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DS11

Bacterial Inoculants and Enzyme Additives [1]

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Can buying large amounts of bacteria or powerful enzymes help increase your farm profit? Many companies selling them think so. Manufacturers of bacterial inoculants and concentrated enzymes claim these products improve the quantity and quality of the final product when added to the forage before ensiling.

If forages are to be preserved for silage, two main goals are: 1) to create and maintain an oxygen-free environment and 2) to have enough lactic acid produced during the fermentation to preserve or pickle the crop. Fermentation aids are designed to help accomplish both goals.

Production of lactic acid depends upon the presence of bacteria that produce lactic acid and an adequate supply of quickly digestible carbohydrates that those bacteria use as a food source to produce lactic acid. Silage fermentation aids contain one or a combination of the following features:

- lactic acid-producing bacteria,
- the quickly digestible carbohydrates bacteria require
- other nutrients required by bacteria
- enzymes and/or microorganisms that increase the availability of easily digestible carbohydrates.

Lactic Acid Production

Use of these products is based on the assumption that lactic acid is not produced quickly enough and in sufficient quantities under natural conditions to obtain efficient fermentation. Under "normal" conditions, bacterial numbers are not limiting. The lactic acid bacteria in plant juices found on the chopper, wagon, blower and pipes during ensiling result in excellent numbers being added to the forage as it is packed. However, there may be times when bacterial numbers are potentially limiting. If so, what are the circumstances and what positive results would be expected if fermentation aids were used?

Benefits (agronomic, nutritional and economic) are often determined by a number of factors, such as the type of forage being ensiled, its moisture content, ensiling practices, the type of silo, the method of application of the additive, the rate of feeding and even the weather. As a result, fermentation aids should be tested over a variety of on-farm circumstances.

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Table 1 contains information gathered from numerous farm experiments around the United States over the past nine years using three forage crops: corn plants, alfalfa and forage sorghum. The silage additives did not give consistent results from one location to another. Therefore, the results from the locations are averaged. Three criteria are shown to evaluate the effectiveness of enzymatic or bacterial inoculant type fermentation aids. They are: 1) ensiling temperature - the lower the temperature, the less threat of heat damage to the forage; 2) loss of dry matter during ensiling, representing total losses from respiration, fermentation, effluent, surface waste and aerobic deterioration prior to feeding; and 3) animal performance - do animals gain weight better or give more milk when they consume inoculated versus uninoculated silages?

Dry Matter Loss Decrease

The fermentation aids were not able to effectively limit the rise in silage temperature (Table 1). However, they did reduce dry matter losses so that more silage was left to feed after the fermentation process had ended. This increase was 2.0% for alfalfa [(85.5- 83.8)/83.8], 2.6% for corn silage [(89.9-87.6)/87.6] and 3.6% for forage sorghum [(88.2 -85.1)/85.1].

Treated silages also resulted in cattle gaining more weight per pound of 100% dry feed consumed. Putting together the improvements in dry matter recovery and feed efficiency results in net improvements of 3.9% for corn silage, 6.3% for alfalfa haylage and 8.7% for sorghum silage when fermentation aids are used. An example calculation for sorghum silage is the following based on 1 ton of silage at 35% dry matter (DM):

Untreated Silage

2000 lb of silage x 35% DM = 700 lb of DM

700 lb of DM x 85.1% recovery of DM = 596 lb of DM

596 lb of DM ÷ 19.3 lb of DM per lb of gain = 30.9 lb of gain

Treated Silage

2000 lb of DM x 35%DM = 700 of DM

700 lb of DM x 88.2% recovery of DM = 617 lb of DM

617 lb of DM ÷ 18.4 lb of DM per lb of gain = 33.6 lb of gain

Improvement

33.6 lb of gain - 30.9 lb of gain = 2.7 lb advantage for treated silage

2.7 lb + 30.9 lb = 8.7% advantage for treated sorghum silage

Therefore, one can possibly expect 8.7% more live weight gain per ton of sorghum silage harvested when the sorghum receives an effective silage additive.

Bacterial inoculants and enzymes have not been as extensively tested with lactating cows as they have with growing animals. In four studies done in Michigan and Wisconsin in which alfalfa-grass silage was fed at about 60%of the ration, enzyme additives were evaluated. The silage treated with the enzyme provided 4.8% more milk per dry pound of feed consumed than the untreated alfalfa haylage.

While a positive response is being demonstrated, what is the economic picture? The value of silage in the silo in Florida will range from $17 to $40 per wet ton, depending on kind, yield and moisture level. Additives may cost from a few cents to a few dollars per ton of silage. Table 2 shows the needed increase in feed value in order to pay for the additive based on the value of the silage and the cost of the additive. As indicated in Table 2 , if an additive costing 80 cents per ton of ensiled forage is added to a silage that is worth $27 per ton, an increase of 3.0% in feed value is needed in order to pay for the additive.

The use of fermentation aids is not always warranted. When proper silage-making procedures are used, the potential improvement from these additives is lessened. Consider using fermentation aids when ensiling overly wet forages. This extra water dilutes out the ability of the bacteria to ferment

the forage. Corn silage and sorghums should be ensued at a moisture level between 63 and 68% and grass haylage should be ensiled between 45 and 60% moisture.

Aids can be useful when ensiling in bunk or trench silos. Physical packing of the forage to exclude unwanted air is more difficult than when using tower silos. Therefore, it takes longer to get the proper bacteria started.

Silage fed only once per day during hot weather conditions can spoil in less than 24 hours. Less than ideal ensiling practices such as filling a silo over a period of weeks rather than days and improper covering and sealing of a silo may decrease expected silage quality. Inoculants may help produce a more acidic silage that may prolong the "shelf life" of the silage. This is, however, speculative.

Guidelines for Selection

1. Ask the salesperson for data from independent sources that prove effectiveness. There are far too many commercial products in the US that have not been adequately tested.

2. The bacteria must be alive. Many companies guarantee this while others do not. Those kept frozen or refrigerated are more stable than those kept at room temperatures.

3. The bacterial inoculants must be added to the forage to provide a minimum of 100,000 colony-forming units (cfu) per gram of fresh forage.

4. Inoculants containing more than one of the species *Lactobacillus, Streptococcus and Pediococcus* offer a greater potential as fermentation aids than inoculants containing only a single or different species.

5. Adding the fermentation aid in a liquid form is more likely to provide a more even coverage over the forage than applying it in a dry form.

Silage inoculants cannot replace good harvesting and ensiling practices. Their use during times of optimum ensiling conditions with most major forages is probably not warranted. However, they can possibly provide an advantage during times when conditions are not ideal.

Table 1.

Table 1. The effect of bacterial inoculants and enzymes on the ensiling process and subsequent silage feeding value.

Treatment		Rise in Silage temperature (F)	Dry matter recovery (%)	Animal performance*	
				ADG	F/G
Alfalfa					
	None	48	83.8	1.87	19.7
	Additives	48	85.5	2.04	18.9
Corn Silage					
	None	48	87.6	2.44	16.1
	Additives	45	89.9	2.49	15.9
Forage sorghum					
	None	50	85.1	1.76	19.3
	Additives	47	88.2	1.83	18.4

*ADG, average daily gain in pound per day; F/G, pounds of dry feed (F) consumed per pound of gain (G).

Table 2.

Table 2. Percentage increase in feed value necessary to pay for the cost of an additive.

Cost of additive per ton of wet silage ($)	Increases at various silagevalues (%)				
	$17	$22	$27	$32	$37
.40	2.4	1.8	1.5	1.3	1.1
.60	3.5	2.7	2.2	1.9	1.6
.80	4.7	3.6	3.0	2.5	2.2
1.00	5.9	4.5	3.7	3.1	2.7
1.20	7.1	5.5	4.4	3.8	3.2