Use of Inoculants in Corn Silage

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Inoculating a forage crop with specific bacteria prior to ensiling can boost the population of desirable species, which may result in better fermentation, aerobic stability, and animal performance. The inoculant industry has grown to the point that the number and diversity of inoculant products available can be overwhelming. This article summarizes inoculant types and benefits as well as provides guidance on what types might be helpful in your corn silage crop.

Homofermentative LAB. The earliest commercial inoculants consisted solely of homofermentative Lactic Acid Bacteria (LAB). Examples include *Lactobacillus plantarum*, *Enterococcus faecium*, and select *Pediococcus* species. They take sugars and convert them to a single product – lactic acid – without CO_2 or other undesirable byproducts evolving. They grow quickly and lower pH, suppressing undesirable and spoilage organisms quickly. They produce minimal waste (e.g., shrink) and conserve more energy.

Despite their strengths, homofermenters alone don't solve all of the issues associated with making corn silage. Often, inoculating with LAB does not necessarily improve silage quality. Corn plants often have enough naturally occurring LAB on their surface, to support adequate fermentation. Inoculation with homofermentative LAB can even decrease aerobic stability when compared to uninoculated corn silage. This makes sense when we consider that lactic acid alone does a poor job of inhibiting yeasts and molds contributing to aerobic deterioration of silage. If inoculation with homofermentative LAB shifts the acid profile too far from acetic acid production in favor of lactic acid, then decreased aerobic stability may be a consequence.

Heterofermentative LAB. In contrast, heterofermentative LAB are less rigid and can produce a variety of fermentation products. Commercial heterofermenters primarily produce lactic and acetic acid, but the amount and ratios of fermentation products depend on species and strain. They generally ensile more slowly than homofermenters and produce some undesirable byproducts, including carbon dioxide. Loss of dry matter as CO_2 is the primary reason for silage "shrink," and is also a source of energy loss. Sometimes ethanol can also be produced, but it is generally lost from the face after opening the silo, representing a loss of energy. When undesirable products are minimal, heterofermenters can impart increased aerobic stability, but will not lower pH as much as homofermenters. Historically, several species of heterofermenters appeared in commercial inoculants, but by far the most common today are strains of *Lactobacillus buchneri*.

L. buchneri avoids many of the negative qualities of other heterofermenters since it uses a unique metabolic pathway. Discovered in the mid-'90s, it slowly converts a small portion of the lactic acid in a preserved crop to acetic acid and 1, 2-propanediol. This process does not produce significant waste and both acetic acid and 1, 2-propanediol contribute to aerobic stability and can prevent silage heating for several days following oxygen exposure. Unfortunately, this conversion of lactic acid only begins after ensiling has progressed enough for sufficient lactic acid to be produced in the silo. Consequently, *L. buchneri*-inoculated silage needs at least 45-60 days to have an increase in aerobic stability.

Mixed LAB. There's no need to choose between hetero- or homo-fermentative LAB species. Many inoculants are formulated with both, sometimes containing a handful of different species. Most commonly, we see the pairing of a fast, efficient homofermenter with the slower *L. buchneri* to provide a rapid pH decrease and maximum aerobic stability. While this seems like an ideal solution, it is not necessarily optimal. A recent review in the *Journal of Dairy Science* found several studies demonstrate that mixed inoculants often, but not always, perform better than the native LAB in uninoculated silages. These silages sometimes perform worse than those inoculated solely with *L. buchneri*.

Should I inoculate my corn silage? This will depend on region, management, economics, weather, risk aversion, etc. Research alone can't answer this, but it can guide decision-making. Inoculation can have an effect on initial ensiling, aerobic stability, and animal performance – each should be weighed when deciding on an inoculant.

For corn silage, available evidence suggests inoculation does not provide noticeable benefit to silage quality during initial ensiling. Native LAB population on the forage surface is often more than equal to the task of ensiling under ideal conditions. It is important to remember, potential benefits of inoculation are greater in cases where sub-optimal conditions (poor yield, wet year) inhibit the native LAB population and/or favor spoilage organisms like clostridia, yeasts, and molds.

Corn silage aerobic stability can be influenced by inoculation. Benefits are largely conferred by *L. buchneri*, but benefits from *L. hilgardii* and *L. brevis* have also been observed. While inoculation is not a guaranteed benefit, it is generally accepted that *L. buchneri*, alone or in a mix, can increase aerobic stability, but dose is important. A meta-analysis reported corn silage stability was 25 hours when uninoculated, 35 hours when inoculated with 100,000 cfu or less *L. buchneri*/g of fresh forage, and an impressive 503 hours when inoculated above 100,000 cfu/g of fresh forage *[J. Dairy Sci. (2006) 89:4005-4013]*. In many cases, inoculation with *L. buchneri* alone produced the best results, but outcomes depended on the native LAB community, which is difficult to predict.

I've written previously about the animal performance benefits of silage inoculation *[Forage Focus August (2019)]*. This is still an active area of research, but a meta-analysis of previously published studies revealed significant and consistent improvements in milk yield and numerical increases in milk fat and protein associated with bacterial inoculation of ensiled forages *[J. Dairy Sci. (2017) 100:4587-4603]*. Studies detailing animal-performance benefits largely focus on homofermentative inoculants. There have been too few feeding trials using silage made with mixed inoculants to draw solid conclusions at this time.

Ultimately, when it comes to making a decision about whether or not to inoculate corn silage, be sure to consider the conditions that year, how important aerobic stability is to you, and if potential animal performance benefits might tip your cost:benefit calculations. If you are consistently getting good, uninoculated fermentation in your corn silage, but want to reduce yeasts and molds and increase aerobic stability, adding an *L. buchneri* inoculant will likely help. If you want to hedge your bets because you're concerned about a wet spring, a mixed inoculant might help and shouldn't hurt.