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Evaluation of interseeded grain sorghum and soybeans as 8 silage crop

Abstract

Interseeded grain sorghum and soybeans were harvested at late-boot, milk, and late-dough maturity stages of the sorghum (62, 77, and 91 days post-planting, respectively). Maximum dry matter yield occurred at the late-dough stage and interseeded silages had higher crude protein contents than the control, late-dough) grain sorghum silage. All silages underwent normal homolactic fermentations and were well preserved. Cellulose and acid detergent fiber contents were also higher in the mixtures than in the control silage, but fiber values decreased as maturity advanced. Digestibilities of most nutrients were similar in the rations, but when considered with chemical composition and yield data, late-dough harvest maximized utilization of the interseeded sorghum-soybean silage. Response to the silage inoculant Biomate® was determined in laboratory silos, and the greatest benefit occurred in the milk stage silage. Cattle fed the late-dough stage grain sorghum control silage had faster (P<.05) gains and higher intakes than those fed the late-dough sorghum-soybean silage. Adding grain improved gain and intake only for cattle fed the interseeded silage. In a subsequent trial, seeding grain sorghum and soybeans in alternating 15-inch rows increased the proportion of soybean plants and crude protein in the mixture at the late-dough harvest, with similar dry matter yields.

Keywords

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Evaluation of Interseeded Grain Sorghum and Soybeans as a Silage Crop

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Summary

Interseeded grain sorghum and soybeans were harvested at late-boot, milk, and late-dough maturity stages of the sorghum (62, 77, and 91 days post-planting, respectively). Maximum dry matter yield occurred at the late-dough stage and interseeded silages had higher crude protein contents than the control, late-dough, grain sorghum silage. All silages underwent normal homolactic fermentations and were well preserved. Cellulose and acid detergent fiber contents were also higher in the mixtures than in the control silage, but fiber values decreased as maturity advanced. Digestibilities of most nutrients were similar in the rations, but when considered with chemical composition and yield data, late-dough harvest maximized utilization of the interseeded sorghum-soybean silage. Response to the silage inoculant Biomate® was determined in laboratory silos, and the greatest benefit occurred in the milk stage silage. Cattle fed the late-dough stage grain sorghum control silage had faster ($P<.05$) gains and higher intakes than those fed the late-dough sorghum-soybean silage. Adding grain improved gain and intake only for cattle fed the interseeded silage. In a subsequent trial, seeding grain sorghum and soybeans in alternating 15-inch rows increased the proportion of soybean plants and crude protein in the mixture at the late-dough harvest, with similar dry matter yields.

Introduction

Interseeded combinations of grain sorghum and soybeans have been used as silage for dairy and beef cattle for many years. More recently, this practice has received attention because of favorable economic factors.

Under good management, selected hybrids of grain sorghum and soybeans have produced as much dry matter (DM) per acre as corn silage. Since the silage is higher in protein and minerals, less supplement is needed to balance rations.

Further studies involving digestibility and animal performance at various stages of maturity are needed to ascertain the best time to harvest the interseeded silage crop.

Experimental Procedures

Trial 1: 1986-87. Field plots were established near the KSU Beef Research Unit. Grain sorghum and soybeans were interseeded in four replications on May 22, 1986, by a grain drill with 6-inch row spacing. Planting rates were 18 lb of DeKalb 41Y grain sorghum and 95 lb of Pershing soybeans per acre. Plots of DeKalb 41Y were also established, using a 30-inch row planter and a 5.5 lb per acre seeding rate.

Anhydrous ammonia at 90 lb per acre was followed by 80 lbs of ammonium phosphate per acre. Lasso® herbicide was applied at .53 liters diluted in 12.4 liters of water per acre.

At each harvest (grain sorghum at late-boot, milk, and late-dough kernel maturities), the mixture was cut with a swather conditioner, wilted to approximately 30% DM, and chopped with a Field Queen forage harvester. The DeKalb 41Y control silage was direct-cut in the late-dough stage. Prior to each harvest, the ratio of grain sorghum to soybean plants was estimated by the square meter quadrant technique. The quadrant was randomly assigned to three locations in each replication. Both crops within the quadrant were cut, separated, placed into large paper bags, and dried at 48 to 50 C. The dried crops were then ground for chemical analyses.

About 4.5 to 5.0 tons of material from each harvest were inoculated with Biomate® silage inoculant and ensiled in 3.9 x 3.9 x 7.8 ft rectangular, plastic lined, pilot silos (three silos per treatment) and stored for 3 months. Eight individually penned Angus and Angus x Hereford heifers were assigned to each silage to determine voluntary intakes and nutrient digestibilities. Chromic oxide was included in each ration at about 20 grams/head/day as a non-digestible marker. There was a 12-day adaptation period followed by a 7-day fecal collection period. Supplements (12.4% of the ration on a DM basis) were fed to balance for crude protein, calcium, and phosphorus. Silages and supplements were fed ad lib twice daily during the first 9 days of the adaptation period, then fed at 90% of the ad lib intake until the end of the trial. Fecal samples were collected twice daily. Composite feed and fecal samples were made for each heifer to obtain apparent digestibility values for DM, crude protein, starch, acid detergent fiber (ADF), and cellulose.

Silage fermentation responses of each of the four silages to Biomate were determined using PVC laboratory silos by procedures described on page 137 of this report. Three silos per treatment were opened at 10, 20, and 40 hours and 4, 14, and 90 days post-filling. At each opening, samples were taken for the measurement of pH, lactic acid, volatile fatty acids, ethanol, and ammonia-nitrogen.

Trial 2: 1986-87. On May 23, an additional 20 acres of the grain sorghum and soybean mixture and 10 acres of DeKalb 41Y were seeded. Each was harvested when the sorghum kernels reached the late-dough stage. The mixture was wilted for approximately 24 hours to 46 to 48 % DM and ensiled in a 14 x 40 ft Harvestore®; the DeKalb 41Y was direct-cut at 42 to 44 % DM and ensiled in an AgBag®. Each silage was full-fed, with or without an additional 25% dry-rolled grain sorghum, to 16 crossbred steer and heifer calves with an initial avg. wt. of 563 pounds. The four rations and other procedures for the 80-day growing trial are described on page 168 of this report.

Trial 3: 1987-88. Field plots were planted in four replications on June 1, 1987. Grain sorghum and soybeans were interseeded in alternate rows with a 15-inch row spacing (Figure 45.1). The mixture was harvested at the late-dough stage of the grain sorghum. The three other treatments were drilled sorghum-soybeans harvested in either the milk or late-dough stages, and the control grain sorghum. Planting rates, fertilizer, and herbicide were similar to those in Trial 1. Procedures for harvesting, ensiling, and estimating the grain sorghum to soybean ratios were the same as those used in Trial 1.

Results and Discussion

Trial 1. Effects of the stage of maturity at harvest on DM yield and chemical composition of the four pre-ensiled crops are shown in Table 45.1. As maturity advanced, the DM yield of the mixture increased and the ratio of grain sorghum to soybeans decreased. Protein content was higher at all stages of maturity in the mixture than in the control grain sorghum ($P<.05$). There was also a slight but nonsignificant decrease in protein content from the late-boot stage through the late-dough stage. This decrease does not correlate well with the increase in the ratio of soybean plants to grain sorghum plants as maturity advanced. It should be noted that the sorghum plants severly shaded the soybeans. Cellulose and ADF contents decreased ($P<.05$) as maturity advanced. Grain sorghum silage had the lowest ADF and cellulose content. Lignin content was higher in the mixture silages, particularly at the milk stage of the grain sorghum.

Table 45.2 shows the effects of the stage of maturity on the composition and fermentation characteristics of the silages. Generally, the silages made at all stages of maturity were well preserved. Lactic acid was predominant, and the pH values were normal. Lactic acid contents were higher ($P<.05$) in the sorghum-soybean silages than in the control grain sorghum silage. Acetic acid and ammonia contents also differed but were within the range found in normal silages. Silage composition values were in accordance with those obtained on the pre-ensiled crops.

Voluntary intakes and apparent nutrient digestibilities are shown in Table 45.3. Digestibility of DM, CP, and cellulose were not affected by the stage of maturity. Further, digestibilities of these nutrients were all similar to those in the grain sorghum silage. Starch and ADF digestibilities decreased as the maturity advanced, and were lowest for the grain sorghum silage. However, digestibility did not differ significantly from the late-boot to the milk stage for starch, and from the milk stage to the late-dough stage for ADF. The amounts of digestible nutrients per acre are also shown in Table 45.3. The amount of digestible DM was significantly higher at the late-dough stage as compared to all the other treatments. The amount of digestible crude protein did not differ at the late-boot, milk, or late-dough stages, but was significantly greater in the sorghum-soybean silage than in the control sorghum silage. Considering the increase in digestible dry matter, harvest at the late-dough stage appears to provide for maximum utilization of the sorghum-soybean mixture.

Response of sorghum-soybean silages at different maturity stages to the inoculant is shown in Table 45.4. The inoculant increased the rate of pH drop ($P<.05$) over the control silage only during the first 4 days post-filling. This response was greater for the milk stage than for the other silages. Lactic acid also differed among the four silages ($P<.05$) and also greater for the milk stage sorghum-soybean silage. Increased lactic acid production, however, was a function of both maturity and time post-filling rather than just the inoculant. It may have been due to the greater amount of water soluble carbohydrates and lactic acid bacteria in the fresh crop at the milk stage (Table 45.1).

Trial 2. Chemical composition and fermentation characteristics of the sorghum-soybean and grain sorghum silages are shown in Table 45.5. Although values for most of the fermentation characteristics differed ($P<.05$), all were within the range expected for well-preserved silages.

Dry matter intake was greater ($P<.05$) for the two grain sorghum silage rations than for the two sorghum-soybean rations. Cattle fed the mixture silage without grain made the slowest ($P<.05$) gains, but feed conversions were similar for the two silages. When considered with DM yield in Trial 1 (13,130 lb/acre for sorghum-soybean silage and 11,400 lb/acre for grain sorghum silage), gain per acre was 139 lb higher for the sorghum-soybean silage than for the grain sorghum silage.

Adding grain increased ($P<.05$) gain and intake of cattle fed the sorghum-soybean silage but not of cattle fed the grain sorghum silage. Feed efficiency was not affected by the grain addition in either silage.

Trial 3. Shown in Table 45.6. are DM yield and crude protein contents of the crops that were ensiled in Trial 3. When grain sorghum and soybeans were interseeded in alternate 15-inch rows, DM yield, crude protein content, and proportion of soybeans increased as compared with the drilled mixture. Planting in alternate rows likely minimized the shading effect of sorghum plants on soybeans.

Figure 45.1. Grain Sorghum and Soybeans Planted in Alternate 15-inch Rows

Table 45.1. Yield and Pre-ensiled Chemical Composition of the Sorghum-Soybean and Grain Sorghum Forages in Trial 1

	Sorghum-Soybean			
Item	Late-boot	Milk	Late-dough	Grain Sorghum
Harvest Date, 1986	July 23	Aug. 7	Aug. 21	Sept. 10
Dry Matter, %	30.8	28.0	30.4	35.4
DM Yield, lb/Acre	10,820	11,490	13,130	11,400
Sorghum : Soybean Whole-plant Ratio	4.9:1	3.5:1	3.4:1	---
	--------------------% of the Forage DM-------------------			
Crude Protein	14.14	13.60	13.05	9.23
Water Soluble Carbohydrate	6.3	9.5	5.1	4.3
Starch	5.0	6.2	9.4	33.4
Lactic Acid Bacteria, Colony-forming units/gram	$6.9x10^{4}$	$8.6x10^{4}$	$4.8x10^{4}$	$1.8x10^{4}$

Table 45.2. Chemical Composition and Fermentation Characteristics of the Four Silages in Trial 1

	Sorghum-Soybean			
Item	Late-boot	Milk	Late-dough	Grain Sorghum
Dry Matter, %	29.6^{b}	26.7^{c}	27.8^{c}	34.5^{a}
pH	4.23^{b}	4.00^{d}	4.30^{a}	4.09^{c}
	----------------% of the Silage DM------------------------			
Crude Protein	13.67^{a}	14.05^{a}	13.98^{a}	9.70^{b}
Cellulose	28.4^{a}	24.9^{b}	24.5^{b}	16.7^{c}
Acid Detergent Fiber	37.6^{a}	33.5^{b}	35.0^{b}	24.8^{c}
Lactic Acid	6.30^{b}	8.27^{a}	8.24^{a}	5.52^{c}
Acetic Acid	1.83^{c}	2.25^{b}	3.48^{a}	1.40^{d}
Ammonia-N	$.18^{b}$	$.17^{b}$	$.28^{a}$	$.12^{c}$
DM Recovery, % of the DM Ensiled	97.5	87.0	87.0	92.8

[abc]Means on the same line with different superscripts differ ($P<.05$).

Table 45.3. Voluntary Intake and Apparent Nutrient Digestibilities of the Four Silage Rations and Yield of Digestible Nutrients per Acre in Trial 1

Item	Sorghum-Soybean Late-boot	Sorghum-Soybean Milk	Sorghum-Soybean Late-dough	Grain Sorghum
No. of Heifers	8	8	8	8
Initial Wt., lb	703	701	704	704
Daily DM Intake, lb	12.06[b]	11.57[b]	12.31[b]	15.51[a]
	Digestibility, %			
Dry Matter	66.5	68.4	65.9	65.5
Crude protein	68.9	71.3	67.5	66.3
Starch	93.7	90.9	88.1	74.2
Acid Detergent Fiber	58.2	54.8	50.1	52.3
Cellulose	69.0	67.6	62.9	65.2
	lb per Acre			
Digestible DM	7,090	7,695	8,665	7,110
Digestible CP	1,055	1,250	1,156	698
Ruminal pH[1]	7.2[a]	7.1[a]	7.2[a]	6.9[b]

[ab]Means on the same line with different superscripts differ (P<.05).

[1]Means of five measurements taken at 1, 2, 4, 6, and 12 hours post-feeding.

Table 45.4. pH and Lactic Acid Content over Time for the Control and Inoculated Silages in Trial 1

Time Post-filling		Sorghum-Soybean Late-boot Control	Late-boot Biomate	Milk Control	Milk Biomate	Late-dough Control	Late-dough Biomate	Grain Sorghum Control	Grain Sorghum Biomate
Hour 10:	pH	5.53	5.33	5.01	4.86	4.94	4.94	4.86	4.70
	Lactic Acid[1]	.63	.59	1.60	1.95	1.38	1.34	.58	.55
Hour 20:	pH	4.52	4.34	4.40	4.18	4.43	4.40	4.52	4.44
	Lactic Acid	1.24	2.14	3.81	4.52	3.14	3.44	1.35	1.50
Hour 40:	pH	4.50	4.25	4.39	4.04	4.21	4.22	4.28	4.24
	Lactic Acid	3.17	3.91	4.89	7.26	5.44	5.48	2.88	2.67
Day 4:	pH	4.28	4.10	4.12	3.89	4.11	4.14	4.16	4.16
	Lactic Acid	4.57	5.69	6.36	9.22	6.08	5.72	4.07	3.76
Day 14:	pH	4.19	4.10	3.95	3.87	4.04	4.05	4.05	4.05
	Lactic Acid	5.65	6.18	7.34	6.51	7.59	6.86	---	---
Day 90:	pH	4.18	4.07	3.88	3.88	4.15	4.18	4.03	4.04
	Lactic Acid	6.36	6.68	10.59	8.42	6.93	6.87	6.95	6.57

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

Table 45.5. Performance by Calves Fed the Four Silage Rations in Trial 2

Item	Sorghum-Soybean[1] w/o	Sorghum-Soybean[1] w	Grain Sorghum[1] w/o	Grain Sorghum[1] w
No. of Calves	8	8	8	8
Initial Wt., lb	563	563	563	563
Final Wt., lb	699	729	727	752
Avg. Daily Gain, lb	1.70[b]	2.08[a]	2.13[a]	2.28[a]
Daily Feed Intake, lb[2]	14.8[c]	17.5[b]	19.8[a]	19.3[a]
Feed/lb of Gain, lb[2]	8.74	8.45	9.29	8.56
Silage Analyses:				
DM, %	46.6		42.7	
pH	4.61		4.16	
	-------------------% of the Silage DM-------------------			
Crude Protein	9.1		8.8	
Lactic Acid	5.77		4.46	
Acetic Acid	2.52		1.57	
Ethanol	.20		.39	
Ammonia-N	.31		.10	
Acid Detergent Fiber	36.4		23.6	

[abc]Means on the same line with different superscripts differ (P<.05).

[1]w/o = 87.6% silage and 12.4% supplement; w = 62.6% silage, 25.0% dry-rolled grain sorghum, and 12.4% supplement.

[2]100% dry matter basis.

Table 45.6. Yield, Protein Content, and the Grain Sorghum to Soybean Whole-Plant Ratio in Trial 3

Item	Sorghum-Soybean Milk (drilled)	Sorghum-Soybean Late-dough (drilled)	Sorghum-Soybean Late-dough (15" rows)	Grain Sorghum
DM Yield, lb/Acre	7,475	8,045	8,955	9,865
Crude Protein, % of the DM	12.8	11.8	16.9	10.4
Sorghum: Soybean Whole-plant Ratio	3.1:1	5.3:1	2.2:1	---