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Using brown midrib 6 dwarf forage sorghum silage and fall-grown oat silage in lactating dairy cow rations

M. T. Harper,* J. Oh,* F. Giallongo,* J. C. Lopes,* G. W. Roth,† and A. N. Hristov*[1]
*Department of Animal Science, and
†Department of Plant Science, The Pennsylvania State University, University Park 16802

ABSTRACT

Double cropping and increasing crop diversity could improve dairy farm economic and environmental sustainability. In this experiment, corn silage was partially replaced with 2 alternative forages, brown midrib-6 brachytic dwarf forage sorghum (*Sorghum bicolor*) or fall-grown oat (*Avena sativa*) silage, in the diet of lactating dairy cows. We investigated the effect on dry matter (DM) intake, milk yield (MY), milk components and fatty acid profile, apparent total-tract nutrient digestibility, N utilization, enteric methane emissions, and income over feed cost. We analyzed the in situ DM and neutral detergent fiber disappearance of the alternative forages versus corn silage and alfalfa haylage. Sorghum was grown in the summer and harvested in the milk stage. Oats were grown in the fall and harvested in the boot stage. Compared with corn silage, neutral detergent fiber and acid detergent fiber concentrations were higher in the alternative forages. Lignin content was highest for sorghum silage and similar for corn silage and oat silage. The alternative forages had less than 1% starch compared with the approximately 35% starch in the corn silage. Ruminal in situ DM effective degradability was similar, although statistically different, for corn silage and oat silage, but lower for sorghum silage. Diets with the alternative forages were fed in a replicated 3 × 3 Latin square design experiment with three 28-d periods and 12 Holstein cows. The control diet contained 44% (DM basis) corn silage. In the other 2 diets, sorghum or oat silages were included at 10% of dietary DM, replacing corn silage. Sorghum silage inclusion decreased DM intake, MY, and milk protein content but increased milk fat and maintained energy-corrected MY similar to the control. Oat silage had no effect on DM intake, MY, or milk components compared to the control. The oat silage diet increased apparent total-tract digestibility of dietary nutrients, except starch, whereas the sorghum diet slightly decreased DM, organic matter, crude protein, and starch digestibility. Cows consuming the oat silage diet had higher milk urea N and urinary urea N concentrations. Milk N efficiency was decreased by the sorghum diet. Diet did not affect enteric methane or carbon dioxide emissions. This study shows that oat silage can partially replace corn silage at 10% of the diet DM with no effect on MY. Brown midrib sorghum silage harvested at the milk stage with <1% starch may decrease DM intake and MY in dairy cows.
Key words: dairy cow, forage, oat silage, sorghum silage

INTRODUCTION

Forage is the most important feed component on dairy farms, and forage shortages can restrict the number of cows that can profitably be milked on a dairy. A fixed land base and annual variation in climatic conditions (e.g., rainfall) are often reasons for a limited amount of forage on farms in the northeastern United States. Additionally, reliance on a few forage crop species, such as corn silage, grown continuously may reduce yields due to weeds, pests, and diseases (Vencill et al., 2012; Gentry et al., 2013). Increasing forage yield by double cropping and improving year-to-year yield stability through crop rotation strategies using a variety of plant species that reduce pest, disease, and climatic risk may increase farm sustainability (Faé et al., 2009; Sindelar et al., 2016). Due to its high concentration of starch, matching the energy content of corn silage is difficult; therefore, variety selection (e.g., brown midrib; **BMR**) and harvest timing (e.g., boot or soft dough stage) are critical for alternative forage quality as plant OM digestibility can change rapidly. To be adopted on a large scale, alternative forages must be suitable for inclusion not only in heifer and dry cow diets, but also in diets for lactating cows because they consume over 50% of the feed on a dairy farm. Therefore, alternative forages must be highly digestible to meet the nutrient needs of the modern high-producing dairy cow.

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[1]Corresponding author: anh13@psu.edu

Sorghum and oat silages are 2 forages that have shown potential as alternative forages for lactating dairy cows. Sorghum (*Sorghum bicolor*) is a C4 warm-season annual grass similar to corn silage, except it has a panicle-type seed head with smaller grain kernels, a higher lignin content, and greater yields in low-moisture conditions (Miron et al., 2007). Sorghum roots are toxic to western corn root worm (*Diabrotica virgifera virgifera*), which can reduce pest pressure on corn if used in a crop rotation (Branson et al., 1969). Brown midrib varieties of sorghum have been developed that have decreased lignin content and increased NDF digestibility (**NDFD**) compared with traditional varieties (Grant et al., 1995; Oliver et al., 2004). The use of brachytic dwarfing decreases lodging in the low lignin BMR varieties while increasing the leaf-to-stem ratio. The BMR-6 variant of forage sorghum has shown NDFD values higher than the BMR-12 variety and equal to corn silage (Oliver et al., 2004). Yields of sorghum are usually lower than corn in good soil with available moisture, but they can match or exceed corn yields on marginal ground particularly in water-stressed conditions (Aydin et al., 1999; Abdelhadia and Santini, 2006).

Oats (*Avena sativa*) are a C3 cool-season annual grass that grows well in the cooler temperatures of the spring and fall as part of a double-cropping strategy to increase annual forage yield per unit area. Earlier studies have not found spring-grown oat silage to be as high quality as corn silage (Burgess et al., 1973; Oltjen and Bolsen, 1980). However, fall-grown oats grow quickly and can be harvested in a highly digestible state with relatively high CP content of around 18% (Contreras-Govea and Albrecht, 2006). Oats do not typically survive northeastern winters and must be harvested in the fall if the goal is inclusion in animal diets. Additionally, oats have the potential to efficiently use fall-applied manure and reduce nitrate leaching (Shepherd, 1999; Di and Cameron, 2002; Carey et al., 2016).

A resilient cropping strategy on a dairy farm would include a diverse variety of alternative forages, although corn silage might still yield over 50% of the annual forage harvest. Therefore, the hypothesis of this study was that both BMR-6 brachytic dwarf forage sorghum and fall-grown oats could serve as alternative forages to feed in addition to corn silage in lactating dairy cow rations in the northeastern United States. The objectives of the experiment were to partially replace corn silage with either BMR-6 brachytic dwarf sorghum silage or oat silage at 10% of the diet DM to reflect a theoretical proportion of whole farm alternative forage crop yield, and to investigate the effects on DMI, MY, milk components and fatty acid (**FA**) profile, nutrient digestibility, N utilization, enteric methane emissions, and income over feed costs (**IOFC**) in lactating dairy cows.

MATERIALS AND METHODS

Crops and Silages

Brown midrib-6 brachytic dwarf forage sorghum (Alta AF 7202; King's Agriseeds, Ronks, PA) and oats (ForagePlus; Seedway, Hall, NY) were grown in Centre County, Pennsylvania, at approximately 40° N on Hagerstown and Hublersburg soils during the summer and fall of 2014. Both crops were planted with a no-till drill (John Deere 1590; Moline, IL) into fields fertilized with 44.8 t/ha of dairy manure before planting, contributing 42 kg/ha of ammonium N. Sorghum was planted with 38-cm row spacing, and oats were planted with 19-cm row spacing. A John Deere 946 mower with a roll conditioner was used to mow both crops and, after wilting to around 30% DM, the forages were gathered and chopped using a John Deere 6750 harvester. Both crops were ensiled without inoculant in 3-m-diameter plastic silage bags (Up North Plastics, Cottage Grove, MN). Sorghum was planted on June 30, 2014, after barley and triticale harvested for forage, at a seeding rate of 7.3 kg/ha and fertilized with 67 kg of N/ha from a 30% urea and ammonium nitrate liquid fertilizer on August 18, 2014. It was mowed on November 10, 2014, at the milk stage of grain development after being partially frost-killed and harvested on November 11, 2014, with a 16-mm theoretical chop length. Oats were planted at a seeding rate of 108 kg/ha on August 16, 2014, after wheat harvested for grain. The oats were mowed in the boot stage on November 8, 2014, and harvested on November 14, 2014, with a 12-mm theoretical chop length. The corn silage, which was the control in this experiment, was a mixture of the following hybrids: Mycogen TMF2R737 (112-d relative maturity; Mycogen, San Diego, CA), Dekalb DKC 52-61 (102-d relative maturity; DeKalb, St. Louis, MO), and NK N60F-3111 (107-d relative maturity; Syngenta, Basel, Switzerland). Corn silage was grown in Centre County, Pennsylvania, at approximately 40°N on Hagerstown and Hublersburg soils and planted between May 1 and May 10, 2014, at a rate of 79,000 seeds/ha. It was planted with a no-till drill (John Deere 1590) into fields fertilized with 44.8 t/ha of dairy manure before planting, contributing 42 kg/ha of ammonium N. An additional 43 kg/ha of N was applied as 30% urea and ammonium nitrate liquid before planting and 100 kg/ha of N in the same form as a sidedress application. Corn silage harvest was conducted between September 15 and September 30 at a target DM of 38% with a 19-mm chop length and ensiled in an upright concrete silo.