IMPROVING SILAGE QUALITY

K. K. Bolsen, M. A. Young, M. K. Siefers, and G. L. Huck

Summary

Results at Kansas State University from over 200 laboratory-scale trials and 28 farm-scale trials showed that bacterial inoculants consistently improved preservation efficiency and nutritive value of the ensiled material. In contrast, anhydrous ammonia or urea adversely affected dry matter recovery and production per ton of crop ensiled. Economic analysis also favored the use of bacterial inoculants over nonprotein-nitrogen additives. Research conducted using corn, sorghum, and alfalfa silages showed that sealing the exposed surface dramatically reduced top spoilage losses in bunker, trench, or stack silos.

(Key Words: Silage, Inoculant, Nonprotein Nitrogen, Top Spoilage.)

Introduction

Advances in silage technology, which include high-capacity precision chop harvesters, improved silos, polyethylene sheeting, shear-cutting silage unloaders, and total mixed rations, have made silage the principal method of forage preservation for dairy and beef cattle producers in North America in the 1990's. Silage quality and nutritional value are influenced by numerous biological and technological factors, including: the crop, stage of maturity and dry matter (DM) content at harvest, chop length, type of silo, rate of filling, forage density after packing, sealing technique, feedout rate, weather conditions at harvest and feedout, use of an effective additive, timeliness of the silage-making activities, and training of personnel. Because many of these are interrelated, it is difficult to discuss their significance individually. However, there are two dominant features of every silage: 1) the crop, its stage of maturity, and its "ensileability" and 2) the management and know-how imposed by the silage maker.

Silage Additives

Additives have been used throughout the 20th century to improve silage preservation by ensuring that lactic acid bacteria (LAB) dominate the fermentation phase. However, the silage additive industry did not play a significant role in silage production in the U.S. until the past two or three decades. Additives can be divided into three general categories: 1) fermentation stimulants, such as bacterial inoculants and enzymes; 2) fermentation inhibitors, such as propionic, formic, and sulfuric acids; and 3) substrate or nutrient sources, such as molasses, urea, and anhydrous ammonia.

Perhaps no other area of silage management has received as much attention among both researchers and livestock producers in recent years as bacterial inoculants. Effective bacterial inoculants promote a faster and more efficient fermentation of the ensiled crop, which increases both the quantity and quality of the silage. The bacteria in the commercial products include one or more of the following species: *Lactobacillus plantarum* or other *Lactobacillus* species, various *Pediococcus* species, and *Enterococcus faecium*. These strains of LAB have been isolated from silage crops or silages and were selected because: 1) they are homofermentative (i.e., ferment sugars predominantly to lactic acid) and 2) they grow rapidly under a wide range of temperature and moisture conditions. Bacterial inoculants have inherent advantages over other additives, including low cost, safety in handling, a low application rate per ton of chopped forage, and no residues or environmental problems.

Enzymes are capable of degrading the plant cell wall and starch, which could provide additional sugars for fermentation to lactic acid and increase the nutritive value of the ensiled material. Although enzymes offer potential to improve silage quality, considerable work needs to be done before they will become commonly used additives.

The justifications for using nonprotein nitrogen (NPN) have been prolonged aerobic stability during the feedout phase and the addition of an economical nitrogen source to low-protein crops, such as corn and sorghum. However, major drawbacks to ammoniation are the potentially dangerous volatile and caustic properties of anhydrous ammonia, with the need for specialized application and safety equipment.

Silage Additive Research at Kansas State University. Evaluation of silage additives began in 1975 in the Department of Animal Sciences and Industry and continues today. These 20 years have lead to the following general conclusions about inoculant and NPN additives.

Question: When should a bacterial inoculant be used?
Answer: Inoculants should be applied to every load of forage ensiled!!
Question: When should NPN, such as urea and anhydrous ammonia, be used?
Answer: Never!! Unless this is the only means of preventing aerobic deterioration during the feedout phase.

Results from over 200 laboratory-scale studies, which involved nearly 1,500 silages and 25,000 silos, indicated that bacterial inoculants were beneficial in over 90% of the comparisons. Inoculated silages had faster and more efficient fermentations -- pH was lower, particularly during the first 2 to 4 days of the ensiling process, and lactic acid content and lactic to acetic acid ratio were higher than in control silages. Inoculated silages also had lower ethanol and ammonia-nitrogen values compared to untreated silages.

Results from 28 farm-scale trials, which evaluated 71 silages, showed that bacterial inoculants consistently improved fermentation efficiency, DM recovery, feed to gain ratio, and gain per ton of crop ensiled in both corn and forage sorghum silages. Applying urea or anhydrous ammonia adversely affected fermentation efficiency, DM recovery, average daily gain, feed to gain ratio, and gain per ton of crop ensiled, particularly for the higher moisture forage sorghums. An additive with a urea-molasses blend had less of a negative influence on silage preservation and cattle performance than urea or anhydrous ammonia.

Economics of Bacterial Inoculant and NPN Silage Additives. An effective bacterial inoculant is a sound investment for every dairy and beef cattle producer who makes and feeds silage. Based upon the results at Kansas State University, a 3 to 4 lb increase in gain per ton of crop ensiled produces $2 to $4 increases in net return per ton of corn or sorghum ensiled. If producers use NPN, they actually lose $4 to $6 per ton of crop ensiled because of the decreased DM recovery, increased feed to gain ratio, and added cost of replacing the loss of volatile nitrogen. These results apply to beef producers who background cattle or grow replacement heifers and to dairy producers who raise heifers.

The use of a bacterial inoculant by dairy producers who make and feed whole-plant corn or sorghum silages and alfalfa silage or haylage in their lactation rations is also a good management decision. The additional "cow days" per ton of crop ensiled, because of the increased DM recovery, and the increased milk per cow per day from the inoculated silage or haylage (.25 to 1.25 lbs) produce $4 to $8 increases in net return per ton of corn or sorghum ensiled and $6 to $10 increases in net return per ton of alfalfa ensiled.

Recommendations. Why leave the critical fermentation phase to chance by assuming that the indigenous microorganisms (those occurring naturally on the forage) are going to be effective in preserving the silage crop? Even if a dairy or beef cattle producer's silage has been acceptable in the past--because silage-making conditions in Kansas are generally good--there are always opportunities for improvement.

Although whole-plant corn and sorghum ensile easily, research data clearly show that the quality of the fermentation and subsequent preservation and utilization efficiencies are improved with bacterial inoculants. Alfalfa (and other legumes) are usually difficult to ensile because of a low sugar content and high buffering capacity. However, adding an inoculant helps ensure that as much of the available substrate as possible is converted to lactic acid, which removes some of the risk of having a poorly preserved, low-quality silage.

Finally, if producers already are doing a good job but using a bacterial inoculant for the first time, they probably will not see a dramatic difference in their silage. But the benefit will be there -- additional silage DM recovery and significantly more milk or beef production per ton of crop ensiled!

Selecting a Bacterial Inoculant. The inoculant should provide at least 100,000 colony-forming units of viable LAB per gram of forage. These LAB should dominate the fermentation; produce lactic acid as the sole end product; be able to grow over a wide range of pH, temperature, and moisture conditions; and ferment a wide range of plant sugars. Purchase an inoculant from a reputable company that can provide quality control assurances along with independent research supporting the product's effectiveness.

Protect Silage from Air and Water

Everyone in the silage business acknowledges that sealing (covering) a horizontal silo (i.e., bunker, trench, or stack) ranks high on the troublesome list, but high on the quality reward list, too. Because so much of the surface of the ensiled material is exposed to air, great potential exists for excessive DM and nutrient losses. The extent of these losses in the top 2 to 4 ft if there is no protection is far greater than most people realize. A barrier must be built against air and water after the filling operation is completed.

Although future technology might bring a more user and environmentally friendly product, polyethylene is the most effective sealing (covering) material today. After it is put over ensiled forage, the sheet must be weighted down. Tires are the most commonly used weights, and they should be placed close enough together that they touch (about 20 to 25 tires per 100 sq ft). In a 1,000-ton bunker silo, an effective seal to protect the top 3 ft of silage can prevent the loss of $500 to $2,500 worth of silage, depending on the value of the crop. The bottom line is that sealing the exposed surface is one of the most important management decisions in any silage program.