., root growth). For instance, Kuo et al. (1997a) reported that a ryegrass cover crop increased below-ground biomass DM by 120 to 170% compared with a control treatment without cover crop. Similarly, Kuo et al. (1997b) reported that a hairy vetch cover crop increased below-ground N by 28% compared with a control treatment without cover crop.

In dairy farming systems, winter forage crops are most frequently annual grasses grown in monoculture (Kaiser et al., 2007; Long et al., 2012). However, based on the potential benefits on soil fertility, the interest in growing grasses in mixtures with legumes has increased over past years. Because grass winter crops can deplete soil N (Ketterings et al., 2015), growing grasses in mixtures with legumes could potentially increase residual soil N and therefore improve forage yields of the successive summer crops. Miguez and Bollero (2006) reported that rye grown in monoculture reduced the successive corn biomass when no N was added to the corn, although this detrimental effect was not observed when rye was grown in mixture with hairy vetch.

For this study, we hypothesized that growing grasses in mixtures with legumes, compared with grasses grown in monoculture, would increase forage yield and improve forage quality of winter crops as well as the following summer crop. Therefore, the objectives of this study were to determine how growing grasses alone or in mixtures with legumes affects (1) the estimated yield, nutritional value, and in vitro digestibility of fresh and ensiled winter crops and (2) the estimated yield, nutritional value, and in vitro digestibility of the following summer annual crop (fresh and ensiled).

MATERIALS AND METHODS

Animal Care and Use

The Institutional Animal Care and Use Committee of Virginia Tech approved all procedures involving dairy cows for collecting rumen contents (protocol 15-234).

Experimental Sites and Climate Data

This study was performed from September 2014 to September 2015 at 3 research stations (hereafter referred as sites) located near Blacksburg (37°11′35″ N; 80°34′42″ W), Blackstone (37°05′10″ N; 77°58′34″ W), and Orange (38°13′03″ N; 78°07′38″ W), Virginia. Average monthly temperature and total precipitation data during the experimental period are presented in Table 1. Weather data were collected from weather stations at each site using the National Centers for Environmental Information of the National Oceanic and Atmospheric Administration (NOAA, US Department of Commerce; www.noaa.gov).

Table 1. Average temperature (°C) and total precipitation (mm) during the growing season of 2014–2015

	Blacksburg		Blackstone		Orange	
Month	Temperature	Precipitation	Temperature	Precipitation	Temperature	Precipitation
Sep 2014	18.4	97	20.8	107	14.3	30
Oct 2014	12.2	104	15.2	74	14.4	109
Nov 2014	3.18	76	6.1	91	5.9	69
Dec 2014	3.4	69	5.4	91	3.8	51
Jan 2015	−0.7	33	1.6	51	0.1	51
Feb 2015	−3.4	53	−0.9	61	−2.4	36
Mar 2015	5.5	117	6.5	89	5.4	89
Apr 2015	11.3	132	13.6	74	12.9	112
May 2015	17.7	61	20	38	19.9	91
Jun 2015	21.8	89	NA[1]	NA	23.1	168
Jul 2015	22.6	109	24.6	112	24.2	150
Aug 2015	21.4	104	23.6	94	23.4	15
Sep 2015	18.6	218	21.6	112	21.2	178

[1]NA = not available.