Focus on Forage
Wisconsin TEAM Forage

Inoculants for Legume-Grass Silage

by Richard Muck

Introduction

Various spoilage microorganisms (bacteria, yeasts and molds) readily grow on crops going into a silo, causing losses in dry matter and quality. To prevent these various microorganisms from growing, two conditions are needed in the silo: an oxygen-free (or anaerobic) environment and a low pH. Many of the oxygen-requiring (aerobic) microorganisms that heat the crop as well as causing losses cannot be stopped by low pH alone. These microorganisms can only be stopped by sealing the silo well to keep out air. On the other hand, bacteria responsible for poor fermentations such as clostridia are stopped by dropping the pH of the crop sufficiently to prevent their growth.

The lowering of pH happens naturally under most circumstances. This is due to lactic acid bacteria on the crop fermenting sugars to lactic and acetic acids as well as to alcohol and several other minor compounds. Lactic acid is the preferred product of fermentation for several reasons. Lactic acid is a strong acid that contains almost the same energy as the original sugars, and can be fermented by rumen microorganisms. The speed and efficiency of the natural fermentation process is highly variable, depending on the number of lactic acid bacteria on the crop, the particular strains of lactic acid bacteria, and the temperature and sugar content of the crop.

Inoculants are silage additives containing lactic acid bacteria that have been selected to grow rapidly and efficiently (producing primarily lactic acid) on crops in the silo. Consequently, they help to insure a good fermentation in the silo. However, the primary economic benefits are in improved dry matter recovery from the silo and improved animal performance.

Richard Muck, Professor
US Dairy Forage Center
Madison, Wisconsin 53706
remuck@facstaff.wisc.edu

Will inoculants reduce silo losses?

When the inoculant bacteria improve fermentation, dry matter losses from the silo decrease 2-3 percentage units on average. In other words, dry matter losses in a well-managed bunker silo would typically be reduced from 15% to 12-13% by inoculation.

This decrease in dry matter loss is largely due to a shift in fermentation. There is no dry matter loss when lactic acid bacteria ferment sugar only to lactic acid. In contrast, producing lactic acid plus alcohol or acetic acid results in up to a 24% loss of the original sugar.

Will inoculants improve bunk stability?

While these products are often marketed as improving bunk stability, research studies show that inoculants generally have little effect on this aspect of silage quality. The reason for this is the inoculant's effect on fermentation. Both lactic and acetic acids, but primarily acetic acid, help inhibit the growth of spoilage microorganisms that cause heating in silage. Thus reducing the acetic acid content has a negative effect on bunk stability. However, lowering pH makes the acids present in silage morelikely to inhibit spoilage microorganisms. In hay-crop silages, the lower pH from inoculation generally compensates for the reduction in acetic acid. The net result is that bunk stability is not affected or sometimes improved slightly by several hours.

Will inoculants increase silage digestibility and intake?

The shift in fermentation produced by inoculants should increase silage digestibility similarly to the improvements in dry matter recovery. In addition, research has documented that at least several products have improved fiber digestibility. The reason for this is not known at this time. These improvements in digestibility have not always led to improvements in intake. A recent survey of inoculant studies in all silage crops found that intake was improved in only 21% of the animal studies whereas as silage fermentation was improved in 60% of the cases.

Can inoculants increase milk production in the dairy cow?

Increases in animal performance have been observed more often than increases in intake. A recent survey of inoculant studies in all silage crops found milk production improved in about half of the studies. In those studies where milk production was improved, milk production increased on average 3 lbs./cow/day.

At what silage moisture content do inoculants work best?

An inoculant should work well at any of the recommended moisture contents for the various silo types (i.e., between 45 and 70% moisture). However, fewer types of naturally occurring lactic acid bacteria will be able to grow well under drier conditions. This suggests that inoculants should be successful more frequently in drier crops.

Do inoculants work equally well on all cuttings during the season?

The most important factor affecting the success of an inoculant is the size of the natural population of lactic acid bacteria on the crop: the higher the natural population the less likely the inoculant will succeed. In alfalfa, the natural population varies with wilting conditions. The natural population is increased by higher average wilting temperatures, longer wilting times, rainfall during wilting, and higher moisture contents at chopping. Consequently these conditions, rather than cutting, are important for determining the best time to use an inoculant on hay-crop silage.

In the following figures, the break-even conditions for using an inoculant are graphed as a function of wilting time, temperature (average of maximum and minimum daily temperatures during wilting), rainfall and moisture content at ensiling. The economics assume an inoculant cost of $1/ton as fed and an economic return of $3/ton when the inoculant succeeds. If your wilting conditions fall below the appropriate line, then an inoculant will be profitable to use.

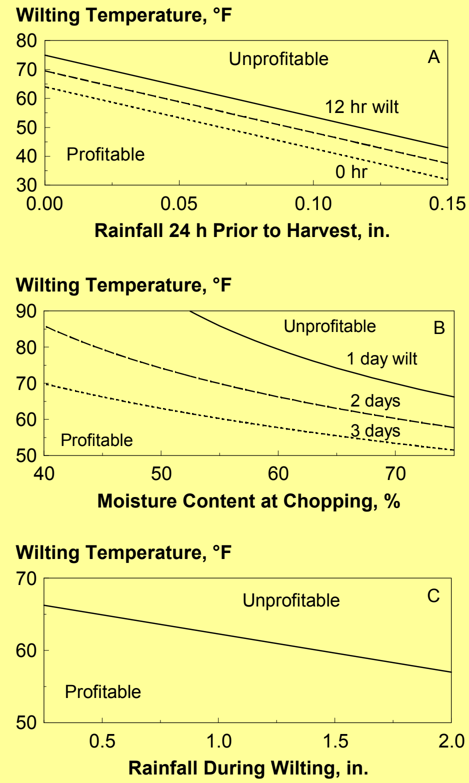

Figure 1. Break-even curves for using an inoculant in making alfalfa silage based on wilting conditions. A) Mowing and chopping the same day, B) 1-3 days wilt, C) 3+ days wilt with rainfall.

Overall under Wisconsin conditions, the profitability of an inoculant will be more variable in first cutting than in subsequent cuttings. This is true because we typically have longer wilting times and a greater likelihood of rainfall during wilting in first cutting, which reduce the chances for an inoculant to succeed. However, it would be wrong to assume that it is unprofitable to use an inoculant in first cutting. Regular use of the graphs for all cuttings will help you maximize your profit from these additives.

What is the correct application rate?

The labeling of inoculants is highly variable and makes comparing products difficult. What is important is the number of lactic acid bacteria applied per unit of crop. One should buy a product that applies at least 90 billion <u>live</u> lactic acid bacteria per ton crop as fed or 100,000 per g crop. Some products tell you how many bacteria are in the bag or bottle. In those cases, you will need to calculate how many will be applied to the crop. Higher numbers than these minimum rates should be better but are not always so.

What organisms should be present in a silage inoculant?

Inoculants may contain one or more strains of lactic acid bacteria. The most common is *Lactobacillus plantarum*. Other *Lactobacillus* or *Pediococcus* species may be present; also *Enterococcus faecium* is common. Rarely, a *Bacillus* species may be present to improve bunk stability. Be skeptical of products that contain other species.

Are there performance differences between specific strains of an organism?

Yes. For example, not all *Lactobacillus plantarum* strains grow at the same speed. Some *L. plantarum* strains may grow better on alfalfa, others better on corn. Some strains may grow better under drier conditions or higher temperatures than others, etc. Because of these differences, it is important to use a product labeled for the crop that you are ensiling. If a product is labeled only for corn silage, don't use it on alfalfa and vice versa.

Is there a difference between dry and liquid products in how they perform?

Both dry and liquid products can be effective, but liquid application has some advantages over dry application. First, these bacteria cannot move around. They grow where they are placed. So inoculants must be applied as uniformly as possible to maximize effectiveness. A liquid sprayed on the crop at the chopper provides the best opportunity to distribute the inoculant uniformly and mix it thoroughly with the crop. Second, the bacteria in a liquid product should be able to begin working faster than a dry product, where the bacteria need to be moistened by plant juices before they can begin to grow. Third, most inoculants need to be kept cool and dry prior to use in order to maintain the activity of the bacteria. This is easiest with the liquid applied products that come in small packages that can be placed in a refrigerator.

There are two issues of concern in using liquid products. First is the water used for diluting the product. If your water supply is chlorinated, the chlorine can kill the lactic acid bacteria if the chlorine level is too high. Use a pool tester to be sure that the chlorine concentration in the water is less than 1 ppm. If it is above 1 ppm, allow the dilution water to sit open to the air overnight to reduce chlorine level, or look for a product that has compounds to take care of the chlorine. Second, once a product has been diluted, it generally needs to be used within a 24-h period. Some products are diluted the night before use; these should be used within 24 h of when they are ready for application. Consequently, there can be some wastage of product if the amount harvested is less than expected due to weather, breakdowns, etc.

How can I tell if I am purchasing a good product?

It is difficult to compare one inoculant with another, but there are some things to look for in purchasing a product. One, look for a product that guarantees to supply at least 90 billion live lactic acid bacteria per ton of crop. Two, be sure to buy a product that is labeled for the crop that you are going to ensile. Three, ask for research (particularly independent research) data to back up the claims for the product. Four, once you have purchased a product, be sure to store and use it according to directions.

How much does it cost to inoculate silage?

Costs vary across products and depending on the volume that you buy. A typical cost is $1 per treated ton of crop, but may vary from $0.60 to more than $2 per ton.

UW Extension   College of Agricultural & Life Sciences, University of Wisconsin-Madison