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# Storage characteristics, nutritive value, and fermentation characteristics of large, round bales of alfalfa–mixed grass forage wrapped with different layers of stretch film[1]

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## ABSTRACT

*Baled silage has become a popular form of forage conservation; however, many practical management questions have not been investigated thoroughly. Our objectives were to evaluate the number of polyethylene wrapping layers and the presence (OB) or absence (SUN) of an $O_2$-limiting barrier within the wrap on the storage characteristics, nutritive value, and silage fermentation characteristics of alfalfa–mixed grass round-bale silages. Thirty-six 1.2 × 1.2-m large, round bales of a mixed sward composed predominantly of alfalfa (Medicago sativa L.; 82 ± 3.8% alfalfa, DM basis) were packaged at 59.8 ± 3.2% DM and wrapped the same day with 4, 5, or 6 layers of the 2 polyethylene films (OB or SUN). Bales were sampled after 127 d at 0 to 0.15-m (SURFACE) and 0.15 to 0.61-m (CORE) depths. Generally, plastic type and number of wrapping layers had minimal effect on nutritive value and silage fermentation characteristics. However, greater concentrations of total fermentation acids, lactic acid, and $NH_3$-N were found within the SURFACE compared with CORE layer ($P \leq 0.03$), but the titratable acidity (mean = 15.4 mEq/kg of DM; $P = 0.27$) and final pH (mean = 5.70; $P = 0.23$) did not differ. Although yeast and mold counts at the SURFACE layer often were nondetectable (<3.0 $log_{10}$ cfu/g), elevated counts were most frequently associated with SUN. An $O_2$-limiting barrier may improve anaerobic integrity at the surface layer of baled silages, but the potential to reduce polyethylene usage may be limited by the risk of internal physical puncture by coarse alfalfa stems.*

**Key words:** alfalfa, baled silage, fermentation, polyethylene layer, nutritive value

## INTRODUCTION

Production of baled silage is increasingly popular with small or mid-sized dairy or beef producers, in part because it reduces risks of rain damage to wilting forage crops. However, silage fermentation within wrapped round bales differs from precision-chopped silages because the forage is considerably drier (45 to 55% DM; Shinners, 2003) than precision-chopped alfalfa silages (≥30% DM; Muck et al., 2003), which restricts production of fermentation acids and limits the associated pH depression within the silage (Nicholson et al., 1991). Furthermore, the long-stem nature of baled forages restricts the release of sugars required for fermentation by lactic acid–producing bacteria (Nichol-

[1] Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply either recommendation or endorsement by the USDA.
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son et al., 1991; Muck et al., 2003), further slowing the rate and limiting the extent of silage fermentation. As such, exclusion of oxygen becomes very critical in the preservation of these silages, and permeability of film to $O_2$ has the potential to stimulate aerobic microorganisms, including yeasts and molds, thereby resulting in aerobic deterioration. Hancock and Collins (2006) evaluated the number of polyethylene wrapping layers on the subsequent preservation of alfalfa baled silage and determined that 2 layers was inadequate for preservation, but there was little advantage gained by using more than 4 film layers within a 5-mo storage period in Kentucky. Similar observations were made by Keles et al. (2009) with perennial ryegrass (*Lolium perenne* L.) forages in Ireland. Previously, Borreani and Tabacco (2008) observed that insertion of an $O_2$-limiting barrier within the polyethylene wrap reduced losses of DM during storage and may permit reduced plastic usage while maintaining good fermentation and storage characteristics. Although 4 polyethylene layers may permit acceptable fermentation, practical field observations suggest this standard of plastic usage is somewhat precarious, and may be unacceptable to many producers for physical reasons, such as the risk of internal puncture by alfalfa stems during handling. Our objectives for this project were to test the effects of 4, 5, or 6 layers of plastic wrap on the silage fermentation, storage characteristics, and the nutritive value of baled alfalfa–mixed grass silages. A concomitant objective was to evaluate a prototype bale wrap containing an $O_2$-limiting barrier (**OB**) against the identical polyethylene wrap without the $O_2$ barrier (**SUN**). Based on previous work at our station (Coblentz et al., 2016), it is unlikely that silage fermentation or storage characteristics will vary appreciably between SUN and OB with a conservative wrapping approach, such as the 6 layers evaluated within this study. However, benefits to including an OB need to be observed when plastic usage is reduced from that conservative standard, and probably need to be clearly evident at 4 plastic layers before the risks of physical compromise to the integrity of the plastic wrap become problematic.

## MATERIALS AND METHODS

### *Description of Field Site and Experimental Layout*

A 5.0-ha site on the University of Wisconsin Marshfield Agricultural Research Station (44°39N, 90°08W) was selected for the experiment. The field site was planted with Nexgrow 6422Q alfalfa (Forage Genetics International, Nampa, ID) and Alfamaster mixed grasses (Barenbrug USA, Tangent, OR) at seeding rates of 5.2 and 3.0 kg/ha, respectively, on May 16, 2013. The second cutting from this site was mowed when the alfalfa reached the first flower stage of growth at 1230 h on July 29, 2015, with a Case-International Harvester Model 8830 (Case IH, Racine, WI) mower-conditioner equipped with a sickle-bar cutting mechanism and metal conditioning rollers; this mower was designed with a maximum cutting width of 3.7 m. After mowing to a residual stubble height of 7.5 cm, the measured swath width was 1.6 ± 0.09 m. Mowed forage was allowed to wilt, undisturbed, until thirty-six 1.2 × 1.2-m large, round bales were made between 1200 and 1330 h the next day (July 30) with a New Holland Roll-Belt 450 round baler (CNH America LLC, Racine, WI) equipped with a rotary cutting system that was not engaged for this research project; therefore, all forage was baled without particle-size reduction, and each bale was bound with 2 revolutions of net wrap. The field site exhibited little variation with respect to topography, but was subdivided into 6 experimental field blocks of approximately equal size (~0.8 ha); field blocks were baled independently to account for any change in forage DM concentrations that may have occurred during the 1.5-h baling process. A total of 6 bales were made per field block. Prior to baling, a technician walked each of the 6 field blocks in a zig-zag pattern, stopping periodically to take grab samples from the hay swaths; these (600 to 750 g, wet basis) samples were sorted by forage type (alfalfa or grass), and dried to constant weight at 55°C to calculate the percentage of DM that each forage type contributed to the total sward. Considered across the entire research site, percentages of alfalfa and mixed grasses were 82 and 18 ± 3.8%, respectively. Although no attempt was made to quantify the specific species composition of the mixed grasses, visual inspection suggested most of the grass within the field site was orchardgrass (*Dactylis glomerata* L.) at the time of the trial.

### *Description of Experimental Treatments*

Two polyethylene bale wraps were evaluated in this study: (1) SUNFILM (750 mm × 1500 m × 25 μm; AEP Industries Inc., Mt. Top, PA), which is a commercial product available throughout the United States (**SUN**); and (2) a prototype film produced identically, but with an $O_2$-limiting barrier (Kuraray America Inc., Pasadena, TX) inserted within the SUN wrap (**OB**). Measured $O_2$ transmission rates for one individual layer of wrap conducted at 101.3 kPa of pressure, 20°C, and 65% relative humidity were 6,931 $cm^3/m^2$ per day for SUN (MOCON Testing Service, Minneapolis, MN) and 198 $cm^3/m^2$ per day for OB (Kuraray America Inc.). The study was a randomized complete block design with a 2 × 3 factorial arrangement of treatments that included 2 wrap types (SUN or OB) and 3 different wrapping protocols (4, 5, or 6 polyethylene layers). With this 2 × 3 factorial arrangement of treatments, one interactive treatment combination was assigned to each of the 6 bales produced within each field block, and treatment assignments were randomized within block such that they were not confounded with baling order.