

Bacterial Silage Inoculants

The most common type of silage additive in North America is the bacterial inoculant. These products supplement the natural lactic acid bacteria on the crop to guarantee a fast and efficient fermentation in the silo. Inoculant bacteria have been isolated from silages or silage crops and selected because they grow rapidly under a wide variety of temperatures and moisture conditions and because they normally produce only lactic acid when growing on the main sugars (glucose, fructose and sucrose) in silage crops.

Observed effects

Scientific studies on inoculants published between 1985 and 1992 were surveyed. Most studies were on alfalfa, cool season grass or corn silage and were performed in either North America or Europe. As indicated in figure 1, inoculants were successful in significantly improving silage fermentation (lowering pH, increasing lactic to acetic acid ratio, reducing ammonia) approximately two-thirds of the time. Separating the results by crop, pH was lowered by inoculants 75% of the time in alfalfa, 71% in grass and only 40% in corn.

Inoculants were less successful in other areas. Recovery of dry matter (DM) from the silo was improved in approximately 60% of the cases whereas aerobic stability was improved in less than half the cases. When an inoculant improved dry matter recovery, increases were generally 2 to 3 percentage points.

Animal performance was least affected by inoculants. Intake and average daily gain in cattle and sheep were improved significantly in only one-fourth of the experiments.

Figure 1 : Percentage of trials in published research (1985-92) where silage inoculants significantly improved animal performance or fermentation. Number of trials per characteristic is above each bar.

Milk production and feed efficiency were improved more often but still in less than half the trials. When significant effects were observed, dry matter intake, average daily gain, milk production and feed efficiency were improved 11, 11, 5 and 9%, respectively, on average.

Animal performance benefits were closely linked with improvements in digestibility. Both dry matter digestibility and animal performance were measured in 31 trials. Animal performance was improved in 9 of the 16 trials where the inoculant improved dry matter digestibility. When digestibility was not affected by the inoculant, only 2 of 15 trials demonstrated positive animal performance. These results suggest that increases in digestibility may be the key factor in explaining why inoculants improve animal performance.

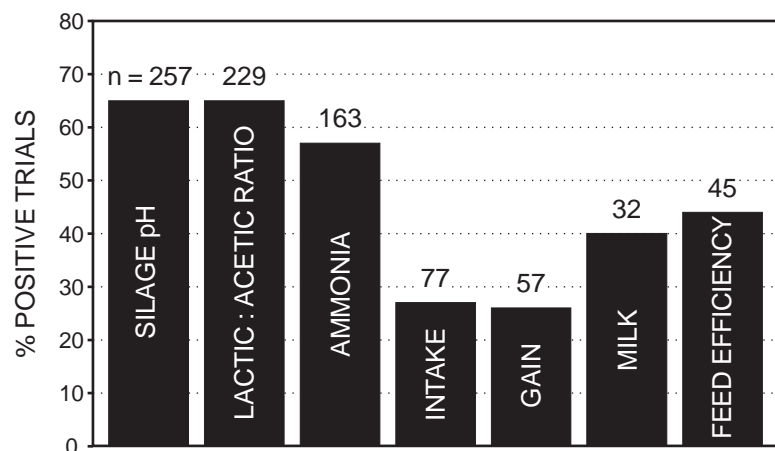
When to use inoculants

Based on the survey of research studies, inoculants clearly are not always effective. This is particularly true for DM recovery and animal performance, the two areas that provide the economic incentive for using an inoculant. To maximize profit, the farmer needs to know when these products are going to be effective.

Three major factors appear to affect inoculant performance:

- the natural lactic acid bacterial population;
- the sugar content of the crop;
- the strains of bacteria in the inoculant.

The most critical factor is the natural population of lactic acid bacteria. The inoculant



lactic acid bacteria must compete with and dominate the natural population to have a positive effect on fermentation and animal performance. Improvements in milk production from inoculated alfalfa silage have only occurred when the inoculant was at least 10 times higher than the natural population of acid-tolerant bacteria.

The second major factor is sugar. Lactic acid bacteria grow on sugar. If the sugar content of the crop is low, the impact of the inoculant will be reduced. This is unlikely to be a problem in corn or barley silage but can reduce effectiveness of inoculants in high moisture alfalfa silages.

The final factor is the activity of the inoculant bacteria on the specific crop to be ensiled. The bacteria found in inoculants are lactic acid bacteria that have been found on various crops and silages. Certain strains of a bacterial species prefer and grow best on specific crops, probably because each crop has a particular mix of nutrients in the plant juices.

Given all these factors, how does the farmer know what product to buy and when to use it most profitably? Here are some guidelines :

- buy a product made for the crop you are ensiling. If that is not possible, try a product for a similar crop. For example, if you are making barley silage, use a corn or grass silage product rather than an alfalfa inoculant.
- apply at least 100 billion (10^{11}) live bacteria per ton of fresh crop. This will increase the odds of the inoculant overtaking the natural population and producing significant effects.
- the product should only contain lactic acid bacteria like *Lactobacillus plantarum*, other *Lactobacillus* species, *Pediococcus* species and/or *Enterococcus (Streptococcus) faecium*.
- use an inoculant that is applied as a liquid to get a good distribution of the bacteria on the crop.
- based on the survey of inoculant studies, inoculants are most successful in alfalfa and grass silages. Their success in cereal silage has been limited. The difference in success is most likely caused by higher natural populations of lactic acid bacteria on cereals at ensiling relative to those on hay crops.

Figure 2 provides the range of conditions when applying an inoculant will be profitable on alfalfa, based on our research. This assumes a 3:1 return on the cost of applying an inoculant when the inoculant succeeds in overwhelming the natural population and

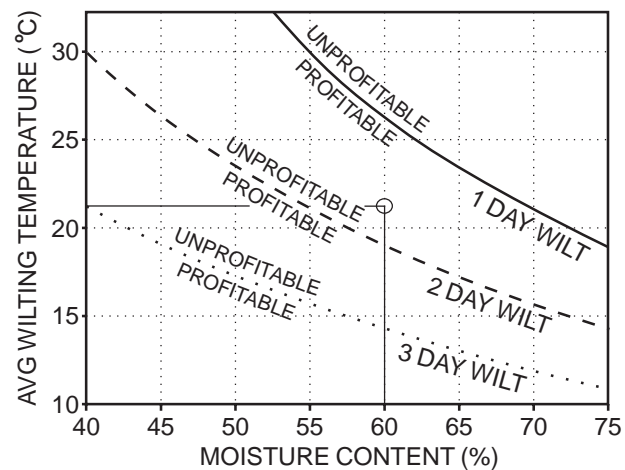


Figure 2 : Conditions under which a silage inoculant will be profitable on alfalfa assuming an inoculant supplying 10^{11} bacteria per ton of crop.

assumes a product that supplies 10^{11} bacteria per ton of alfalfa. The average wilting temperature is the average of the daytime high and low air temperatures between mowing and chopping. For example, if the alfalfa is mowed on Monday and chopped on Wednesday, average together these four temperatures: the afternoon highs for Monday and Tuesday and the morning lows on Tuesday and Wednesday.

Determine moisture content of the crop at chopping (see article 1D1). Then take the average temperature and moisture content to find whether use of an inoculant will be profitable. For example, if the average temperature is 21°C and the moisture content of the chopped alfalfa is 60%, then you should use an inoculant if there has only been one day between mowing and harvest - the intersection point is on the profitable side of the 1 day wilt curve. If the crop has been drying two or more days, an inoculant will not be profitable.

Overall, these products are useful at improving silage fermentation and animal performance, particularly in hay crop silages. They are not always successful because of high natural levels of lactic acid bacteria and insufficient sugar content of the crop. However, means of predicting when they will be successful in alfalfa have been developed, improving the potential profitability from their use.

adapted and condensed from an article by :
R.E Muck, Ph.D.
USDA Dairy Forage Research Center
Madison, Wisconsin