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Effects of dairy slurry on silage fermentation characteristics and nutritive value of alfalfa[1]

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ABSTRACT

Dairy producers frequently ask questions about the risks associated with applying dairy slurry to growing alfalfa (*Medicago sativa* L.). Our objectives were to determine the effects of applying dairy slurry on the subsequent nutritive value and fermentation characteristics of alfalfa balage. Dairy slurry was applied to 0.17-ha plots of alfalfa; applications were made to the second (HARV1) and third (HARV2) cuttings during June and July of 2012, respectively, at mean rates of 42,400 ± 5271 and 41,700 ± 2397 L/ha, respectively. Application strategies included (1) no slurry, (2) slurry applied directly to stubble immediately after the preceding harvest, (3) slurry applied after 1 wk of post-ensiled regrowth, or (4) slurry applied after 2 wk of regrowth. All harvested forage was packaged in large, rectangular bales that were ensiled as wrapped balage. Yields of DM harvested from HARV1 (2,477 kg/ha) and HARV2 (781 kg/ha) were not affected by slurry application treatment. By May 2013, all silages appeared to be well preserved, with no indication of undesirable odors characteristic of clostridial fermentations. *Clostridium tyrobutyricum*, which is known to negatively affect cheese production, was not detected in any forage on either a pre- or post-ensiled basis. On a pre-ensiled basis, counts for *Clostridium* cluster 1 were greater for slurry-applied plots than for those receiving no slurry, and this response was consistent for HARV1 (4.44 vs. 3.29 $\log_{10}$ genomic copies/g) and HARV2 (4.99 vs. 3.88 $\log_{10}$ genomic copies/g). Similar responses were observed on a post-ensiled basis; however, post-ensiled counts also were greater for HARV1 (5.51 vs. 5.17 $\log_{10}$ genomic copies/g) and HARV2 (5.84 vs. 5.28 $\log_{10}$ genomic copies/g) when slurry was applied to regrowth compared with stubble. For HARV2, counts also were greater following a 2-wk application delay compared with a 1-wk delay (6.23 vs. 5.45 $\log_{10}$ genomic copies/g). These results suggest that the risk of clostridial fermentations in alfalfa silages is greater following applications of slurry. Based on pre- and post-ensiled clostridial counts, applications of dairy slurry on stubble are preferred (and less risky) compared with delayed applications on growing alfalfa.
Key words: alfalfa, clostridia, dairy slurry, nutritive value, silage fermentation

INTRODUCTION

Dairy producers located in the north-central United States are increasingly seeking more land area on which to distribute dairy manure, largely in response to requirements for responsible management of nutrient loads. Currently, many states require nutrient management plans tailored for each specific dairy enterprise that establish thresholds for manure application rates that are based on N or P requirements for crop growth rather than the more practical, but sometimes urgent, need to empty manure-storage reservoirs. In addition, distribution of dairy manure has been increasingly associated with production of corn (*Zea mays* L.), especially corn silage, thereby limiting application windows to early spring or after fall harvest. This paradigm has been exacerbated in recent years because of greater dependence on corn silage to meet forage needs, increased size of dairy herds, and the poorer harvest efficiencies associated with multiple harvests of perennial forage crops. The close association of manure application with corn production can be problematic for several reasons, including increased risk of nutrient runoff because of poor residual ground cover and increased producer stress when spring or fall weather is especially wet, thereby prohibiting heavy equipment traffic across fields. The critical need for summer or

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other windows of opportunity for manure hauling has been identified previously (Rotz et al., 2005; Hedtcke et al., 2011). Although potential management strategies that open summer windows of opportunity for manure hauling have largely targeted perennial grasses, such as orchardgrass (*Dactylis glomerata* L.), as sites to receive manure (Hedtcke et al., 2011), producers also ask questions frequently about the advantages and disadvantages of applying manure to growing alfalfa. Extension materials have been developed to provide guidance for this management option (Lory et al., 2000; Ketterings et al., 2006; Rankin, 2006).

Within this context, one caution mentioned commonly is to avoid salt burn, which is caused by applications of dairy slurry to immature alfalfa regrowth that is particularly sensitive to ammonium and salts in the manure (Lory et al., 2000; Ketterings et al., 2006; Rankin, 2006). It has also been suggested that salt-burned hay may be less acceptable to livestock than undamaged hay (Lory et al., 2000). For alfalfa, the extent of damage from salt burn or smothering varies with the application rate of solids and the timing of rain or irrigation after applications of manure (Lamb et al., 2005; Ketterings et al., 2007). Another potential problem with applying dairy slurry onto growing alfalfa is the potential inoculation of alfalfa silage with various microorganisms, such as enterobacteria and clostridia (Buxton and O'Kiely, 2003), both of which are known for their deleterious effects on silage fermentation and quality. Generally, enterobacteria can be controlled by good ensiling techniques, and reductions in their numbers reflects good ensiling conditions, adequate availability of nutrients and water, and efficient conversion of those nutrients to fermentation products yielding a low silage pH (Pahlow, et al., 2003). Because the magnitude of DM and energy losses associated with clostridial silage fermentations can be severe (McDonald et al., 1991), control of clostridial fermentations has been researched extensively, particularly in northern Europe, where wilting conditions are poor. Within this context, 3 general types of clostridia have been identified. Saccharolytic clostridia primarily ferment sugars and organic acids (including lactic acid), yielding butyric acid, carbon dioxide, and hydrogen, but exhibit little activity against proteins or AA (Muck, 1988; McDonald et al., 1991; Rooke and Hatfield, 2003). One specific example of saccharolytic clostridia is *Clostridium tyrobutyricum*, which can survive the ruminant digestive tract, compromise milk quality via fecal contamination of the udder, and is associated negatively with cheese production through the phenomenon known as late blowing (Pahlow et al., 2003). In contrast, proteolytic clostridia, such as *Clostridium sporogenes*, largely ferment AA, resulting in various undesirable end products, particularly ammonia and amines (Muck, 1988; McDonald et al., 1991; Rooke and Hatfield, 2003). Some clostridia [*Clostridium perfringens* (*welchii*)] may exhibit both saccharolytic and proteolytic activities (McDonald et al., 1991). Generally, the end products of clostridial fermentations are not as acidic as lactic acid, thereby elevating silage pH and destabilizing the silage mass (Rooke and Hatfield, 2003). Perhaps more importantly, several reviews (Muck, 1988; Weiss et al., 2003) have concluded that the greater concentrations of amines, ammonia, and butyric acid within clostridial silages are likely to have a negative effect on voluntary intake by ruminant livestock. Furthermore, clostridia are spore formers, which enable them to resist desiccation, and survive while adhered to standing forage for long periods of time (Davies et al., 1996).

Although direct cause and effect relationships are difficult to establish independent of other management or environmental factors, several studies (Rammer et al., 1994, 1997; Davies et al., 1996; Rammer and Lingvall, 1997) have linked manure application to higher clostridial spore counts on a pre- or post-ensiled basis, or with greater concentrations of ammonia or butyric acid within mostly wet (often direct-cut) grass silages in northern Europe. Considerably less research is available evaluating the effects of dairy slurry applied to growing alfalfa or other legumes. Currently, a maximum moisture concentration of 70% is recommended when ensiling alfalfa (Muck et al., 2003), primarily to avoid clostridial fermentations; alfalfa is especially susceptible to these problematic fermentations because it has relatively low concentrations of water-soluble carbohydrates (**WSC**) and a greater buffering capacity (**BC**) than cool-season grasses (Albrecht and Beauchemin, 2003). In addition, dairy slurry may not only affect clostridial counts associated with alfalfa at ensiling, but summaries of studies with cool-season grasses also suggest that application of slurry may negatively affect the sugar concentrations and reduce the buffering capacity of the pre-ensiled crop (Buxton and O'Kiely, 2003). Our objectives for the current study were to assess the effects of dairy slurry application on silage fermentation, clostridial counts, and the forage nutritive value of alfalfa silages conserved as balage.

MATERIALS AND METHODS

Field Procedures

Description of Field Site and Experimental Layout. A 2.7-ha site on the University of Wisconsin Marshfield Agricultural Research Station, located near Stratford, Wisconsin (44°7′N, 90°1′W), was selected for the experiment. The soil type at that location was