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Abstract

Inoculant (1177 in one trial) and non-protein nitrogen (LSA-100 in two trials) silage additives were evaluated with whole-plant forage sorghum silage. Steers fed LSA-100 silage gained faster than steers fed control silage supplemented with soybean meal (4.8% in trial 1; 12% in trial 2). Feed conversion was improved 11% in trial 1 and was similar to the control silage in trial 2. Silage inoculated with 1177 supported rates and efficiencies of gain similar to the control silage. Of the nitrogen added from LSA-100, 90.9% in trial 1 and 86.2% in trial 2 was recovered from the concrete stave silos. Dry matter recoveries averaged 6.0 percentage units less for LSA-100 silages than controls, however 1177 increased recovery by 2.65 units. In general, silage from the bottom half of each silo was far more stable in air than that from the top half. The additives did not consistently affect aerobic stability.

Keywords

Cattlemen's Day, 1983; Report of progress (Kansas State University. Agricultural Experiment Station); 427; Beef; Inoculant; Urea-molasses; Sorghum silage

Inoculant and Urea-molasses Additives for Forage Sorghum Silage[1,2,3]

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Summary

Inoculant (1177 in one trial) and non-protein nitrogen (LSA-100 in two trials) silage additives were evaluated with whole-plant forage sorghum silage. Steers fed LSA-100 silage gained faster than steers fed control silage supplemented with soybean meal (4.8% in trial 1; 12% in trial 2). Feed conversion was improved 11% in trial 1 and was similar to the control silage in trial 2. Silage inoculated with 1177 supported rates and efficiencies of gain similar to the control silage.

Of the nitrogen added from LSA-100, 90.9% in trial 1 and 86.2% in trial 2 was recovered from the concrete stave silos. Dry matter recoveries averaged 6.0 percentage units less for LSA-100 silages than controls, however 1177 increased recovery by 2.65 units. In general, silage from the bottom half of each silo was far more stable in air than that from the top half. The additives did not consistently affect aerobic stability.

Introduction

In Kansas, forage sorghum silage is often the main component in cattle growing rations. Improved hybrid forage sorghum varieties can produce comparable dry matter yields to corn, with less fertilizer and moisture. In a previous trial, an inoculant additive improved dry matter recovery of forage sorghum silage while a non-protein nitrogen additive improved rate and efficiency of gains over the control silage fed with soybean meal (Progress Report 413, Kansas Agriculture Expt. Station). The two trials reported here continued our evaluation of inoculant and NPN additives for forage sorghum silage.

[1] Research was conducted jointly at the Hays Branch Experiment Station, Hays, and at Kansas State University, Manhattan.

[2] Pioneer 1177® Silage Inoculant contains dried Lactobacillus plantarum fermentation product and dried Streptococcus faecium fermentation product.

[3] Pioneer Hi-Bred International, Inc., Des Moines, IA 50308.
LSA-100® liquid feed (molasses, urea, phosphoric and sulfuric acids to reduce pH to 3.0-3.2, ammonium polyphosphate, and trace minerals) contains 100% crude protein (not more than 99.5% non-protein nitrogen). Namalco, Inc., Willow Grove, PA 19090.

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Experimental Procedure

Trial 1: Forage sorghum silages were made at the Hays Branch Experimental Station in September, 1981 using DeKalb FS 4 hybrid, direct-cut in the medium-dough stage at 27 to 29% dry matter (DM). Treatments were control (no additive), and LSA-100, applied by hand at the silage blower, at 36 lb per ton of fresh crop. Silages were made in concrete stave silos (10 x 30 ft).

Dry matter losses during fermentation, storage, and feedout were measured by accurately weighing and sampling all loads of fresh crop ensiled and later weighing and sampling all silage removed from the silos. Ensiling temperatures were monitored for the first 10 weeks.

About 225 lb of fresh crop was removed from each silo during filling, and for each treatment, six plastic container silos (5 gallon capacity) were tightly filled by hand. The containers were sealed by lids fitted with rubber O-ring seals and Bunson valves, then transported immediately to Manhattan and stored in a room at about 30 C.

Stave silos were opened after 70 days and the silage fed at a uniform rate for the next 17 weeks. Silages were sampled weekly and cornposited to form a biweekly sample for chemical analyses. The 5 gallon plastic silos were opened approximately 210 days post-ensiling.

Thirty crossbred steers were fed at the Hays Station in a 122 day growth trial (November 20, 1981 to March 21, 1982). The steers, averaging 500 lb, were implanted with 36 mg of Ralgro and randomly allotted by weight, breeding, and previous gains to the two silage rations, one pen of 15 steers per ration. One lot was fed control silage *ad libitum* plus 1.83 lb of soybean meal (SBM) and .40 lb of premix (DM basis). The other lot was fed LSA-100 silage *ad libitum* plus 1.39 lb of grain sorghum, .44 lb of SBM, and .40 lb of premix. Rations were mixed and fed once daily and salt was available free-choice.

Average initial and final steer weights were on a pay-weight to pay-weight basis. To allow for weight loss during the weighing day, the steers were weighed collectively by pens, at the start of each weighing day and then weighed individually. All individual steer weights were pencil shrunk 4.0% to obtain the adjusted individual steer weights.

To measure aerobic stability, approximately 60 lb of fresh silage was obtained from 3 ft below the surface in the center of each silo at three times that corresponded to the top, middle, and bottom thirds of the silos. Those samples were transported immediately to Manhattan where they were divided into 4.0 lb lots and each lot was placed in an expanded polystyrene container lined with plastic. A thermocouple wire was placed in the center of each container and cheese cloth stretched across the top. Containers were stored at 18 to 20 C and the silage temperature was recorded twice daily. After a designated number of days of air exposure, replicated containers of each silage were weighed, mixed, and sampled and dry matter loss was determined.

Trial 2: Forage sorghum silages were made at the Beef Research Unit in Manhattan on October 23, 1981 using Pioneer 947 hybrid, direct-cut in the hard-dough stage at 42 to 43% DM. Treatments were: 1) control (no additive); 2) LSA-100 (40 lb per ton of fresh crop); and 3) Pioneer 1177 inoculant (1.0 lb per ton of fresh crop). LSA-100 was poured over the top of each load of crop in the front unloading forage wagons just prior to ensiling and 1177 was applied by hand at the blower. Silages were made in three concrete stave silos (10 x 50 ft), filled by the alternate-load method. Total harvest and filling time was 6 hours.

Dry matter losses during fermentation, storage, and feedout were measured as described in trial 1. Ensiling temperatures were monitored for the first 5 weeks.

For each treatment, six 5 gallon plastic silos were prepared as described for trial 1, except a hydraulic press was used to compact the fresh crop. In addition, six nylon bags were filled with about 30 lb of crop and buried at each of two depths in the concrete silos.

Stave silos were opened after 21 days and silage was fed at a uniform rate for the following 8 weeks. Silage sampling procedures were the same as described in trial 1. The plastic container silos were opened at 70 days post-ensiling. The nylon bags were recovered approximately 10 and 45 days after the stave silos were opened.

Thirty-six crossbred steers were individually fed in a 56 day growth trial (November 9, 1981 to January 4, 1982). The steers, averaging 487 lb, were implanted with 36 mg of Ralgro and allotted by weight to the three silage rations (12 steers per ration). The rations were the appropriate silage fed *ad libitum* plus 2.00 lb of SBM, .09 lb of rolled grain sorghum, .07 lb of limestone, and .07 lb of premix (DM basis). In the LSA-100 silage ration, 1.61 lb of rolled grain sorghum replaced an equal amount of SBM. Rations were mixed and fed twice daily. All steers were weighed individually on 2 consecutive days, after 16 hr without feed and water, at the start and at the end of the growing trial.

To measure aerobic stability, silage was removed twice during the feeding trial that corresponded to the top and bottom halves of the silos as described in trial 1.

Results and Discussion

Trial 1: Chemical analyses of the two silages are shown in Table 13.1. Both silages were well preserved and had undergone lactic acid fermentations. The non-protein nitrogen in the LSA-100 silage caused it to have lower nitrogen-free extract (NFE) and hot water insoluble-nitrogen (HWIN) values; it had higher pH, lactic, acetic, and total fermentation acids (TFA), and ammonia-nitrogen than control silage. The ammonia produced from the NPN may have acted as a buffer and allowed more carbohydrate to be fermented to acids. The addition of 35.7 lbs of LSA-100/ton of fresh crop raised the crude protein (CP) content of the silage 4.36 percentage units above the original forage, a 90.9% recovery of the supplemental nitrogen.

Ensiling temperatures are shown in Figure 13.1. The graph shows changes from the initial forage temperatures and represents daily mean readings of three thermocouples per silo. LSA-100 silage had the fastest temperature rise, peaked at day 4, and plateaued at 7.5 C above its initial temperature for the first 30 days post-ensiling. Control silage peaked in 7 days and plateaued at 5.0 C above its initial temperature for the first 40 days.

Steer performances are shown in Table 13.2. LSA-100 silage supported 4.8% faster gains than the control silage supplemented with SBM. Feed intake was 5% less, but feed efficiency was 11% better for the LSA-100 silage.

The DM lost during fermentation, storage, and feedout was 2.45 percentage units higher for the LSA-100 silage than the control (Table 13.3). Losses from the 5-gallon silos were similar for the control and LSA-100 silages and lower than losses normally expected in large farm-scale silos. Silage in these experimental silos probably represents that which is produced under the ideal conditions in the concrete silos, ie., near the center of the ensiled mass.

Shown in Table 13.4 are steer gains per ton of crop ensiled. These data combine feedlot performance (Table 13.2) and silage recovery data from the concrete silos (Table 13.3). LSA-100 silage produced 3.9 extra pounds of steer gain per ton of ensiled crop.

Silage from the top third of both silos was unstable when exposed to air (Table 13.5). In subsequent measurements, aerobic stability of both silages increased but LSA-100 was still more stable than the control, as indicated by less heating and lower DM losses during exposure to air.

Trial 2: Chemical analyses of the three silages are shown in Table 13.1. All three silages underwent a restricted lactic acid fermentation, as indicated by the relatively high pH and low lactic acid and TFA levels. LSA-100 silage had the lowest lactic and highest acetic acid values. Acidity (pH's) were numerically similar for the control and 1177 silages, but LSA-100 silage was approximately one pH unit less acid. The addition of 40.0 lb of LSA-100 per ton of fresh crop raised the CP 2.23 percentage units above the original forage, a recovery of 86.2% of the supplemental nitrogen.

Ensiling temperatures increases are shown in Figure 13.2. LSA-100 silage temperature increased through the entire monitoring period, reaching 28 C over its initial temperature by day 18. The control and 1177 silages had much slower increases in temperature, reaching a plateau of 10 to 15 C above initial temperatures by day 12.

Steer performances are shown in Table 13.2. LSA-100 silage supported 12% faster gains than the control and 16% faster gains than 1177 silage ($P<.05$). Feed intake was highest ($P<.05$) for the LSA-100 silage. Feed efficiencies were numerically and statistically similar for all three silage rations.

The DM lost during fermentation, storage, and feedout was lowest for the 1177 silage and highest for the LSA-100 silage (Table 13.3). Five to six percent of the DM ensiled was discarded as non-feedable spoilage when the silos were opened. These high surface losses resulted from poor compaction and air penetration due to the dryness of the ensiled forage. Dry matter losses from the buried bags and 5-gallon silos were numerically similar for the three silage treatments.

Shown in Table .4 are steer gains per ton of crop ensiled. These data combine feedlot performance (Table 13.2) and silage recovery data (Table 13.3). Compared with the control, LSA-100 sorghum silage produced 6.6 fewer pounds and 1177 2.7 extra pounds of steer gain per ton of ensiled crop.

Silage from the top half of all three silos were highly unstable when exposed to air (Table 13.6). The control silage from the bottom half was still unstable, but the two additive silages were slightly more stable than the control and LSA-100 silage was somewhat more stable than 1177 silage.

Table 13.1. Chemical Analyses of the Forage Sorghum Silages Made in Concrete Stave Silos in Trials 1 and 2[1]

	Silage, trial 1		Silage, trial 2		
Item	Control	LSA-100	Control	LSA-100	1177
Dry matter, %	29.11	29.23	43.67	42.41	42.92
pH	4.01	4.21	4.48	5.66	4.75
	% of the DM				
Crude protein	8.29	12.65	10.11	12.34	9.72
Crude fiber	22.28	22.38	19.04	20.71	20.58
Ether extract	2.05	3.23	3.35	3.61	3.77
Ash	8.15	8.20	6.72	7.13	7.26
NFE	58.21	53.54	60.79	56.22	58.67
Lactic acid	4.98	5.50	2.99	2.68	3.13
Acetic acid	3.07	3.28	1.28	2.30	1.28
Propionic acid	.01	.01	.01	.01	.01
Butyric acid	.04	.07	Trace	Trace	Trace
TFA	8.19	8.99	4.30	5.04	4.44
	% of the total N				
HWIN	61.02	43.77	67.74	62.58	69.69
Ammonia-N	4.59	20.77	2.10	38.11	4.99

[1] Each value is the mean of nine composited samples in trial 1 and five composited samples in trial 2.

Table 13.2. Performance by Steers Fed the Forage Sorghum Silage Rations in Trials 1 and 2

Item	Silage, trial 1 Control	Silage, trial 1 LSA-100	Silage, trial 2 Control	Silage, trial 2 LSA-100	Silage, trial 2 1177
Number of steers	15	15	12	11	11
Initial wt., lb	500	503	484	487	493
Final wt., lb	711	712	582	598	587
ADG, lb	1.87	1.96	1.74[ab]	1.98[a]	1.65[b]
Daily feed intake, lb[1]					
sorghum silage	12.41	11.79	10.23	11.27	9.66
soybean meal	1.83	.44	2.00	.51	2.00
grain sorghum	---	1.39	.09	1.61	.09
premix[2,3]	.20	.20	.07	.07	.07
ground limestone	.11	.11	.07	.07	.07
ammonium sulfate	.09	.09	---	---	---
total	14.70	14.02	12.46[b]	13.49[a]	11.88[b]
Feed/lb of gain, lb[1]	8.11	7.22	7.23	7.21	7.18

[1] 100% dry matter basis.
[2] Trial 1 premix supplied 30,000 IU vitamin A, 300 mg monensin, 90 mg Tylan. 5 mg cobalt, 30 mg copper, 7 mg iodine, 150 mg iron, 100 mg manganese, and 272 mg zinc per steer daily.
[3] Trial 2 premix consisted of 56.9% salt, 34.5% tallow and 8.6% trace mineral salt providing 30,000 IU vitamin A and 150 mg monensin per steer daily.
[a,b] Means in the same row with different superscripts differ ($P<.05$) within trial.

Table 13.3. Forage Sorghum Silage Recoveries and Losses from the Concrete Stave and Experimental Silos in Trials 1 and 2

Trial number, silo type and silage treatment	DM recovered: Feedable	DM recovered: Non-feedable (spoilage)	DM lost during fermentation, storage, and feedout
	% of the DM ensiled		
Trial 1:			
Concrete stave			
Control	79.98	1.90	18.12
LSA-100	75.99	3.44	20.57
5 gallon silo[1]			
Control	96.55	---	3.45
LSA-100	96.53	---	3.47
Trial 2:			
Concrete stave			
Control	84.39	4.41	11.20
LSA -100	76.22	5.47	18.31
1177	87.04	5.77	7.19
Nylon bag[2]			
Control	96.70	---	3.30
LSA-100	95.53	---	4.47
1177	96.66	---	3.34
5 gallon silo[3]			
Control	96.66	---	3.34
LSA-100	95.58	---	4.42
1177	96.86	---	3.14

[1] Each value is the mean of six silos opened at 160 days post-ensiling.
[2] Each value is the mean of six bags, except LSA-100 which is the mean of four bags.
[3] Each value is the mean of six silos opened at 70 days post-ensiling.

Table 13.5. Forage Sorghum Silage Temperature Changes and Losses of Dry Matter During Air Exposure in Trial 1

Silage location in silo	Day of initial rise above ambient temp.[1]	Maximum temp.[2]	Days of air exposure					
			Accumulated temp.[2]			DM loss[3]		
Top Third:			2	4	6	2	4	6
Control	2	42.4	19.6	60.9	71.5	2.33	11.11	--
LSA-100	1	47.0	27.4	61.6	73.9	7.92	16.18	--
			Accumulated temp.			DM loss		
Middle Third			3	9	22	3	9	22
Control	3	42.9	4.25	76.3	--	1.18	11.77	--
LSA-100	*	*	*	*	*	*	3.27	4.09
			Accumulated temp.			DM loss		
Bottom Third			5	8	13	5	8	13
Control	6	40.0	0	43.1	97.1	<1.0	2.92	8.73
LSA-100	9	23.0	0	1.4	11.8	<1.0	<1.0	<1.0

[1] 1.7 C rise or higher.
[2] Centegrade
[3] % of DM exposed
*No temperature rise.

Table 13.6. Forage Sorghum Silage Temperature Changes and Losses of Dry Matter During Air Exposure in trial 2

Silage location in silo	Day of initial rise above ambient temp.[1]	Maximum temp.[2]	Days of air exposure 1					
			Accumulated temp. 2			DM loss 3		
			2	4	8	2	4	8
Top Half:								
Control	1	50.8	24.1	71.2	133.2	3.57	10.38	--
LSA-100	1	40.7	25.2	53.0	76.5	4.45	9.80	--
1177	1	43.8	18.9	59.7	114.4	4.52	8.72	--
Bottom Half:								
Control	1	37.4	19.6	52.8	86.9	3.24	9.06	--
LSA-100	4	34.5	<1.0	2.5	33.7	1.20	4.07	--
1177	2	33.0	7.4	24.9	72.4	1.59	6.83	--

[1] 1.7 C rise or higher.
[2] Degrees Centegrade.
[3] % of DM exposed.

Table 13.4. Steer Gain Per Ton of Forage Sorghum Crop Ensiled in Trials 1 and 2[1]

Item	Silage, trial 1		Silage, trial 2		
	Control	LSA-100	Control	LSA-100	1177
Silage fed, lb/ton	1599.6	1519.8	1687.8	1524.4	1740.8
Silage/lb of gain, lb	27.03	24.07	24.10	24.03	23.93
Steer gain/ton of sorghum crop ensiled, lb	59.2	63.1	70.0	63.4	72.7

[1] Values are adjusted to the same dry matter content for each silage, 30%.

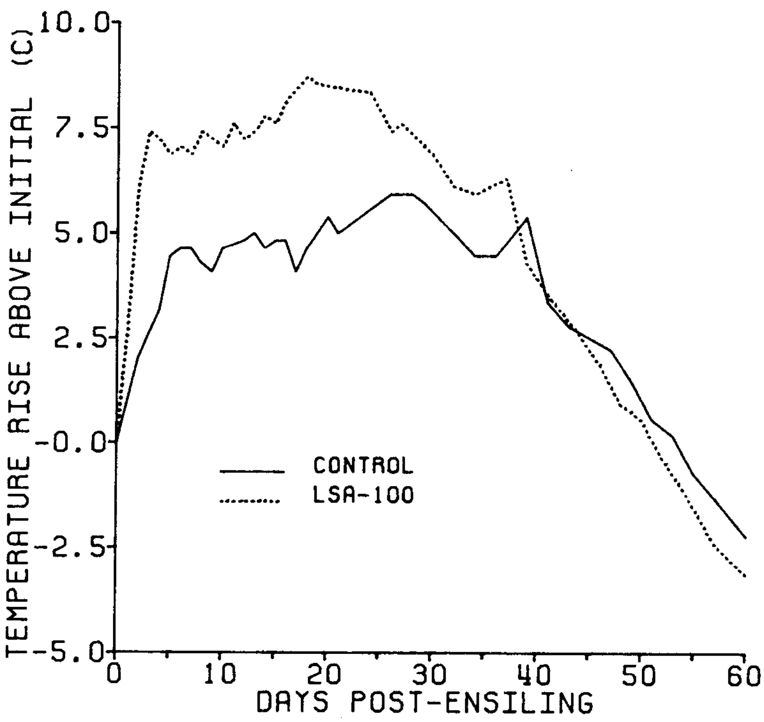

Figure 13.1. Temperature rise above initial forage ambient for the two forage sorghum silages in trial 1.

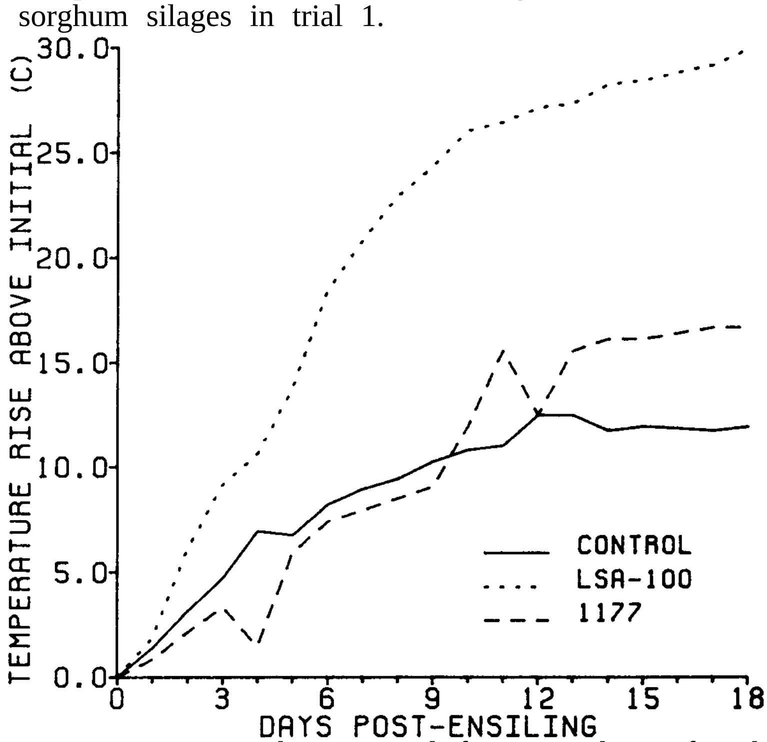

Figure 13.2. Temperature rise above initial forage ambient for the three forage sorghum silages in trial 2.