Bale Silage Production Issues

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Bale silage production has seen increases in both popularity and technical advancements in recent years. In the Mississippi-Louisiana area where high rainfall and humidity limit successful hay production, bale silage production has grown from less than one percent of dairies in 1995 to more than 30 percent in 2005 (Walz et al., 2005). In addition, several of the larger (more than 200 cows) cow-calf operations in the area have adopted the technology. Factors other than the problematic drying conditions prevalent in the region which have driven baleage use are: wide availability of machinery such as tedders, rakes, balers, and wrappers specifically designed for bale silage, high costs of hay barn construction, research data to support the efficacy of bale silage production, and ready access to custom producers. Recent reports from Europe (Borreani and Tabacco, 2006) and Puerto Rico (Gonzalez and Rodriguez, 2003) indicate that bale silage technology is finding new users in other regions where hay production is difficult. The objectives of this report are 1) to provide research evidence that will refute several myths associated with bale silage production and 2) to provide practical guidelines for producing bale silage from forages typically grown in the Gulf Coast region of the United States.

Bale silage technology is based on the idea that wilted forage may be baled and covered with some form of plastic to limit oxygen entry, thereby reducing proliferation of undesirable microorganisms such as yeasts, molds, clostridial bacteria. In the absence of oxygen, a restricted lactic fermentation takes place and the end result is a forage conservation product that remains relatively stable for 8-12 months. One of the first myths perpetuated by some is that large bale silage may be successfully stored in bags, tubes, or stacks because the oxygen stored within any of these containers is not sufficient to cause excess respiration. In the mid to late nineteen eighties, these were the primary structures/methods used for making baleage, but results were often less than stellar.

In 1990, Straub and coworkers reported on a series of bale silage experiments conducted at the University of Wisconsin and the USDA/ARS Dairy Forage Research Center. Alfalfa was mowed and conditioned with a 3.7m mower conditioner and left in the windrow until forage moisture was reduced to approximately 60-65% moisture. Storage systems evaluated during the four-year storage period were bale bags, a triangular stacking system, and an end-to-end storage system. In the final three years of the study a stretch plastic bale wrapping machine was added which used 1.5 mil white stretch wrap plastic. In year 1, plastic damage from rodents was evident on all systems. In addition, considerable molding and moisture accumulation was evident in bags and both stacking systems. All treatments were considered failures. In the second year, the end to end system was replaced with a bale wrapping system using a four-ply wrap of 1.5 mil sheeting applied in a single wrap. The bale wrapping system produced high quality baleage with little evidence of molding except at the plastic lap. The stacked bales had considerable external mold with a foam-like appearance, but the internal quality was acceptable. The bagged bales exhibited both external and interior mold and were discarded. Dry matter losses were least for wrapped bales (4.3%) and greatest for bales in bags (7.3%). Bale bags were discontinued after the second year due to difficulty in sealing bags and moldiness. In the third and fourth years of the study, the bale stacking system was compared to bale wrapping. Propionic acid (1%) was added to bale exteriors to retard mold on bales in the stacking system. In year three, the stacking system was successful, but in year four the stacked baleage was moldy and unfit for feeding. Problems with the stacks were attributed to failures with sealing the structure and bales squatting and turning over. Alfalfa wrapped in stretch film made high quality bale silage in both years and the authors concluded that the stretch wrap plastic system was the only bale silage technique that consistently provided acceptable results.

Florida researchers (Cromwell, et al., 1994) compared the stretch wrap system to plastic bale bags and multiple bale plastic tubes for bermudagrass bale silage production. Bale bags were found unacceptable because of their high cost (6-8 dollars/bag) and excessive labor required to load and seal bales. Bales stored in the plastic tube system exhibited considerable mold, and a large portion of the forage was not eaten by cattle. Wrapped bales all produced high quality baleage provided plastic integrity was maintained throughout the summer.

Subsequent to this research, we conducted a study at the Southeast Research Station to evaluate the several bale silage systems for ryegrass baleage production (McCormick, et al., 2002). Treatments were: 1) bale tube 2), Flexi-bagger bale tube, 3) stretch wrap bales stored on side and 4) stretch wrapped bales stored on end. Results from the six-month storage period are provided in Table 1.

Table 1. Storage system affects on ensiling characteristics of ryegrass round bale silage.

	Storage System			
	Wrap-end	Wrap-side	Flexi-bagger	Stuffer
Dry matter, %	45.0	41.9	44.7	44.1
Initial bale wt, lb	1322	1502	1514	1390
Final bale wt, lb	1308	1500	1400	1370
Shrink, %	5.4	4.6	11.4	4.2
pH	4.75[a]	4.70[a]	5.33[b]	5.36[b]
Lactic acid, %	2.13	2.64	2.2	1.75
Acetic acid. %	0.84	1.32	1.24	1.15
Bale temp, F	80.9[a]	74.5[a]	99.2[b]	83.4[a]
Mold score[1]	1.00[a]	1.42a	2.50[b]	3.60[c]
Bales fed, %	100.0	100.0	80.0	0.0

[1] Visual score on bale exterior where 1 = no visible mold and 5 = extensive mold.
[A, B, C] Values in a row with different letters differ statistically ($P < 0.05$).

The Flexi-bagger system utilized heavy three-ply bags which were “stretched” by steel fingers so that the plastic collapsed back tightly on the bales. The objective of this system was to eliminate air and reduce molding. The data clearly indicate that the flexibag tube system was superior to the stuffer tube, but bales did experience considerable heating at feed-out and moldiness remained a problem, though not as severe as with the loose tube system. Plastic quality on the end-stored bales was superior to all treatments and bale configuration remained unchanged from initial wrapping. Plastic on the ends of individually wrapped bales overlap many more times than on the sides forming a protective layer which may have inhibited interior moisture condensation thereby eliminating mold. These data indicate that wrapped bales should be stored on end for long-term storage. A follow up study compared three individual wrappers as to effectiveness in ryegrass bale silage production. There were no differences in storage losses or nutritive value for three-point hitch, turn table, or turn table with bale pick up individual wrap systems (McCormick et al., 2002). Although the author is unaware of any direct evaluations between bale silage produced with individually wrapped bales and the "in line" wrappers, recent research from Arkansas indicates these new "stretch tube wrappers" are suitable for making high quality orchard grass and wheat bale silage (Rhewin et al., 2005). Further, the efficacy of these new stretch wrappers that form tubes by applying stretch film to the sides of the bales is supported by the fact that five of six custom producers in the southern Mississippi/Louisiana area employee this technology. The in-line wrappers are faster and require less plastic than the machines that wrap individual bales completely. The research discussed above clearly demonstrates that preformed bags, preformed tubes, and bale stacks are not methods of choice for bale silage production. Stretch-wrap either applied individually as a complete wrap on the sides to form a tube has proven to be the most economical and effective means of producing round bale silage.

Probably no assertion has caused producers more ensilage disasters, particularly with immature annual ryegrass, than the proclamation of some wrapper representatives that "you can bale right behind the cutter". An abundance of research indicates that the optimum wilting time varies with crop species, drying conditions, mechanical conditioning, windrow thickness, and ground moisture. Certainly, more important than how long the forage has been left to dry is the final dry matter achieved prior to baling. Early studies by Australian researchers (Valentine et al, 1984) compared ryegrass-clover-turnip mixtures baled at 27, 37, or 47% dry matter (DM). These studies were carried out with bale bags so storage losses were high. None the less, bales stored at the higher DM concentration experienced substantially lower storage losses than the high moisture bales. An analysis of 84 ryegrass baleage crops in Britain revealed that DM contents ranged from 21.5 to 29.7 in the years from 1984 to 1987 (Haigh, 1990). The author concluded that forage must be wilted to at least 28% DM to maintain ammonia N content below 10% of total N, minimize butyric acid concentrations, and optimize animal performance. In more recent work (Huhnke, et al., 1997) ryegrass and legume-grass silages ranging in initial DM contents from 35 to 75% were evaluated. After six months in storage neither apparent DM losses nor forage quality were affected by initial moisture content. Bates and co-workers (1989) from the University of Florida studied the affect of moisture content on bermuda grass and perennial peanut baleage production. They ensiled 5-week old bermudagrass directly after cutting (27.4% DM) and after a 3.5hour wilt (48.8 % DM). Dry matter losses were nearly four times as high for direct cut forages compared to wilted bermudagrass (11.7 vs 2.9%). Moreover, ammonia N represented over 14% of total N compared to 7.7% for wilted forage indicating superior fermentation and retention of protein quality. High moisture contents in perennial peanuts yielded even more undesirable bale silage. The authors concluded that legumes, because of their inherent lack of water soluble carbohydrates and high buffering capacity may require storage at higher DM concentrations than for grasses. Subsequent research dealing with moisture affects on alfalfa bale silage production indicates that DM ranges from 50-80 percent make acceptable baleage, particularly when four or more layers of stretch wrap are applied (Undersander and Wood, 1999; Han et al;, 2004). Given the bulk of this research, most immature forages will require at least a 4-hour wilt period for successful fermentation. The table below gives the average time required to wilt forages grown at the Southeast Research Station to 40-60 % DM (forage conditioned with a flail type conditioner and left in 4 ft windrows until baling).

Table 2. Approximate wilt times for various bale silage crops grown in Louisiana.

	Wilting time, hrs	
Crop	Avg	Range
Annual ryegrass	48	12-96
Bermudagrass	4	1-24
Crabgrass	24	4-30
Bahiagrass	4	1-24
Sorghum	48	24-72
Alfalfa	24	4-30

It's worth noting that the high moisture content in 4 ft height sorghum is very difficult to bring below 65% within a 48 hour period. The heavy nature of the crop precludes tedding therefore it often must be baled at moistures somewhat higher than recommended. Nevertheless, the high plant sugar content and low buffering capacity usually allow it to ferment acceptably and produce good quality bale silage (McCormick et al., 2004).

As implied from the tabular data above, we have studied bale silage production on a wide range of annual and perennial forages grown in Louisiana. However, we have spent more time studying factors contributing to successful baleage production for annual ryegrass than any other forage. The reasons for this are simple. Annual ryegrass is the most widely grown winter annual in Louisiana. It is easily established and in south Louisiana the growing season stretches from early October through mid-May. In plot tests, tonnage harvested often exceeds five tons of dry matter per acre. Forage quality is excellent when the plant is immature, but by the time the plant can be harvested as hay (Late April to mid May) the plant is seeded out and often contain less than 10% protein and more than 40% ADF. Most producers in the area graze ryegrass from early December through the winter and then make one or two baleage cuttings in the spring. More and more dairymen are setting aside ryegrass acreage solely for bale silage production. In good years they are able to make 3 to 4 cuttings beginning in December and ending in May. Listed below are recommendations for ryegrass baleage production based on our research and that of many other scientists.

Best Management Practices for Ryegrass Bale Silage Production

1) Select a recommended, late maturing ryegrass variety (unless ryegrass is over-seeded on summer hay fields).
2) Clip or graze uniformly to 3-4 inches and apply 50-75 unit of N fertilizer.
3) Harvest at boot to early heading stage of maturity.
4) Wilt forage until dry matter is in the 40-60% range.
5) Reduce bale size compared to conventional hay (usually 4x4 or 4x5 ft).
6) Use plastic or untreated sisal twine.
7) Wrap within 2 hours of baling.
8) Use a minimum of four layers of stretch film and at least six layers for long-term storage or on bales outside the optimum moisture range.
9) Use bale handlers on individual bales and minimize handling of wrapped bales prior to feed-out.
10) Store bales on a clean, well drained area.
11) Consider use of inoculants on low sugar crops.
12) Separate cuttings and core-sample for forage quality analysis.

Ryegrass managed as described above often contains 40-50% dry matter at baling and contains more than 20% protein and less than 30% ADF. For most beef cattle operations we recommend allowing the ryegrass to mature to the full bloom stage which generally yields a product containing 12-16% protein and 34-38% ADF. At the later stage, yield is often 10-20% greater.

In the table below we have listed the average forage quality of annual ryegrass and other forages grown for optimum yield and quality at the Southeast Research Station. Also included are producer sample averages for Mississippi and Louisiana bale silage crops analyzed at the Southeast Research Station Forage Quality Lab (McCormick et al., 2005; Walz et al., 2005).

Table 3. Quality analysis of producer and research samples at the Southeast Res. Station.

	Dry matter, %		Protein, %		NDF, %	
Crop[1]	Producers	Station	Producers	Station	Producers	Station
Ryegrass	44.8	40.1	14.9	19.2	64.6	61.4
crabgrass/signalgrass	47.7	43.1	10.8	19.9	65.3	61.3
sorghum/millet	37.5	28.8	9.8	13.1	73.1	68.5
bermudagrass	48.9	44.9	9.3	13.0	73.6	73.2
Bahiagrass	55.5	50.2	9.2	12.9	72.4	68.9

[1] Producer averages based on 117 ryegrass, 4 crabgrass, 4 sorghum, 8 bermudagrass, and 10 bahiagrass bale silage producer samples submitted in 2004.

Although the above sample analyses appear reasonably good for producer samples, the range in quality was substantial. For example, dry matter and protein ranged from 17.9 to 69.4% and 7.1 to 24.8%, respectively for ryegrass producer samples.

In summary, the bale silage concept has evolved tremendously during the last twenty five years. Technological advances such as balers with knives for chopping forages, combined baler-wrapper machines, improvements in stretch plastics, and improved equipment for conditioning and tedding forages promise to enhance the effectiveness of the bale silage forage conservation system. More research is needed to address the nutritional advantages and liabilities of bale silage. Producers are also interested in determining the optimum time to harvest, morning or evening. Is interseeding legumes in summer perennial pastures a feasible means of improving baleage quality? Do the brown mid-rib sorghum and millet genotypes possess advantages when stored as baleage? How can we effectively reduce molds and deteriation in high DM baleages? Why do there appear to be more problems properly producing ryegrass bale silage from fields fertilized with poultry litter than commercial fertilizers? There is obviously much to learn and many questions to answer, but the future for the bale silage system appears bright (particularly in places like Louisiana where the skies are often cloudy).

References

Bates, D. B., W.E. Kunkle, C.G. Chambliss, and R.P. Cromwell. 1989. Effect of dry matter and additives on bermudagrass and Rhizoma Peanut round bale silage. J. Prod. Agric. 2:91-96.

Borreani, G. and E. Tabacco. 2006. The effect of a baler chopping system on fermentation and losses of wrapped bales of alfalfa. Agron. J. 98:1-7.

Cromwell, R. P., W. E. Kunkle, G. D. Sadler, and C. G. Chambliss. 1994. The plastic wrapper is the key to making high quality round bale silage. Univ. of Fla. Circ. #1072.

Gonzalez, G. and A.A. Rodriguez. 2003. The effect of storage method on fermentation characteristics, aerobic stability, and forage intake of tropical grasses ensiled in round bales. J. Dairy Sci. 86:926-933.

Haigh, P. M. 1990. The effect of dry matter content on the preservation of big bale silages made during the autumn on commercial farms in South Wales 1983-1987. Grass and Forage Sci. 45:29-34.

Han, K. J. M. Collins, E. S. Vanzant, and C. T. Dougherty. 2004. Bale density and moisture effects on alfalfa round bale silage. Crop. Sci. 44:914-919.

Huhnke, R. L., R.E. Muck, and M. E. Payton. 1997. Round bale silage storage losses of ryegrass and legume grass forages. Appl. Eng. In Agric. 13 (4):451-457.

McCormick, M. E., J. F. Beatty, and J. M. Gillespie. 2002. Ryegrass bale silage research and management practices. LSU AgCenter Res. Sum. # 144.

McCormick, M. E., and C. Coxe. 2005. Summer-grown baleage crops for dairy cattle. In Southeast Research Station Field Day Summaries, 2005. LSU AgCenter Res. Sum. # 05-63-0168, pg 2-4.

Rhein, R. T., W. K. Coblentz, J. E. Turner, C. F. Rosenkrans, Jr., R. K. Ogden, and D. W. Kellogg. 2005. Aerobic stability of wheat and orchardgrass round-bale silages during winter. J. Dairy Sci. 88:1815-1826.

Undersander, D. and T. Wood. 1999. Plastic wrapping large round bales at 20 to 40%moisture. Proc. AFGC annual meeting. Pg. 82.

Valentine, S. C., M. J. Cochrane, and B., D. Bartsch. 1984. Nutrient losses in round bales of pasture silage under various storage systems. Austral. Inst. Agric. Sci. 50:246-251.

Walz, R., M. E. McCormick, L. Zeringue, and J. Simmons. 2005. Southeast Research Station Forage Quality Laboratory producer sample results, 2004. In Southeast Res. Sta. Field Day Sum. Research Sum. # 05-63-0168. pg 31-35.