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Abstract

Fourteen commercial silage inoculants were evaluated in 32 trials using nine different crop species harvested in 1987 and ensiled in PVC laboratory silos. Microorganism profiles of the crops showed high numbers of lactic acid bacteria (LAB) in all but one trial. Most inoculants supplied relatively high numbers of LAB per gram of crop--52 of the 66 inoculant samples supplied more than 10 (100,000) viable LAB per gram. The forage crops--wheat, bromegrass, sudangrass, and alfalfa--were highly responsive to the inoculants. When compared to untreated silages, treated silages had lower pH, acetic acid, ethanol, and ammonia-nitrogen values and higher lactic acid content. In general, late summer- and early autumn-harvested row crops--corn, grain sorghum, forage sorghum, and high moisture shelled corn--ensiled rapidly, and most inoculants had limited effect on the rate and efficiency of fermentation.

Keywords

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Effect of Commercial Inoculants on Fermentation of 1987 Silage Crops

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Summary

Fourteen commercial silage inoculants were evaluated in 32 trials using nine different crop species harvested in 1987 and ensiled in PVC laboratory silos. Microorganism profiles of the crops showed high numbers of lactic acid bacteria (LAB) in all but one trial. Most inoculants supplied relatively high numbers of LAB per gram of crop--52 of the 66 inoculant samples supplied more than 10^5 (100,000) viable LAB per gram.

The forage crops--wheat, bromegrass, sudangrass, and alfalfa--were highly responsive to the inoculants. When compared to untreated silages, treated silages had lower pH, acetic acid, ethanol, and ammonia-nitrogen values and higher lactic acid content.

In general, late summer- and early autumn-harvested row crops--corn, grain sorghum, forage sorghum, and high moisture shelled corn--ensiled rapidly, and most inoculants had limited effect on the rate and efficiency of fermentation.

Introduction

Our objective was to continue evaluating how commercial inoculants affect the rate and efficiency of silage fermentation. We included 32 crops to provide a much wider range of ensiling conditions than in our previous studies (KAES, Reports of Progress 494 and 514).

Experimental Procedures

The 14 inoculants evaluated and active ingredients as listed by the manufacturer or distributor are shown in Table 39.1. All silages were made from crops grown near Manhattan in 1987. A description of the crops used, harvest dates, and chemical compositions are presented in Table 39.2.

The laboratory silos were 4 x 14 inch PVC pipes closed with Jim-Caps on each end. One Jim-Cap was fitted with a Bunsen valve to allow gases to escape. For filling, 100 to 125 lbs of fresh crop were placed on a plastic sheet, and the inoculant was applied and mixed thoroughly. All inoculants, except Silagest, were applied as liquids and all were used within 3 to 4 weeks after being received from the manufacturer. After all silage treatments were prepared, the silos were filled on an alternating schedule, which distributed the time from harvest through silo filling equally across all treatments. The silos were packed with a hydraulic press, which excluded air and filled all silages to similar densities. Silos were stored at approximately 85 F. Three silos per treatment were opened at various times post-filling during the first week, and end-product silages were evaluated at 42 or 90 days.

Chemical Analyses of the Pre-ensiled Crops and Silages. Pre-ensiled crops were analyzed for dry matter (DM), pH, total nitrogen, water soluble carbohydrates, acid detergent fiber, neutral detergent fiber, and buffer capacity. Silages fermented from 6 hours to 7 days were analyzed for pH and lactic acid; end-product silages (42 or 90 days), for pH, lactic acid, volatile fatty acids, total nitrogen, and ammonia-nitrogen.

Microbiological Evaluations. Post-harvested, pre-ensiled samples of the crops and inoculants were weighed, mixed in a high-speed blender, and diluted in sterile buffer. The following microorganism counts were made after appropriate dilutions with sterile buffer:

Mesophilic count. That count provided an index of the number of aerobic and facultative anaerobic bacteria. Samples were added to Standard Plate Count agar (DIFCO) and incubated for 3 days at 32 C.

Yeast and mold count. Potato Dextrose agar was used with tetracycline and chloramphenicol (100 ug/ml each) to kill bacteria. The plates were incubated at 21 C for 3 days.

Lactic acid bacteria count. This measured the natural populations of lactic acid bacteria (LAB) present on the crops and the LAB provided by inoculants at the time they were applied to the crops. Samples were added to Bacto Lactobacilli MRS Broth to which 1.5% Agar (Difco) was added and incubated 3 days at 32 C.

All counts were converted to colony-forming units per gram of crop or per gram or ml of inoculant.

Statistical Analyses. Mean responses of each inoculated crop were compared to the mean response of the untreated (control) crop by the analyses of variance procedure for a complete block design.

Results and Discussion

Presented in Tables 39.3 to 39.7 are the microorganism profiles of the crops and number of LAB supplied to the pre-ensiled corp by the inoculants used in the 32 trials. Presented in Tables 39.8 to 39.16 and Figures 39.1 to 39.2 are silage fermentation results over time for the 32 crops and 53 of the 66 inoculant vs. control comparisons made in 1987. Results from Trials 11 through 32 are preliminary and inoculant effects on the ensiled crops are limited to pH and lactic acid data.

Trials 1 to 5. Wheat, sudangrass, and bromegrass all had relatively high numbers of LAB on the pre-ensiled forage, but all five were highly "responsive" to the inoculants (Table 39.8; 39.9; and 39.10). With few exceptions, the inoculated silages had significantly lower pH and higher lactic acid values than control silages at every opening time. End product-inoculated silages had lower ($P<.05$) pH, acetic acid, ethanol, and ammonia-nitrogen values and higher ($P<.05$) lactic acid content than control silages. Inoculants that provided less than 10^5 LAB per gram of crop did not increase the fermentation rate as fast as those that provided 10^5 or more per gram.

In Trial 1, Medipharm Soluble, which supplied the greatest number of LAB per gram of crop (420,000), gave the fastest drop in pH and highest lactic acid production during the first 48 hours (Figures 39.1 and 39.2). However, there was no relationship between number of LAB and rate of fermentation for the inoculants that supplied 140,000 to 310,000 per gram. Pioneer 1174, which provided 140,000 per gram, gave the second lowest pH and second highest lactic acid values among the inoculated silages at 48 hours post-filling.

Trials 6 to 13. The eight alfalfa crops harvested between June 19 and November 11 represented a wide range of ensiling conditions--DM content ranged from 32.5 to 53.3%; crude protein, from 17.1 to 24.4%; acid detergent fiber, from 18.7 to 34.1%; buffer capacity, from 42.6 to 68.6 milliequivalents; and water soluble carbohydrates, 3.5 to 7.5 percent. The pre-ensiled material had 10^5 or more LAB per gram, with alfalfa in Trial 10 being the only exception.

All 11 inoculants increased the rate and efficiency of the silage fermentation in the eight trials (Tables 39.11 to 39.13). In general, the untreated-control alfalfa silages fermented much slower than was expected, and rate of pH drop and lactic acid production appeared to be influenced more by crop DM content than by numbers of LAB present on the crop or buffer capacity. With very few exceptions, end product-inoculated alfalfa silages had lower ($P<.05$) pH, acetic acid, ethanol, and ammonia-nitrogen values and higher ($P<.05$) lactic acid content than control silages.

In Trial 9, Medipharm Soluble provided the greatest number of LAB per gram of alfalfa (320,000) and produced the most rapid fermentation during the first 4 days. Biomate, which provided 100,000 per gram, gave the second lowest pH and highest lactic acid values, even though five inoculants provided greater numbers of bacteria.

Trials 14 to 20. The seven whole-plant corns were all low "response" crops, which underwent extremely rapid fermentations (Table 39.14). All 14 silages were at or below a pH of 4.2 by 24 hours and a pH of 4.0 by 48 hours post-filling. The three inoculants, Medipharm Soluble, Ecosyl, and Biomate, provided 10^5 to 10^6 LAB per gram of crop (i.e., 100,000 to 1,000,000 bacteria), but the pre-treated crops already contained from 5×10^5 to 1.5×10^7 per gram, which was up to 15 times more LAB than the number provided by the inoculants.

Trials 21 to 23 and 29 to 32. The three high moisture shelled corns ranged from 24.6 to 34.0% moisture, and the pre-treated grain had relatively high numbers of LAB (over 1,000,000 per gram). The wetter corns ensiled rapidly, with pH dropping below 5.0 by 48 hours (Table 39.15). Although Pioneer 1186 inoculant supplied 500,000 LAB per gram in Trial 22, it did not influence the rate of pH decline. The drier corn in Trial 23 fermented very slowly, with the untreated corn still above pH 5.4 after 7 days. The inoculated shelled corns had significantly lower pH values than the control, beginning at 48 hours post-filling for Medipharm Soluble and 4 days for Pioneer 1186.

The grain sorghum and sorghum and soybeans all had high LAB populations, ranging from 1.5 to 12 million bacteria per gram of pre-treated crop. In spite of the high LAB counts, Biomate increased the rate of pH decline during the first 4 days post-fillings (Table 39.15).

Trials 24 to 28. The five forage sorghums were generally low "response" crops, characterized by high LAB numbers on the pre-treated material. The sorghums did not ensile as rapidly as the whole-plant corns, likely because of cooler initial temperatures and higher buffer capacities for the sorghums. Five of the six inoculants used supplied at least 10^5 LAB per gram of crop and, in four of the five trials, inoculants gave lower pH and higher lactic acid values ($P<.05$) during the first 4 days post-filling (Table 39.16).

Our studies the previous two years indicated that if a silage crop had a high number of lactic acid bacteria present at harvest (500,000 or more per gram), adding more with an inoculant was unlikely to affect the ensiling rate (KAES, Report of Progress 514). The corn and sorghum crops ensiled in Trials 14 to 32 had an average initial LAB count of over 5,000,000 per gram, and, as expected, most untreated controls ensiled almost as rapidly as the inoculated crops. However, the hay crops ensiled in the first 13 trials also had an average initial LAB count of over 1,000,000 per gram, yet all untreated controls ensilied much slower than inoculated forages.

Knowing only the numbers of LAB present on the crop will not always predict the rate and efficiency of silage fermentation. It is essential that the microbial population be identified, that the ratio of homofermentative (single product fermentation) to heterofermentative (multiple product fermentation) bacteria be determined, and that the growth characteristics of the bacterial strains be differentiated in a silage environment. Other factors including crop characteristics (i.e., dry matter and fermentable carbohydrate content, buffer capacity, physical structure), silage management techniques (i.e., chopping length, packing density, sealing), and climatic conditions (i.e., growing season, air temperature, humidity) will play a role in silage fermentation and response to inoculants.

Table 39.1. List of the 14 Inoculants Evaluated in the 32 Trials, Their Manufacturer or Distributor, and Their Lactic Acid Bacteria Content

Inoculant	Manufacturer or Distributor	Lactic Acid Bacteria
AGMASTER® ALFALFA SILAGE INOCULANT (AgMaster)	Marschall Products Division of Miles Laboratories, Madison, Wisconsin	*Lactobacillus plantarum* and *Pediococcus acidilactici*
BIOMATE LAB CONCENTRATE (Biomate)	Chr. Hansen's Laboratory, Inc., Milwaukee, Wisconsin	*L. plantarum* and *P. cerevisiae*
BIOPOWER	BioTechniques Laboratories, Inc., Redmond, Washington	*Streptococcus faecium* and *L. plantarum*
BTA SILAGE INOCULANT (BTA)	BioTechnica Agriculture, Inc., Overland Park, Kansas	*L. plantarum* and *P. acidilactici*
DEL-N-SILE	Deltown Chemurgic, Fraser, New York	*L. plantarum* and *S. faecium*
ECOSYL	C-I-L Inc., London Ontario, Canada	*L. plantarum*
MEDIPHARM SOLUBLE (Medipharm)	Medipharm USA, Des Moines Iowa	*S. faecium* M-74, *L. acidophilus*, *Pediococcus sp.*, and *L. plantarum*
PIONEER BRAND 1186 HIGH MOISTURE CORN INOCULANT (1186)	Pioneer Hi-Bred International, Inc., Des Monies, Iowa	*L. plantarum* (multiple strains) and *S. faecium*
PIONEER BRAND 1174 WATER SOLUBLE SILAGE INOCULANT (1174)	Pioneer Hi-Bred International, Inc., Des Monies, Iowa	*L. plantarum* (multiple strains) and *S. faecium*
ROHACENT® (7057)	Rohm Tech, Inc., Malden, Massachusetts	*L. plantarum*
SILAGEST	InterBio, Inc., Naperville, Illinois	*L. plantarum*, *L. acidophilus*, *L. bulgaricus*, *L. coryniformis*, *S. thermophilus*, and *P. acidilactici*
SI CONCENTRATE 40 A/F	Great Lakes Biochemical Co., Inc., Milwaukee, Wisconsin	*L. plantarum*, *L. brevis*, *P. acidilactici*, *S. cremoris*, and *S. diacetylactis*
TRILAC	QualiTech, Inc., Chaska, Minnesota	*L. plantarum* and *P. cerevisiae*
XEROFERM	Xeroferm Laboratories, Portland, Oregon	*L. plantarum*, *S. faecium*, and *Pediococcus sp.*

Table 39.2. Description, Harvest Date, and Chemical Composition for the Crops Used in 32 Trials[1,2]

Trial No., Crop Description, Harvest Date (1987) and DM (%)	Chemical Composition			
	CP	ADF	BC	WSC
1. Newton wheat; flowering stage; May 15; 35.7	13.9	35.0	32.4	9.6
2. Arkan wheat; hard-dough stage June 4; 41.0	10.9	31.4	27.3	9.2
3. Bounty 205 hybrid wheat; soft-dough stage; June 4; 37.5	11.3	29.9	26.8	10.2
4. Trudan hybrid sudangrass; vegetative stage; July 23; 35.6	14.6	27.2	50.9	13.5
5. First cutting bromegrass; heading stage; June 5; 46.3	---	---	31.5	---
6. Second cutting alfalfa; June 19; 32.5	20.7	33.7	52.6	5.4
7. Second cutting alfalfa; July 6; 51.0	18.1	34.1	53.1	7.4
8. Third cutting alfalfa; July 10; 40.5	---	---	54.8	7.7
9. Third cutting alfalfa; July 31; 39.6	---	---	54.5	4.7
10. Fourth cutting alfalfa; Aug. 22; 42.5	23.6	23.7	42.6	---
11. Fifth cutting alfalfa; post-frost; Oct. 6; 53.3	23.3	22.8	60.1	9.6
12. Fifth cutting alfalfa; post-frost; Oct. 14; 41.4	24.4	18.7	68.6	11.1
13. Fifth cutting alfalfa; post-hard freeze; Nov. 11; 45.0	17.1	29.2	59.8	7.6
14. Hoegemeyer 2689 corn; early-dent stage; Aug. 6; 37.0	6.3	23.9	18.9	8.0
15. Hoegemeyer 2689 corn; early-dent stage; Aug. 7. 36.2	6.9	23.8	21.0	7.0
16. Hoegemeyer 2689 corn; early-dent stage; Aug. 8; 36.1	6.5	25.1	18.4	5.5
17. Ohlde 0-230 corn; mid-dent stage; Aug. 11; 39.0	6.3	24.6	19.8	7.7
18. Ohlde 0-230 corn; mid-dent stage; Aug. 12; 41.2	6.3	24.8	20.4	6.0

Table 39.2. con't.

Trial No., Crop Description, Harvest Date (1987) and DM (%)	Chemical Composition			
	CP	ADF	BC	WSC
19. Pioneer 3183 corn; mid-dent stage; Aug. 19; 37.5	6.0	23.8	18.3	8.6
20. Pioneer 3183 corn; mid-dent stage; Aug. 20; 38.5	6.2	23.6	20.0	8.9
21. High moisture rolled shelled corn; Aug. 21; 34.0	---	---	---	---
22. High moisture rolled shelled corn, Aug. 22; 28.5	---	---	---	---
23. High moisture ground shelled corn; post-hard freeze; Sept. 30; 24.6.	9.8	---	---	---
24. DeKalb FS-5 forage sorghum Aug. 28; 28.8	---	---	26.6	---
25. Pioneer 947 forage sorghum; Sept. 4; 35.2	---	---	27.7	---
26. Funk's 102 F forage sorghum; Sept. 23; 30.5	7.0	28.0	26.5	12.4
27. DeKalb 25E forage sorghum; post-frost; Oct. 8; 32.8	6.0	30.0	23.3	---
28. DeKalb 25E forage sorghum post-frost; Oct. 13; 34.0	7.0	28.4	25.2	---
29. DeKalb 42Y grain sorghum (late-milk stage) and Pershing soybeans; drilled inter-seeding; Aug. 17; 34.9	12.8	---	29.0	---
30. DeKalb 42Y grain sorghum (late-dough stage) and Pershing soybeans; drilled inter-seeding; Aug. 23; 36.6	11.8	---	31.0	---
31. DeKalb 42Y grain sorghum (late-dough stage) and Pershing soybeans; 15-inch alternate row interseeding; Aug. 22; 34.4	16.9	---	25.2	---
32. DeKalb 42Y grain sorghum; late-dough stage; Aug. 22; 33.0	10.4	---	23.4	---

[1]DM = Dry matter; CP = crude protein as a % of the crop DM; ADF = acid detergent fiber as a % of the crop DM; BC = buffer capacity as milliequivalents of NaOH/100g of crop DM; WSC = water soluble carbohydrates as a % of the crop dry matter.

[2]All forage sorghums in Trials 24 to 28 were harvested at the late-dough stage of maturity.

Table 39.3. Microorganism Profile of the Crop and Numbers of Lactic Acid Bacteria Supplied to the Pre-ensiled Crop by the Inoculants used in the Wheat, Sudangrass, and Bromegrass Trials

	Wheat			Sudan-grass	Brome-grass
Item	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Microbes:	CFU[1]/gram of Crop				
Mesophilic	$1.4x10^8$	$2.7x10^8$	$2.7x10^8$	$5.7x10^7$	$7.4x10^7$
Lactic Acid Bacteria	$9.5x10^5$	$5.0x10^6$	$8.2x10^5$	$7.5x10^6$	$4.6x10^6$
Yeast and Mold	$1.0x10^5$	$5.1x10^5$	$4.4x10^5$	$7.5x10^3$	$5.0x10^3$
Inoculant:	CFU of LAB[2] supplied/gram of Crop				
AgMaster	$2.1x10^5$	---	---	---	---
Biomate	$1.6x10^5$	$1.1x10^5$	$1.1x10^5$	$1.5x10^5$	$1.4x10^5$
BioPower	$3.1x10^5$	---	---	---	---
1174	$1.4x10^5$	$6.3x10^4$	$6.3x10^4$	$1.4x10^5$	---
7057	$1.5x10^5$	---	---	---	---
SI Conc	$8.7x10^4$	$1.1x10^5$	$1.1x10^5$	$8.0x10^4$	---
Medipharm	$4.2x10^5$	---	---	---	---
Xeroferm	$5.4x10^3$	$2.3x10^4$	$2.3x10^4$	$1.7x10^4$	---

[1]Colony-forming units.
[2]Lactic acid bacteria.

Table 39.4 Microorganism Profiles of the Pre-ensiled Crop and Numbers of Lactic Acid Bacteria Supplied to the Crop by the Inoculants Used in the Alfalfa Trials

Item	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11	Trial 12	Trial 13
Microbes:	CFU[1]/gram of Crop							
Mesophilic	$3.8x10^7$	$6.2x10^7$	$6.9x10^7$	$2.8x10^7$	---	$3.4x10^7$	$1.0x10^7$	$5.1x10^7$
Lactic Acid Bacteria	$6.2x10^5$	$5.6x10^6$	$4.0x10^6$	$8.6x10^5$	$4.0x10^3$	$9.0x10^5$	$9.0x10^5$	$1.0x10^5$
Yeast and Mold	$7.0x10^3$	$5.1x10^4$	$4.1x10^4$	$2.5x10^4$	---	$2.7x10^4$	$2.8x10^4$	$4.8x10^4$
Inoculant:	CFU of LAB[2] supplied/gram of Crop							
AgMaster	---	---	---	$1.8x10^5$	---	---	---	---
Biomate	---	---	---	$1.0x10^5$	$1.5x10^5$	---	---	---
BioPower	---	---	---	$2.5x10^5$	---	---	---	---
BTA	---	---	---	---	---	---	---	$2.8x10^5$
Del-N-Sile	$6.5x10^5$	---	---	---	---	---	---	---
Ecosyl	$2.9x10^5$	---	---	$2.2x10^5$	---	---	$1.1x10^6$	---
1174	---	---	---	$1.3x10^5$	---	---	---	---
SI Conc	---	$8.8x10^4$	$1.1x10^5$	$2.7x10^5$	---	$5.8x10^5$	---	---
Medipharm	---	---	---	$3.2x10^5$	---	---	---	---
TriLac	$2.9x10^5$	---	---	---	---	---	---	---
Xeroferm	---	$2.0x10^4$	---	$2.5x10^4$	---	---	---	---

[1]Colony-forming units.

[2]Lactic acid bacteria.

Table 39.5. Microorganism Profile of the Pre-ensiled Crop and Numbers of Lactic Acid Bacteria Supplied to the Crop by the Inoculants Used in the Whole-crop Corn Trials

Item	Trial 14	Trial 15	Trial 16	Trial 17	Trial 18	Trial 19	Trial 20
Microbes:	-----------CFU[1]/gram of Crop-----------						
Mesophilic	$8.4x10^7$	$1.4x10^9$	$1.0x10^8$	$1.7x10^8$	$1.6x10^8$	---	---
Lactic Acid Bacteria	$9.4x10^6$	$8.4x10^6$	$1.5x10^7$	$1.2x10^7$	$9.0x10^6$	$5.0x10^5$	$5.8x10^6$
Yeast and Mold	$3.6x10^5$	$8.5x10^5$	$2.0x10^6$	$6.8x10^5$	$5.6x10^5$	$1.2x10^6$	---
Inoculant:	-----------CFU of LAB[2] supplied/gram of Crop-----------						
Biomate	---	---	---	---	---	$1.5x10^5$	$1.5x10^5$
Ecosyl	---	---	---	$1.0x10^5$	$1.5x10^5$	---	---
Medipharm	$5.0x10^5$	$5.2x10^5$	$1.5x10^6$	---	---	---	---

[1]Colony-forming units.

[2]Lactic acid bacteria.

Table 39.6. Microorganism Profile of the Pre-ensiled Crop and Numbers of Lactic Acid Bacteria Supplied to the Crop by the Inoculants used in the High Moisture Shelled Corn and Forage Sorghum Trials

Item	High Moisture Corn			Forage Sorghum				
	Trial 21	Trial 22	Trial 23	Trial 24	Trial 25	Trial 26	Trial 27	Trial 28
Microbes:	-----	-----	-----	----- CFU[1]/gram of Crop -----	-----	-----	-----	-----
Mesophilic	$6.8x10^7$	$6.2x10^7$	$2.8x10^7$	$3.4x10^7$	$4.4x10^7$	$9.3x10^7$	$5.1x10^7$	$2.0x10^7$
Lactic Acid Bacteria	$3.2x10^6$	$1.4x10^6$	$9.0x10^6$	$4.4x10^5$	$5.8x10^6$	$4.3x10^6$	$1.4x10^5$	$1.5x10^6$
Yeast and Mold	$3.2x10^5$	$3.5x10^5$	$5.5x10^4$	$5.5x10^4$	$4.0x10^4$	$3.5x10^5$	$2.9x10^5$	$6.2x10^4$
Inoculants:	-----	-----	-----	----- CFU of LAB[2] supplied/gram of Crop -----	-----	-----	-----	-----
Biomate	---	---	---	$1.8x10^5$	$1.7x10^5$	---	---	$2.7x10^5$
Ecosyl	---	---	$4.4x10^4$	---	---	---	---	---
1174	---	---	---	$1.3x10^5$	---	---	---	$1.8x10^5$
1186	$2.4x10^5$	$5.0x10^5$	$2.4x10^5$	---	---	---	---	---
Silagest	---	---	---	---	---	---	$2.0x10^6$	---
SI Conc	---	---	---	$3.1x10^5$	---	---	---	$1.5x10^5$
Medipharm	---	---	$4.6x10^6$	---	---	---	---	---
TriLac	---	---	---	---	---	$4.6x10^5$	---	---
Xeroferm	---	---	---	$1.8x10^4$	---	---	---	$1.5x10^4$

[1]Colony-forming units.

[2]Lactic acid bacteria.

Table 39.7. Lactic Acid Bacteria Profile of the Pre-ensiled Crop and Numbers of LAB supplied to the Pre-ensiled Crop by the Inoculants Used in the Grain Sorghum and Soybean Trials

Item	Grain Sorghum and Soybeans			Grain Sorghum
	Trial 29	Trial 30	Trial 31	Trial 32
	-----	----- CFU[1]/gram of Crop -----	-----	-----
Lactic Acid Bacteria	$1.2x10^7$	$4.5x10^6$	$8.1x10^6$	$7.6x10^6$
Inoculant:	-----	----- CFU of LAB[2] supplied/gram of Crop -----	-----	-----
Biomate	$1.6x10^5$	$1.5x10^5$	$1.7x10^5$	$1.6x10^5$

[1]Colony-forming units.
[2]Lactic acid bacteria.

Table 39.8. pH and Chemical Composition over Time for the Wheat Silages in Trial 1

Time Post-filling and Item[1]		Control	AgMaster	Biomate	BioPower	1174	7057	SI Conc	Medipharm	Xeroferm
Initial:	pH	---------------------------------------mean ≐ 6.42---------------------------------								
Hour 24:	pH*	6.14	5.88	5.47	5.94$_x$	5.85	6.06^x	6.14^x	5.07	6.09^x
	Lactic*	1.18	1.52	2.10	1.49^x	1.53	1.36	1.21	1.88	1.28
Hour 48:	pH*	6.04	4.85	4.66	5.10	4.62	4.91	5.83$_x$	4.39	5.59
	Lactic*	2.00	3.99	3.92	3.24	4.32	3.24	2.23^x	5.00	2.53
Day 4:	pH*	5.64	4.26	4.29	4.44	4.19	4.22	4.85	4.13	4.72
	Lactic*	2.77	7.24	5.83	6.49	7.79	5.08	4.36	6.85	4.82
Day 7:	pH*	5.08	4.12	4.14	4.27	4.09	4.10	4.48	4.07	4.36
	Lactic*	3.99	8.75	7.82	7.60	9.17	9.04	6.00	7.48	7.00
Day 42:	pH*	4.31	4.06	4.05	4.13	4.07	4.06	4.20	4.01	4.10
	Lactic*	6.85	9.53	9.64	8.24	9.64	10.05	8.03	9.79	9.88
	Acetic*	2.19	1.08	.89	1.01	.87	.97	1.15	.78	1.21
	Ethanol*	.320	.093	.096	.092	.087	.096	.084$_x$	.091	.107
	NH_3-N	.236	.201	.185	.172	.158	.166	.212^x	.173	.193

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.

*Statistical analyses showed control vs. inoculant means differed (P < .05), unless the inoculant mean has a superscript(x).

Table 39.9. pH and Chemical Composition over Time for the Wheat Silages in Trials 2 and 3

		Trial 2					Trial 3				
Time Post-filling and Items[1]		Control	Biomate	1174	SI Conc	Xeroferm	Control	Biomate	1174	SI Conc	Xeroferm
Initial:	pH	---------------mean = 6.41-----------					------------mean = 6.39------------				
Hour 24:	pH*	5.76	4.72	5.10	5.06	5.11	5.61	4.70	4.98$_x$	4.98	5.04$_x$
	Lactic*	.90	2.24	1.51	1.62	1.47	1.34	2.43	1.77^x	2.25	1.99^x
Hour 48:	pH*	5.66	4.35	4.38	4.48	4.62	5.35	4.36	4.30	4.39	4.50
	Lactic*	1.79	4.36	4.22	3.53	3.57	1.87	5.27	4.91	4.37	3.93
Day 4:	pH*	5.10	4.13	4.10	4.16	4.22	4.77	4.06	4.01	4.10	4.14
	Lactic*	2.24	6.14	5.99	5.75	5.19	2.82	6.52	6.56	5.85	5.30
Day 7:	pH*	4.73	4.08	4.04	4.08	4.11	4.45	4.03	3.96	4.02	4.04
	Lactic*	3.44	6.27	6.01	5.85	6.12	4.22	6.57	6.93	6.57	7.06
Day 42:	pH*	4.23	4.10	4.06	4.11	4.09	4.18	4.02	4.00	4.04	4.03
	Lactic*	5.58	5.90	6.46	5.85	6.27	5.97	7.00	6.60	6.40	6.72
	Acetic*	1.40	.55	.66	.80	.81	1.72	.71	.62	.71	.67
	Ethanol*	.173	.055	.058	.048	.078	.165	.049	.050	.083	.068
	NH_3-N	.171	.158	.157	.157	.163	.184	.157	.171	.154	.156

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.

*Statistical analyses showed control vs. inoculant means differed (P < .05) within a trial, unless the inoculant mean has a superscript(x).

Table 39.10. pH and Chemical Composition over Time for the Sudangrass and Bromegrass Silages in Trials 4 and 5

Time Post-filling and Item[1]		Trial 4: Sudangrass Control	Bio-mate	1174	SI Conc	Xero-ferm	Trial 5: Bromegrass Control	Bio-mate
Initial:	pH*	5.87	5.86	5.85	5.87	5.85	5.94	5.95
Hour 12:	pH*	5.66	5.48	5.60	5.65^x	5.63^x	6.02	5.94
	Lactic*	.37	.52	.45	.42^x	.40^x	.25	.43
Hour 24:	pH*	5.26	4.49	4.65	4.87	4.79	6.02	5.34
	Lactic*	.88	1.97	1.76	1.50	1.61	.34	1.21
Hour 48:	pH*	5.02	4.24	4.31	4.34	4.48	5.57	4.41
	Lactic*	1.90	5.06	5.98	4.50	3.55	1.23	3.56
Day 4:	pH*	4.84	4.10	4.09	4.14	4.22	5.34	4.27
	Lactic*	2.87	7.27	7.82	7.24	6.40	1.82	5.03
Day 90:	pH*	4.47	4.08	4.06	4.12	4.10	4.75	4.12
	Lactic*	3.32	6.30	7.20	5.74	6.48	---	---
	Acetic*	1.40	.73	.92	.97	.73	---	---
	Ethanol*	.233	.198	.219^x	.196	.163	---	---
	NH_3-N	.105	.064	.058	.075	.079	---	---

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.

*Statistical analyses showed control vs. inoculant means differed ($P < .05$) within a trial, unless the inoculant mean has a superscript(x).

Table 39.11. pH and Chemical Composition over Time for the Alfalfa Silages in Trial 9

Time Post-filling and Item[1]		Control	Ag-Master	Biomate	Bio-Power	Ecosyl	1174	SI Conc	Medi-pharm	Xero-ferm
Initial:	pH	mean = 5.90								
Hour 12:	pH*	5.86	5.34	5.39	5.81^{x}	5.73^{x}	5.74^{x}	5.73^{x}	4.96	5.66^{x}
	Lactic*	.43	.72	1.08	.77	.52^{x}	.59^{x}	.54^{x}	1.40	.48^{x}
Hour 24:	pH*	5.66	4.98	4.94	5.20	4.97	5.03	5.10	4.83	5.04
	Lactic*	.60	2.46	2.61	2.44	1.91	2.88	1.75	3.46	1.65
Hour 48:	pH*	5.47	4.96	4.87	5.09	4.87	5.07	4.97	4.81	5.02
	Lactic*	1.34	3.75	4.06	3.71	3.39	3.64	3.17	4.32	3.24
Day 4:	pH*	5.40	5.00	4.92	5.08	4.94	5.01	5.05	4.80	5.04
	Lactic*	2.13	4.01	4.09	4.23	4.00	3.97	3.54	4.24	3.71
Day 90:	pH*	4.98	4.82	4.79	4.92	4.85	4.97^{x}	4.86	4.73	4.96^{x}
	Lactic*	4.47	4.45^{x}	5.12	5.20	5.21	4.98^{x}	4.57^{x}	5.38	4.64^{x}
	Acetic*	2.69	2.54^{x}	2.38	2.60^{x}	2.45	2.77^{x}	2.76^{x}	1.99	2.79^{x}
	Ethanol*	.243	.084	.089	.079	.083	.091	.117	.050	.091
	NH_3-N	.302	.301	.293	.303	.297	.308	.294	.251	.306

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.
*Statistical analyses showed control vs. inoculant means differed ($P < .05$), unless the inoculant mean has a superscript(x).

Table 39.12. pH and Chemical Composition over Time for Selected Alfalfa Treatments in Trials 6, 7, 8, and 10.

Time Post-filling and Item[1]		Trial 6		Trial 7			Trial 8		Trial 10	
		Control	Del-N-Sile	Control	SI Conc	Xeroferm	Control	SI Conc	Control	Biomate
Initial:	pH	5.95	5.96	5.98	5.98	5.99	5.99	5.99	6.10	6.10
Hour 12:	pH*	5.53	5.28	6.01	6.00^{x}	6.01^{x}	5.97	5.93^{x}	6.08	6.07^{x}
	Lactic*	1.45	2.36	.19	.24^{x}	.27^{x}	.34	.39^{x}	.37	.25^{x}
Hour 24:	pH*	5.39	4.65	5.91	5.73	5.65	5.83	5.20	6.08	5.34
	Lactic*	1.71	5.64	.45	.67^{x}	.66^{x}	.58	1.23	.31	1.77
Hour 48:	pH*	5.09	4.58	5.81	5.36	5.24	5.62	4.61	6.01	5.11
	Lactic*	3.40	5.02	.86	2.13	2.22	.95	4.48	.60	3.64
Day 4:	pH*	4.92	4.55	5.54	4.62	4.81	5.36	4.53	---	---
	Lactic*	4.20	5.08	1.91	4.69	4.00	2.05	5.98	---	---
Day 7:	pH*	4.81	4.51	5.22	4.55	4.61	5.17	4.48	5.46	5.12
	Lactic*	5.27	6.83	2.56	5.09	5.28	2.81	6.72	3.19	4.96
Day 90:	pH*	4.58	4.43	4.67	4.38	4.41	4.70	4.47	5.34	5.09
	Lactic*	4.41	6.41	4.94	6.99	7.45	5.63	6.62	4.90	5.60
	Acetic*	3.23	2.22	1.79	1.32	1.40	2.41	1.53	2.75	2.72^{x}
	Ethanol*	.400	.190	.102	.048	.046	.235	.055	.136	.108
	NH_3-N*	.312	.203	.218	.172	.183	.265	.199	.380	.371^{x}

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.
*Statistical analyses showed control vs. inoculant means differed ($P < .05$) within a trial, unless the inoculant mean has a superscript(x).

Table 39.13. pH and Lactic Acid over Time for Selected Alfalfa Treatments in Trials 11, 12, and 13

Time Post-filling and Item[1]		Trial 11		Trial 12		Trial 13	
		Control	SI Conc	Control	Ecosyl	Control	BTA
Initial:	pH	6.02	6.03	5.98	5.99	6.22	6.23
Hour 24:	pH	6.00	5.99[x]	5.39	5.36[x]	6.27	6.19[x]
	Lactic	---	---	2.72	2.91[x]	---	---
Hour 48:	pH*	5.99	5.99[x]	5.20	5.07	5.74	5.20
	Lactic*	---	---	3.78	4.14	---	---
Day 4:	pH*	5.97	5.47	5.04	4.82	5.32	4.82
	Lactic*	---	---	7.58	9.49	---	---
Day 7:	pH*	5.91	4.96	4.90	4.71	5.18	4.74
	Lactic*	---	---	8.07	9.79	---	---
Day 90:	pH*	5.40	4.50	4.66	4.62[x]	4.80	4.62

[1]Lactic acid is reported as a % of the silage dry matter.
*Statistical analyses showed control vs. inoculant means differed (P<.05) within a trial, unless the inoculant mean has a superscript(x).

Table 39.14. pH and Chemical Composition over Time for the Corn Silages in Trials 14 to 20

Time Post-filling and Item[1]		Trials 14, 15, & 16[A]		Trials 17 & 18[B]		Trials 19 & 20[B]	
		Control	Medipharm	Control	Ecosyl	Control	Biomate
Initial:	pH	5.80	5.80	5.79	5.76	5.98	5.98
Hour 6:	pH	5.16	5.06	5.02	5.02	5.55	5.52
	Lactic	.82	.88	---	---	---	---
Hour 12:	pH	4.34	4.25	4.58	4.54	4.72	4.66
	Lactic	1.91	2.13	---	---	---	---
Hour 24:	pH	4.14	4.12	4.24	4.22	4.24	4.19
	Lactic	2.93	3.30	---	---	---	---
Hour 48:	pH	3.91	3.90	4.03	4.01	3.94	3.92
	Lactic	4.56	4.71	---	---	---	---
Day 90:	pH	3.92	3.91	3.92	3.88	3.86	3.85
	Lactic	6.01	6.29	---	---	---	---
	Acetic	1.07	1.06	.97	1.00	---	---
	Ethanol	.83	.59	1.17	.93	---	---

[1]Acids, ethanol, and NH_3 are reported as a % of the silage dry matter.
[A]Values reported were averaged across the three trials.
[B]Values reported were averaged across the two trials.

Table 39.15. pH over Time for Selected High Moisture Shelled Corn, Grain Sorghum and Soybeans, and Grain Sorghum Silages in Trials 22, 23, 29, 31, and 32

	High Moisture Corn					Grain Sorghum and Soybeans				Grain Sorghum	
	Trial 22		Trial 23			Trial 29		Trial 31		Trial 32	
Time Post-filling[1]	Control	1186	Control	1186	Medi-pharm	Control	Bio-mate	Control	Bio-mate	Control	Bio-mate
	pH										
Initial:	6.10	6.12	6.10	6.12	6.09	---	---	---	---	---	---
Hour 12*	5.36	5.37^{x}	---	---	---	4.80	4.67	5.91	5.86^{x}	5.23	5.19^{x}
Hour 24*	5.06	5.08^{x}	6.16	6.06^{x}	6.06^{x}	4.65	4.40	4.92	4.45	4.77	4.60
Hour 48*	4.87	4.87^{x}	6.00	5.91^{x}	5.84	4.49	4.24	4.21	4.11	4.38	4.27
Day 4*	4.78	4.79^{x}	5.73	5.51	5.36	4.22	4.08	4.17	4.06	4.15	4.09^{x}
Day 7*	4.54	4.58^{x}	5.46	5.15	4.97	---	---	---	---	---	---
Day 42*	4.26	4.31^{x}	4.76	4.39	4.35	4.06	4.06^{x}	4.09	4.06^{x}	4.11	4.06^{x}

[1]In Trials 29, 31, and 32 the 12, 24, and 48 hour times were actually 10, 20, and 40 hours, respectively.

*Statistical analyses showed control vs. inoculant means differed ($P < .05$) within a trial, unless the inoculant mean has a superscript(x).

Table 39.16. pH and Lactic Acid over Time for Selected Forage Sorghum Treatments in Trials 24 to 28

		Trial 24			Trial 25		Trial 26		Trial 27		Trial 28		
Time Post-filling and Item		Control	Bio-mate	1174	Control	Bio-mate	Control	Tri-Lac	Control	Sila-gest	Control	Bio-mate	1174
Initial:	pH	5.92	5.91	5.92	5.93	5.93	5.98	5.96	5.89	5.90	5.94	5.94	5.95
Hour 6:	pH*	---	---	---	5.26	5.21	5.80	5.68	5.78	5.76^{x}	5.88	5.86^{x}	5.86^{x}
Hour 12:	pH*	4.93	4.74	4.86^{x}	4.75	4.73^{x}	4.78	4.66	5.71	5.69^{x}	4.73	4.66	4.70^{x}
	Lactic*	.94	1.26	1.21	1.04	1.38	---	---	---	---	---	---	---
Hour 24:	pH*	4.40	4.24	4.31	4.65	4.60	4.44	4.34	4.48	4.40	4.40	4.30	4.34
	Lactic*	1.52	2.19	1.81	1.87	1.97^{x}	1.12	1.40	---	---	---	---	---
Hour 48	pH*	4.14	4.03	4.04	4.41	4.36	4.11	4.07^{x}	4.24	4.20^{x}	4.21	4.11	4.11
	Lactic*	3.02	4.11	3.63^{x}	3.67	3.88^{x}	3.90	4.18^{x}	---	---	---	---	---
Day 4:	pH*	3.92	3.88	3.86^{x}	4.22	4.19^{x}	3.96	3.95^{x}	4.07	4.01	4.03	3.97^{x}	3.91
	Lactic*	5.41	5.71^{x}	6.60	4.80	5.47	5.79	5.92^{x}	---	---	---	---	---
Day 90:	pH*	3.86	3.84^{x}	3.83^{x}	4.11	4.09^{x}	3.93	3.90^{x}	3.92	3.90^{x}	3.98	3.96^{x}	3.90
	Lactic	---	---	---	---	---	6.33	6.56^{x}	---	---	---	---	---

[1]Lactic acid is reported as a % of the silage dry matter.
*Statistical analyses showed control vs. inoculant means differed ($P < .05$) within a trial, unless the inoculant mean has a superscript(x).

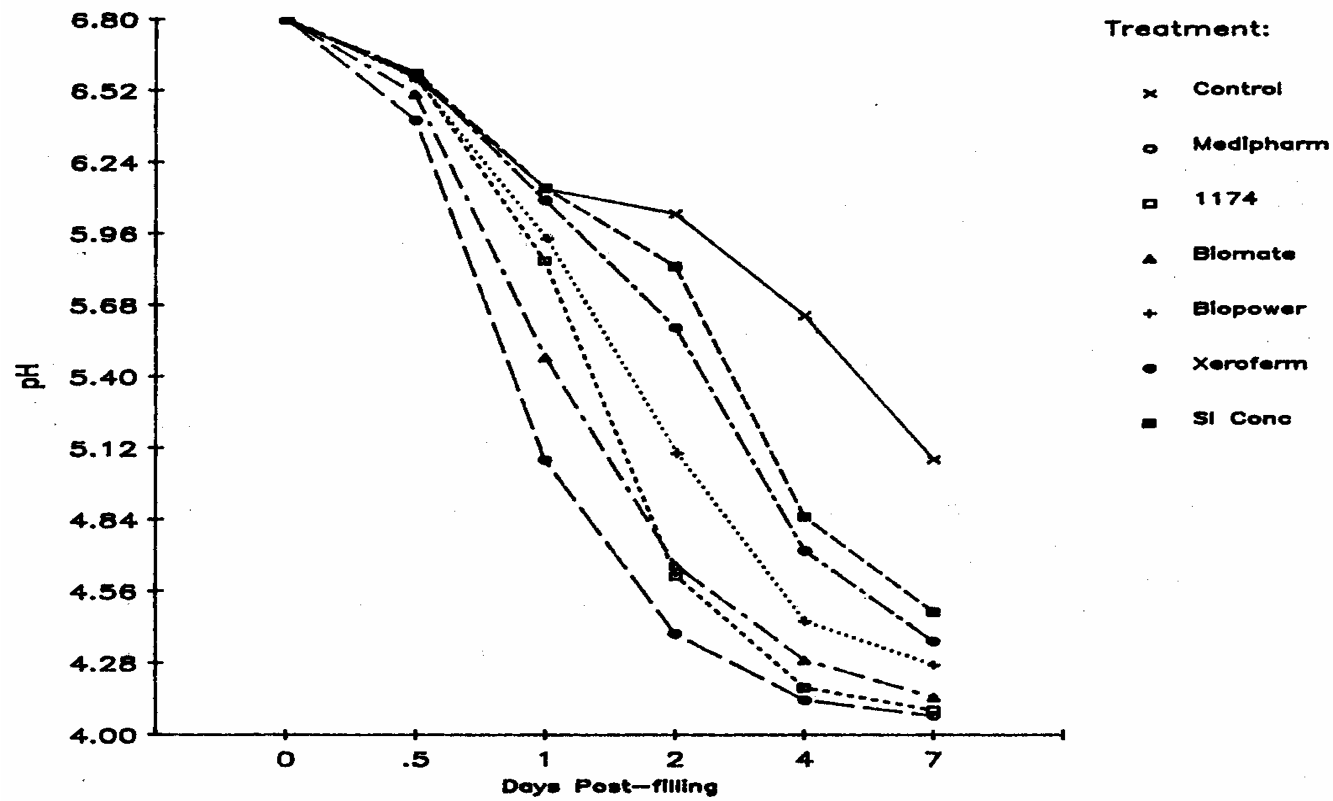

Figure 39.1. pH over Time for the Wheat Silages in Trial 1

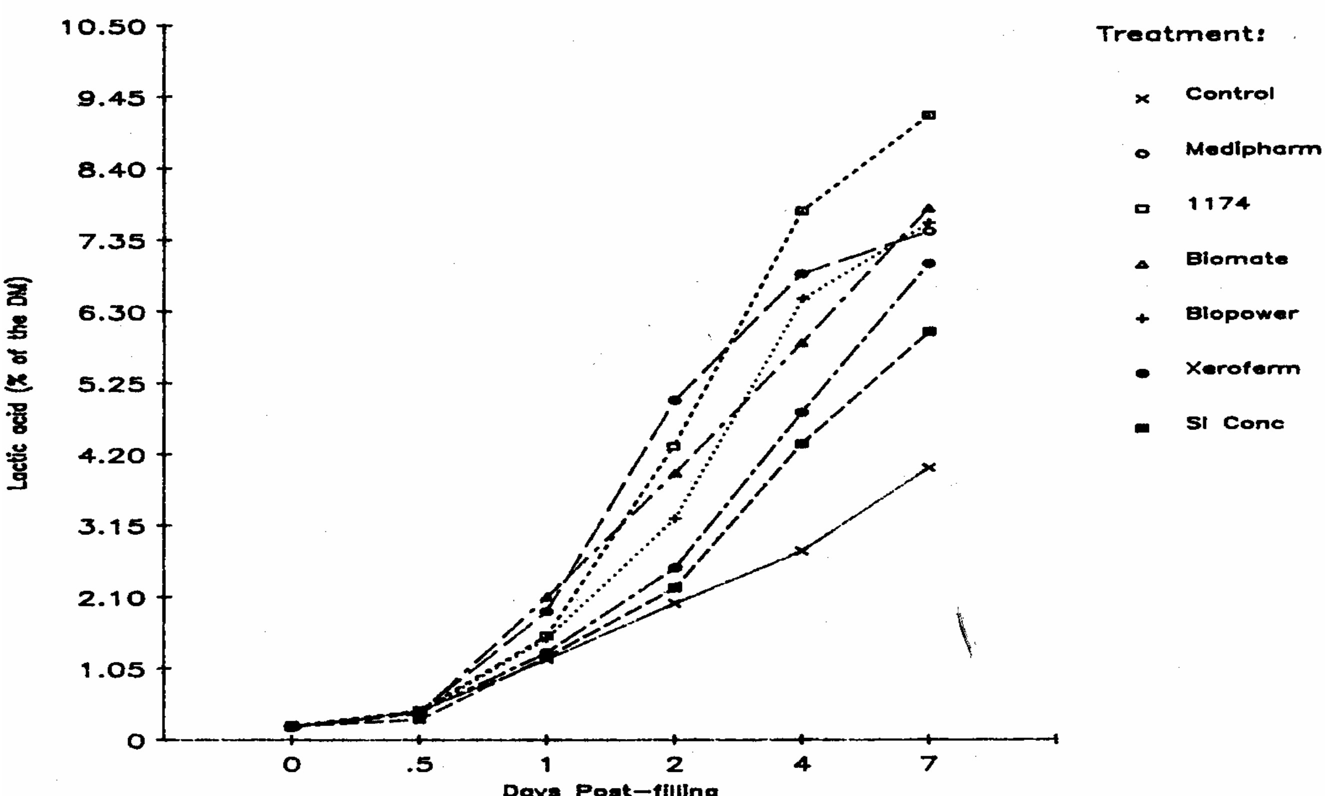

Figure 39.2. Lactic Acid over Time for the Wheat Silages in Trial 1