Effect of Commercial Inoculants on the Fermentation of Alfalfa, Corn, Forage Sorghum, and Triticale Silages[1]

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Summary

Fourteen commercial inoculants were evaluated in seven trials using alfalfa, corn, forage sorghum, and triticale silages. Microbial profiles of the inoculants and of the crops differed widely. Viable lactic acid bacteria (LAB) supplied per gram of fresh crop by the inoculants ranged from less than 10^3 to over 10^5. Only the alfalfas had 10^3 or fewer LAB per gram of crop when the forages were treated and as a result, fermentation responses were excellent for those inoculants that supplied 10^4 or more LAB per gram of treated crop. Corn and triticale underwent a very rapid fermentation rate with very little response to the inoculants. The forage sorghums did not ensile as rapidly as the corn because of their cooler initial temperatures, and most inoculants had little or no effect on the fermentation characteristics. The results of these experiments indicate that if a crop has a high number of LAB, adding more in the form of an inoculant is unlikely to improve the silage fermentation. If a crop has a low number of LAB, it probably will respond to an inoculant, provided the inoculant supplies a large number of viable bacteria.

Introduction

Silage additives are receiving fairly wide acceptance in the U.S. Recently, Bolsen and Heidker (1985)[2] published a guide to over 150 silage additive products marketed in the U.S. Those additives contained over 120 different active ingredients. Microbial inoculants were the most numerous. Over 40 claims are made by the 91 manufacturers or distributors cited in the guide. We believe the buyer should look for good evidence that inoculants improve the fermentation and conservation processes. Results from laboratory-scale experiments are helpful, especially if the crops used are similar to the buyer's. Under laboratory conditions, effective silage inoculants should speed the drop in pH through a faster and greater production of lactic acid.

The objective of these seven trials was to determine the effect of commercial silage inoculants on the rate and efficiency of fermentation in alfalfa, corn, forage sorghum, and triticale. We included 14 products to provide evaluation over a wider range of inoculants than in our previous trials (Report of Progress 494).

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[1]Financial assistance was provided by Sanofi Sante Animale, 37 Avenue George V, 75008 Paris, France.

[2]Bolsen, K.K. and J.I. Heidker. 1985. Silage Additives USA. Chalcombe Publications, Box 1222, Manhattan, Kansas 66502.

Experimental Procedures

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. All silages were made in 1985 from crops grown near Manhattan. For filling, 100 to 125 lbs of fresh crop was placed on a plastic sheet, and the additive applied and mixed thoroughly. The control crop was also hand-mixed. 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.

The 14 inoculants evaluated and active ingredients as listed by the manufacturer or distributor are shown in Table 34.1.

Compositions of the pre-ensiled crops used in all the following experiments are shown in Table 34.2. All inoculants and their microbial counts are shown in Table 34.3.

Table 34.1. List of the Inoculants Evaluated, their Manufacturer or Distributor, and their Active Ingredient(s)

Inoculant	Manufacturer or Distributor	Active Ingredient(s)
AGMASTER® ALFALFA SILAGE INOCULANT	Marschall Products Division of Miles Laboratories, Madison, Wisconson	Lactobacillus plantarum and Pediococcus acidilactici
AGMASTER® CORN SILAGE INOCULANT		Lactobacillus xylosus and Pediococcus acidilactici
BIOMATE LAB CONCENTRATE	Chr. Hansen's Laboratory, Inc., Milwaukee, Wisconsin	Lactobacillus plantarum and Pediococcus cerevisiae
BIOPOWER™	BioTechniques Laboratories, Inc., Redmond, Washington	Streptococcus faecium and Lactobacillus plantarum
BIOSILLAC	Kemi-Intressen AB, Sundbyberg, Sweden	Lactobacillus plantarum and other species

Table 34.1. (continued) List of the Inoculants Evaluated, their Manufacturer or Distributor, and their Active Ingredient(s)

FORAGER	Shell Chemicals (UK) Ltd	Lactobacillus plantarum, Lactobacillus bulgaricus, Lactobacillus coryneformis, Lactobacillus acidophilus, Pediococcus acidilactici, Streptococcus thermophilus, cellulase and hemicellulase, Pectinase
KEM LAC	Kemin Industries, Inc., Des Moines, Iowa	Lactobacillus plantarum, Lactobacillus bulgaricus, and Lactobacillus acidophilus
KOFASIL LAC	Plate Kofasil GmBh, Bonn, West Germany	Lactobacillus plantarum, Streptococcus faecium , and Pediococcus
PIONEER BRAND 1174 CONCENTRATED SILAGE INOCULANT	Pioneer Hi-Bred International, Inc., Des Moines, Iowa	Lactobacillus plantarum (multiple strains) and Streptococcus faecium
PIONEER BRAND 1177 SILAGE INOCULANT	Pioneer Hi-Bred International, Inc., Des Moines, Iowa	Lactobacillus plantarum (multiple strains) and Streptococcus faecium
SI CONCENTRATE 40 A/F	Great Lakes Biochemical Co., Inc., Milwaukee, Wisconsin	Lactobacillus plantarum, Lactobacillus brevis, Pediococcus acidolactici, Streptococcus cremoris, and Streptococcus diacetylactis
SILO-BEST SOLUBLE	Cadco, Inc., Des Moines, Iowa	Streptococcus faecium M-74, Lactobacillus acidophilus, Pediococcus sp., and Lactobacillus plantarum
SURE-SILE	Microbial Developments, Ltd; Malvern Link, Worcs. UK	Lactobacillus plantarum, Pediococcus acidilactici, enzymes, and nutrients
USO_3M (experimental)	Sanofi Santi Animale, Paris, France	Lactobacillus plantarum, Lactobacillus casei, and enzymes.

Table 34.2. Composition of the Pre- Ensiled Crops Used in the Seven Trials

Item	Trial 1: Triticale	Trial 2: Alfalfa	Trial 3: Corn	Trial 4: Sorghum	Trial 5: Alfalfa	Trial 6: Sorghum	Trial 7: Sorghum
Dry Matter, %	33.4	38.3	31.3	32.6	43.5	29.85	25.0
pH	6.35	5.97	5.83	5.88	5.98	5.92	5.93
Buffer Capacity[1]	36.3	49.2	16.3	23.4	48.6	17.4	19.1
	% of the Crop DM						
WSC[2]	9.40	6.75	12.20	13.36	7.95	14.40	16.95
Total Nitrogen	2.01	2.77	1.34	1.15	2.83	1.37	1.15
Insol. Nitrogen	1.00	1.82	.91	.82	1.92	.98	.86
NDF[2]	65.1	48.7	39.6	66.7	*	59.8	*
ADF[2]	41.8	32.3	21.4	41.5	30.4	36.9	*
	Colony-Forming Units per gram of Crop						
Mesophilic	$7.5x10^8$	$3.3x10^7$	$2.3x10^8$	$1.5x10^8$	$6.0x10^7$	$7.5x10^7$	$1.0x10^8$
Lactic Acid Bacteria**	$4.9x10^5$	$2.7x10^3$	$2.6x10^6$	$2.5x10^4$	$<10^3$	$2.9x10^5$	$2.0x10^5$
Yeasts and Molds	$4.6x10^6$	$1.5x10^4$	$4.9x10^6$	$2.2x10^5$	$2.1x10^4$	$1.2x10^6$	$1.0x10^6$

[1]Milliequivalents of NaOH/100 g of crop dry matter.
[2]WSC = water soluble carbohydrates, NDF = neutral detergent fiber, and ADF = acid detergent fiber.
*Not available
**$1x10^3$=1,000; $1x10^6$=1,000,000.

Table 34.3. Numbers of Colony-Forming Units (CFU) of Lactic Acid Bacteria (LAB) in the Silage Inoculants and Numbers of LAB Applied per Gram of Fresh Crop

Silage Inoculant	Trial 1: Triticale		Trial 2: Alfalfa		Trial 3: Corn		Trial 4: Forage Sorghum	
	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop
A	$1.3x10^8$	$3.4x10^5$	$7.9x10^7$	$2.1x10^5$	---	---	---	---
B	---	---	---	---	$8.3x10^7$	$2.2x10^5$	$5.0x10^5$	$1.2x10^3$
C	$5.0x10^7$	$1.1x10^5$	$1.7x10^8$	$3.2x10^5$	$1.3x10^8$	$2.5x10^5$	$7.7x10^7$	$1.5x10^5$
D	$4.0x10^7$	$3.7x10^4$	$2.2x10^7$	$2.0x10^4$	$1.1x10^7$	$1.0x10^4$	$2.6x10^6$	$2.7x10^3$
E	$6.5x10^5$	$<10^3$	$1.2x10^6$	$1.2x10^3$	$1.5x10^5$	$<10^3$	$3.0x10^3$	$<10^3$
F	$<10^3$	$<10^3$	$<10^3$	$<10^3$	---	---	---	---
G	$1.0x10^5$	$<10^3$	$<10^3$	$<10^3$	$<10^3$	$<10^3$	---	---
H	$3.2x10^6$	$6.4x10^3$	$3.8x10^7$	$7.6x10^4$	$4.4x10^6$	$8.8x10^3$	$7.5x10^4$	$<10^3$
I	---	---	---	---	$7.9x10^5$	$1.0x10^3$	$3.5x10^5$	$<10^3$
J	$2.1x10^7$	$1.1x10^4$	$3.7x10^6$	$1.8x10^3$	$6.5x10^6$	$3.2x10^3$	$1.8x10^6$	$<10^3$
K	$5.0x10^7$	$6.6x10^4$	$5.6x10^7$	$7.4x10^4$	$3.2x10^7$	$4.2x10^4$	$1.8x10^7$	$2.9x10^4$
L	$8.8x10^6$	$8.8x10^3$	$3.7x10^7$	$3.7x10^4$	$1.6x10^6$	$1.6x10^3$	$<10^3$	$<10^3$
M	---	---	---	---	$3.4x10^5$	$<10^3$	$1.6x10^5$	$<10^3$
N	$1.4x10^8$	$7.0x10^4$	$5.5x10^7$	$2.8x10^4$	$3.0x10^7$	$1.5x10^4$	$<10^3$	$<10^3$

Table 34.3. (continued)

Silage Inoculant	Trial 5: Alfalfa		Trial 6: Forage Sorghum		Trial 7: Forage Sorghum	
	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop	CFU/ml or g of Inoculant	CFU Applied/g of Fresh Crop
B	---	---	---	---	$1.9x10^8$	$5.0x10^5$
C	---	---	---	---	$2.8x10^8$	$5.3x10^5$
E	---	---	$1.3x10^6$	$1.5x10^3$	---	---
G	---	---	---	---	$8.0x10^6$	$1.2x10^4$
K	$6.6x10^7$	$8.7x10^4$	$4.6x10^6$	$5.3x10^3$	---	---
N	---	---	$3.1x10^7$	$1.6x10^4$	---	---

Trial 1: Triticale. Silages were made from early-dough stage triticale (from ARCO Seed Co.) on June 19. The direct-cut crop contained 33 to 34% dry matter (DM) at harvest. The 11 inoculants evaluated are shown in Table 34.3. Three silos per treatment were opened at 24 and 48 hours and 4 and 90 days post-filling.

Trial 2: Alfalfa. Silages were made from 2nd-cutting alfalfa on July 2, and the crop was field-wilted to approximately 38% DM prior to harvest. The 11 inoculants evaluated are shown in Table 34.3. All other procedures were as described in Trial 1, except additional opening times for control and inoculants C, E, and N included 12 hours and 7 and 21 days post-filling.

Trial 3: Corn. Silages were made from dent-stage corn on August 14 and the crop contained approximately 38% DM at harvest. The 12 inoculants evaluated are shown in Table 34.3. Three silos per treatment were opened at 12, 24, and 48 hours and 90 days post-filling. Additional opening times for control and inoculants C, E, and N were 6 hours and 7 and 21 days post-filling.

Trial 4: Forage Sorghum. Silages were made from late-dough stage forage sorghum (DeKalb 25E hybrid) on October 29. The crop contained approximately 33% DM at harvest. The 11 inoculants evaluated are shown in Table 34.3. Three silos per treatment were opened at 12, 24, and 48 hours and 21 and 90 days post-filling.

Trial 5: Alfalfa. Silages were made from 3rd-cutting alfalfa on July 16, and the crop was field-wilted to 42 to 44% DM at harvest. The inoculant evaluated is shown in Table 34.3. Three silos per treatment were opened at 24 and 48 hours and 4, 14, and 90 days post-filling.

Trial 6: Forage Sorghum. Silages were made from late-dough stage Acco Paymaster 351 hybrid forage sorghum on October 3. The crop contained approximately 30% DM at harvest. The three inoculants evaluated are shown in Table 34.3. Three silos per treatment were opened at 12 and 24 hours and 4, 21, and 90 days post-filling.

Trial 7: Forage Sorghum. Silages were made from late-dough stage forage sorghum (DeKalb 25E) on October 17. The crop contained approximately 25% DM at harvest. The three inoculants evaluated are shown in Table 34.3. Three silos per treatment were opened at 12, 24, and 48 hours and 4, 21, and 90 days post-filling.

Chemical Analyses of the Pre-ensiled Crops and Silages. Pre-ensiled crops were analyzed for DM, pH, total nitrogen (N), insoluble nitrogen, water soluble carbohydrates, acid detergent fiber, neutral detergent fiber, and buffer capacity. Silages from 6 hours to 14 days were analyzed for pH and lactic acid; 21-day silages for pH, lactic acid, and volatile fatty acids (VFA); and 90-day silages for DM, pH, lactic acid, VFA, ethanol, total N, and ammonia-nitrogen.

Microbiological Evaluations. Pre-ensiled samples of forage and inoculants were weighed, mixed in a high-speed blender and then diluted in sterile buffer. The following microorganism counts were made after appropriate dilutions with sterile buffer:

Mesophilic count. The mesophilic 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) in the forage and the LAB provided by inoculants at the time they were applied to the forage. Rogosa agar (DIFCO) was used, and the incubation was at 37 C for 3 days.

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

Results and Discussion

Results in Table 34.2 indicate widely different microbial profiles for the seven crops. Only the alfalfa in Trials 2 and 5 had 10^3 (1,000) or fewer LAB per gram of crop when the forages were treated and the silos were filled. The triticale and corn each had over 10^6 (one million) LAB per gram of crop, which are very high populations for pre-ensiled forages. Two of the forage sorghums had over 10^5 LAB per gram of crop, which is also considered a relatively high count.

The LAB numbers for the 14 silage inoculants, and the LAB applied per gram of treated crop in the seven trials are shown in Table 34.3. The inoculants were obtained directly from the manufacturer or were supplied by a representative of Sanofi Sante Animale in June and July of 1985. The products were stored according to label instructions until their last use in October 1985. Four inoculants (E, F, G, and M) supplied less than 10^3 viable LAB per gram of treated crop during their first use; three inoculants (H, I, and L) provided less than 10^4 (10,000) viable LAB per gram. Seven products supplied at least 10^4 LAB per gram on July 2 in Trial 2, but only two of these (C and K) provided 10^4 on October 29 in Trial 4. Clearly, there were large differences among inoculants in their initial numbers of LAB and in viability during storage.

Trial 1. Results are presented in Table 34.4. the triticale underwent a very rapid pH drop during the first 24 hours post-filling, from about 6.20 initially to between 4.19 and 4.27. It is not surprising that none of the 11 inoculants speeded the ensiling process, even those that supplied 10^4 or 10^5 LAB per gram of treated crop. The crop already contained 1.5 times more LAB than the number provided by inoculant A (490,000 vs. 340,000 per gram) and 6 times more than the number provided by inoculant K (490,000 vs. 66,000 per gram).

Trial 2. Results are shown in Table 34.5 and Figures 34.1 and 34.2. The alfalfa was highly "responsive", especially during the first 4 days post-filling. Seven inoculants (A, C, D, H, K, L, and N) dramatically increased the rates of pH decline and lactic acid production. These products also provided at least 10^4 LAB per gram of treated crop. Chemical composition differences among control and inoculated silages were narrowed in the day 90 silages. However, treated silages generally had lower pH, acetic acid, ethanol, and NH_3-N values and higher lactic acid contents than control silage.

Trial 3. Results are shown in Table 34.6 and Figures 34.3 and 34.4. The corn was a low response crop, which underwent an extremely rapid fermentation rate even in the control silage. All 12 silages were at or below a pH of 4.5 by hour 12 post-filling and at or below a pH of 4.1 by hour 24. Several of the inoculant silages had numerically lower pH values and higher lactic acid contents at hour 12, but differences were not consistently maintained at subsequent opening times. Few, if any, trends occurred in the data to correlate the day 90 silage characteristics with those of the products.

Trial 4. Results are shown in Table 34.7. The forage sorghum was a low response crop and had a composition profile similar to that of the corn used in Trial 3. The sorghum did not ensile as rapidly as the corn, but its cooler initial temperature at harvest (55 vs. 90 F) was largely responsible for the slower fermentation. The surprisingly low LAB numbers in most products eliminated any possibility of significant effects on rate and efficiency of fermentation. Inoculant C had the highest LAB applied per gram of crop (1.5×10^5) and it also gave the lowest pH at hours 24 and 48. Again, as was observed in Trial 3, the day 90 silages were very well preserved and of similar chemical composition.

Trial 5. Results are shown in Table 34.8 and confirm the results obtained with inoculant K in the early alfalfa trial (Table 34.5). At 48 hours post-filling, the treated silage had a one-unit lower pH (4.84 vs. 5.82) and 4.5 times as much lactic acid (5.78 vs. 1.28%) as the control silage.

Trials 6 and 7. Results are shown in Table 34.9 and are similar to those obtained with the forage sorghum used in Trial 4 (Table 34.7). Both the hybrids (Acco 351 and DeKalb 25E) were low response crops, characterized by high numbers of LAB on the pre-ensiled forage and sufficient water soluble carbohydrates to produce a relatively rapid silage fermentation. Although four of the six inoculants supplied 10^4 or 10^5 LAB per gram of treated crop, none produced a consistently lower pH or higher lactic acid content compared with the control from hour 12 to day 4 post-filling.

For a crop to ensile properly, an energy source (such as glucose or starch) and lactic acid bacteria must be present under anaerobic conditons. If a crop has a high number of lactic acid bacteria, adding more in the form of an inoculant is unlikely to affect the rate and efficiency of the ensiling process. If a crop is low in lactic acid bacteria, it probably will respond to an inoculant, provided the inoculant contains a large number of bacteria. Thus, a quick test for counting viable lactic acid bacteria, both in crops and in silage inoculants, would be a great advantage to silage producers.

Our data indicate that the number of lactic acid bacteria necessary for a rapid, efficient fermentation is about 10^5 CFU per gram of crop. When a crop with a low count is supplemented with an inoculant, it is important that the inoculant provides a high number of viable bacteria.

Table 34.4. pH and Chemical Composition Over Time for the Triticale Silages in Trial I

Time Post-filling and Item[1]		Control	Silage Inoculant Treatment A	C	D	E	F	G	H	J	K	L	N
Initial:	pH	6.22	6.20	6.25	6.26	6.26	6.24	6.22	6.22	6.19	6.22	6.27	6.26
	Lactic	.07	.07	.06	.05	.07	.05	.05	.04	.07	.05	.05	.04
Hour 24:	pH	4.26	4.24	4.19	4.21	4.24	4.25	4.25	4.24	4.24	4.24	4.26	4.27
	Lactic	2.28	2.60	2.12	2.48	2.33	2.53	2.50	2.43	2.46	2.43	2.30	2.42
Hour 48:	pH	4.04	4.03	3.99	4.03	4.04	4.04	4.04	4.03	4.04	4.03	4.03	4.03
	Lactic	4.20	3.74	4.24	3.86	3.87	4.16	4.66	4.79	4.66	4.10	4.35	4.08
Day 4:	pH	4.13	4.14	4.12	4.12	4.12	4.13	4.12	4.12	4.15	4.12	4.11	4.11
	Lactic	4.76	4.82	4.80	4.85	4.68	5.27	4.44	4.80	4.52	4.69	4.40	5.26
Day 90:	pH	4.09	4.10	4.09	4.09	4.08	4.12	4.10	4.12	4.09	4.07	4.08	4.11
	Lactic	7.74	6.46	6.10	6.70	6.26	6.40	7.53	6.51	7.34	7.61	8.50	7.12
	Acetic	2.36	2.81	3.68	2.09	2.27	2.22	2.08	1.97	2.26	2.61	2.18	2.30
	Total	10.38	9.49	10.10	9.00	9.28	8.97	9.91	8.69	9.94	10.48	10.93	9.78

[1]Acids are reported as a % of the silage dry matter.

Table 34.5. pH and Chemical Composition Over Time for the Alfalfa Silages in Trial 2

Time Post-filling and Item[1]		Control	Silage Inoculant Treatment A	C	D	E	F	G	H	J	K	L	N
Initial:	pH	5.97	5.97	5.97	5.99	5.95	5.99	5.99	5.99	5.98	5.97	5.97	5.97
	Lactic	.14	.12	.15	.11	.16	.15	.13	.13	.14	.14	.15	.14
Hour 12:	pH	6.13		4.88		6.16							6.14
	Lactic	.32		2.59		.22							.19
Hour 24:	pH	6.05	4.72	4.65	5.18	5.87	6.07	5.99	5.22	5.85	5.01	5.22	5.40
	Lactic	.53	3.29	5.19	2.17	1.66	.42	.78	3.07	1.27	3.09	2.35	2.20
Hour 48:	pH	5.73	4.63	4.64	4.80	5.38	5.74	5.67	5.04	5.52	4.76	5.00	4.86
	Lactic	2.03	6.50	6.44	5.84	3.27	1.95	1.79	4.20	2.69	4.66	4.22	4.51
Day 4:	pH	5.08	4.57	4.61	4.70	4.98	5.05	5.32	4.84	5.15	4.66	4.92	4.68
	Lactic	3.90	6.71	6.92	7.33	5.86	4.71	4.16	6.84	4.33	6.82	6.25	6.48
Day 7:	pH	4.79		4.59		4.80							4.61
	Lactic	6.85		7.24		6.91							8.58
Day 21:	pH	4.68		4.57		4.72							4.59
	Lactic	6.87		7.08		6.82							6.96
Day 90:	pH	4.79	4.52	4.60	4.58	4.68	4.60	4.68	4.72	4.72	4.58	4.72	4.56
	Lactic	4.99	4.80	5.31	7.68	4.82	6.90	4.58	4.06	3.81	5.09	5.13	5.76
	Acetic	2.06	.96	1.52	1.33	1.91	1.70	1.34	1.14	1.54	1.23	1.27	1.89
	Total acids	7.06	5.86	6.84	9.05	6.73	8.63	6.04	5.25	5.43	6.37	6.46	7.66
	Ethanol	.23	.16	.24	.16	.25	.19	.14	.13	.19	.23	.18	.26
	NH_3-N	.24	.22	.21	.22	.26	.27	.24	.23	.24	.23	.24	.19

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

Table 34.6. pH and Chemical Composition Over Time for the Corn Silages in Trial 3

Time Post-filling and Item[1]		Silage Inoculant Treatment												
		Control	B	C	D	E	G	H	I	J	K	L	M	N
Initial:	pH	5.82	5.82	5.82	5.80	5.83	5.80	5.83	5.84	5.81	5.81	5.82	5.79	5.81
	Lactic	.25	.24	.24	.21	.23	.26	.26	.27	.27	.29	.21	.29	.27
Hour 6:	pH	5.51		5.42		5.47								5.49
	Lactic	.35		.46		.45								.50
Hour 12:	pH	4.53	4.43	4.41	4.49	4.43	4.40	4.35	4.36	4.50	4.30	4.30	4.45	4.39
	Lactic	1.12	1.34	1.08	1.11	.93	1.46	1.80	1.87	1.38	1.42	2.00	1.19	1.33
Hour 24:	pH	4.07	4.05	4.05	4.08	4.07	4.08	4.01	4.02	4.10	4.00	4.02	4.10	4.06
	Lactic	2.51	3.45	2.76	3.28	2.98	3.03	3.94	3.19	2.81	3.39	2.83	3.23	2.84
Hour 48:	pH	3.89	3.89	3.88	3.90	3.89	3.89	3.87	3.88	3.93	3.88	3.90	3.91	3.90
	Lactic	4.02	4.19	3.97	4.90	4.29	4.59	5.07	4.87	4.72	4.23	5.22	4.46	4.23
Day 7:	pH	3.76		3.76		3.76								3.76
	Lactic	5.84		6.22		5.65								5.30
Day 21:	pH	3.69		3.68		3.69								3.69
	Lactic	5.22		5.87		5.62								6.00
	Acetic	1.56		1.41		1.71								1.61
	Total	6.78		7.28		7.33								7.61
Day 90:	pH	3.86	3.87	3.86	3.87	3.87	3.87	3.88	3.87	3.90	3.89	3.90	3.87	3.86
	Lactic	5.99	6.50	6.10	6.05	6.70	6.71	5.49	7.23	6.84	5.36	5.84	6.39	6.69
	Acetic	1.50	1.88	3.40	2.37	2.75	1.88	2.07	2.13	1.80	3.07	3.63	2.43	1.42
	Total acids	7.49	8.38	9.50	8.42	9.45	8.59	7.56	9.36	8.64	8.47	9.47	8.82	8.11
	Ethanol	2.26	2.07	2.01	2.11	2.15	2.43	2.37	2.20	1.96	2.43	2.13	2.22	2.70
	NH_3-N	.11	.09	.10	.09	.10	.09	.09	.09	.09	.09	.10	.09	.11

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

Table 34.7. pH and Chemical Composition Over Time for the Forage Sorghum Silages in Trial 4

Time Post-filling and Item[1]		Silage Inoculant Treatment											
		Control	B	C	D	E	H	I	J	K	L	M	N
Initial:	pH	5.84	5.90	5.85	5.89	5.89	5.88	5.85	5.90	5.91	5.72	5.82	5.90
	Lactic	.21	.26	.26	.24	.23	.26	.28	.24	.24	.27	.28	.20
Hour 12:	pH	5.51	5.50	5.54	5.52	5.58	5.47	5.46	5.54	5.58	5.53	5.44	5.57
	Lactic	.59	.38	.56	.40	.48	.47	.40	.39	.36	.47	.53	.48
Hour 24:	pH	4.52	4.46	4.36	4.51	4.52	4.50	4.51	4.50	4.49	4.50	4.51	4.53
	Lactic	1.43	1.57	1.66	1.27	2.40	1.31	1.35	1.21	1.41	1.71	1.50	2.61
Hour 48:	pH	4.26	4.21	4.17	4.26	4.26	4.25	4.28	4.26	4.24	4.25	4.26	4.26
	Lactic	3.60	3.86	4.70	3.87	3.92	3.88	4.50	3.65	3.85	3.68	3.14	3.94
Day 21:	pH	3.86	3.87	3.87	3.87	3.86	3.84	3.88	3.86	3.85	3.85	3.87	3.86
	Lactic	5.72	4.71	5.46	4.81	5.70	5.00	4.75	5.36	5.21	3.40	5.60	5.52
Day 90:	pH	3.88	3.89	3.89	3.87	3.87	3.86	3.89	3.82	3.86	3.87	3.87	3.88
	Lactic	5.48	4.88	5.20	5.64	5.90	5.41	5.92	5.22	5.37	5.20	5.10	5.22
	Acetic	1.22	1.47	.56	1.67	.44	1.15	1.33	.60	.70	.82	1.39	.40
	Total acids	6.70	6.35	5.76	7.31	6.34	6.56	7.25	5.82	6.07	6.02	6.49	5.62
	NH_3-N	.06	.06	.05	.06	.06	.06	.06	.06	.06	.06	.06	.06

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

Table 34.8. pH and Chemical Composition Over Time for the Alfalfa Silages in Trial 5

Time Post-filling and Item[1]		Control	Inoculant K
Initial:	pH	5.97	5.97
	Lactic	.21	.18
Hour 24:	pH	6.11	5.70
	Lactic	.30	1.43
Hour 48:	pH	5.82	4.84
	Lactic	1.28	5.78
Day 4:	pH	5.42	4.80
	Lactic	3.31	7.03
Day 14:	pH	4.99	4.73
	Lactic	5.60	6.81
Day 90:	pH	4.81	4.76
	Lactic	5.91	6.18
	Acetic	2.53	1.88
	Total acids	8.46	8.14
	NH_3-N	.23	.21

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

Table 34.9. pH and Chemical Composition Over Time for the Forage Sorghum Silages in Trials 6 and 7

Time Post-filling and Item[1]		Trial 6				Trial 7			
			Inoculant				Inoculant		
		Control	E	K	N	Control	B	C	G
Initial:	pH	5.92	5.93	5.92	5.91	5.74	5.74	5.73	5.73
	Lactic	.23	.21	.25	.24	.28	.16	.24	.22
Hour 12:	pH	4.84	4.85	4.79	4.79	4.79	4.78	4.78	4.74
	Lactic	.73	.71	.83	.82	1.16	1.01	.89	.83
Hour 24:	pH	4.52	4.55	4.53	4.55	4.27	4.26	4.25	4.27
	Lactic	1.18	1.49	1.32	1.68	2.25	2.22	2.07	2.06
Hour 48:	pH	--	--	--	--	4.00	3.99	3.98	4.02
	Lactic	--	--	--	--	3.70	3.48	3.74	3.34
Day 4:	pH	4.09	4.10	4.09	4.08	3.90	3.88	3.87	3.89
	Lactic	3.61	3.93	3.54	3.96	3.84	3.92	4.05	3.81
Day 21:	pH	4.00	4.01	4.01	3.94	3.85	3.83	3.82	3.85
	Lactic	4.25	4.31	4.21	4.49	*	*	*	*
Day 90:	pH	4.04	4.05	4.07	3.96	3.89	3.88	3.88	3.90
	Lactic	4.54	4.55	4.58	4.93	4.23	4.11	4.63	3.95
	Acetic	1.57	1.63	1.67	1.66	2.21	1.85	1.92	2.13
	Total acids	6.21	6.27	6.33	6.73	6.48	6.00	6.59	6.13
	Ethanol	*	*	*	*	1.06	1.21	1.29	1.18
	NH_3-N	.08	.08	.09	.08	.07	.06	.06	.07

[1]Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.
*Not available.

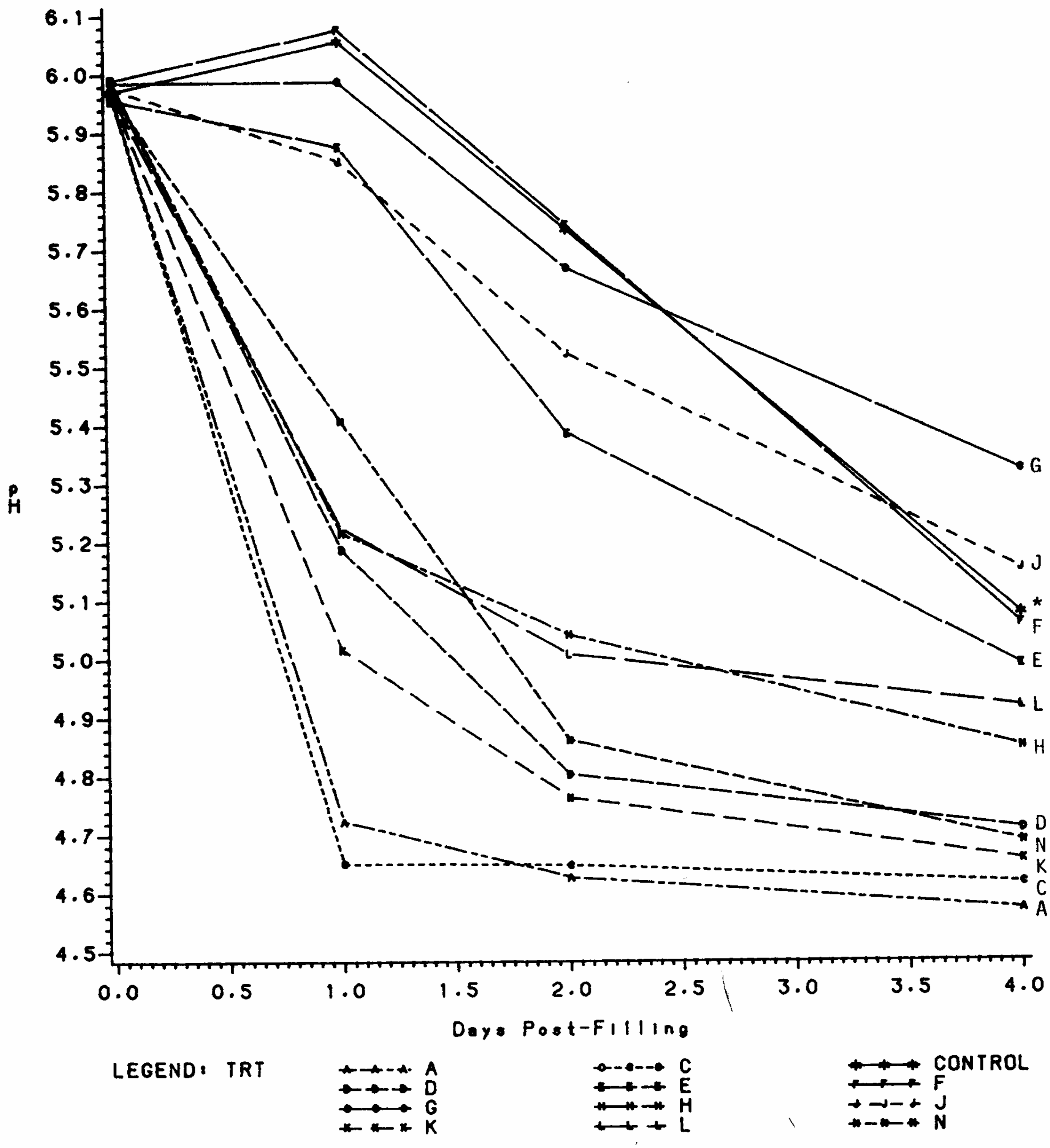

Figure 34.1. Effect of Inoculants on pH Over Time for Alfalfa Silages in Trial 2

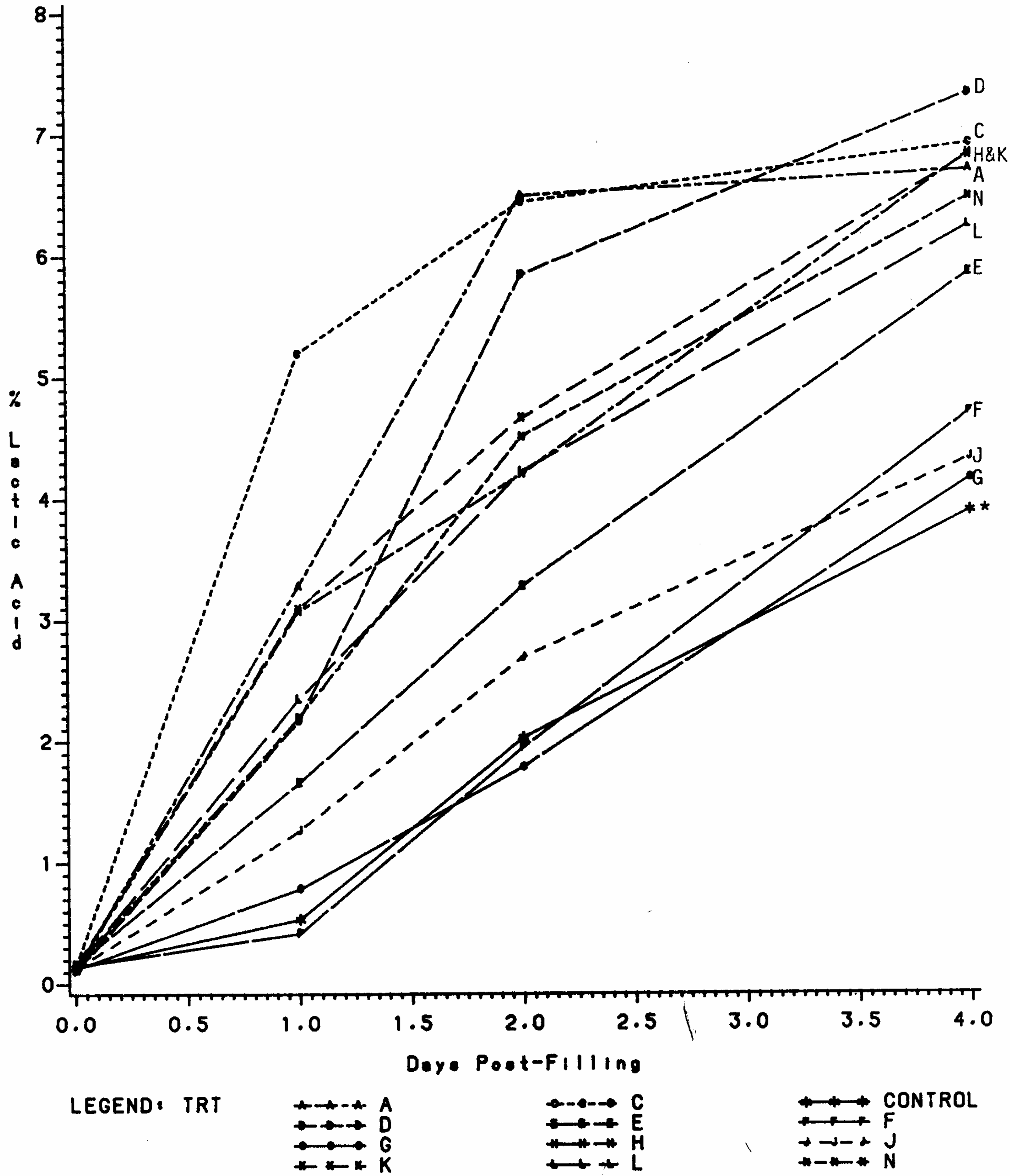

Figure 34.2. Effect of Inoculants on Lactic Acid Over Time for the Alfalfa Silages in Trial 2

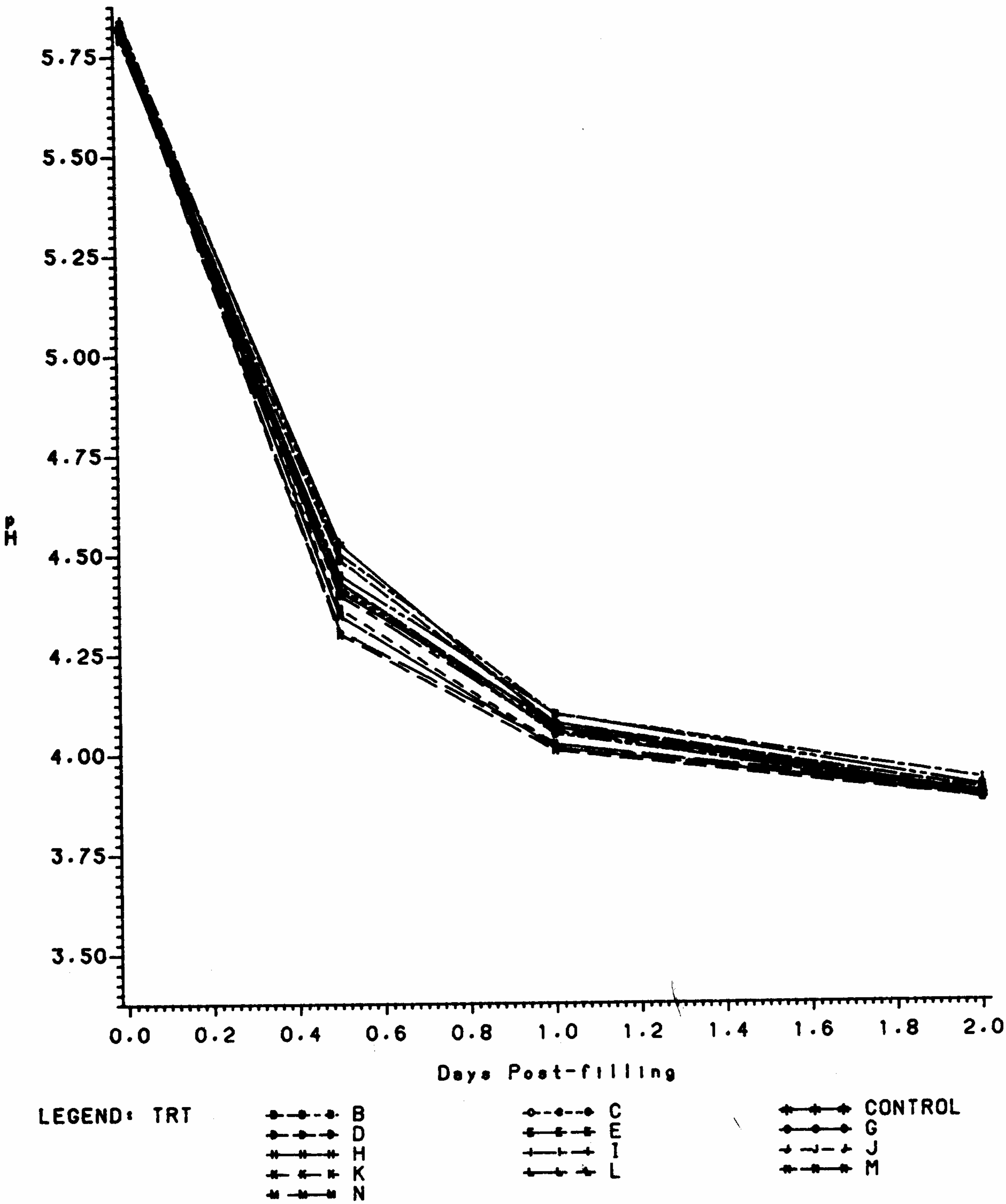

Figure 34.3. Effect of Inoculants on pH Over Time for the Corn Silages in Trial 3

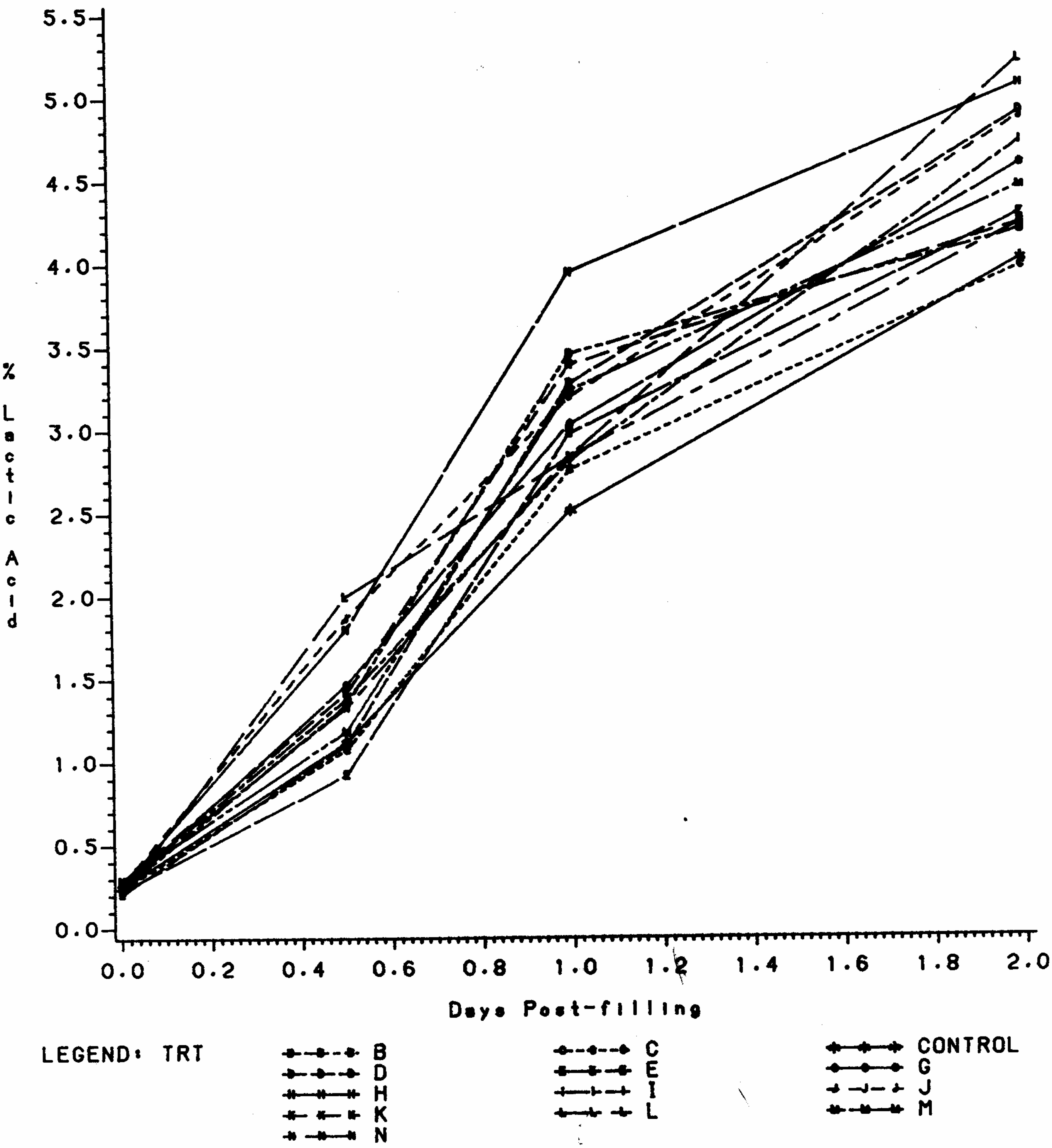

Figure 34.4. Effect of Inoculants on Lactic Acid Over Time for the Corn Silages in Trial 3