Silage Inoculants: What the Research Indicates About When and How to Use Them

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With all variables – crop varieties, weather, packing density, speed of covering – no two silage crops are the same, which is why scientists are reluctant to give generalized statements regarding when and how to use silage inoculants. A more favorable and scientific response is, "it depends."

Through the years, research has answered questions about the effect of silage inoculants under various conditions. The following is an overview of this research and general recommendations. But first, a review on how silage inoculants work and the different types of inoculants.

In general, inoculants work by shifting silage fermentation in a direction that better preserves the crop. This happens when the lactic acid bacteria in the inoculant overwhelm the natural lactic acid bacteria on the crop. However, even the best inoculants are not always successful.

Two Types: Homofermenters and Heterofermenters

There are two main types of silage inoculants: the traditional homofermentative types (i.e., *Lactobacillus plantarum*, the *Pediococcus* species, and *Enterococcus faecium)* and the more recently used heterofermentative bacteria (i.e., *Lactobacillus buchneri)*. A third type, combining homofermenters with *L. buchneri*, is beginning to be marketed.

Homofermenters get their name because they turn 6-carbon sugar molecules into one product – lactic acid. Heterofermenters produce multiple products. For example, they may turn one 6-carbon sugar into one lactic acid + one acetic acid + CO_2; or turn one 6-carbon sugar into one lactic acid + one ethanol + CO_2; or turn one lactic acid into one acetic acid + CO_2.

The different end products of fermentation can be compared:

- **lactic acid** – strong acid, weak spoilage inhibitor, fermented by bacteria in rumen;
- **acetic acid** – weak acid, good spoilage inhibitor, not fermented in rumen;
- **ethanol** – neutral, poor spoilage inhibitor, partially fermented in rumen;
- **CO_2** (carbon dioxide) – lost DM.

The type of inoculant used depends partially on the goal. If the goal is to preserve crop quality as close to that of the crop at ensiling, use an inoculant that maximizes lactic acid production – a homofermenter. If the goal is to produce a silage that does not heat, use an inoculant that produces acetic acid, the heterofermenter, *L. buchneri*.

Studies with Homofermenters

A review of published studies by Muck and Kung in 1997 resulted in data that are still useful today in showing the effects of adding homfermentative inoculants to silage. On average, pH was lowered, but not every time; it lowered the pH more often in hay crops vs. whole grain silages. The percentage of trials in which the pH dropped was: alfalfa silage, 58%; grass silage, 63%; corn silage, 43%; and small grain silage, 31%. DM recovery was improved in 38% of the trials. In the trials that showed an improvement in DM recovery, it was improved by an average of 6%. When all trials were averaged, the improvement in DM recovery was 2-3%. Regarding animal performance improvement: 27% of trials showed an improvement in feed intake, 52% showed an improvement in weight gain, and 46% showed an improvement in milk production. In the trials that showed improvement, the increases in feed intake, weight gain, and milk production were typically in the range of 3-5%.

Finally, when bunk life/aerobic stability were measured, there was an improvement in ~28% of the trials and a reduction in 31% of the trials. Changes were generally positive in hay crop silages and negative in corn and small grain silages. In most cases, the effects, whether positive or negative, were small.

Studies with *L. buchneri*

In warm weather, bunk life is often an issue with corn and small grain silages. Due to failure of homofermenters to increase aerobic stability, scientists began to look for inoculants that could keep silages from heating when exposed to air. One recent solution has been the heterofermentative species *L. buchneri*, which produces acetic acid from both sugar and lactic acid. Studies with *L. buchneri* have shown a fairly consistent rise in acetic acid concentration and results in a silage with a slightly higher pH. Because acetic acid inhibits yeasts and molds, the *L. buchneri*-treated silages have been more aerobically stable than untreated silage.

In terms of DM losses, silages treated with *L. buchneri* have been intermediate between untreated silage and silage treated with homofermentative inoculants. CO_2 gas is made and lost while producing acetic acid. Typically, there is a 1-2% improvement in DM recovery over untreated silage.

In lactation trials with *L. buchneri*-treated silage, bunk life/aerobic stability increased consistently. Acetic acid also increased consistently – greater than 5% DM in several cases. However, there has been no effect on DM intake by the cows, and there has been little or no effect on milk production in most cases.

Studies Combining Homofermenters and *L. buchneri*

When combining two types of silage inoculants, the best of both worlds would be expected – good fermentation, except for elevated acetic acid; the DM recovery and animal performance of a standard inoculant; and the bunk life/aerobic stability of *L. buchneri*. It is too soon to draw a conclusion based on published research. Several studies have shown combinations behaved more like the *L. buchneri* treatment than the homofermentative bacteria treatment in terms of aerobic stability, fermentation products, and pH. Additional animal trials need to be reported to know how the cows will perform.

Harvest Conditions when Inoculants Appear to Be Most Useful

While some producers use inoculants all of the time as an insurance policy, others strive to use it when they suspect it will be most useful. In the studies outlined, inoculants were used no matter what the harvest condition; results might be better than if a forage producer used the 'educated guess' approach of when to use inoculants.

Research points to the following conditions when positive outcomes are more likely to occur:

- In hay crop silage – wilting times of one day or less; longer wilting times only if cool and dry.
- In corn silage – harvested on the dry side or immediately after a killing frost.

Wet or Dry Inoculants?

Producers often ask whether wet inoculants or dry inoculants work better. There appears to be no research that has specifically studied this issue. However, there is some common sense advice. First and foremost, these products work only if the bacteria are alive when first applied. Consequently, the products should be stored properly, in a cool, dry place. This is easier with a wet inoculant due to its small packaging which can be kept in a refrigerator until needed. Do not use chlorinated water to dilute wet inoculants unless the chlorine level is less than 1 ppm or unless the inoculant contains chemicals to take care of the chlorine. Chlorine is meant to kill bacteria and cannot discriminate between bad bacteria and the good lactic acid bacteria in inoculants.

The bacteria cannot move around on their own; they depend on the producer to spread them uniformly across the crop. Spreading uniformly is often easier with wet products because they can be sprayed on the crop by the chopper. However, there has been some recent concern from research in Delaware that dark colored tanks may get hot enough in the summer sun to cause a reduction in the numbers of live bacteria in the inoculant. A wet or dry product should be chosen based on whether or not the product can be kept alive both before and during application, and how well a producer can mix it with the crop.

Summary

Standard homofermentative inoculants are the best route to improve DM recovery and animal performance. They are a good fit for hay crop silages but are less likely to be successful on corn silage. It is harder to get consistent improvements in corn silage and there are bunk life issues when they do work.

If a forage producer is having silage bunk life/aerobic stability problems, is it due to a management issue that can be solved without an additive such as getting a higher silage density, sealing the silo better or feeding out at a faster rate? If not, heterofermentative inoculants may be a good alternative to propionic acid or anhydrous ammonia. They are safer to handle, cost competitive, and have similar effects on DM recovery and animal performance. *L. buchneri* is effective 80-90% of the time on corn silage. However, the bacterium is a slow grower that takes 45-60 days of storage time before having much effect. Consequently, it is not an answer to heating problems with immature silage.