

## Bacterial Inoculants For Silage

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**P**reservation of silage has a great impact on forage quality. While most dry matter losses which occur during storage are due to aerobic respiration, most quality changes occur during fermentation. The crucial step of fermentation may be aided by bacterial inoculants. Inoculants are initially inactive organisms that, when added to silage, become active and can help break down plant sugars. Benefits of inoculants can include: reduced temperatures in the silo, reduced dry matter and energy losses while in storage, reduced protein solubilization, higher animal performance, and longer bunk life.

Inoculants are not effective in all harvesting situations, as they do not always enhance fermentation. A knowledge of how and when inoculants work will allow them to be used more profitably.

### What Bacterial Inoculants Do

Bacterial inoculants work by increasing the rate and extent of lactic acid fermentation (the good kind) thus reducing the likelihood of clostridial activity which produces butyric acid (the bad kind); this helps to lower the pH of silage. In general terms, pH can be defined as a measure of acidity; in silage, a low pH is desirable. When the pH is lowered enough, a stable phase is reached. In this phase, the silage will store without spoilage until it comes into contact with oxygen in the air.

During fermentation, pH is reduced by bacteria in silage breaking down plant sugars into acids. Other compounds such as ethanol and carbon

dioxide result but these do not affect storability. Lactic acid and acetic acid are both commonly produced during fermentation; lactic acid is stronger and more effective in lowering pH, so it is the basis for most inoculant use.

Bacteria are present in silage at harvest. However, when the naturally occurring population is low, addition of inoculants may aid in the process of lowering pH. This is partly because of the increase in the number of bacteria in silage. Also, the inoculants may contain bacteria which are more effective at lowering pH than those naturally occurring in silage. When used under correct conditions, inoculants can actually reduce the time it takes for the silage to reach a stable state.

### Bacterial Math

When dealing with silage inoculants, the numbers involved often need explanation. The unit used in measuring quantities of bacteria is colony forming units per gram, or cfu/g. Each cfu/g of silage means that, on average, one lactic acid-producing bacteria has been added to each gram of silage (wet weight) that was treated. An enormous number of bacteria are needed to carry out the process of silage fermentation. It is generally agreed that 100,000, or  $10^5$  cfu/g is the minimum level of bacteria that a silage inoculant should supply. Because these bacteria grow rapidly, a doubling of the population may not represent a major change; a tenfold increase can make a significant difference, however.

## **Inoculant Product Label Information**

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The application rate of lactic acid-producing bacteria is paramount to the success of inoculation. Most labels give the cfu/g as applied to the silage when label directions are followed. If they do not, request this information from the supplier to make sure the rate is sufficient. The active ingredient to look for is lactobacillus. There are many strains of these bacteria which vary slightly in effectiveness, but for the most part, they work similarly. Many times an inoculant mixture will contain enzymes. These do sometimes improve the silage quality, but generally are not economically beneficial.

Directions for application vary widely among brands and forms. It is vital that you follow label directions closely. For example: one commercially available inoculant is in a dry flowable form and should be applied at a rate of 1 lb per ton of chopped forage; another inoculant is in dry form, but 1 lb is diluted in 200 lb of water and the mixture is applied at a rate of 2 lb per ton of forage. Other inoculants may come in liquid form which may or may not need to be diluted. Be sure to follow the directions on the product label to be sure you are getting the application rate you need.

## **Deciding When To Use Bacterial Inoculants**

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### *Cost*

There are many bacterial inoculants available on the market. The cost of using them per ton of silage (wet weight) varies from less than \$0.65/ton to more than \$1.00/ton. Some dealers offer incentive programs to high-volume buyers that will further lower the cost of inoculating. Equipment for applying water-soluble inoculants can cost from \$200 to \$480 depending on the application rate desired. For high-volume inoculant buyers, many dealers may be willing to loan equipment or sell it at reduced prices.

### *Profitability*

Although, as listed before, there are many benefits to using silage inoculants, they may not always be profitable to use. Profitability can be measured in

terms of positive silage effects: changes in quality, storability, and composition, and/or in terms of increased animal performance.

If, for example, alfalfa silage is worth \$30/ton, and inoculants cost about \$1/ ton of forage treated, the reduction in DM loss needed for economic benefit is 1/30, or 3%. When inoculants are effective, they reduce DM loss by about 4%. Therefore, for profitable application in the long run, the likelihood of effectiveness must be

$$3/4 = 0.75 = 75\%$$

to make inoculants profitable. In other words, a benefit of 4% loss reduction achieved at least 75% of the time will result in breakeven treatment. Consistent application when the odds of success (in terms of reducing storage loss) are greater than 75% will be profitable in the long run.

When inoculants are effective in increasing animal performance, there is generally a 3% increase in milk production; this translates into nearly a three-to-one investment return. This means that the likelihood of effectiveness for economic benefit with regard to animal performance must be

$$1/3 = 0.33 = 33\%$$

for profitable inoculation. In other words, consistent application when the odds of success (in terms of animal performance) are greater than 33% will be profitable in the long run.

The general guideline for an inoculant to profitably affect silage quality is to add  $10^5$  cfu/g. However, except for very cool field curing temperatures, the inoculant must add  $10^6$  cfu/g to economically increase animal performance. Few if any commercial inoculants provide this level of bacteria at the recommended application rate, making it difficult to effectively improve animal performance by use of inoculation alone.

## **Factors Effecting Inoculant Performance**

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Field curing temperature, moisture content, and wilting time of the silage have an effect on inoculant success. It is important to remember that these factors change each day. All factors must be considered before making the decision to use inoculants in a given situation.

The amount of moisture in silage is important to the effectiveness of inoculants and naturally present lactic acid bacteria in fermentation. As a general guideline, the moisture content must be in the 50-70% range. However, other conditions such as wilting time and temperature may require the moisture content to be in a more specific range for economic benefit.

## When To Inoculate

The type of forage being ensiled also makes a difference in inoculant performance. There is quite a bit of debate over inoculation of corn silage. Corn silage generally shows less of the effects of inoculation than alfalfa silage, primarily because it is relatively easy to make good corn silage without inoculation. Some research has shown increased corn silage quality with inoculation, but inoculants are generally less profitable on corn silage than on alfalfa silage.

Temperature during wilting of alfalfa plays a large role in determining when inoculants are profitable because the naturally occurring population of lactic acid bacteria is a function of temperature. In general, cooler wilting temperatures throughout the entire wilting time would result in greater effect from the inoculant because of lower natural populations. Figure 1 shows the average wilting temperature necessary for inoculation to be profitable for various

moisture/wilting time combinations. This graph reflects consideration of temperature, moisture content, wilting time, and uses estimations of the natural bacterial population to show when inoculation is a good option. Moisture content must also be considered when comparing inoculant success at different lengths of wilting time. The longer silage is wilted, the drier it must be for profitable use of inoculants. A 24 hour difference in wilting time may mean that the silage must contain 10% more dry matter for inoculation to be profitable.

As a general guideline, inoculation will have positive economic effects on alfalfa silage wilted for less than 24 hours in both warm and cool weather, as long as the inoculant supplies  $10^5$  (100,000) cfu/g of silage.

Figure 1 shows the conditions under which inoculating at  $10^5$  (100,000) cfu/g is cost effective. To use the graph, locate the appropriate moisture content curve and identify the appropriate wilting time. If the average wilting temperature is below the corresponding point on the curve, inoculation is profitable.

For example, if the moisture content is 60%, wilting time was 48 hours and the average temperature during wilting was 68°F, inoculation is most likely profitable. Average wilting temperatures above 69°F likely result in economic loss over the long run.

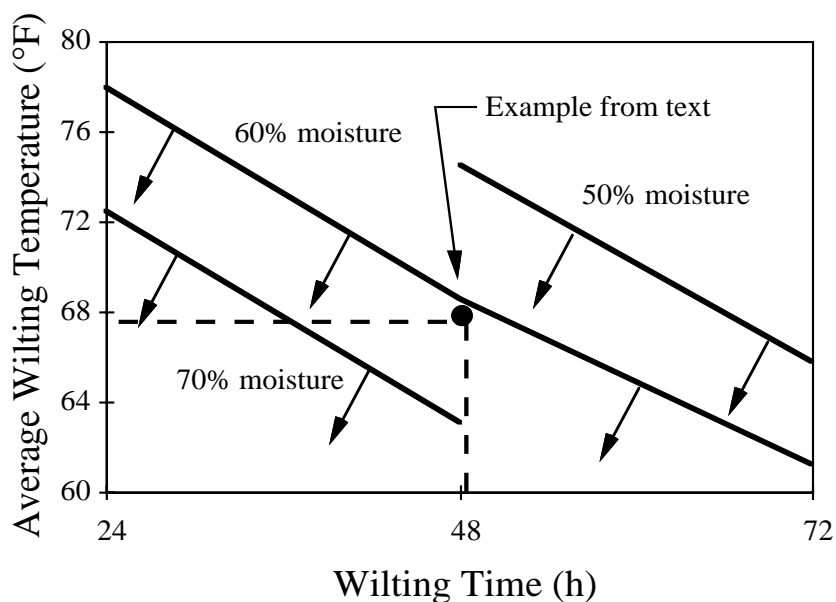


Figure 1. Graphical illustration of those conditions for which inoculation of alfalfa silage is generally profitable. Inoculate when wilting time and average temperature during wilting fall below or to the left of the relevant curve.

## Summary

Inoculants are generally effective with:

- cooler wilting temperatures
- 50% to 70% moisture content
- 100,000 ( $10^5$ ) or higher cfu/g addition
- shorter wilting times ( 24 hours or less )

Inoculants aren't generally effective with:

- low sugar content in plants
- low level of cfu/g addition
- long wilting times

Bacterial inoculants for silage can boost profits if used properly. By evaluating the weather conditions and the wilting time for the cut crop, inoculants can be used when there is a very good chance of their success.

## Reference

Pitt, R. E., 1990. *The probability of inoculant effectiveness in alfalfa silages*. Trans. of the ASAE 33(6): 1771-1778.

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