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Annual Grasses Preserved as Silage:
Fermentation Characteristics, Nutritive Value, and Quality

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Annual Grasses Preserved as Silage: Fermentation Characteristics, Nutritive Value, and Quality

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Abstract

This bulletin brings together 13 independent experiments that address aspects of fermentation (pH and fatty acid production), nutritive value (laboratory estimates of dry matter disappearance and chemical composition), and quality (animal responses) of cool-season and warm-season annual forages preserved as silage. Although we conducted each experiment independently, those with similar objectives have been grouped and appear under four section headings. Our focus in this bulletin is the evaluation of temperate corn and tropical corn cultivars with lesser research directed to small grains, forage sorghum, and pearlmillet as silages.

Our intent in producing this bulletin is to make available original research data in a summarized format, with associated methodology, for future reference. A brief Results and Discussion section has been included for each experiment followed by a Summary section highlighting the major findings. Consequently, the interested reader is directed to the Summary and Conclusions section of each experiment for an assessment of the findings that is not reiterated elsewhere.

Introduction

Animal production enterprises that require a large, reliable source of forage of maximum nutritive value have frequently included either annual warm-season or cool-season forages, or both, in their production systems. These annuals, generally preserved as silage for animal production systems, can be advantageously produced in the U.S. mid-Atlantic and farther south by taking advantage, in the case of cool-season grass, of the moderate winter, and in the case of warm-season grass, of the hot, humid summers with generally favorable rainfall.

Of the annual warm-season grasses, corn (*Zea mays* L.) has been the primary choice because of its ease of production, harvesting, and preservation as excellent quality silage as well as maintaining maximum nutritive value. Annual sorghums [*Sorghum bicolor* (L.) Moench] and millets [*Pennisetum americanum* (L.) Leeke, formerly *P. glaucum* (L.) R, Br] have also played a role, but are frequently lacking in nutritive value.

The small grains, or annual cool-season grasses, consisting of wheat (*Triticum aestivum* L. emend. Thell.), triticale (X*Triticosecale* Wittmack), barley (*Hordeum vulgare* L.), and oats (*Avena sativa* L.), have all been grown and preserved as silage with wheat, triticale, and barley generally preferred because of their yield potentials. Oats, however, have also had an important role.

The potential of double cropping with cool-season and warm-season annuals grown in sequence, or double cropping with warm-season annuals grown in sequence on the same land resource, offers economic advantages in terms of nutrient production. The residual impact of one crop on the subsequent crop in a double cropping system warrants some consideration.

Of the corn cultivars used for silage, the adapted, temperate ones have generally served this role. Tropical corn cultivars, however, are also available that can be planted later and have provided a viable silage for producing animals. Generally, tropical corn cultivars have a lesser grain component but greater fiber concentration in the forage component than temperate cultivars, but tropical cultivars are noted for greatest forage yields. The agronomics and forage potential of tropical corn across the southeastern United States has been the subject of a Southern Regional Symposium and worthy of examining (Teare and Brown, 1991).

In the Upper South, where the summer growing season is shorter compared with the Lower South, double cropping with a small grain followed by corn can be readily practiced. The maturity of small grains, generally in the boot- to late-boot stage, occurs early enough to permit the planting of either temperate or tropical corn cultivars. In cases where a small grain harvest is delayed until seed-set, sufficient variation occurs in tropical corn cultivars to permit planting into mid-June. In Section I of this bulletin, we compare ensiling characteristics, nutritive value, and quality of several adapted temperate corn cultivars with that of various alternative annual forages when preserved as silage. Forages compared include several tropical corn cultivars, forage sorghum, and pearlmillet. In Section II, we examine the ensiling characteristics, nutritive value, and quality of two prominent small grains. And in Section III, we consider small grains and corn responses when grown in a double cropping setting. Also, we report in Section IV the results of independent experiments conducted to compare only animal preference among selected cultivars.

Our main focus in this bulletin is to provide a record of data obtained from several different experiments on the evaluation of these selected annual cool-season and warm-season grasses that might contribute to improved animal daily performance during stressful periods. Only the main points have been highlighted in the Results and Discussion section and in the Summary and Conclusions section. The general procedures used in conducting the research presented in this bulletin are provided in the Appendices. Throughout the bulletin, "nutritive value" refers to laboratory estimates of in vitro dry matter disappearance and the chemical composition of the forage (such as crude protein and neutral detergent fiber), and "quality" refers to animal responses (such as dry matter intake, dry matter digestibility, masticate characteristics, and preference).

I. Warm-Season Annuals

Experiment 1. Temperate Corn Dekalb 689 Compared with Two Tropical Corn Silages: Ensiling Characteristics, Nutritive Value, and Quality

Temperate corn cultivars are the primary source of corn for silage in the United States. Our objective in this experiment was to compare the nutritive value and quality of the adapted temperate corn cultivar Dekalb 689 with two tropical corn cultivars when preserved as silage.

Materials and Methods

Three corn cultivars were planted, grown, and harvested using conventional procedures. These cultivars were evaluated:

Temperate corn:
1. Dekalb 689

Tropical corn (TP):
2. Dekalb 678C (TP-1)
3. Pioneer X304C (TP-2)

All forages were preserved in upright experimental silos (Appendix GP-1) and were not disturbed for at least 60 days following ensiling so fermentation could proceed to completion.

Digestion (Experiment 1A) and mastication (Experiment 1B) experiments were conducted using steers in a randomized complete block design. In Experiment 1A, three steers were used per treatment—being blocked by weight in groups of three (range of 538 to 611 pounds; mean = 603 pounds) and assigned at random within group to a treatment (Appendix GP-2). In Experiment 1B, silages were evaluated by three to five steers, depending on treatment (Appendix GP-3). All as-fed, weighback, masticate, and fecal samples were analyzed according to standard procedures (Appendix GP-6), and data were analyzed statistically according to the experimental design (Appendix GP-7).

Results and Discussion

Experiment 1A

At ensiling, the dry matter concentrations of the silages were similar, averaging 42.7%. Following fermentation, the pH, ethanol, and fatty acids concentrations were likewise similar among forages (Table 1.1). Although the lactic acid concentrations of the two tropical cultivars were similar, differences approached significance ($P = 0.06$) and the tropical cultivar average concentration was greater than that of the temperate corn.

Steers digested the dry matter of temperate corn silage greater than the two tropicals, which were similar in dry matter digestibility. But steers digested the cellulose of temperate corn lesser than they digested that of tropical cultivars (Table 1.2). The lesser digestion of hemicellulose for the temperate corn versus tropical corn also approached significance ($P = 0.06$).

The nutritive value of the as-fed temperate corn silage was generally greater compared with that of the tropical corns, the temperate corn having greater in vitro dry matter disappearance and crude protein and lesser acid detergent fiber and cellulose (Table 1.3). Also, some selective consumption was evident by the magnitude of the difference values (weighback concentration minus as-fed concentration). The greatest selectivity, however, was noted for TP-2 (Pioneer X304C).

Fecal composition reflects the greater crude protein (CP) concentration of the as-fed temperate corn silage, being greater compared with the tropical corns, which were similar (Table 1.4). Particle size distribution of the feces, however, was similar among all cultivars (data are shown with masticate in Figure 1.1).

Experiment 1B

The masticate dry matter was similar among all three corn cultivars, averaging 16.9%, and median particle size was similar among the silages (Table 1.5). The whole masticate reflects the nutritive value of the as-fed temperate silage (Table 1.3), being greater in in vitro dry matter disappearance and crude

protein and lesser in neutral detergent fiber than the whole masticate from tropical corn silages. This was also evident for all three particle-size classes. The proportions of the whole masticate that composed the large, medium, and small particle sizes were generally similar among the three corn silages. The distribution of masticate and fecal particles for each sieve size can be viewed in Figure 1.1.

Summary and Conclusion

- All silages ensiled well with pH measures of ≤ 4.3 and were readily eaten by steers.
- Steers digested the dry matter of the temperate cultivar (Dekalb 689) greater than that of the tropical cultivars (Dekalb 678C and Pioneer X304C).
- The nutritive value of the as-fed and the masticated silage generally reflected the greater digestibility of the temperate silage dry matter.

Table 1.1. Dry matter (DM) and fermentation characteristics of temperate and tropical corn silages (DM basis).

Cultivar	DM	pH	Ethanol	Fatty Acids			
				Acetic	Propionic	Lactic	Butyric
	%		——————————%——————————				
Temperate corn (TM):							
Dekalb 689	44.5[1]	4.3	0.18	0.79	0.029	2.53	0.004
Tropical corn (TP):							
Dekalb 678C (TP-1)	41.8	4.1	0.25	1.26	0.020	5.02	—
Pioneer X304C (TP-2)	41.9	4.0	0.41	1.04	0.028	4.97	—
Significance (*P*):							
Treatment	0.66	0.15	0.63	0.62	0.58	0.11	
TM vs. TP	0.42	0.08	0.51	0.43	0.55	0.06	
TP-1 vs. TP-2	0.98	0.66	0.53	0.66	0.44	0.95	

[1] Each value is the mean of two samples (replicates 1 and 2 pooled, and 3 and 4 pooled).

Table 1.2. Dry matter (DM) and neutral detergent fiber (NDF) digestibility and digestibilities of associated fiber fractions[1] of temperate and tropical corn preserved as silages, Experiment 1A (DM basis).

Cultivar	DM	NDF	Fiber Fractions		
			ADF	HEMI	CELL
	——————————%—————————-				
Temperate corn (TM):					
Dekalb 689	59.8[2]	34.8	36.0	33.5	39.0
Tropical corn (TP):					
Dekalb 678C (TP-1)	55.5	44.2	42.6	46.2	48.2
Pioneer X304C (TP-2)	55.7	39.5	36.1	43.3	42.7
Significance (P):					
Treatment	0.01	0.15	0.14	0.13	0.07
TM vs. TP	0.01	0.09	0.26	0.06	0.05
TP-1 vs. TP-2	0.83	0.27	0.09	0.59	0.12

[1] ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of three steers.

Table 1.3. In vitro dry matter disappearance (IVDMD) and associated nutritive value[1] of as fed (AF) temperate and tropical corn preserved as silages, Experiment 1A (dry matter basis).

Cultivar	IVDMD		CP		NDF		Fiber Fractions			
	AF	DV[2]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	%									
Temperate corn (TM):										
Dekalb 689	68.2[3]	-1.2	8.1	-0.1	46.0	2.0	23.4	22.6	19.0	4.0
Tropical corn (TP):										
Dekalb 678C (TP-1)	57.3	1.9	7.3	-1.1	58.2	2.4	32.0	26.2	25.9	5.5
Pioneer X304C (TP-2)	59.9	-5.3	7.5	-1.5	55.3	11.9	29.1	26.2	23.7	4.9
Significance (P):										
Treatment	0.05	0.06	0.02	0.03	0.15	0.05	0.07	0.33	0.06	0.14
TM vs. TP	0.03	0.78	0.01	0.02	0.08	0.12	0.04	0.18	0.03	0.09
TP-1 vs. TP-2	0.30	0.02	0.11	0.26	0.52	0.03	0.24	0.99	0.21	0.29

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DV = difference value (weighback concentration minus AF concentration).

[3] Each value is the mean of two samples (replicate 1 and 2 pooled and 3 and 4 pooled).

Table 1.4. Composition[1] of feces from steers fed temperate and tropical corn silages (dry matter basis).

Cultivar	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Temperate corn (TM):						
Dekalb 689	10.3[2]	73.3	37.1	36.3	28.7	7.7
Tropical corn (TP):						
Dekalb 678C (TP-1)	8.9	73.2	41.5	31.7	30.2	10.0
Pioneer X304C (TP-2)	9.1	73.9	41.2	32.7	29.9	10.3
Significance (*P*):						
Treatment	0.08	0.73	0.02	<0.01	0.31	<0.01
TM vs. TP	0.03	0.79	0.01	<0.01	0.15	<0.01
TP-1 vs. TP-2	0.73	0.48	0.76	0.11	0.75	0.28

[1]CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of three steers.

Table 1.5. Masticate dry matter (DM), median particle size (MPS), and particle-size classes and associated nutritive value[1] of temperate and tropical corn preserved as silages, Experiment 1B (DM basis).

Cultivar	Whole Masticate					Particle-size classes[2]								
						Large			Medium			Small		
	DM	MPS	IVDMD	CP	NDF	Prop[3]	IVDMD	NDF	Prop	IVDMD	NDF	Prop	IVDMD	NDF
	%	mm	%											
Temperate corn (TM):														
Dekalb 689	18.1[4]	2.1	70.0	7.7	45.6	58.9	65.7	50.7	26.2	70.3	39.7	14.9	83.3	16.0
Tropical corn (TP):														
Dekalb 678C (TP-1)	17.5	2.3	60.8	6.5	58.5	64.9	50.0	63.8	25.2	64.0	52.3	9.9	77.5	29.1
Pioneer X304C (TP-2)	15.1	2.0	56.8	6.5	62.2	50.9	50.5	67.7	36.1	58.5	59.3	13.0	69.5	39.9
Significance (*P*):														
Treatment	0.54	0.39	<0.01	0.03	0.04	0.23	<0.01	<0.01	0.12	0.03	<0.01	0.20	0.02	<0.01
TM vs. TP	0.44	0.77	<0.01	0.01	0.02	0.86	<0.01	<0.01	0.28	0.01	<0.01	0.17	0.01	<0.01
TP-1 vs. TP-2	0.40	0.21	0.10	0.97	0.50	0.10	0.01	0.22	0.06	0.13	0.06	0.29	0.06	0.04

[1] IVDMD = in vitro dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber.

[2] Large = ≥ 1.7 mm; medium = < 1.7 and ≥ 0.5 mm; small = < 0.5 mm.

[3] Prop = proportion of whole masticate DM.

[4] Each value is the mean of three to five steers.

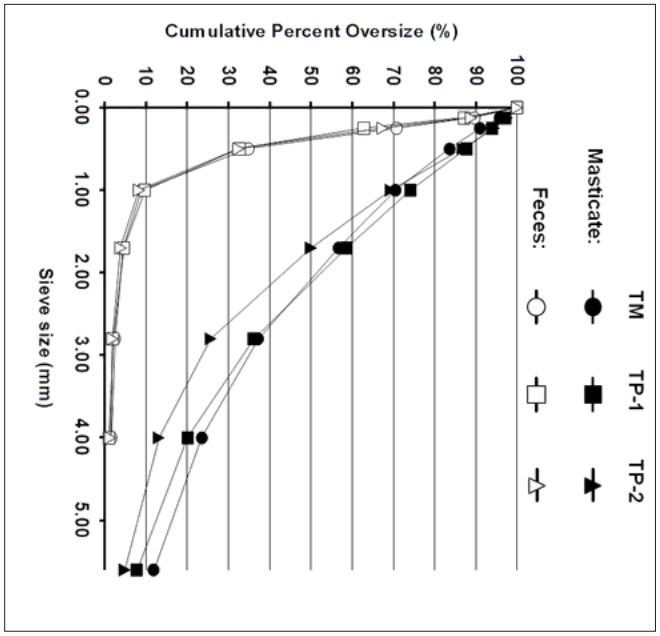

Figure 1.1. Particle size distribution of masticate and feces dry matter of temperate (TM = Dekalb 689) and tropical (TP-1 = Dekalb 678C and TP-2 = Pioneer X304C) corn silages (dry matter basis).

Experiment 2. Temperate Corn Pioneer 3154 Compared with Two Tropical Corn Silages: Ensiling Characteristics, Nutritive Value, and Quality

Temperate corn cultivars make up the primary source of corn for silage in the United States. Our objective in this experiment was to compare the nutritive value and quality of the adapted temperate corn cultivar Pioneer 3154 with two tropical corn cultivars when preserved as silage.

Material and Methods

Three corn cultivars were planted, grown, and harvested using conventional procedures. These cultivars were evaluated:

Temperate corn:
1. Pioneer 3154

Tropical corn:
2. Dekalb 678C (TP-1)
3. Pioneer X304C (TP-2)

All forages were preserved in upright experimental silos (Appendix GP-1) and were not disturbed for at least 60 days following ensiling so fermentation could proceed to completion.

Digestibility (Experiment 2A) and mastication (Experiment 2B) experiments were conducted using steers in a randomized complete block design. In Experiment 2A, four steers were used per treatment, being blocked in groups of three by weight (range of 482 to 609 pounds, mean = 555 pounds) and assigned at random within group to a treatment (Appendix GP-2). In Experiment 2B, silages were evaluated by six steers (Appendix GP-3). All as-fed, weighback, masticate, and fecal samples were analyzed according to standard procedures (Appendix GP-6), and data were analyzed statistically according to the experimental design (Appendix GP-7).

Results and Discussion

Experiment 2A

At ensiling, the morphology of the temperate corn differed appreciably from that of the tropical cultivars, which were generally similar (not compared statistically, Table 2.1). Dry matter of the ensiled corn forage was greater for the temperate corn, averaging 33.2% compared with 26.1% for the tropical corn forages, which were similar (Table 2.2). Silages fermented well with pH measures of 4.1 and below. The temperate silage produced lesser propionic and lactic acids compared with the tropical silages, which were similar. The more favorable pH noted for silages in this experiment—compared with the pH of silages in Experiment 1—is, in part, attributed to greater moisture concentrations at ensiling, which probably aided packing, thereby excluding more oxygen. This is reflected in greater concentrations of lactic acid in this experiment compared with those in Experiment 1.

Steers digested the dry matter of the three corn silages similarly, as well as the neutral detergent fiber and its constituent fiber fractions (Table 2.3). This finding is consistent with the nutritive value of the as-fed silage being similar in average in vitro true dry matter disappearance (76%), crude protein (9%), and neutral detergent fiber (52%) (Table 2.4).

Composition of fecal samples reveals a greater concentration of crude protein from tropical corn silages compared with temperate and consistent with the relationship of the as-fed silages (Table 2.5 and Table 2.3). The neutral detergent fiber and its constituents were similar in concentration among the three corn silages.

Experiment 2B

Examination of masticate reveals no difference in dry matter concentration, median particle size, or nutritive value among the three silages (Table 2.6). This is also the case among cultivars within each particle-size class. The noted exception, however, was the lesser in vitro true dry matter disappearance of temperate corn silage within each class. The particle-size distribution of masticate dry matter reveals the general similarity of the two tropical cultivars compared with a different distribution noted for the temperate corn silage (Figure 2.1).

Summary and Conclusions

- As expected, temperate corn had a greater proportion of its dry matter as ear (51.3%) when compared with tropical cultivars (36.9% to 37.4%).

- All silages fermented well with pH measures of ≤ 4.1 and were readily eaten by steers.
- Steers digested the dry matter and neutral detergent fiber and its fiber constituents similarly regardless of corn type.
- The similarity in dry matter digestibility among cultivars was generally reflected in the nutritive value of both the as-fed silage and the masticate.

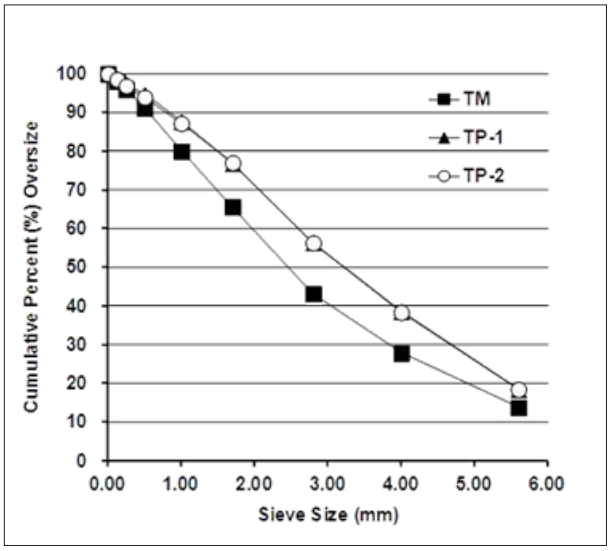

Figure 2.1. Particle size distribution of masticate dry matter of temperate (TM = Pioneer 3154) and Tropical (TP-1 = Dekalb 678; TP-2 = Pioneer X304C) corn silages.

Table 2.1. Morphology of temperate and tropical corn cultivars evaluated in Experiments 2A and 2B.

Cultivar	Forage					Ear		
	Leaf	Sheath	Stalk	Tassel	Ear	Grain	Cob	Husk
	————% of Total Plant ————					—% of Total Ear—		
Temperate corn:								
Pioneer 3154	11.2[1]	7.2	29.9	0.5	51.3	72.2	16.6	11.2
Tropical corn:								
Dekalb 678C	19.0	10.6	31.7	1.3	37.4	39.0	24.6	36.4
Pioneer X304C	18.7	10.4	32.5	1.5	36.9	52.4	20.4	27.2

[1]Each value is the average of 10 stalks and the mean of five samples.

Table 2.2. Dry matter (DM) and fermentation characteristics of ensiled temperate and tropical corn fed in Experiments 2A and 2B (DM basis).

Cultivar	DM	pH	Alcohols		Fatty Acids			
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric
	%		%					
Temperate corn (TM):								
Pioneer 3154	33.2[1]	4.1	0.54	0.002	0.79	0.026	4.48	0.009
Tropical corn (TP):								
Dekalb 678C (TP-1)	25.6	3.8	1.07	0.030	1.25	0.068	6.57	-
Pioneer X304C (TP-2)	26.6	3.9	0.41	0.009	1.22	0.080	7.04	0.025
Significance (*P*):								
Treatment	0.01	0.14	0.76	0.16	0.38	0.08	0.05	0.50
TM vs. TP	<0.01	0.07	0.82	0.15	0.21	0.05	0.03	0.85
TP-1 vs. TP-2	0.21	0.66	0.53	0.14	0.93	0.42	0.40	0.30

[1] Each value is the mean of four samples.

Table 2.3. Dry matter (DM) digestibility and digestibilities of neutral detergent fiber (NDF) and fiber fractions[1] of temperate and tropical corn silages, Experiment 2A (DM basis).

Cultivar	DM	NDF	Fiber Fractions[1]		
			ADF	HEMI	CELL
	%				
Temperate corn (TM):					
Pioneer 3154	62.5[2]	52.6	51.4	53.9	56.5
Tropical corn (TP):					
Dekalb 678C (TP-1)	61.6	49.5	52.2	45.5	58.5
Pioneer X304C (TP-2)	66.8	51.2	55.6	44.9	61.3
Significance (*P*):					
Treatment	0.19	0.81	0.61	0.27	0.61
TM vs. TP	0.50	0.60	0.52	0.12	0.43
TP-1 vs. TP-2	0.10	0.74	0.46	0.91	0.57

[1] ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four steers.

Table 2.4. In vitro true dry matter disappearance (IVTD) and associated nutritive value[1] of as fed (AF) temperate and tropical corn silages, Experiment 2A (dry matter basis).

Cultivar	IVTD	CP	NDF	Fiber Fractions			
				ADF	HEMI	CELL	Lignin
	%						
Temperate corn (TM):							
Pioneer 3154	73.7[2]	7.7	54.0	29.3	24.6	24.2	4.7
Tropical corn (TP):							
Dekalb 678C (TP-1)	76.0	9.7	52.8	31.1	21.7	26.3	4.5
Pioneer X304C (TP-2)	78.0	9.5	48.2	28.1	20.1	23.6	4.3
Significance (*P*):							
Treatment	0.11	0.20	0.29	0.43	0.07	0.36	0.50
TM vs. TP	0.07	0.11	0.29	0.87	0.04	0.63	0.35
TP-1 vs. TP-2	0.21	0.83	0.24	0.25	0.22	0.22	0.52

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of two samples (replicates 1 and 2 pooled and replicates 3 and 4 pooled).

Table 2.5. Composition[1] of feces from steers fed temperate and tropical corn silages, Experiment 2A (dry matter basis).

Cultivar	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Temperate corn (TM):						
Pioneer 3154	8.1[2]	68.0	37.7	30.3	27.6	8.5
Tropical corn (TP):						
Dekalb 678C (TP-1)	9.1	69.0	38.6	30.4	28.4	8.8
Pioneer X304C (TP-2)	9.6	70.2	37.5	32.8	27.3	8.6
Significance (*P*):						
Treatment	0.01	0.39	0.15	0.16	0.62	0.90
TM vs. TP	<0.01	0.26	0.45	0.27	0.83	0.70
TP-1 vs. TP-2	0.20	0.45	0.07	0.10	0.36	0.81

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four steers.

Table 2.6. Masticate dry matter (DM), median particle size (MPS), and particle-size classes and associated nutritive value[1] of temperate and tropical corn preserved as silages, Experiment 2B (DM basis).

Cultivar	Whole Masticate					Particle-size classes[2]								
						Large			Medium			Small		
	DM	MPS	IVTD	CP	NDF	Prop[3]	IVTD	NDF	Prop	IVTD	NDF	Prop	IVTD	NDF
	%	mm	——— % ———											
Temperate corn (TM):														
Pioneer 3154	13.5[4]	2.44	74.3	7.5	52.7	65.6	72.8	55.2	25.5	73.6	52.4	8.9	79.8	37.7
Tropical corn (TP):														
Dekalb 678C (TP-1)	11.9	3.17	75.6	8.9	57.8	76.8	74.7	58.5	17.8	76.9	52.1	5.4	86.2	31.2
Pioneer X304C (TP-2)	11.7	3.17	74.8	9.1	56.6	77.0	73.5	59.1	16.9	75.6	52.4	6.1	86.5	30.4
Significance (*P*):														
Treatment	0.24	0.21	0.75	0.17	0.31	0.19	0.05	0.50	0.23	0.06	0.98	0.11	0.01	0.27
TM vs. TP	0.13	0.11	0.58	0.09	0.18	0.10	0.04	0.29	0.12	0.03	0.95	0.06	<0.01	0.15
TP-1 vs. TP-2	0.79	0.99	0.68	0.77	0.70	0.97	0.06	0.84	0.82	0.15	0.89	0.53	0.51	0.84

[1] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber.
[2] Large = ≥ 1.7 mm; medium = < 1.7 and ≥ 0.5 mm; small = < 0.5 mm.
[3] Prop = proportion of whole masticate DM.
[4] Each value is the mean of three steers.

Experiment 3. Temperate Corn Pioneer 31G20 Compared with Two Tropical Corn Silages: Ensiling Characteristics, Nutritive Value, and Quality

Temperate corn cultivars make up the primary source of corn for silage in the United States. Our objective in this experiment was to compare the nutritive value and quality of the adapted temperate corn cultivar Pioneer 31G20 with two tropical corn cultivars when preserved as silage.

Materials and Methods

Three corn cultivars were planted, grown, and harvested using conventional procedures. The experiment was conducted for two years with each year presented separately. These cultivars were evaluated:

Temperate corn:
1. Pioneer 31G20

Tropical corn (TP):
2. Dekalb XL660 (TP-1)
3. Pioneer 3098 (TP-2)

All forages were preserved in upright experimental silos (Appendix GP-1) both years and were not disturbed for at least 60 days following ensiling. This permitted fermentation to proceed to completion. At harvest in Year 1, plants of each cultivar were separated into morphological components of leaf, sheath, stalk, tassel, and ear. Each ear was further separated into grain, cob, and husk. All parts were oven-dried and expressed as a percent of the total plant dry matter (Appendix GP-1).

Dry matter intake and digestibility were determined in both years using steers in a randomized complete block design. In Year 1, three steers were used per treatment, being blocked in groups of three by weight (mean = 679.7 ± 22 pounds), and were fed an average of 13.1% in excess during the intake phase. In Year 2, four steers were used per treatment, being blocked in groups of three by weight (mean = 543 ± 35 pounds), and were fed an average of 12.7% in excess during the intake phase (Appendix GP -2). In both years, all as-fed, weighback, and fecal sam-

ples were analyzed according to standard procedures (Appendix GP -6), and data were analyzed statistically according to the experimental design (Appendix GP -7).

Results and Discussion

Year 1

The morphological differences between the temperate and tropical cultivars were noted primarily in the ear component. The ear accounted for about 52% of the temperate corn cultivar compared with a mean of about 35% for the two tropical cultivars (Table 3.1). Although the percentage of dry matter at feeding differed among the silages, with temperate corn greatest, all silages fermented well with pH measures of ≤ 4.6 (Table 3.2). The major difference in fatty acid production was noted for lactic acid, of which the tropical cultivars had greater concentrations than temperate corn (Table 4.2).

Dry matter intake was similar and surprisingly greatest for the tropical silages (mean = 2.19 pounds per 100 pounds of body weight) compared with the temperate cultivar (1.79 pounds per 100 pounds of body weight; Table 3.3). Digestibilities of the dry matter, however, were similar among cultivars (mean 62.3%). Digestible intakes reflect the dry matter intake being greatest for the tropical corn cultivars (which were similar) compared with the temperate cultivar.

Examination of the as-fed silage indicates that the temperate corn cultivar was greatest in nutritive value (greatest in in vitro true dry matter disappearance and least in neutral detergent fiber and its constituent fiber fractions and crude protein) compared with the tropical cultivars, which generally were similar (Table 3.4). This, relative to dry matter intake, may indicate some degree of off odor or flavor associated with the fermented temperate corn. Examination of the fecal dry matter composition indicates greater crude protein and lesser neutral detergent fiber, and its constituents acid detergent fiber and lignin, from temperate corn than tropical corn (Table 3.5). This would generally be associated with greater nutritive value and quality and further indicates that the fermentation of the temperate corn cultivar was possibly limiting steer acceptance and intake.

Year 2

When ensiled, the dry matter of the corn forage averaged 31.5% with no difference among cultivars (Table 3.6). The pH measures of all silages were adequate, indicating good fermentation, with the pH of the temperate cultivar lesser than the mean pH of the two tropicals. Silage of the temperate cultivar had greater concentrations of methanol and lactic acid, but lesser isobutyric acid, than the tropical silages. However, both methanol and isobutyric concentrations were small.

Steers consumed all three silages similarly, averaging 1.83 pounds of dry matter per 100 pounds of body weight. Also, dry matters of all three silages were digested similarly, averaging 61.1%. The tropical silages averaged greater in the digestibility of neutral detergent fiber, acid detergent fiber, hemicellulose, and cellulose than did the temperate silage. These greater digestibilities occurred in the tropical silages—with greater digestible intake of neutral detergent fiber, acid detergent fiber, hemicellulose and cellulose, with TP-2 (Pioneer 3098) greater in these than TP-1 (Dekalb XL660), as summarized in Table 3.7.

The as-fed temperate silage was generally greater in nutritive value (greater in in vitro true dry matter disappearance and crude protein and lesser in neutral detergent fiber and the fiber fractions) than the silages from tropical cultivars (Table 3.8). Further, TP-2 was generally of greater nutritive value than TP-1. Difference values (weighback concentration minus as-fed concentration) further indicate that some selective consumption occurred, but consumption was generally similar among the three silages.

Fecal composition reflects, but to a lesser degree, the greater nutritive value of the temperate cultivar, being greater in crude protein and lesser in acid detergent fiber and lignin concentration (Table 3.9). No differences were noted between the tropical cultivars in fecal composition.

More recent cultivar releases, such as P2088YHR or P1745BVT or the tropical P30F35HR, warrant assessment for their dry matter yield potentials.

Summary and Conclusions

Year 1

- Temperate corn had the greatest proportion of ear and the least of stem and husk components.
- All three silages fermented well with pH measures of ≤ 4.6, although temperate corn generally stabilizes at a pH of ≤ 3.9.
- Steers consumed the two tropical silages similarly (mean = 2.19 pounds per 100 pounds of body weight), and greater than they consumed temperate corn silage (1.79 pounds per 100 pounds of body weight), but all three silages had similar dry matter digestibilities (mean = 62.3%).
- The nutritive value of the temperate silage was greater than that of the tropical silages, indicating possible fermentation problems, which reduced temperate silage dry matter intake.

Year 2

- Steers consumed and digested the temperate and tropical silages similarly, eating an average of 1.83 pounds per 100 pounds of body weight with a digestibility of 61%.
- Steers digested the neutral detergent fiber and its constituent fiber fractions of the silage dry matter greater in the tropical corn compared with the temperate corn, resulting in greater digestible intakes of each constituent.

Table 3.1. Morphology of temperate and tropical corn cultivars, Year 1 (dry matter basis).

Cultivar	Forage						Ear	
	Leaf	Sheath	Tassel	Husk	Dead	Ear	Grain	Cob
	————————% of Total Plant ————————						—% of Total Ear—	
Temperate corn:								
Pioneer 31G20	15.6[1]	25.1	0.5	6.6	0.1	52.1	81.7	18.3
Tropical corn:								
Dekalb XL660 (TP-1)	16.1	36.6	1.0	11.2	1.9	33.2	80.7	19.3
Pioneer 3098 (TP-2)	13.9	33.9	1.3	8.0	3.5	39.4	80.2	19.8

[1] Values represent a composite sample.

Table 3.2. Dry matter (DM) and fermentation characteristics of ensiled temperate and tropical corn (DM basis).

Cultivar	DM	pH	Alcohols		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		——————————————————— % ———————————————————						
Temperate corn (TM):									
Pioneer 31G20	26.0[1]	4.5	0.05	0.03	1.45	0.14	1.59	0.22	0.03
Tropical corn (TP):									
Dekalb XL660 (TP-1)	22.6	4.6	0.03	0.05	1.37	0.08	2.67	0.04	0.02
Pioneer 3098 (TP-2)	25.9	4.4	0.03	0.03	0.99	0.03	3.92	0.05	0.02
Significance (*P*):									
Treatment	<0.01	0.38	0.69	0.02	0.37	0.02	0.06	0.08	0.82
TM vs. TP	0.01	0.89	0.42	0.03	0.35	0.01	0.04	0.04	0.08
TP-1 vs. TP-2	<0.01	0.19	0.88	0.02	0.29	0.13	0.13	0.88	0.62

[1] Each value is the mean of three samples.

Table 3.3. Dry matter (DM) intake (DMI), digestibilities and digestible intakes of DM and associated nutritive value of temperate and tropical corn preserved as silage, Year 1 (DM basis).

Cultivar	DMI	Digestibilities[1]					Digestible Intakes				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	lb/100 lb[2]	——————%——————					——————— lb/100 lb[2] ———————				
Temperate corn (TM):											
Pioneer 31G20	1.79[3]	63.7	48.3	50.8	45.2	54.7	1.14	0.45	0.26	0.18	0.25
Tropical corn (TP):											
Dekalb XL660 (TP-1)	2.12	60.1	55.0	59.9	47.7	63.3	1.22	0.65	0.41	0.24	0.37
Pioneer 3098 (TP-2)	2.25	63.1	51.6	51.4	52.0	57.7	1.42	0.65	0.37	0.28	0.36
Significance (*P*):											
Treatment	0.02	0.47	0.36	0.25	0.23	0.36	0.09	0.08	0.08	0.07	0.09
TM vs. TP	0.01	0.39	0.21	0.26	0.19	0.24	0.09	0.04	0.04	0.05	0.04
TP-1 vs. TP-2	0.26	0.34	0.46	0.16	0.31	0.35	0.13	0.97	0.49	0.24	0.77

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Body weight basis.

[3] Each value is the mean of three steers.

Table 3.4. In vitro true dry matter disappearance (IVTD) and associated nutritive value[1] of as-fed (AF) temperate and tropical corn silages, Year 1 (dry matter basis).

Cultivar	IVTD		CP		NDF		Fiber fractions			
	AF	DV[2]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	——————————————————% ——————————————————									
Temperate corn (TM):										
Pioneer 31G20	79.3[3]	1.5	9.1	-1.2	50.9	-3.5	28.4	22.6	25.1	2.9
Tropical corn (TP):										
Dekalb XL660 (TP-1)	71.8	-0.5	9.9	0.0	57.6	-0.5	33.1	24.5	28.6	1.5
Pioneer 3098 (TP-2)	71.9	-3.2	9.9	-1.0	55.9	2.3	32.1	23.8	27.6	4.0
Significance (*P*):										
Treatment	<0.01	0.20	0.07	0.17	<0.01	0.41	<0.01	0.01	<0.01	<0.01
TM vs. TP	<0.01	0.14	0.03	0.22	<0.01	0.25	<0.01	0.01	<0.01	<0.01
TP-1 vs. TP-2	0.89	0.27	0.95	0.13	0.06	0.52	0.11	0.13	0.09	0.01

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DV = difference value (weighback concentration minus AF concentration).

[3] Each value is the mean of three samples.

Table 3.5. Chemical composition[1] of feces from steers fed temperate and tropical corn silages, Year 1 (dry matter basis).

Cultivar	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Temperate corn (TM):						
Pioneer 31G20	12.7[2]	66.0	34.7	31.3	28.0	6.1
Tropical corn (TP):						
Dekalb XL660 (TP-1)	11.1	69.9	37.2	32.7	28.8	7.7
Pioneer 3098 (TP-2)	10.3	71.4	41.3	30.2	30.2	8.3
Significance (*P*):						
Treatment	0.07	0.01	0.01	0.13	0.17	<0.01
TM vs. TP	0.04	<0.01	0.01	0.89	0.15	<0.01
TP-1 vs. TP-2	0.34	0.13	0.02	0.06	0.25	0.07

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
[2] Each value is the mean of three steers.

Table 3.6. Dry matter (DM) and fermentation characteristics of temperate and tropical corn silages, Year 2 (DM basis).

Cultivar	DM	pH	Alcohols		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		%						
Temperate corn (TM)[1]:									
Pioneer 31G20	32.1	3.9	0.63	0.03	1.29	0.01	3.78	0.02	<0.01
Tropical corn (TP)[2] :									
Dekalb XL660 (TP-1)	29.9	4.2	0.10	<0.01	1.49	<0.01	2.25	0.01	0.02
Pioneer 3098 (TP-2)	32.4	4.2	0.10	0.01	1.34	0.05	2.18	0.02	0.01
Significance (*P*):									
Treatment	0.24	0.03	0.27	0.11	0.63	0.04	0.12	0.44	0.02
TM vs. TP	0.43	0.01	0.12	0.05	0.42	0.28	0.05	0.46	0.01
TP-1 vs. TP-2	0.13	0.46	0.99	0.61	0.50	0.02	0.92	0.31	0.09

[1] Each value is the mean of four samples.
[2] Each value is the mean of three samples.

Table 3.7. Dry matter (DM) intake (DMI), digestibilities and digestible intakes of DM and associated nutritive value[1] of temperate and tropical corns preserved as silage, Year 2 (DM basis).

Cultivar	DMI	Digestibilities					Digestible Intakes				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	lb/100 lb[2]	——————% ——————					——————— lb/100 lb[2] ———————				
Temperate corn (TM):											
Pioneer 31G20	1.84[3]	62.5	37.6	40.9	33.5	46.8	1.15	0.29	0.17	0.12	0.18
Tropical corn (TP) :											
Dekalb XL660 (TP-1)	1.89	61.7	53.8	54.8	52.5	59.8	1.17	0.62	0.35	0.27	0.34
Pioneer 3098 (TP-2)	1.76	59.2	47.1	48.7	45.1	53.4	1.05	0.46	0.27	0.20	0.26
Significance (*P*):											
Treatment	0.84	0.31	0.02	0.03	0.02	0.05	0.72	0.01	0.01	0.01	0.02
TM vs. TP	0.93	0.30	0.01	0.02	0.01	0.03	0.74	0.01	0.01	0.01	0.01
TP-1 vs. TP-2	0.57	0.25	0.16	0.16	0.17	0.16	0.48	0.08	0.09	0.06	0.08
MSD[4]	0.60	5.4	10.3	9.5	11.9	10.2	0.42	0.18	0.10	0.08	0.10

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Body weight basis.

[3] Each value is the mean of four steers.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 3.8. In vitro dry matter disappearance (IVDMD) and associated nutritive value[1] of as-fed (AF) temperate and tropical corn silages, Year 2 (dry matter basis).

Cultivar	IVDMD		CP		NDF		Fiber Fractions			
	AF	DV[2]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	——————————————————————- % ——————————————————————									
Temperate corn (TM):										
Pioneer 31G20	81.5[3]	-2.3	7.7	-0.9	42.7	3.5	23.4	19.3	20.8	2.3
Tropical corn (TP) :										
Dekalb XL660 (TP-1)	70.4	-3.4	6.5	-0.1	61.5	2.9	34.0	27.5	30.4	3.9
Pioneer 3098 (TP-2)	72.6	-8.1	7.4	-0.8	56.6	11.7	31.5	25.1	27.6	3.7
Significance (*P*):										
Treatment	<0.01	0.06	<0.01	0.25	<0.01	0.30	<0.01	<0.01	<0.01	<0.01
TM vs. TP	<0.01	0.09	0.01	0.27	<0.01	0.48	<0.01	<0.01	<0.01	<0.01
TP-1 vs. TP-2	<0.01	0.06	<0.01	0.20	0.02	0.17	0.04	0.01	0.01	0.19
MSD[4]	1.0	5.1	0.5	1.3	3.5	15.3	2.2	1.4	1.8	0.4

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DV = difference value (weighback concentration minus AF concentration).

[3] Each value is the mean of four samples.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 3.9. Chemical composition[1] of feces from steers fed temperate and tropical corn silages, Year 2 (dry matter basis).

Cultivar	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Temperate corn (TM):						
Pioneer 31G20	11.2[2]	69.6	36.4	33.2	29.6	6.1
Tropical corn (TP) :						
Dekalb XL660 (TP-1)	9.8	70.0	37.2	32.9	29.5	7.1
Pioneer 3098 (TP-2)	9.9	70.3	37.7	32.7	30.0	7.4
Significance (*P*):						
Treatment	0.01	0.70	0.12	0.51	0.79	0.03
TM vs. TP	<0.01	0.46	0.06	0.30	0.80	0.01
TP-1 vs. TP-2	0.87	0.74	0.37	0.67	0.54	0.52
MSD[3]	0.9	2.5	1.4	1.2	2.1	0.9

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four steers.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Experiment 4. Tropical Corn Planted and Ensiled on Differing Dates: Steer Intake, Digestibility, and Preference

Plant composition and morphology at time of ensiling may alter fermentation characteristics and hence the quality of the silage. This in turn may alter the preference exhibited by animals. Our objective in this experiment was to determine the silage quality and any preference steers demonstrate for a tropical corn when planted and harvested at differing dates, compared with an adapted temperate corn used as a standard.

Materials and Methods

Conventional field planting of an adapted temperate corn (Pioneer 3156) and plantings of a tropical corn (made in May and June and ensiled in September and October) provided the experimental silages. The following five silage treatments were evaluated for relative preference:

Temperate corn:

1. Pioneer 3156 (Standard) planted April 20 and ensiled August 16

Tropical corn—Pioneer X304C:

2. Planted May 23 and ensiled September 8
3. Planted May 23 and ensiled September 22
4. Planted June 26 and ensiled September 25
5. Planted June 26 and ensiled October 18

Forage for the intake and digestion phase (Experiment 4A) was harvested with a conventional forage chopper and stored in upright experimental silos (Appendix GP-1) at the NC State University Forage Animal Metabolism Unit, Raleigh, NC. Forages for the preference phase (Experiment 4B) were ensiled in plastic buckets serving as miniature silos (Appendix GP-1). In the intake and digestion phase, 15 steers (mean weight = 588 ± 50 pounds) were used in a randomized complete block design with three steers per treatment. The steers were grouped by weight into three sets of five each and randomly assigned within group to each of the five silage treatments, which were conducted according to standard procedures (GP-2). Animals were fed an average of 13.3% in excess.

The preference phase (Experiment 4B) consisted of a series of eight 30-minute preference evaluations involving both two-treatment and three-treatment comparisons (Appendix GP-5). Each evaluation was conducted as a randomized complete block design with four steer (weight range of 1,000 to 1,400 pounds) replicates. The total dry matter intake was determined, and the intake rate (grams/minute) calculated. All as-fed, weighback, and fecal samples were analyzed according to standard procedures (Appendix GP-6), and data were statistically analyzed according to the experimental design (Appendix GP-7).

Results and Discussion

The morphology and yield potential of the temperate and tropical cultivars used for dry matter intake and digestibility estimates indicate appreciable differences among the treatments (Table 4.1). As expected, the temperate corn had the greatest proportion of the whole plant dry matter as ear, regardless of when the tropical cultivar was planted and harvested. When the tropical cultivar was planted in June and harvested in October, it had the greater proportion of ear and the grain fraction (79.3%) was comparable to that of the temperate cultivar (84.2%). Greatest dry matter yield occurred for the tropical cultivar when planted in May and harvested in September (Table 4.1).

Experiment 4A (Intake and Digestion)

At feeding, the dry matter of the temperate silage (ensiled in upright silos) was greatest at 43% with the other four treatments ranging between 21% and 30% (Table 4.2). However, all silages fermented well with pH measures of ≤ 4.2. Noteworthy in these silages was the general lack of propionic acid, as well as minimal concentrations of butyric acid and methanol.

Although fermentation characteristics differed among silages, steer dry matter intake and digestibility of dry matter and neutral detergent fiber and its fractions were not altered by corn type or by planting and harvesting dates (Table 4.3). The digestible intakes of neutral detergent fiber and its fractions did differ between temperate and tropical corn, with the temperate corn least for all fractions. The associated fecal composition also reflects differences between

temperate and tropical corn silages. Crude protein concentrations of feces from tropical corn were greater than those of feces from temperate corn, but the fiber and its fractions were lesser in feces from tropical corn (Table 4.4).

The as-fed silages varied in most constituents between the temperate corn silage and tropical corn silages with the temperate corn silage greater in nutritive value (Table 4.5). Within the tropical corn silages, the May planted silages were generally of lesser nutritive value than the June planted silages, whereas nutritive value was not altered by date of harvest. The difference values indicate that selective consumption may have occurred for the temperate corn, whereas little selectivity is evident for the tropical corns (Table 4.5).

Characterization of the masticate, which represents each animal's diet, indicates similar particle size among all corn silages, but the temperate corn silage masticate was generally greater in nutritive value (Table 4.6). The noted exception is less crude protein in temperate corn silage versus the tropical corn silages. Temperate corn silage had a similar proportion of the masticate dry matter as large and medium particle sizes, as did the tropical silages, but the temperate had a greater proportion of small particles. The nutritive value of the various particle-size classes also varied, both between temperate and tropical corn silages and among the tropical silages (Table 4.6).

Experiment 4B (Preference Phase)

Although the dry matter of the silages used for preference evaluation differed among the treatments, all ensiled well with pH measures of ≤ 3.9 (Table 4.7). Forage harvested in October generally had the greatest dry matter concentrations at feeding compared with the September harvest. Differences were evident for a number of the fermentation products. Most notable were the greater ethanol concentrations for the May-planted silage harvested in October and the greater lactic acid concentration in the June-planted silage harvested in September.

In all four preference evaluations that compared the temperate corn with the tropical corn, regardless of the tropical corn treatment, the temperate was greatly preferred (Table 4.8). Furthermore, no differences were noted between the tropical corns that could be related to their treatment in any of the comparisons.

Comparisons within the tropical corn silages revealed preference for the October-harvested forage when planted in June versus May (Evaluation 6, Table 4.9) and when both were planted in June but harvested in October (Evaluation 8, Table 4.9).

Examination of the nutritive value of the five silages indicates that the temperate corn silage was superior (greater in vitro true dry matter disappearance and lesser in neutral detergent fiber and constituent fiber fractions) to the tropical corn regardless of planting or harvest date (Table 4.10). Within the tropical corn silage treatments, a planting-date by harvest-date interaction was generally present for all variables, but this was mainly associated with a magnitude shift and not to crossovers, and consequently of little concern (Table 4.10). The striking difference within the tropical corn silages and their treatments was the greater nutritive value of the June-planted forage harvested in October compared with the other treatments. These differences in nutritive value are consistent with each silage's relative rank in the preference evaluations.

Summary and Conclusion

- The temperate corn silage and the tropical corn silages from four different treatments all were well preserved with desirable fermentation characteristics.
- Temperate corn silage was consumed similarly to the tropical corn silages, but temperate silage was strongly preferred when animals were given a choice over the tropical corn silages.
- Among the tropical corn silages, corn planted in June and harvested in October was generally preferred over May planting or September harvests. Silage quality, however, was similar among all silages.
- Silages made from any of the treatments evaluated can provide a useful feed source for ruminant production systems.

Table 4.1. Morphology, height, and dry matter yield of temperate and tropical corn preserved as silage and fed in Experiments 4A (dry matter basis).

Silage	Forage[1]						Ear[1]		Height[2]	Yield[2]
	Leaf	Stalk	Tassel	Husk	Dead	Ear	Grain	Cob		
	——————— % of Total Plant ———————-						— % of Ear —		ft	ton/ac
Temperate corn (TM):										
Pioneer 3156	4.9	26.2	0.4	8.8	4.0	55.7	84.2	15.8	10.2[a]	6.0[b]
Tropical corn (TP; Pioneer X304C):										
Planted May 23:										
Harvested Sept. 8	19.1	56.4	1.8	9.8	3.7	9.2	40.7	59.3	9.0[b]	5.6[b]
Harvested Sept. 22	14.0	49.7	1.2	10.0	3.2	21.9	68.3	31.7	9.6[a]	7.8[a]
Planted June 26:										
Harvested Sept. 25	18.8	35.3	1.4	15.0	0.3	29.2	63.7	36.3	7.9[c]	4.4[c]
Harvested Oct. 18	12.3	30.5	0.9	9.3	2.6	44.4	79.3	20.7	8.5[bc]	4.3[c]
Significance (*P*):										
Treatment	-	-	-	-	-	-	-	-	<0.01	<0.01
MSD[3]	-	-	-	-	-	-	-	-	0.70	0.9

[1] Each value is the composite of 10 plants.

[2] Each value is the average of two sample strips and the mean of three replicates. Means with same superscript are similar.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.2. Dry matter (DM) at feeding and fermentation characteristics of temperate corn silage and tropical corn silages planted and harvested at different dates, Experiment 4A (DM basis).

Silage	DM	pH	Alcohols		Fatty Acids			
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric
	%		——————————————% ——————————————					
Temperate corn (TM):								
Pioneer 3156	43.5[1]	4.2	0.19	-	0.70	-	2.41	0.01
Tropical corn (TP; Pioneer X304C):								
Planted May 23 (PM):								
Harvested Sept. 8 (H1)	20.7	3.7	1.33	-	2.09	0.01	9.19	-
Harvested Sept. 22 (H2)	22.6	3.8	1.25	-	1.74	-	7.61	-
Planted June 26 (PJ):								
Harvested Sept. 25 (H1)	22.2	3.7	1.22	0.02	1.81	-	8.00	-
Harvested Oct. 18 (H2)	30.4	3.9	0.27	-	1.55	0.01	5.45	0.01
Significance (*P*):								
Treatment	<0.01	<0.01	<0.01		<0.01		<0.01	
TM vs. TP	<0.01	<0.01	<0.01		<0.01		<0.01	
PM vs. PJ	<0.01	0.39	0.01		0.13		0.01	
PM: H1 vs. H2	0.13	0.44	0.75		0.12		0.04	
PJ: H1 vs. H2	<0.01	0.03	<0.01		0.23		<0.01	
MSD[2]	2.4	0.14	0.48		0.45		1.37	

[1] Each value is the mean of three replicate samples.

[2] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.3. Dry matter (DM) intake (DMI), digestibilities and digestible intakes of DM and associated nutritive value[1] of temperate corn silage and tropical corn silages planted and harvested on different dates, Experiment 4A (DM basis).

Silage	DMI	Digestibilities					Digestible Intakes				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	lb/100 lb[2]	——————— % ———————					——————— lb/100 lb[2] ———————				
Temperate corn (TM) :											
Pioneer 3156	1.80[3]	67.0	42.7	42.0	43.0	48.6	1.21	0.29	0.14	0.15	0.15
Tropical corn (TP; Pioneer X304C):											
Planted May 23 (PM):											
Harvested Sept. 8 (H1)	1.79	60.9	54.9	57.0	52.1	62.2	1.09	0.62	0.37	0.25	0.35
Harvested Sept. 22 (H2)	1.80	60.7	52.2	54.1	49.5	57.4	1.09	0.56	0.33	0.23	0.29
Planted June 26 (PJ):											
Harvested Sept. 25 (H1)	1.96	59.5	47.1	50.1	43.4	57.0	1.16	0.50	0.29	0.22	0.30
Harvested Oct. 18 (H2)	1.92	67.1	53.9	55.4	53.3	60.5	1.29	0.50	0.27	0.24	0.26
Significance (*P*):											
Treatment	0.57	0.48	0.56	0.39	0.71	0.38	0.50	0.03	0.01	0.17	<0.01
TM vs. TP	0.53	0.27	0.19	0.08	0.38	0.08	0.63	<0.01	<0.01	0.02	<0.01
PM vs. PJ	0.15	0.53	0.61	0.62	0.65	0.83	0.16	0.17	0.04	0.64	0.07
PM: H1 vs. H2	0.94	0.97	0.75	0.72	0.77	0.50	0.95	0.49	0.40	0.58	0.08
PJ: H1 vs. H2	0.72	0.20	0.43	0.52	0.34	0.62	0.36	0.99	0.65	0.62	0.27
MSD[4]	0.37	15.3	23.3	21.7	25.6	18.9	0.35	0.19	0.10	0.10	0.07

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Body weight basis.

[3] Each value is the mean of three steers.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.4. Chemical composition[1] of feces from steers fed temperate corn silage and tropical corn silages planted and harvested on different dates, Experiment 4A (dry matter basis)

Silage	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	——————————— % ———————————					
Temperate corn (TM):						
Pioneer 3156	15.4[2]	64.3	31.8	32.5	25.5	5.0
Tropical corn (TP; Pioneer X304C):						
Planted May 23 (PM):						
Harvested Sept. 8 (H1)	12.3	70.5	38.3	32.2	30.3	6.6
Harvested Sept. 22 (H2)	12.0	70.7	37.9	32.7	29.7	6.6
Planted June 26 (PJ):						
Harvested Sept. 25 (H1)	12.9	69.8	35.7	34.1	27.8	6.6
Harvested Oct. 18 (H2)	13.0	64.7	32.1	32.6	25.7	5.3
Significance (*P*):						
Treatment	0.02	<0.01	<0.01	0.13	0.01	<0.01
TM vs. TP	<0.01	<0.01	<0.01	0.47	0.01	<0.01
PM vs. PJ	0.20	0.01	<0.01	0.09	<0.01	0.03
PM: H1 vs. H2	0.68	0.93	0.71	0.46	0.60	0.87
PJ: H1 vs. H2	0.93	0.01	0.01	0.06	0.90	0.01
MSD[3]	2.0	3.2	2.1	1.7	2.7	0.8

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of three steers.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.5. In vitro true dry matter disappearance (IVTD) and associated nutritive value[1] of as-fed (AF) temperate corn silage and tropical corn silages planted and harvested on different dates, Experiment 4A (dry matter basis).

Silage	IVTD		CP		NDF		Fiber fractions			
	AF	DV[2]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	%									
Temperate corn (TM):										
Pioneer 3156	81.1[3]	-16.1	7.5	-1.2	42.7	28.7	21.5	21.2	19.5	1.4
Tropical corn (TP; Pioneer X304C):										
Planted May 23 (PM):										
Harvested Sept. 8 (H1)	70.6	2.2	9.3	2.9	62.6	-4.3	35.8	26.8	31.8	2.8
Harvested Sept. 22 (H2)	70.4	1.0	8.9	1.1	59.2	-1.4	33.5	25.6	28.4	2.6
Planted June 26 (PJ):										
Harvested Sept. 25 (H1)	76.3	-1.6	9.7	1.0	54.3	0.4	29.3	24.9	26.7	1.9
Harvested Oct. 18 (H2)	76.1	1.8	8.5	0.8	48.7	-0.6	25.0	23.6	22.5	1.8
Significance (*P*):										
Treatment	<0.01	<0.01	<0.01	0.39	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
TM vs. TP	<0.01	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PM vs. PJ	<0.01	0.39	0.79	0.44	<0.01	0.28	<0.01	0.01	<0.01	<0.01
PM: H1 vs. H2	0.91	0.63	0.26	0.37	0.26	0.42	0.33	0.21	0.09	0.5
PJ: H1 vs. H2	0.94	0.20	<0.01	0.92	0.09	0.76	0.09	0.17	0.05	0.81
MSD[4]	4.6	5.4	0.7	5.3	6.5	7.4	5.0	2.0	4.1	0.4

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DV = difference value (weighback concentration minus AF concentration).

[3] Each value is the mean of three samples.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.6. Whole-masticate dry matter (DM), median particles size (MPS), particle-size classes[1] and associated nutritive value[2] of temperate corn silage and tropical corn silages planted and harvested on different dates, Experiment 4A (DM basis).

Silage	Whole Masticate					Particle-size classes								
						Large			Medium			Small		
	DM	MPS	IVTD	CP	NDF	Prop[3]	IVTD	NDF	Prop	IVTD	NDF	Prop	IVTD	NDF
	%	mm	%											
Temperate corn (TM):														
Pioneer 3156	20.0[4]	3.5	82.6	6.8	40.1	70.3	78.1	46.1	16.3	81.5	38.9	13.4	94.9	10.2
Tropical corn (TP; Pioneer X304C):														
Planted May 23 (PM):														
Harvested Sept. 8 (H1)	10.7	2.9	72.9	8.0	61.6	74.6	71.0	63.8	19.3	75.2	57.8	6.1	79.9	41.6
Harvested Sept. 22 (H2)	11.6	3.1	72.8	7.8	58.6	70.9	69.3	63.0	18.6	74.9	54.8	10.5	86.0	32.3
Planted June 26 (PJ):														
Harvested Sept. 25 (H1)	11.7	3.5	76.3	8.6	56.1	76.4	73.9	60.1	16.1	78.4	52.0	7.5	90.0	27.5
Harvested Oct. 18 (H2)	15.1	3.3	78.1	7.6	48.5	70.3	74.5	55.1	19.0	79.9	44.7	10.7	91.2	20.0
Significance (*P*):														
Treatment	<0.01	0.26	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	0.22	<0.01	<0.01	<0.01	<0.01	<0.01
TM vs. TP	<0.01	0.28	<0.01	<0.01	<0.01	0.24	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	<0.01	<0.01
PM vs. PJ	<0.01	0.08	<0.01	0.09	<0.01	0.77	<0.01	<0.01	0.27	<0.01	<0.01	0.53	<0.01	<0.01
PM: H1 vs. H2	0.04	0.53	0.92	0.42	0.01	0.23	0.02	0.39	0.72	0.62	0.01	0.02	0.03	<0.01
PJ: H1 vs. H2	<0.01	0.46	0.01	<0.01	<0.01	0.05	0.32	<0.01	0.11	0.03	<0.01	0.09	0.68	<0.01
MSD[5]	0.8	0.7	1.1	0.3	2.0	7.4	1.2	1.7	4.5	1.1	2.1	3.7	5.4	4.3

[1] Large = > 1.7mm; medium = ≤1.7mm and >0.5mm; small < 0.5 mm.

[2] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber.

[3] Prop = proportion of dry matter.

[4] Each value is the mean of six steers.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 4.7. Dry matter (DM) and fermentation characteristics of temperate corn silage and tropical corn silages planted and harvested on different dates and evaluated for preference, Experiment 4B (DM basis).

Silage	DM	pH	Alcohols		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		%						
Temperate corn (TM):									
Pioneer 3156	34.6[1]	3.8[2]	2.56[2]	0.02[2]	1.30[2]	0.05[2]	5.25[2]	0.05[2]	0.02[2]
Tropical corn (TP; Pioneer X304C):									
Planted May 23 (PM):									
Harvested Sept. 8 (H1)	26.3	3.8	2.63	0.04	1.92	0.04	6.61	0.02	0.03
Harvested Sept. 22 (H2)	35.5	3.8	4.19	0.02	1.25	0.08	5.68	0.01	0.02
Planted June 26 (PJ):									
Harvested Sept. 25 (H1)	19.8	3.7	2.72	0.52	2.31	0.04	8.79	0.01	0.05
Harvested Oct. 18 (H2)	35.2	3.9	0.70	0.02	1.43	0.01	5.11	0.01	0.01
Significance (*P*):									
Treatment	-	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.03	0.27
TM vs. TP	-	0.14	0.98	0.01	<0.01	0.17	<0.01	<0.01	0.90
PM vs. PJ	-	0.01	<0.01	0.03	0.01	<0.01	0.03	0.47	0.78
PM: H1 vs. H2	-	0.02	0.24	<0.01	<0.01	0.20	<0.01	0.38	0.06
Interaction	-	0.68	<0.01	0.06	0.27	<0.01	<0.01	0.95	0.22

[1] Values for DM are the composite of four samples (replicates).

[2]Values are the mean of four samples.

Table 4.8. Preference evaluations[1] comparing temperate corn silage and various tropical corn silages planted and harvested on different dates, Experiment 4B (dry matter basis).

Silage	Evaluation 1			Evaluation 2			Evaluation 3			Evaluation 4		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn (TM):												
Pioneer 3156	970[a]	12.1[a]	87.8[a]	1,015[a]	10.9[a]	104[ab]	1,136[a]	12.6[a]	93.5[a]	1,053[a]	11.6[a]	101.5[a]
Tropical corn (TP; Pioneer X304C):												
Planted May 23 (PM):												
Harvested Sept. 8 (H1)	111[b]	1.5[b]	144[a]				20[b]	0.4[b]	29[a]			
Harvested Sept. 22 (H2)				44[b]	0.5[b]	34[b]	89[b]	1.0[b]	137[a]			
Planted June 26 (PJ):												
Harvested Sept. 25 (H1)	119[b]	0.5[b]	56[a]							5[b]	0.1[b]	20.5[a]
Harvested Oct. 18 (H2)				220[b]	1.4[b]	168[a]				26[b]	0.2[b]	32.6[a]
Significance (*P*):												
Treatment	<0.01	<0.01	0.19	<0.01	<0.01	0.07	<0.01	<0.01	0.51	<0.01	<0.01	0.14
MSD[3]	294	4.9	113	228	3.9	115	319	4.8	242	185	3.3	9

[1]Each value is the mean of four steers. Means with same superscript are similar.

[2] DMI = dry matter intake.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments

Table 4.9. Preference evaluations comparing two silages at a time of a tropical corn planted and harvested on different dates, Experiment 4B (dry matter basis).

Silage[1]	Evaluation 5			Evaluation 6			Evaluation 7			Evaluation 8		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Planted May 23 (PM):												
Harvested Sept. 8 (H1)	609[3]	8.4	115.7				661	8.7	98.6			
Harvested Sept. 22 (H2)				319	4.7	100.5	577	8.8	93.3			
Planted June 26 (PJ):												
Harvested Sept. 25 (H1)	183	1.3	76.8							45	0.6	37.8
Harvested Oct. 18 (H2)				836	9.4	116				1135	14.4	81.7
Significance (*P*):												
Treatment	0.21	0.12	0.19	0.03	0.12	0.12	0.73	0.98	0.87	<0.01	<0.08	0.12

[1] Pioneer X304C.

[2] DMI = dry matter intake.

[3] Each value is the mean of four steers.

Table 4.10. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of temperate and tropical silages fed in eight preference evaluations, Experiment 4B (dry matter basi

Silage	IVTD	CP	NDF	Fiber Fractions			
				ADF	HEMI	CELL	Lignin
	——————————————— % ———————————————-						
Temperate corn (TM):							
Pioneer 3156	83.1[2]	8.2	40.1	20.1	18.0	16.6	3.1
Tropical corn (TP; Pioneer X304C):							
Planted May 23 (PM):							
Harvested Sept. 8 (H1)	72.5	9.2	51.9	33.1	23.1	26.1	6.1
Harvested Sept. 22 (H2)	73.8	10.3	50.3	30.6	21.5	23.7	6.1
Planted June 26 (PJ):							
Harvested Sept. 25 (H1)	68.1	9.1	62.5	40.1	23.9	32.2	6.9
Harvested Oct. 18 (H2)	77.7	7.3	46.9	26.9	19.9	21.2	5.1
Significance (*P*):							
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
TM vs. TP	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PM vs. PJ	0.81	<0.01	<0.01	0.02	0.67	0.01	0.34
PM: H1 vs. H2	<0.01	0.13	<0.01	<0.01	0.01	<0.01	<0.01
Interaction	<0.01	<0.01	<0.01	<0.01	0.17	<0.01	<0.01

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four samples.

Experiment 5. Temperate and Tropical Corn Compared with Forage-type Sorghums when Preserved as Silage: Ensiling Characteristics, Nutritive Value, and Quality

Although corn has generally been the preferred annual forage for conservation as silage, forage sorghum also has great potential in the Southeast. One major advantage of sorghums is their adaptation to withstand periods of drought and still produce desirable dry matter yields of acceptable forage quality. Our objective in this experiment was to compare silages from both temperate and tropical corn with silage from an intermediate normal forage sorghum and a forage sorghum selected for greater sugar concentration.

Materials and Methods

Conventional planting practices were used to establish stands of two corn cultivars and two forage-sorghum cultivars as designated below:

Corn:
1. Temperate corn silage—Pioneer 3156
2. Tropical corn silage—Pioneer X304C

Forage sorghum:
3. Intermediate, normal sorghum silage—Pioneer 841F
4. Sweeter sorghum silage—Brandies

The four cultivars were planted in adjacent fields, side dressed with 100 pounds of nitrogen per acre, cut for silage at the hard-dough (dent) stage with a conventional field chopper, and ensiled in upright experimental silos (Appendix GP-1). The experimental silos were not disturbed for at least 60 days so fermentation could proceed to completion.

The experimental silages were evaluated for dry matter intake and digestibility (Experiment 5A) and masticate characteristics (Experiment 5B). Steers were used in a randomized complete block design in both experiments with three steers (replicates) per treatment in the intake and digestion experiment and six steers per treatment in the mastication experiment (Appendix GP-2 and GP-3). In the intake and digestion experiment, steers (mean weight = 619 ± 73 pounds) were fed at 12.8% excess.

All as-fed, weighback, masticate, and fecal samples were analyzed according to standard procedures (Appendix GP-6), and the data were statistically analyzed according to the experimental design (Appendix GP-7).

Results and Discussion

Tropical corn had the greatest height and consequently greatest dry matter yield compared with the other forages (Table 5.1). The two sorghums yielded similarly and least compared with corn. The silages differed in dry matter concentration, with the corn silage dry matter being greater than that of the sorghums (Table 5.1). However, the pH measures of all silages were 3.9 or less, indicating acceptable fermentation. Some differences were noted between corn and sorghum silages and cultivars within each, but silages of all cultivars were dominated by acetic and lactic acid production (Table 5.1). Isobutyric was detected, but concentrations were less than 0.007% and were ignored.

Experiment 5A

Steers consumed corn and sorghum silages similarly, averaging 1.83 pounds per 100 pounds of body weight (Table 5.2). However, within the forage sorghums, steers consumed normal forage sorghum silage greater than sweeter forage sorghum silage. Steers, on average, digested corn and forage sorghum silages similarly (mean = 62.4%), but digested temperate corn silage greater than tropical corn silage and sweet forage sorghum silage greater than normal forage sorghum silage (Table 5.2). The neutral detergent fiber and its fiber fractions were more digestible in silages of forage sorghum than in silages of corn. Within the corn silages, these fractions were more digestible in tropical corn than in temperate corn, whereas the two sorghum silages were generally similar. These same relationships were also present for the digestible intakes.

The in vitro true dry matter disappearance of the as-fed silages was similar between corn and sorghum silages. Temperate corn silage, however, was of great-

er nutritive value than sorghum silage. Within the corn silages, temperate silage was generally superior in nutritive value than tropical silage. And within the sorghum silages, the sweeter cultivar was generally superior to the normal.

The differences in how steers digested silages—between corn and forage sorghum, between temperate and tropical corn, and between normal and sweeter forage sorghum—is evident in fecal composition (Table 5.4).

Experiment 5B.

Masticate of the silages revealed that upon ingestion, steers incorporated saliva similarly for both corn and sorghum silages as dry matter concentrations of the whole masticates were similar (Table 5.5). Within the corn silages, however, dry matter concentration was greater for temperate corn than for tropical corn silage. Median particle size was greater for corn silages than for sorghum silages, and the normal sorghum silage was chewed more than the sweeter sorghum silage.

The nutritive value of the masticated silages differed only in crude protein between corn and sorghum silages, with forage sorghum silage being greatest in crude protein. However, silages of cultivars within the corn and sorghum classes generally differed in crude protein and neutral detergent fiber.

Further, the proportion of the whole-masticates dry matter that consisted of large- and medium-size particles differed between corn and sorghum silages, whereas the proportion of smaller particles was similar. The distribution of masticate dry matter across sieve sizes is presented for each silage in Figure 5.1. Associated with the difference in particle size among cultivar silages were also nutritive value differences (Table 5.4). Although numerous differences occurred, in many cases these were small and probably of limited biological importance.

Summary and Conclusion

- Both corn silages and forage sorghum silages preserved well with pH measures of 3.9 or less and with acetic and lactic acids dominating.
- Steers consumed both corn and forage sorghum silages similarly, averaging 1.83 pounds of dry matter per 100 pounds of body weight.
- Dry matter digestibilities of corn and forage sorghum silages were similar at 62%, but tropical corn was digested lesser than temperate corn even though digestible intakes were similar.
- The criteria for selecting either corn or forage sorghum for preservation as silage may need to be based as much on adaptation to the environment for acceptable dry matter production as it is based on forage quality.

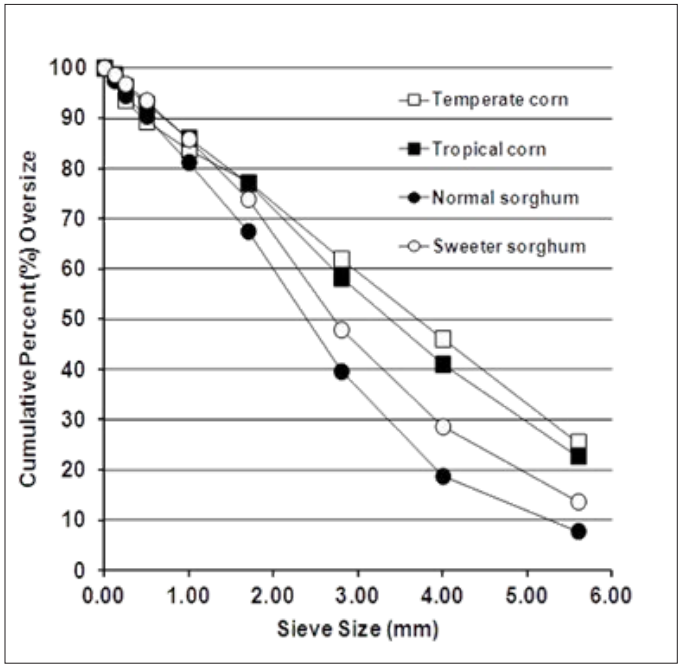

Figure 5.1. Particle size distribution of masticate dry matter of corn and sorghum silages (temperate corn = Pioneer 3156; tropical corn = Pioneer X304C; normal sorghum = Pioneer 841F; sweeter sorghum = Brandies).

Table 5.1. Dry matter (DM) yield and fermentation characteristics of ensiled corn and forage sorghum, Experiments 5A and 5B (DM basis).

Silage[1]	Height	Yield	DM	pH	Alcohols		Fatty Acids		
					Ethanol	Methanol	Acetic	Propionic	Lactic
	ft	ton/ac	%		——————————- % ——————————-				
Corn (CN):									
Temperate (TM)	8.7[2]	6.54[2]	29.5[3]	3.7[3]	2.14[3]	0.03[3]	1.27[3]	0.04[3]	5.61[3]
Tropical (TP)	12.2	8.61	24.9	3.9	0.61	0.03	1.53	0.00	7.06
Forage Sorghum (FS):									
Normal (NS)	4.9	3.79	24.9	3.8	0.94	0.04	1.26	0.01	8.13
Sweeter (SS)	7.5	4.59	27.3	3.9	1.09	0.03	2.58	0.01	5.60
Significance (*P*):									
Treatment	<0.01	<0.01	0.01	0.12	<0.01	0.05	<0.01	<0.01	0.01
CN vs. FS	<0.01	<0.01	<0.01	0.05	<0.01	0.85	0.02	<0.01	0.04
TM vs. TP	<0.01	<0.01	0.13	0.49	<0.01	0.01	<0.01	0.04	0.22
NS vs. SS	<0.01	0.18	0.04	0.21	0.12	0.25	<0.01	0.59	<0.01

[1] Temperate = Pioneer 3156; Tropical = Pioneer X304C; Normal = Intermediate Pioneer 841F; Sweeter = Brandies.

[2] Each value is the mean of six harvest strips.

[3] Each value is the mean of three replicate samples.

Table 5.2. Dry matter (DM) intake (DMI), digestibilities, and digestible intakes of DM and associated nutritive value[1] of corn and forage sorghum preserved as silage, Experiment 5A (DM basis).

Silage[2]	DMI	Digestibilities					Digestible Intakes				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	lb/100 lb[3]	—————— % ——————					—————— lb/100 lb[3]——————				
Corn (CN):											
Temperate (TM)	1.99[4]	64.0	20.8	16.7	23.5	24.8	1.27	0.13	0.06	0.07	0.07
Tropical (TP)	1.76	59.8	47.1	46.4	47.9	52.5	1.06	0.45	0.27	0.18	0.25
Forage Sorghum (FS):											
Normal (NS)	2.06	61.4	49.1	49.6	48.2	57.5	1.26	0.50	0.31	0.19	0.29
Sweeter (SS)	1.50	64.5	53.2	55.5	49.7	62.3	0.97	0.43	0.27	0.16	0.25
Significance (*P*):											
Treatment	0.16	0.02	<0.01	<0.01	0.03	<0.01	0.21	<0.01	<0.01	0.01	<0.01
CN vs. FS	0.57	0.23	<0.01	<0.01	0.04	<0.01	0.66	<0.01	<0.01	0.03	<0.01
TM vs. TP	0.35	0.01	<0.01	<0.01	0.02	<0.01	0.20	<0.01	<0.01	<0.01	<0.01
NS vs. SS	0.05	0.04	0.32	0.08	0.85	0.05	0.10	0.09	0.12	0.24	0.09

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Temperate = Pioneer 3156; Tropical = Pioneer X304C; Normal = Intermediate Pioneer 841F; Sweeter = Brandies.

[3] Body weight basis.

[4] Each value is the mean of three steers.

Table 5.3. In vitro true dry matter disappearance (IVTD) and associated nutritive value[1] of as-fed (AF) corn and forage sorghum preserved as silage, Experiment 5A (dry matter basis).

Silage[2]	IVTD		CP		NDF		Fiber fractions			
	AF	DV[3]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	%									
Corn (CN):										
Temperate (TM)	79.8[4]	-0.9	9.0	-1.0	33.3	2.7	18.3	15.0	15.2	2.8
Tropical (TP)	71.6	-0.4	7.3	-0.3	54.8	3.0	33.2	21.5	26.9	5.6
Forage Sorghum (FS):										
Normal (NS)	74.1	0.9	11.8	-0.7	49.7	0.1	30.6	19.1	24.3	5.2
Sweeter (SS)	76.6	-1.7	6.0	-0.2	54.3	1.5	32.9	21.4	26.5	5.0
Significance (*P*):										
Treatment	0.02	0.96	<0.01	0.16	<0.01	0.96	<0.01	<0.01	<0.01	<0.01
CN vs. FS	0.78	0.93	<0.01	0.39	<0.01	0.93	<0.01	<0.01	<0.01	<0.01
TM vs. TP	<0.01	0.93	<0.01	0.08	<0.01	0.93	<0.01	<0.01	<0.01	<0.01
NS vs. SS	0.21	0.63	<0.01	0.19	<0.01	0.63	0.06	0.01	0.03	0.32

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
[2] Temperate = Pioneer 3156; Tropical = Pioneer X304C; Normal = Intermediate Pioneer 841F; Sweeter = Brandies.
[3] DV = difference value (weighback concentration minus AF concentration).
[4] Each value is the mean of three samples.

Table 5.4. Chemical composition[1] of feces from steers fed corn and forage sorghum preserved as silage, Experiment 5A (dry matter basis).

Silage[2]	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Corn (CN):						
Temperate (TM)	12.8[3]	71.0	38.6	32.4	29.4	7.9
Tropical (TP)	9.9	72.9	43.1	29.9	31.2	10.3
Forage Sorghum (FS):						
Normal (NS)	13.1	64.8	39.4	25.5	26.4	10.3
Sweeter (SS)	11.2	70.2	39.9	30.3	27.5	9.4
Significance (*P*):						
Treatment	<0.01	<0.01	0.02	<0.01	<0.01	0.01
CN vs. FS	0.04	<0.01	0.14	<0.01	<0.01	0.11
TM vs. TP	<0.01	0.09	<0.01	0.01	0.03	0.01
NS vs. SS	0.01	<0.01	0.60	<0.01	0.14	0.18

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
[2] Temperate = Pioneer 3156; Tropical = Pioneer X304C; Normal = Intermediate Pioneer 841F; Sweeter = Brandies.
[3] Each value is the mean of three steers.

Table 5.5. Whole-masticate dry matter (DM), median particles size (MPS), particle-size classes[1] and associated nutritive value[2] of corn and forage sorghum preserved as silage, Experiment 5B (DM basis).

Silage[3]	Whole Masticate					Particle-size classes								
						Large			Medium			Small		
	DM	MPS	IVTD	CP	NDF	Prop[4]	IVTD	NDF	Prop	IVTD	NDF	Prop	IVTD	NDF
	%	mm	%											
Corn (CN):														
Temperate (TM)	16.0[5]	3.5	81.2	7.9	36.3	77.2	78.8	43.8	12.2	82.8	34.1	10.7	93.4	13.6
Tropical (TP)	12.4	3.3	71.3	6.3	56.6	77.1	69.6	59.6	15.7	74.6	49.3	7.2	86.5	25.9
Forage Sorghum (FS):														
Normal (NS)	13.8	2.3	75.1	10.0	47.5	67.5	73.8	49.4	22.9	74.9	46.7	9.6	85.6	25.7
Sweeter (SS)	14.7	2.7	77.8	5.8	51.9	73.9	75.1	55.4	19.6	78.4	47.1	6.5	85.3	29.9
Significance (*P*):														
Treatment	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CN vs. FS	0.97	<0.01	0.84	0.01	0.21	<0.01	0.66	0.33	<0.01	<0.01	<0.01	0.25	<0.01	<0.01
TM vs. TP	<0.01	0.25	<0.01	<0.01	<0.01	0.96	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01
NS vs. SS	0.12	0.04	0.06	<0.01	0.04	0.01	0.08	<0.01	0.01	<0.01	0.72	0.01	0.76	0.06

[1] Large = > 1.7mm; medium = ≤1.7mm and >0.5mm; small < 0.5 mm.

[2] IVTD = in vitro true dry matter disappearance; CP = crude protein; NDF = neutral detergent fiber.

[3] Temperate = Pioneer 3156; Tropical = Pioneer X304C; Normal = Intermediate Pioneer 841F; Sweeter = Brandies.

[4] Prop = proportion of dry matter.

[5] Each value is the mean of six steers.

Section II. Cool-Season Annuals

Winter annual forages provide the opportunity to double crop our land resources. Summer annuals, such as corn or sorghum, can be planted in the spring and followed by winter annuals seeded after the harvest of the annual summer crop. This system requires, however, that the winter annual crop be harvested early enough in the spring to permit planning of the subsequent summer annual crop. This generally is most easily accomplished if the winter annual crop can be removed and preserved as silage.

Experiment 6. Barley and Triticale Preserved as Silage: Ensiling Characteristics, Nutritive Value, and Quality

Our objective in this experiment was to evaluate and compare the ensiling potential, nutritive value, and quality of barley and triticale when preserved as silage.

Materials and Methods

Uniform stands of Starling barley and the hybrid triticale 498 provided the experimental forages which were evaluated in each of two years. The stands were established each year in the fall following normal planting practice. Both forages were top-dressed each year in early February with 70 pounds of nitrogen per acre. The forages were harvested by mid-April with a conventional field chopper set to leave a 3-inch stubble. The chopped forage was blown into a self-unloading wagon and transported to the NC State University Forage Animal Metabolism Unit, Raleigh, NC, where it was packed into upright experimental silos according to standard procedures (Appendix GP-1).

The barley and triticale ensiled the spring of each year was evaluated that following fall for intake and digestibility (Appendix GP-2). Steers were used in a randomized complete block design to evaluate the silages each year. In Year 1, six steers (mean weight = 504 ± 39 pounds) were used and fed at an average of 13.8% in excess. In Year 2, eight steers (mean weight = 501 ± 47.6 pounds) were used and fed at an average of 13.1 % in excess.

All as-fed, weighback, and fecal samples were analyzed according to normal procedure (Appendix GP-6), and the data were statistically analyzed according to the experimental design (Appendix GP-7).

Results and Discussion

Fermentation Characteristics

The dry matter of the forages at ensiling differed in Year 1 with barley being least (Table 6.1). The pH measures of the Year 1 silages were similar, but the triticale silage was generally least in alcohol and fatty acid concentrations. These differences in alcohol and fatty acid concentrations were not noted in Year 2, in which dry matter at ensiling was similar at 29.3% and, consequently, other variables were also similar. The differences noted in Year 1 appear to be related to the greater dry matter of triticale at ensiling.

Intake and Digestibility

In Year 1, steers consumed the barley and triticale similarly (2.21 pounds per 100 pounds of body weight), but digested barley greater (P = 0.01) than triticale (Table 6.2). Digestibility of neutral detergent fiber (NDF), acid detergent fiber (ADF), and cellulose (CELL) was also greater in barley than triticale. Digestible intakes, however, were not altered. In Year 2, intakes by steers were similar (1.87 pounds per 100 pounds of body weight), as noted in Year 1, but averaged lower. Also, steers digested dry matter similarly in Year 2 with greater digestibility for triticale noted for NDF, hemicellulose (HEMI), and CELL, and generally opposite that reported in Year 1.

Fecal composition between the silages was generally similar in both years. Some differences occurred, but these differences were rather small and probably of little biological importance (Table 6.3).

Examination of the as-fed silages revealed little differences in nutritive value between barley and triticale in Year 1, whereas in Year 2, barley was gen-

erally of greater nutritive value than triticale (Table 6.4). Difference value (weighback concentration minus as-fed concentration) for in vitro true dry matter disappearance, crude protein, and neutral detergent fiber indicated that some selective consumption may have occurred, but no differences were noted between small grain species in either year (Table 6.4).

Summary and Conclusions

- Barley and triticale ensiled well with pH measures of the fermented silages of 4.3 or less.
- Dry matter intakes of the two silages were generally similar, with dry matter digestibility greater for barley in Year 2 but similar to triticale in Year 1.
- Digestible intakes of dry matter and nutritive value constituents were generally similar between the two silages.
- Barley and triticale, both winter annual grasses, can be ensiled and serve as a feed source in ruminant production systems.

Table 6.1. Ensiling characteristics of barley and triticale silages (dry matter basis).

Silage	DM[1]	pH	Alcohols		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		%						
Year 1[2]:									
Barley	30.0	4.3	0.55	0.018	3.28	0.46	4.41	0.54	0.010
Triticale	46.4	4.2	0.09	0.007	0.94	0.02	3.41	0.02	0.007
Significance (*P*):	<0.01	0.25	<0.01	0.05	<0.01	<0.01	0.13	<0.01	0.63
Year 2[3]:									
Barley	29.3	3.7	1.21	0.037	2.15	0.07	8.92	0.10	0.004
Triticale	29.7	3.8	1.03	0.029	2.37	0.07	8.73	0.10	0.013
Significance (*P*):	0.43	0.48	0.66	0.08	0.16	0.10	0.70	0.55	0.13

[1] DM = dry matter

[2] Each value is the mean of three replicate samples.

[3] Value for DM is the mean of four samples, and the other values are the mean of three samples.

Table 6.2. Dry matter (DM) intake (DMI), digestibilities, and digestible intakes of DM and associated nutritive value[1] of barley and triticale silages (DM basis).

Silage	DMI	Digestibilities					Digestible Intakes				
		DM	NDF	ADF	HEMI	CELL	DM	NDF	ADF	HEMI	CELL
	lb/100 lb[2]	%					lb/100 lb[2]				
Year 1[3]:											
Barley	2.30	69.4	58.1	58.3	57.9	64.9	1.59	0.73	0.44	0.28	0.42
Triticale	2.12	60.6	48.0	46.9	49.5	54.3	1.29	0.55	0.32	0.23	0.32
Significance (*P*):	0.68	0.01	0.01	0.03	0.06	0.01	0.33	0.27	0.20	0.40	0.27
Year 2[4]:											
Barley	2.10	65.1	55.3	56.4	53.9	64.3	1.40	0.62	0.36	0.26	0.35
Triticale	1.65	66.3	64.0	64.2	63.8	72.5	1.06	0.59	0.36	0.23	0.35
Significance (*P*):	0.09	0.44	0.02	0.10	0.01	0.01	0.05	0.61	0.91	0.32	0.93

[1] NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Body weight basis.

[3] Each value is the mean of three steers.

[4] Values for DMI are the mean of four steers and the other values the mean of three steers.

Table 6.3. Chemical composition[1] of feces from steers fed barley and triticale silages (dry matter basis).

Silage	CP	NDF	Fiber Fractions			
			ADF	HEMI	CELL	Lignin
	%					
Year 1[2]:						
Barley	8.7	71.1	42.2	28.9	30.5	10.5
Triticale	9.4	69.4	41.2	28.2	30.6	9.5
Significance (*P*):	0.13	0.04	0.11	0.16	0.87	0.02
Year 2[3]:						
Barley	9.9	70.7	39.4	31.3	27.7	10.6
Triticale	10.2	69.1	41.3	27.8	27.3	12.3
Significance (*P*):	0.68	0.24	0.11	0.03	0.49	<0.01

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
[2] Each value is the mean of three steers.
[3] Each value is the mean of four steers.

Table 6.4. In vitro true dry matter disappearance (IVTD) and associated nutritive value[1] of as-fed (AF) barley and triticale silages (dry matter basis).

Silage	IVTD		CP		NDF		Fiber fractions			
	AF	DV[2]	AF	DV	AF	DV	ADF	HEMI	CELL	Lignin
	%									
Year 1[3]:										
Barley	68.0	0.8	9.6	-0.6	54.3	-0.7	33.0	21.3	28.1	4.6
Triticale	69.3	-1.3	8.5	-0.3	54.6	2.7	32.6	21.9	28.0	4.4
Significance (*P*):	0.29	0.63	0.04	0.34	0.89	0.55	0.77	0.39	0.94	0.24
Year 2[4]:										
Barley	73.3	-2.1	8.7	-1.2	53.7	4.5	30.9	22.8	26.3	4.1
Triticale	68.8	-3.1	10.7	-1.5	59.7	5.1	36.2	23.5	31.2	4.7
Significance (*P*):	0.01	0.75	<0.01	0.72	<0.01	0.87	<0.01	0.03	<0.01	0.02

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.
[2] DV = difference value (weighback concentration minus AF concentration).
[3] Each value is the mean of three samples.
[4] Each value is the mean of four samples.

Experiment 7. Ensiled Small Grain Following Tropical Corn at Two Planting Rates: Fermentation Characteristics and Nutritive Value

In double cropping systems, carryover effects from the previous crop can influence the subsequent crop. This influence could take the form of altered growth, which can alter dry matter yield and its associated nutritive value. Our objective in this experiment was to examine fermentation products and the nutritive value of a barley and a triticale silage following a corn crop that was planted at two populations: 15,000 and 30,000 plants per acre.

Materials and Methods

Following harvest of the corn crop, barley and triticale were seeded in three replicates the same fall following standard procedures (Appendix GP-1). This planting provided the experimental forages and was repeated a second year. Both forages were topdressed each year with 70 pounds of nitrogen per acre. The forages were harvested by early May from the three replicates. A strip 3 feet wide by 40 feet long was cut to a 3-inch stubble, passed through a conventional field chopper, and ensiled in miniature silos (Appendix GP-1).

At opening, each miniature silo was emptied, mixed, and sampled, and the samples were analyzed for fermentation products and nutritive value constituents according to standard procedures (Appendix GP-6). The data were statistically analyzed as a randomized complete block design (Appendix GP-7).

Results and Discussion

Dry matter concentrations in Year 1 differed among treatments as did pH and concentrations of methanol, propionic, lactic, butyric, and isobutyric acids (Table 7.1). Most of the differences, however, were between species (barley and triticale), with differences within species (between cultivars or corn plant populations) generally lacking. All silages were well preserved with pH measures of ≤ 4.9 for barley and ≤ 4.4 for triticale.

The nutritive value of the small grains also differed as noted for each variable (Table 7.2). As reported for fermentation characteristics, the differences were essentially all associated with small grain species. Barley was greater in in vitro true dry matter disappearance and crude protein and least in neutral detergent fiber and its constituent fiber fractions. Differences were generally lacking among treatments or between corn plant populations within either barley or triticale.

In Year 2, dry matter concentrations of the silages ranged from 29.7% to 32.7% (Table 7.3) and much less than in Year 1 (range of 39% to 48%). Treatments differed, but the differences were minimal and associated mainly with species. Contrary to Year 1, no differences were evident between cultivars for any of the other variables. Similar to Year 1, no differences were noted within cultivar due to corn cultivar or planting population.

The nutritive value of the barley and triticale silages in Year 2 reflect Year 1 in that barley had greatest in vitro true dry matter disappearance and least neutral detergent fiber and its fiber constituents (Table 7.4). In Year 2, barley following Pioneer 3098 corn planted at 30,000 plants per acre was least in in vitro dry matter disappearance and greatest in neutral detergent fiber compared with the other three treatments. This indicates some potential reduction in silage quality. Triticale showed no differences among the prior corn treatments.

Summary and Conclusions

- In general, both barley and triticale fermented well and the silages were stable.
- Neither small grain was altered in either fermentation characteristics or nutritive value when planted following tropical corn regardless of corn plant population.
- Barley appears to be of greater nutritive value compared with triticale.

Table 7.1. Ensiling characteristics of barley and triticale when grown following corn previously planted at two populations, Year 1 (dry matter basis).

Treatment			DM[3]	pH	Alcohols		Fatty Acids				
Small Grain	Following Corn				Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	Cultivar[1]	Population[2]	%		%						
Barley:											
	DKXL660	15	42.4[4]	4.7	1.60	0.08	0.56	0.04	2.10	0.89	0.03
		30	39.7	4.8	1.94	0.10	0.59	0.05	2.25	1.07	0.02
	PN3098	15	39.1	4.7	1.91	0.13	0.43	0.18	2.35	1.47	0.05
		30	39.6	4.9	1.71	0.13	0.54	0.13	2.50	1.14	0.04
Triticale:											
	DKXL660	15	47.2	4.3	1.88	0.05	0.48	-	3.79	0.06	0.02
		30	47.2	4.3	2.11	0.03	0.50	-	3.71	0.02	0.01
	PN3098	15	47.6	4.3	1.68	0.07	0.44	t[5]	3.49	0.09	0.02
		30	47.6	4.4	1.42	0.03	0.32	-	2.67	0.03	0.01
Significance (*P*):											
Treatment			<0.01	<0.01	0.97	<0.01	0.18	0.02	0.01	<0.01	<0.01
MSD[6]			3.2	0.4	2.24	0.05	0.25	0.12	1.17	0.35	0.01

[1] DK = Dekalb; PN = Pioneer.

[2] 15 = 15,000; 30 = 30,000 plants per acre.

[3] DM = dry matter.

[4] Each value is the mean of three samples.

[5] t = trace.

[6] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 7.2. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of barley and triticale silages following corn previously planted at two populations, Year 1 (dry matter basis).

Treatment						Fiber Fractions			
Small Grain	Following Corn		IVTD	CP	NDF	ADF	HEMI	CELL	Lignin
	Cultivar[2]	Population[3]	%						
Barley:									
	DKXL660	15	72.0[4]	8.2	51.1	32.5	18.6	27.0	3.8
		30	70.8	8.1	52.6	33.6	19.0	29.0	4.1
	PN3098	15	69.3	8.5	54.2	35.2	19.0	30.2	4.2
		30	70.4	8.3	52.9	34.3	18.5	29.4	4.2
Triticale:									
	DKXL660	15	62.7	6.7	65.0	42.0	23.0	37.0	5.2
		30	63.1	6.3	64.7	41.9	22.8	36.2	5.1
	PN3098	15	61.3	6.2	67.1	43.9	23.2	37.3	5.2
		30	61.1	6.1	66.6	42.7	23.9	36.6	5.2
Significance (*P*):									
Treatment			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[5]			4.2	0.9	5.0	3.9	1.5	3.9	0.5

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DK = Dekalb; PN = Pioneer.

[3] 15 = 15,000; 30 = 30,000 plants per acre.

[4] Each value is the mean of three samples.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 7.3. Ensiling characteristics of barley and triticale when grown following corn previously planted at two populations, Year 2 (dry matter basis).

Treatment					Alcohols		Fatty Acids				
Small Grains	Following Corn		DM[3]	pH	Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	Cultivar[1]	Population[2]	%		%						
Barley:											
	DKXL660	15	30.5[4]	4.0	4.36	0.04	1.2	t[5]	4.83	t	0.02
		30	29.7	4.1	4.15	0.03	1.14	t	4.30	t	0.02
	PN3098	15	30.4	4.1	3.48	0.05	1.19	-	4.33	0.01	0.03
		30	30.7	4.2	3.68	0.04	1.27	-	4.03	0.01	0.02
Triticale:											
	DKXL660	15	31.6	4.1	4.27	0.04	1.34	-	3.72	t	0.03
		30	31.0	4.1	4.59	0.04	1.22	t	4.72	0.01	0.03
	PN3098	15	31.9	4.2	3.89	0.04	1.44	-	3.89	0.01	0.02
		30	32.7	4.2	3.36	0.04	1.36	0.01	3.90	0.04	0.03
Significance (*P*):											
Treatment			0.03	0.46	0.71	0.43	0.18	0.37	0.48	0.48	0.21
MSD[6]			1.8	0.2	2.48	0.02	0.31	0.02	1.73	0.05	0.02

[1] DK = Dekalb; PN = Pioneer.

[2] 15 = 15,000; 30 = 30,000 plants per acre.

[3] DM = dry matter.

[4] Each value is the mean of three samples.

[5] t = trace.

[6] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 7.4. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of barley and triticale silages following corn previously planted at two populations, Year 2 (dry matter basis).

Treatment									
Small grain	Following Corn		IVTD	CP	NDF	Fiber Fractions			
	Cultivar[2]	Population[3]				ADF	HEMI	CELL	Lignin
			%						
Barley:									
	DKXL660	15	75.3[4]	11.2	51.6	31.2	20.4	26.7	3.6
		30	74.5	11.1	52.4	32.5	20.0	27.5	3.8
	PN3098	15	75.5	11.1	50.5	30.9	19.6	26.4	3.5
		30	72.5	10.9	54.6	34.1	20.5	29.7	3.9
Triticale:									
	DKXL660	15	70.3	10.9	58.2	37.2	21.0	32.7	4.4
		30	69.5	11.2	59.7	37.7	22.0	33.3	4.4
	PN3098	15	70.4	10.8	58.4	37.3	21.1	32.6	4.4
		30	70.7	11.0	58.3	36.8	21.5	32.4	4.3
Significance (*P*):									
Treatment			<0.01	0.97	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[5]			1.5	1.8	2.3	1.7	1.0	1.8	0.2

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] DK = Dekalb; PN = Pioneer.

[3] 15 = 15,000; 30 = 30,000 plants per acre.

[4] Each value is the mean of three samples.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Section III. Double Cropping Associations

In double cropping systems, characteristics of the previous crop can influence the following crop. This influence may take the form of altered growth, which may alter dry matter yield and its associated nutritive value. The major opportunity for such carryover effects would be best observed when corn (rapid grower) is immediately planted into small grain stubble as opposed to small grain seeded into corn stubble. In the latter case, the growth of small grain proceeds slowly during the winter.

Experiment 8. Temperate and Tropical Corn Following Small Grain Harvested for Silage: Fermentation Characteristics and Nutritive Value

Our objective in this experiment was to examine fermentation products and the silage nutritive value of temperate and tropical corn at two plant populations following the production of either barley or triticale.

Material and Methods

Following harvest of the barley (May 9) and triticale (May 19), three corn cultivars were planted at two planting rates. The temperate corn was planted (April 17) using conventional methods and ensiled (August 3). The two tropical cultivars were planted (June 8) into the same plot area as the previous small grains and ensiled (September 28 or 29) giving the following ten treatments:

Temperate corn (Pioneer 31G20):
1. Planted at 15,000 plants per acre
2. Planted at 30,000 plants per acre

Tropical corn following barley:
3. Dekalb XL660 planted at 15,000 plants per acre
4. Pioneer 3098 planted at 15,000 plants per acre
5. Dekalb XL660 planted at 30,000 plants per acre
6. Pioneer 3098 planted at 30,000 plants per acre

Tropical corn following triticale:
7. Dekalb XL660 planted at 15,000 plants per acre
8. Pioneer 3098 planted at 15,000 plants per acre
9. Dekalb XL660 planted at 30,000 plants per acre
10. Pioneer 3098 planted at 30,000 plants per acre

Corn plantings were made in 14 feet wide by 25 feet long plots in a randomized complete block design with three replicates. All plantings received 70 pounds of nitrogen per acre as a side dress. A random, 10-foot length was cut in early October from each plot and hand fed through a forage chopper, and each treatment was ensiled in miniature silos (Appendix GP-1). The exception was the temperate corn—for which the forages from the two plant population treatments were combined prior to chopping, thoroughly mixed after chopping, and ensiled as one treatment, resulting in nine treatments.

At opening, each miniature silo was emptied, mixed, sampled, and samples analyzed for fermentation products and nutritive value constituents according to standard procedures (Appendix GP-6). The data were statistically analyzed as a randomized complete block design (Appendix GP-7).

Results and Discussion

Dry matter concentrations of the silages differed among treatments. However, all treatments ensiled well with similar pH measures of ≤ 3.8 (Table 8.1). In general, dry matter differences were mainly cultivar related with temperate corn being greatest but similar to most of the treatments within Pioneer 3098 and greater than the Dekalb XL660 silages. Ethanol concentrations differed, which was mainly associated with Pioneer 3098 silage following triticale. Acetic acid concentrations differed among silages and were mainly cultivar related with temperate silage least compared with Dekalb XL660, and Dekalb XL660 was generally similar with Pioneer 3098. The exception was the Pioneer 3098 treatment at 30,000 plants per acre and following triticale. It is noteworthy that propionic and isobutyric acids were essentially absent in all silages.

The nutritive value differed among the silages, being related essentially to cultivar as opposed to

treatments within cultivars. Temperate corn silage was greatest in in vitro true dry matter disappearance and lesser in neutral detergent fiber and its fiber constituents (Table 8.2). The two tropical corn silages were generally similar in nutritive value with little difference among treatments within cultivar.

Summary and Conclusions

- All silages ensiled well with final pH measures of ≤ 3.8.
- Following barley or triticale in a double cropping system did not alter temperate or tropical corn fermentation responses or the nutritive value of either resulting silage.
- Planting corn at either 15,000 or 30,000 plants per acre did not alter fermentation characteristics or nutritive value of the resulting silages.

Table 8.1. Ensiling characteristics of temperate and tropical corn when ensiled following barley and triticale (dry matter basis).

Treatment			DM[3]	pH	Alcohols		Fatty Acids				
Cultivar	Population[1]	Following[2]	%		Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
					%						
Temperate corn:											
Pioneer 31G20	15/30	-	30.8[4]	3.7	2.07	0.04	1.42	-	6.61	t[5]	-
Tropical corn:											
Dekalb XL660	15	B	26.0	3.7	2.26	0.04	1.82	-	6.95	0.01	-
		T	28.5	3.7	1.81	0.05	1.89	-	6.88	0.01	-
	30	B	26.4	3.7	1.90	0.03	1.86	-	7.66	0.01	t
		T	27.9	3.7	2.07	0.04	1.96	-	6.94	0.02	-
Pioneer 3098	15	B	29.5	3.8	2.20	0.04	1.56	0.01	6.64	0.02	0.01
		T	30.4	3.8	0.92	0.05	1.55	-	5.94	-	t
	30	B	28.8	3.7	1.63	0.05	1.48	-	6.06	0.01	t
		T	29.7	3.8	1.41	0.05	1.71	-	5.84	t	t
Significance (*P*):											
Treatment			<0.01	0.07	0.05	0.61	<0.01	0.01	0.10	0.39	0.17
MSD[6]			1.72	0.07	0.95	0.03	0.23	0.01	1.51	0.03	0.01

[1] 15 = 15,000; 30 = 30,000 plants per acre.

[2] B = barley; T = triticale.

[3] DM = dry matter.

[4] Each value is the mean of three replicates.

[5] t = trace.

[6] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 8.2. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of temperate and tropical corn when ensiled following barley and triticale (dry matter basis)

Treatment			IVTD	CP	NDF	Fiber Fractions			
Cultivar	Population[2]	Following[3]				ADF	HEMI	CELL	Lignin
			%						
Temperate corn:									
Pioneer 31G20	15/30	-	78.3[4]	7.4	45.2	25.5	19.8	23.0	2.4
Tropical corn:									
Dekalb XL660	15	B	70.5	6.9	57.5	33.3	24.2	29.2	3.3
		T	72.1	6.8	55.6	32.0	23.6	28.0	3.0
	30	B	70.2	6.6	58.6	34.3	24.3	29.6	3.5
		T	69.2	6.8	57.9	33.6	34.3	30.0	3.5
Pioneer 3098	15	B	70.1	7.3	56.1	32.2	23.9	27.9	3.4
		T	69.3	6.4	56.7	32.9	23.8	29.4	3.8
	30	B	67.5	6.8	58.7	34.5	24.1	30.5	4.0
		T	68.4	6.6	58.7	34.5	24.2	31.0	3.9
Significance (*P*):									
Treatment			<0.01	0.26	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[5]			2.9	1.1	3.4	2.5	1.1	2.6	0.5

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] 15 = 15,000; 30 = 30,000 plants per acre.

[3] B = barley; T = triticale.

[4] Each value is the mean of three replicates.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Experiment 9. Ensiled Temperate and Tropical Corn in a Double Cropping System: Morphology, Fermentation Characteristics, and Steer Preference

This experiment is an expansion of Experiment 8 in which a temperate and two tropical corn cultivars, planted at two populations following small grains, were ensiled and evaluated for fermentation products and nutritive value. Our objectives in this experiment were to further describe the morphology of the cultivars in Experiment 8 and to determine if fermentation products or nutritive value altered steer preference.

Material and Methods

Following harvests of barley and triticale, planting and harvesting of a temperate and two tropical corns using conventional methods were conducted on dates comparable to the dates noted in Experiment 8. Plantings were made following small grain harvest as noted in Experiment 8. The following ten silage treatments resulted and were used for experimentation:

Temperate corn (Pioneer 31G20):

1. Planted at 15,000 plants per acre
2. Planted at 30,000 plants per acre

Tropical corn following barley:

3. Dekalb XL660 planted at 15,000 plants per acre
4. Pioneer 3098 planted at 15,000 plants per acre
5. Dekalb XL660 planted at 30,000 plants per acre
6. Pioneer 3098 planted at 30,000 plants per acre

Tropical corn following triticale:

7. Dekalb XL660 planted at 15,000 plants per acre
8. Pioneer 3098 planted at 15,000 plants per acre
9. Dekalb XL660 planted at 30,000 plants per acre
10. Pioneer 3098 planted at 30,000 plants per acre

Corn plantings were made in 14-foot wide by 25-foot long plots in a randomized complete block design with three replications that were previously occupied by small grains. A random 10-foot length was cut in early October from each plot. Five stalks were randomly selected from each plot and used for morphological determination (Appendix GP-1). The cut forages were then hand-fed through a forage chopper and ensiled in miniature silos (Appendix GP-1).

The stalks selected for morphological determination were separated into leaf, stem, tassel, husk, and ear (grain and cob) components. Each was expressed as a percent of the whole-stalk dry matter. The ear was further separated into the grain and cob components and expressed as a percent of the total ear.

At feeding, each miniature silo was opened and the contents emptied, thoroughly mixed, and sampled. The samples were analyzed for fermentation products and nutritive value constituents according to standard procedures (Appendix GP-6).

Six separate 30-minute preference evaluations involving two, three, and four treatment comparisons were conducted. Each evaluation was conducted as a randomized complete block design with six steer (weight range of 1,430 to 2,150 pounds) replicates. The total dry matter intake and feeding times were recorded, and the intake rate (grams/minute) was calculated. The data were statistically analyzed according to the experimental design (Appendix GP-7).

Results and Discussion

Morphology of the three corn cultivars planted to the two population densities differed in the proportion of whole-plant dry matter present as leaf, stem, husk, and ear (Table 9.1). Although a few exceptions occurred, generally differences in these plant fractions were attributed to cultivar differences and not to planting density or to the preceding small grain.

Dry matter at opening of silos was greatest for the temperate corn silage, whereas that of the tropical corn silage was lesser and generally similar among treatments within cultivar (Table 10.2). Forage from all 10 treatments fermented well with similar pH measures of 3.8 to 4.0. Differences were noted among treatments in ethanol, methanol, lactic, and butyric acid concentrations, and these differences were generally between temperate and tropical corn silages. Some exceptions were noted, but no trends were evident.

Preference evaluations, comparing from two to four treatments in each evaluation, revealed no differences in dry matter intake between or among temperate and tropical cultivars, nor was any differences noted if the silages were planted at 15,000 or 30,000 plants per acre or if the corn followed barley or triticale (Tables 9.3 and 9.4).

Examination of the nutritive value of the fed silages indicates that all measurements, except crude protein, differed among the 10 treatments (Table 9.5). Also, the data indicate that differences were again all cultivar associated, with temperate corn being different compared to the tropical corns, which were similar. Further, no differences were noted within cultivar related to plant population (plants per acre) or if the corn planting followed directly behind barley or triticale.

The degree of similarity in preference among the 10 treatments, in light of the greater nutritive value of temperate corn, is surprising even for short-term preference evaluations. This may be attributed, in part, to the similarity in degree of fermentation (expressed by pH) among the silages.

Summary and Conclusions

- All silages fermented well and were stable regardless of cultivar, planting population, and previous small grain seedings.
- Temperate corn silage had greater nutritive value compared with the two tropical corn silages.
- Steers showed no short-term (30 minute) preference in terms of dry matter intake among any of the silages offered.
- No carryover effect was evident in corn-silage preference when following either barley or triticale in a double cropping system.

Table 9.1. Morphology of temperate and tropical corn cultivars planted at two populations following barley and triticale and preserved as silage (dry matter basis).

Treatment			Forage						Ear	
Silage	Population[1]	Following[2]	Leaf	Stem	Tassel	Husk	Dead	Ear	Grain	Cob
			—————————— % of Plant ——————————						—% of Total Ear	
Temperate corn:										
Pioneer 31G20	15	-	10.4[3]	23.3	0.7	11.4	1.2	53.0	78.4	21.6
	30		12.5	24.4	0.8	7.2	0.5	54.6	81.3	18.7
Tropical corn:										
Dekalb XL660	15	B	16.1	28.4	0.7	13.3	2.0	39.5	81.5	18.5
		T	14.4	32.3	1.0	12.3	2.6	37.4	80.9	19.1
	30	B	16.1	35.2	0.6	12.1	4.0	32.0	78.6	21.4
		T	16.2	35.3	1.1	11.5	2.9	33.0	78.2	21.8
Pioneer 3098	15	B	12.3	31.8	0.7	11.8	2.4	41.0	80.8	19.2
		T	12.6	32.4	0.7	12.9	2.4	39.0	80.3	19.7
	30	B	14.5	35.3	1.1	11.4	1.8	35.9	77.6	22.4
		T	14.8	32.1	0.8	10.2	2.5	39.6	79.5	20.5
Significance (*P*):										
Treatment			<0.01	<0.01	0.37	0.01	0.01	<0.01	0.65	0.65
MSD[4]			2.2	3.7	0.7	2.7	1.6	5.5	7.7	7.7

[1] 15 = 15,000; 30 = 30,000 plants per acre.

[2] B = barley; T = triticale.

[3] Each value is the average of five plants and the mean of three land replicates.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 9.2. Dry matter (DM) and fermentation characteristics of temperate and tropical corns ensiled for silage (DM basis).

Treatment			DM	pH	Alcohols		Fatty Acids				
Silage	Population[1]	Following[2]			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
			%		%						
Temperate corn:											
Pioneer 31G20	15	-	35.9[3]	3.8	1.51	0.04	1.31	-	5.61	0.05	0.01
	30	-	37.8	3.8	1.47	0.04	1.15	-	5.25	0.02	0.01
Tropical corn:											
Dekalb XL660	15	B	27.6	3.8	1.03	0.07	1.68	-	6.63	t	0.01
		T	28.4	3.9	0.53	0.05	1.68	t[4]	6.47	0.01	0.01
	30	B	27.2	4.0	0.84	0.06	1.58	t	6.98	t	0.01
		T	27.5	3.8	0.68	0.06	1.60	t	6.89	0.01	0.01
Pioneer 3098	15	B	30.1	3.9	0.52	0.06	1.64	-	6.38	t	0.01
		T	30.2	3.8	0.51	0.05	1.56	-	6.43	t	0.01
	30	B	27.0	3.9	0.54	0.05	1.70	-	7.19	0.01	0.01
		T	28.9	3.9	0.34	0.04	1.23	-	5.40	t	0.01
Significance (*P*):											
Treatment			<0.01	0.29	<0.01	0.04	0.08	0.47	0.02	0.03	<0.01
MSD[5]			2.0	0.2	0.40	0.002	0.51	0.004	1.35	0.03	0.003

[1] 15 = 15,000; 30 = 30,000 plants per acre.

[2] B = barley; T = triticale.

[3] Each value is the mean of three samples (replicates).

[4] t = trace.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 9.3. Preference evaluations (Evaluations 1 thru 3) comparing temperate corn and various tropical corn silages planted at two populations following barley and triticale (dry matter basis).

Treatment			Evaluation 1			Evaluation 2			Evaluation 3		
Silage	Population[1]	Following[2]	DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
			g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:											
Pioneer 31G20	15	-	337[4]	3.1	79.5						
	30	-				569[4]	4.5	106.9			
Tropical corn:											
Dekalb XL660	15	B									
		T	252	3.1	117.0				443[4]	4.5	94.5
	30	B				395	4.4	85.5	303	3.0	95.2
		T									
Pioneer 3098	15	B	472	4.6	106.6				195	2.6	68.1
		T									
	30	B				290	3.3	120.4	497	5.3	94.0
		T									
Significance (*P*):											
Treatment			0.56	0.67	0.70	0.33	0.78	0.60	0.31	0.45	0.44
MSD[5]			523	5.0	120.9	460	4.9	89.2	444	5.0	51.5

[1] 15 = 15,000; 30 = 30,000 plants per acre.

[2] B = barley; T = triticale.

[3] DMI = dry matter intake.

[4] Each value is the mean of six steers.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 9.4. Preference evaluations (Evaluations 4 thru 6) comparing temperate corn and various tropical corn silages planted at two populations following barley and triticale (dry matter basis).

Treatment			Evaluation 4			Evaluation 5			Evaluation 6		
Forage	Population[1]	Following[2]	DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
			g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:											
Pioneer 31G20	15	-	329[4]	2.7	180.8	178[4]	1.8	159.8			
	30	-	611	4.8	109.3						
Tropical corn:											
Dekalb XL660	15	B	227	2.3	158.7	441	4.3	95.1	486[4]	5.3	101.3
		T				880	8.4	121.8			
	30	B									
		T	371	4.0	85.7				498	4.9	95.6
Pioneer 3098	15	B									
		T				675	6.1	103.9			
	30	B									
		T									
Significance (*P*):											
Treatment			0.30	0.46	0.67	0.25	0.16	0.08	0.95	0.86	0.51
MSD[4]			519	4.6	240.5	705	5.5	35.5	-	-	-

[1] 15 = 15,000; 30 = 30,000 plants per acre.

[2] B = barley; T = triticale.

[3] DMI = dry matter intake.

[4] Each value is the mean of six steers.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 9.5. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of temperate and tropical corn silages planted at two populations following barley and triticale (dry matter basis).

Treatment			IVTD	CP	NDF	Fiber Fractions			
Silage	Population[2]	Following[3]				ADF	HEMI	CELL	Lignin
			——————————————————%——————————————————						
Temperate corn:									
Pioneer 31G20	15	-	83.8[4]	7.9	41.6	22.3	19.3	19.7	2.0
	30	-	84.4	8.1	39.4	20.7	18.7	18.5	1.8
Tropical corn:									
Dekalb XL660	15	B	74.1	8.4	51.9	29.1	22.9	25.9	2.9
		T	73.9	8.6	51.8	28.7	23.1	25.5	3.0
	30	B	75.5	9.0	50.5	28.2	22.3	25.0	2.7
		T	72.3	7.6	52.9	30.1	22.8	26.8	3.1
Pioneer 3098	15	B	73.9	8.9	51.3	29.0	22.3	25.5	3.1
		T	72.4	8.3	51.6	29.2	22.4	25.7	3.2
	30	B	74.5	9.4	48.9	27.5	21.4	24.2	2.9
		T	73.9	8.7	48.6	27.4	21.2	24.1	2.9
Significance (*P*):									
Treatment			<0.01	0.17	<0.01	<0.01	0.02	<0.01	<0.01
MSD[5]			4.4	1.7	6.9	4.3	2.8	3.5	0.6

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] 15 = 15,000; 30 = 30,000 plants per acre.

[3] B = barley; T = triticale.

[4] Each value is the mean of three samples.

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Section IV. Preference Evaluations of Warm-Season Annuals

Ruminants, when offered the opportunity, will selectively consume their daily diet. Grazing animals will initially select a diet greater in green leaf and select against dead and stemmy tissue. As the opportunity to select decreases, the time of grazing will generally increase but daily dry matter intake will remain constant or decrease. In confined feeding, animals will also selectively consume their daily diet if given the opportunity. Generally, the total mixed ration (TMR) avoids a large degree of selectivity with the idea that each mouthful ingested will be similar in nutritive value. When feeding a chopped hay to avoid some degree of selectivity, the unconsumed feed (weighback) will frequently be characterized by stemmy tissue. It is interesting to note that the degree of selective consumption will vary from animal to animal. In steer trials in which chopped hays have been fed, one can observe a range in weighback characteristics that varies—with some animals consuming essentially all the offered feed, some animals leaving a mat of weighback consisting of some leaf but generally with a preponderance of stem, some animals leaving a range of stemmy tissue, and some animals leaving only the heavy stems (which are generally identified as basal stems) of the harvested forage.

Clearly, ruminants preferentially select based on both nutritive value (composition) as well as on physical properties. In the case of fermented forage, the conventional nutritive value characteristics have been converted, in part, into end products of fermentation that have their own characteristics and affect animal preference. Our general objectives in this section were to determine the degree of steer preference for various silages based on silage type (species) or on imposed management differentials (such as planting and harvesting times). The specific objectives for the following experiments are stated after each experiment title.

Experiment 10. Tropical Corn Silages of Different Cultivars and Maturities: Fermentation Characteristics, Nutritive Value, and Preference

In a small grain and corn double cropping system, the development or intended use of the small grain crop may delay the date that the subsequent corn crop can be planted. Our objectives in this experiment were to determine the changes in fermentation characteristics and nutritive value of two tropical corn cultivars planted at increasing two-week delays and to determine any subsequent preference by steers for the silage.

Materials and Methods

Three corn cultivars consisting of the temperate cultivar Pioneer 3154 and two tropical cultivars, Dekalb 678C and Pioneer X304C, served as the experimental forages. The following nine treatments were evaluated:

Temperate corn—Pioneer 3154:
1. Planted May 15

Tropical corn—Dekalb 678C:
2. Planted May 15
3. Planted June 1
4. Planted June 15
5. Planted July 1

Tropical corn—Pioneer X304C:
6. Planted May 15
7. Planted June 1
8. Planted June 15
9. Planted July 1

All plantings were made and managed according to standard procedures. The temperate forage was cut September 3, and all of the tropical corn treatments were cut October 23. Forage was passed through a conventional field chopper and ensiled in miniature silos according to standard procedures (Appendix GP-1) for use in preference trials. The miniature silos

were stored undisturbed for a minimum of 60 days prior to opening.

The nine experimental silages were evaluated for preference in five evaluations. Each evaluation consisted of a randomized complete block design using three steer replicates. Samples were obtained from each replicate, all were processed according to standard procedures (Appendix GP-6), and the data were statistically analyzed according to the experimental design (GP-7).

Results and Discussion

Percent dry matter at harvest differed among treatments with temperate corn greatest at 49.6%. Little change in percent dry matter was noted among the May 15, June 1, and June 15 planting dates within a tropical cultivar or between cultivars. Corn planted July 1, however, was much lesser in dry matter, which is associated with the reduced degree of maturity. All silages ensiled well though, with desirable pH measures of ≤ 4.0. Ethanol production, as well as acetic and lactic acid concentrations, varied among treatments (Table 10.1). The major differences occurred between the temperate corn silage and the tropical silages, with the temperate corn silage greatest in ethanol and least in acetic and lactic acids. Some differences were evident within the tropical corn silages among planting dates, but differences were few.

When steer preferences between the two tropical corn silages were compared for the May 15 (Evaluation 1), June 1 (Evaluation 2), and July 1 (Evaluation 3) planting dates, only silage from the July 1 planting showed a difference (Table 10.2). Clearly Dekalb 678C was preferred over Pioneer X304C. The comparison of the silages planted at different dates within Dekalb 678C (Evaluation 4) indicated that the July 1 planted silage was preferred over the earlier plantings. This comparison within Pioneer X304C was not conducted because of insufficient silage. Comparison of the May 15 planting of temperate corn with the two tropical silages planted on the same date showed no difference overall, However, the minimum significant difference test (MSD) indicates that the temperate was preferred over the tropical Pioneer X304C.

The nutritive value of the nine silages indicates differences among them in all constituents except crude protein (Table 10.3). As expected, temperate corn silage was greatest in in vitro dry matter disappearance and least in neutral detergent fiber and its constituent fiber fractions. This concurs with the short-term dry matter intake noted in the preference evaluation (Evaluation 5, Table 10.2). Within the tropical corn silages, Dekalb 678C planted July 1 had greatest in vitro dry matter disappearance compared with the May 15 and June 15 plantings and was also preferred (Evaluation 4, Table 10.2).

Summary and Conclusions

- All corn silages, regardless of cultivar and planting date, ensiled well and resulted in stable silages.
- Steers showed no preference between tropical silages planted May 15 and June 1 but preferred silage of Dekalb 678C over that of Pioneer X304C when planted July 1.
- Within Dekalb 678C, the July planting was preferred over plantings made May 15 and June 1.

Table 10.1. Dry matter (DM) and fermentation characteristics of temperate corn and tropical corn cultivars planted on four dates (DM basis).

Cultivars	Planting Date	DM	pH	Ethanol	Fatty Acids		
					Acetic	Propionic	Lactic
		%		——————————— % ———————————			
Temperate corn:							
Pioneer 3154	May 15	49.6[1]	4.0	0.45	0.47	0.03	2.67
Tropical corn:							
Dekalb 678C	May 15	38.7	4.0	0.22	0.91	0.04	3.50
	June 1	39.0	4.0	0.11	0.75	0.03	3.49
	June 15	41.0	4.0	0.19	0.90	0.02	3.81
	July 1	30.2	3.9	0.22	1.07	0.04	3.82
Pioneer X304C	May 15	38.5	3.9	0.31	0.85	0.03	3.65
	June 1	36.5	4.0	0.15	0.80	0.02	3.17
	June 15	38.3	4.0	0.10	1.10	0.02	3.71
	July 1	31.2	3.9	0.16	1.14	0.03	4.12
Significance (*P*):							
Treatment		<0.01	0.02	<0.01	<0.01	0.46	0.01
MSD[2]		4.0	0.1	0.09	0.19	0.03	0.64

[1] Each value is the mean of three replicates.

[2] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 10.2. Preference evaluations (Evaluations 1 thru 5) between and among temperate and tropical cultivars planted at differing dates (dry matter basis).

Cultivars	Planting Date	Evaluation 1[1]			Evaluation 2[1]			Evaluation 3[1]			Evaluation 4[1]			Evaluation 5[2]		
		DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
		g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:																
Pioneer 3154	May 15													1595[a]	9.2[a]	160.7[a]
Tropical corn:																
Dekalb 678C	May 15	1283	8.9	138.5							483[a]	4.1[ab]	138.0[a]			
	June 1				1600	14.1	122.5				400[a]	3.0[b]	89.8[a]			
	June 15													920[ab]	6.6[a]	111.0[a]
	July 1							2667	15.0	181.0	1817[b]	11.6[a]	157.5[a]			
Pioneer X304C	May 15	1100	7.9	182.1												
	June 1				933	7.7	120.4									
	June 15													570[b]	3.4[a]	92.0[a]
	July 1							117	0.6	171.1						
Significance (*P*):																
Treatment		0.84	0.87	0.39	0.35	0.35	0.82	0.03	<0.01	0.96	0.01	0.06	0.22	0.12	0.16	0.41
MSD[4]		-	-	-	-	-	-	-	-	-	820	7.6	93.6	1022	6.5	122.3

[1] Each value is the mean of three replicates.

[2] Each value is the mean of four to six replicates.

[3] DMI = dry matter intake.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments (means with the same superscript are similar).

Table 10.3. In vitro dry matter disappearance (IVDMD) and nutritive value[1] of silages of temperate corn and tropical corn cultivars planted on four dates (dry matter basis).

Cultivars	Planting Date	IVDMD	CP	NDF	Fiber Fractions			
					ADF	HEMI	CELL	Lignin
		%						
Temperate corn:								
Pioneer 3154	May 15	71.0[2]	8.0	42.5	21.1	21.4	17.4	3.1
Tropical corn:								
Dekalb 678C	May 15	55.9	7.3	63.6	34.5	29.1	27.7	6.4
	June 1	58.0	7.9	60.5	32.9	27.6	26.4	5.7
	June 15	62.5	7.3	52.7	28.6	24.1	23.6	4.4
	July 1	63.3	8.0	56.2	28.9	27.3	24.3	4.4
Pioneer X304C	May 15	52.9	7.2	65.2	34.7	30.4	28.3	60
	June 1	55.7	7.4	61.2	33.0	28.2	27.2	5.5
	June 15	57.9	7.5	58.3	31.2	27.1	25.7	4.7
	July 1	60.7	8.2	54.7	27.7	27.1	22.7	4.6
Significance (*P*):								
Treatment		<0.01	0.36	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[3]		4.4	1.5	7.9	4.6	4.7	3.7	1.1

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of three replicates.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Experiment 11. Silages of Temperate and Tropical Corns, Forage Sorghums, and Pearlmillet: Steer Preference

Corn, sorghum, and pearlmillet generally differ in morphology and in nutritive value representing extremes in proportions of leaf, stem, and grain. Our objectives in this two-year experiment were to determine if wide differences in morphology and subsequent fermentation characteristics would change silage nutritive value and if changes would be a major factor in altering steer preference for one silage over another.

Materials and Methods

A small plot experiment consisting of six forages seeded in 14-foot wide by 25-foot long plots in a randomized complete block design with four replicates served as the experimental forages. The plots were planted and harvested by conventional methods. The forage at harvest was packed into miniature silos using standard procedures (Appendix GP-1). The following six forages were ensiled and their silages evaluated in a series of preference evaluations:

Corn:
Temperate corn:
1. Pioneer 3156 (harvested September 17)

Tropical corn:
2. Pioneer 3098 (harvested September 30)
3. Pioneer X304C (harvested September 30)

Forage sorghum:
4. Intermediate normal—Pioneer 841F (harvested September 17)
5. Sweet sorghum—Brandies (harvested October 28)

Millet:
6. Pearlmillet—Hybrid 3-mil-X (harvested September 17)

A series of seven short-term preference evaluations involving two- and three-way comparisons were conducted (Appendix GP-5) using 500- to 800-pound steers. Each evaluation was conducted as a randomized complete block design with four steer replicates. Each evaluation was conducted for 30 minutes. Silage intake and time devoted to eating were recorded, and total dry matter intake and intake rate (grams/minute) were determined.

A sample of each silage replicate (miniature silo) was obtained prior to feeding and analyzed for dry matter, fermentation characteristics, and nutritive value (Appendix GP-6). Data were analyzed statistically according to the experimental design. When more than two treatment comparisons were made in an evaluation, a minimum significant difference was determined and included in the data table to separate differences among treatments (Appendix GP-7). This experiment was conducted over two years with each year presented separately.

Year 1

Results and Discussion

The morphological components of the representative cultivars evaluated in this experiment indicate a wide range in differences (Table 11.1). When expressed as a proportion of the total plant dry matter, temperate corn, of the three corn cultivars evaluated, had the least leaf and stalk but the most ear compared with tropical corns. Tropical corns were similar in morphology. The sorghums had similar proportion of leaf, but the normal forage sorghum (Pioneer 841F) had a greater proportion of head and lesser stem compared with Brandies sorghum. Pearlmillet, on the other hand, resembled Brandies sorghum in morphological components.

Dry matter concentration at ensiling varied among the representative cultivars with the corn silages greater than the forage sorghums and pearlmillet least (Table 11.2). However, all forages fermented well with pH measures of ≤ 3.9. Although a number of differences were noted among cultivars in fermentation characteristics, those characteristics most noticeable are the greatest ethanol concentrations in the Brandies sorghum silage and greatest concentrations of acetic and lactic acids present in the pearlmillet silage.

Among the temperate and tropical corn cultivars, steers preferred Pioneer X304C over 3098 tropical

corn and 3156 temperate corn (Table 11.3). No differences in preference, however, were noted among the forage sorghums and pearlmillet or between temperate corn and the forage sorghums. In two-way preference evaluations, steers showed no significant preference between the two tropical corns, forage sorghums, or between tropical corn and pearlmillet or temperate corn and pearlmillet (Table 11.4).

A number of differences, as measured by nutritive value, existed among the cultivars evaluated (Table 11.5). But these nutritive differences, along with differences in fermentation characteristics (Table 11.2), apparently had little influence on animal acceptance. Steers in general showed little preference among or between the various silages evaluated.

Summary and Conclusions

- All six silages ensiled well with desirable pH measures of ≤ 3.9.
- Fermentation characteristics and nutritive value differed appreciably among the six silages but apparently not of sufficient magnitudes to alter steer preference.
- Among the corn cultivars, steers preferred the tropical Pioneer X304C over the other tropical (Pioneer 3098) and temperate (Pioneer 3156) cultivars.
- These results would support use of any of the cultivars as a potential forage silage.

Year 2

Results and Discussion

The cultivars varied in dry matter concentration at ensiling with the corn cultivars generally greater compared with the sorghums or pearlmillet (Table 11.6). However, all six silages fermented well with pH measures of ≤ 4.0, although some significant differences were noted.

Although many differences were noted among the fermentation characteristics, except for butyric and isobutyric acid concentrations, the noted differences are the greater concentration of ethanol in the Brandies sorghum followed at some distance by temperate corn, with the least ethanol found in the tropical corns (Table 11.6). Also, the Brandies sorghum had the greatest concentrations of lactic acid followed by pearlmillet and the corns.

Steer preference, whether in the three-way comparisons (Table 11.7) or two-way comparisons (Table 11.8), was always in favor of temperate corn with greatest dry matter intake and time devoted to eating. No preference was noted between the two tropical corns, whereas the intermediate sorghum was generally preferred over Brandies sorghum (exception is Evaluation 2, Table 11.7). It is noted that of theses six silages, four (Pioneer 3156 and X304C corn and Pioneer 841F and Brandies forage sorghum) were evaluated for dry matter intake and digestibility (See Experiment 5A, Table 5.2).
The strong preference for temperate corn silage over the other silages is evident when examining the in vitro true dry matter disappearance and composition of the silages (Table 11.9). Temperate corn has the greatest in vitro true dry matter disappearance and the least neutral detergent fiber compared with the other silages.

Summary and Conclusions

- All six forages fermented well resulting in stable silages with pH measures of 4.0 or less.
- Silages of temperate corn were generally preferred over the silages of the other cultivars.
- No preference was demonstrated for silage from one tropical corn over the other tropical corn.
- Silage of intermediate forage sorghum was generally preferred over silage of Brandies forage sorghum, but differences were not always significant.

Table 11.1. Morphological description of corn, sorghum and pearlmillet cultivars evaluated in Year 1 (dry matter basis).

Silage	Forage								Ear	
	Height	DM[1]	Leaf	Stalk	Tassel	Husk	Dead	Ear	Grain	Cob
	ft	%	——————————% of Total ——————————-						— % of Ear —	
Temperate corn:										
Pioneer 3156	5.4[2]	36.2	9.7[2]	27.6	0.5	9.5	5.0	47.7	81.3	18.7
Tropical corn:										
Pioneer X304C	9.5	30.7	15.6	46.5	1.0	12.0	4.0	20.9	65.6	34.4
Pioneer 3098	8.0	32.8	16.0	44.2	1.4	11.0	4.7	22.7	69.6	30.4
Forage sorghum:										
Pioneer 841F	4.6	28.7	14.8	37.5	-	-	5.2	42.5	-	-
Brandies	7.4	23.8	11.4	67.5	-	-	4.9	16.2	-	-
Pearlmillet:										
Hybrid 3-mil-X	5.5	26.0	20.6	27.0	-	-	1.6	20.8	-	-

[1] DM = dry matter.

[2] Each value is the average of eight stalks and the mean of four samples.

Table 11.2. Dry matter (DM) at ensiling and fermentation characteristics of temperate and tropical corns, forage sorghums and pearlmillet silages, Year 1[1] (DM basis).

Silage	DM	pH	Alcohols		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		——————————————————————— % ———————————————————————						
Temperate corn:									
Pioneer 3158	35.6^{ab}	3.8^{abc}	0.46^{b}	0.02	1.31^{c}	0.05	5.95^{b}	0.03	0.01
Tropical corn:									
Pioneer X304C	31.8^{bc}	3.8^{ac}	0.33^{b}	0.01	2.13^{ab}	0.01	6.62^{ab}	0.01	0.01
Pioneer 3098	36.8^{a}	3.9^{ab}	0.38^{b}	0.02	1.45^{c}	0.01	6.35^{b}	0.01	0.01
Forage sorghum:									
Pioneer 841F	29.5^{cd}	3.7^{c}	0.87^{b}	0.02	1.65^{bc}	0.02	7.08^{ab}	0.01	<0.01
Brandies	26.8^{de}	3.8^{bc}	2.30^{a}	0.02	1.63^{bc}	0.03	6.61^{ab}	0.01	0.01
Pearlmillet:									
Hybrid 3-mil-X	24.4^{e}	3.9^{a}	0.23^{b}	0.02	2.44^{a}	0.01	7.53^{a}	0.01	0.01
Significance (*P*):									
Treatments	<0.01	0.03	0.01	0.78	<0.01	0.25	0.05	0.52	0.38
MSD[2]	4.3	0.10	1.06	0.17	0.51	0.04	1.14	0.05	0.02

[1] Each value is the mean of four replicates, and means with same superscript are similar.

[2] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 11.3. Preference evaluations (Evaluations 1 thru 3) comparing silages of three cultivars at a time, Year 1[1] (dry matter basis).

Silage	Evaluation 1			Evaluation 2			Evaluation 3		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:									
Pioneer 3156	63[b]	0.9[b]	109.1				125	2.8	49.3
Tropical corn:									
Pioneer X304C	913[a]	11.4[a]	79.9						
Pioneer 308	117[b]	1.3[b]	113.9						
Forage sorghum:									
Pioneer 841F				1,137	6.7	132.4[a]	925	9.1	83.5
Brandies				235	3.1	55.7[ab]	415	4.7	74.5
Pearlmillet:									
Hybrid 3-mil-X				170	3.3	27.3[b]			
Significance (*P*):									
Treatments	<0.01	<0.01	0.88	0.30	0.62	0.06	0.43	0.53	0.69
MSD[3]	288	3.5	199	1,685	11.0	93.3	1,576	14.9	108.9

[1] Each value is the mean of four replicates, and means with the same superscript are similar.

[2] DMI = dry matter intake.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 11.4. Preference evaluations (Evaluations 4 thru 7) comparing silages of two cultivars at a time, Year 1[1] (dry matter basis).

Silage	Evaluation 4			Evaluation 5			Evaluation 6			Evaluation 7		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:												
Pioneer 3156										795	8.1	97.6
Tropical corn:												
Pioneer X304C	890	12.3	80.9				773	15.5	57.3			
Pioneer 3098	220	3.3	56.9									
Forage sorghum:												
Pioneer 841F				390	3.7	153.1						
Brandies				717	9.7	55.5						
Pearlmillet::												
Hybrid 3-mil-X							407	6.0	33.2	195	3.2	33.7
Significance (*P*):												
Treatments	0.18	0.07	0.58	0.56	0.33	0.35	0.53	0.39	0.24	0.27	0.44	0.10

[1] Each value is the mean of four steers.

[2] DMI = Dry matter intake.

Table 11.5. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of silages fed in the seven preference evaluations in Year 1[2] (dry matter basis).

Silage	IVTD	CP	NDF	Fiber Fractions			
				ADF	HEMI	CELL	Lignin
	%						
Temperate corn:							
Pioneer 3156	75.4^{b}	9.2^{b}	49.3^{c}	27.6^{c}	21.7^{a}	20.7^{d}	3.8^{c}
Tropical corn:							
Pioneer X304C	73.5^{b}	8.8^{c}	52.8^{b}	30.3^{b}	22.5^{a}	24.5^{bc}	4.7^{b}
Pioneer 3098	73.9^{b}	10.4^{a}	51.6^{bc}	30.1^{b}	21.6^{a}	23.8^{c}	4.8^{b}
Forage sorghum:							
Pioneer 841F	74.6^{b}	9.3^{bc}	49.3^{c}	30.7^{b}	18.5^{b}	23.6^{c}	4.5^{b}
Brandies	79.4^{a}	6.3^{d}	50.8^{bc}	31.0^{b}	19.8^{b}	25.6^{b}	4.5^{b}
Pearlmillet:							
Hybrid 3-mil-X	64.4^{c}	10.5^{a}	60.4^{a}	37.5^{a}	22.9^{a}	28.7^{a}	6.1^{a}
Significance (*P*):							
Treatments	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[3]	2.37	0.47	2.53	1.53	1.67	1.45	0.45

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four replicates and means with the same superscript are similar.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 11.6. Dry matter (DM) at ensiling and fermentation characteristics of temperate and tropical corns, forage sorghums and pearlmillet evaluated in Year 2[1] (DM basis).

Silage	DM	pH	Alcohol		Fatty Acids				
			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
	%		%						
Temperate corn:									
Pioneer 3156	34.6[a]	3.9[c]	2.73[b]	0.02[b]	1.31[b]	0.05[b]	5.44[c]	0.06[a]	0.03[a]
Tropical corn:									
Pioneer X304C	38.0[b]	4.0[a]	0.39[c]	0.02[b]	1.33[b]	0.02[c]	5.87[c]	0.02[a]	0.01[a]
Pioneer 3098	31.2[c]	3.9[cb]	0.55[c]	0.02[b]	1.92[a]	0.02[c]	7.05[b]	0.03[a]	0.02[a]
Forage sorghum:									
Pioneer 841F	29.3[d]	4.0[ab]	1.26[b]	0.02[b]	1.35[b]	0.02[c]	6.73[b]	0.08[a]	0.04[a]
Brandies	24.4[e]	3.8[c]	11.42[a]	0.02[b]	1.85[a]	0.12[a]	8.78[a]	0.09[a]	0.08[a]
Pearlmillet:									
Hybrid 3-mil-X	26.4[f]	3.9[c]	1.62[b]	0.04[a]	1.28[b]	0.05[b]	7.13[b]	0.04[a]	0.01[a]
Significance (*P*):									
Treatments	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.46	0.29
MSD[2]	1.7	0.09	1.73	0.01	0.04	0.036	0.71	0.10	0.09

[1] Each value is the mean of four replicates, and means with the same superscript are similar.

[2] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 11.7. Preference evaluations (Evaluations 1 thru 3) comparing silages of three cultivars at a time, Year 2[1] (dry matter basis).

Silage	Evaluation 1			Evaluation 2			Evaluation 3		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:									
Pioneer 3156	943[a]	10.8[a]	88.1[b]				1180[a]	12.0[a]	115.8[a]
Tropical corn:									
Pioneer X304C	15[b]	0.23[b]	16.1[b]						
Pioneer 3098	83[b]	0.89[b]	139.6[a]						
Forage sorghum:									
Pioneer 841F				425	4.1	102.3[a]	355[b]	2.9[b]	120.5[a]
Brandies				293	4.9	84.6[a]	60[c]	0.5[b]	50.6[b]
Pearlmillet:									
Hybrid 3-mil-X				287	3.6	99.2[a]			
Significance (*P*):									
Treatments	<0.01	<0.01	0.03	0.57	0.71	0.49	<0.01	<0.01	0.01
MSD[3]	296	1.26	88.9	385	4.5	41.1	242	4.9	41.6

[1] Each value is the mean of four steers, and means with the same superscript are similar.

[2] DMI = Dry matter intake.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 11.8. Preference evaluations (Evaluations 4 thru 7) comparing silages of two cultivars at a time, Year 2[1] (dry matter basis).

Silage	Evaluation 4			Evaluation 5			Evaluation 6			Evaluation 7		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:												
Pioneer 3156										1063	11.7	107.4
Tropical corn:												
Pioneer X304C	217	1.9	74.3				340	4.9	117.1			
Pioneer 3098	715	10.1	74.3									
Forage sorghum:												
Pioneer 841F				710	7.1	101.8						
Brandies				153	2.0	95.8						
Pearlmillet:												
Hybrid 3-mil-X							730	8.3	98.1	293	3.3	108.3
Significance (*P*):												
Treatments	0.14	0.04	0.99	0.01	0.01	0.71	0.38	0.59	0.62	0.01	0.06	0.97

[1] Each value is the mean of four steers.

[2] DMI = dry matter intake.

Table 11.9. In vitro true dry matter disappearance (IVTD) and nutritive value[1] of silages fed in the seven preference evaluations in Year 2[2] (dry matter basis).

Silage	IVTD	CP	NDF	Fiber Fractions			
				ADF	HEMI	CELL	Lignin
	%						
Temperate corn:							
Pioneer 3156	83.1[a]	8.24[a]	40.1[c]	20.1[e]	18.0[b]	16.6[c]	3.1[f]
Tropical corn:							
Pioneer X304C	74.8[bc]	8.37[a]	48.8[b]	29.0[c]	22.4[a]	23.4[b]	5.2[c]
Pioneer 3098	75.3[bc]	8.42[a]	49.2[b]	29.1[c]	22.5[a]	23.6[b]	4.9[d]
Forage sorghum:							
Pioneer 841F	77.4[b]	8.56[a]	36.3[d]	22.5[b]	15.1[c]	17.7[c]	3.9[e]
Brandies	71.4[c]	5.43[b]	57.5[a]	36.7[b]	23.9[a]	29.5[a]	6.0[b]
Pearlmillet:							
Hybrid 3-mil-X	66.4[d]	7.82	60.1[a]	38.5[a]	23.5[a]	30.6[a]	6.6[a]
Significance (*P*):							
Treatments	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[3]	4.51	0.86	2.74	1.51	1.48	1.27	0.21

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Each value is the mean of four replicates, and means with the same superscript are similar.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Experiment 12. Corn and Sorghum Forage Types and Cultivars Ensiled at Differing Maturities: Steer Preference

The morphology and nutritive value of forages change with advancing maturity. This is especially evident for forages that produce a grain component, as occurs with corn, sorghum, and millets. Increasing the grain components further alters ensiling characteristics such as volatile fatty acid concentrations. In this experiment, we evaluated the preference by steers for a temperate corn, four tropical corn cultivars, and a sweet forage sorghum cultivar when ensiled at several maturities.

Material and Methods

A small-plot experiment was conducted consisting of six forage cultivars planted in 14-foot wide by 25-foot long plots in a randomized complete block design with three replicates. These plots provided the experimental forage. The plots were planted and harvested by conventional methods and the forage packed into miniature silos using standard procedures (Appendix GP-1). The silos were stored under cover, being undisturbed for at least 60 days prior to opening, and the silages were used in a series of preference evaluations.

The forages consisted of the temperate corn Pioneer 3156; tropical corns Dekalb 678C, Pioneer X304C, Dekalb 660XL, and Pioneer 3098; and Brandies forage sorghum. Each cultivar was planted early or late and harvested early or late, or both, giving 19 treatment combinations as delineated in Table 12.1. The early-harvested corn was ensiled in the early-milk stage and the late-harvested corn ensiled in the late-dent stage. The early harvested Brandies sorghum was ensiled in the boot stage and the late-harvested sorghum was ensiled when fully headed. At time of harvest, estimates of forage height (10 measurements per plot) and dry matter yield (10-foot strips) were obtained, and samples (five stalks per plot) were taken and separated into morphological components.

A series of short-term preference evaluations were conducted (Appendix GP-5). Because of limited quantities of silage, especially of those that are generally preferred, comparisons were initially limited with priority given to preference evaluations among management strategies (seeding date and harvest date) within cultivar. Preference was determined with steers weighing 500 to 800 pounds. Each evaluation was conducted as a randomized block design with five steer replicates. Each evaluation was conducted for 30 minutes, silage intake and time devoted to eating were recorded, and total dry matter intake and intake rate (grams/minute) determined.

At feeding the silos were opened and any surface mold removed. A sample of each silage replicate (miniature silo) was obtained and analyzed for dry matter, fermentation characteristics, and nutritive value (Appendix GP-6). Data were analyzed statistically according to the experimental design (Appendix GP-7). When more than two treatment comparisons were made in an evaluation, a minimum significant difference was determined and included in the data table to separate difference among treatments (Appendix GP-7).

Results and Discussion

The height, yield potential, and morphological description of the 19 silages evaluated in this experiment reveal the wide degree of variation present (Table 12.2). Dry matter concentration and fermentation characteristics were also generally different ($P < 0.01$) among experimental silages and consistent with the ranges in planting and harvesting date (Table 12.2).

Dry matter differences ranged from a least of about 19% (Treatments 4, 8, and 16) to the greatest of about 42% (Treatment 1; Table 12.3). The pH measures of all silages, however, were ≤ 4.0—ranging from 3.7 for Pioneer X304C silage planted early and ensiled early (Treatment 8) to 4.0 for temperate corn silage also planted early and ensiled early (Treatment 1). The pH measures of all silages indicate a stable preservation. Ethanol was produced in all silages, with the least concentrations present in temperate corn (Treatment 1) and the most in Brandies forage sorghum (Table 12.3, Treatments 18 and 19).

Methanol was present in most of the corn silages, but not in the sorghum silages. Lactic acid dominated in the silages, followed by acetic and propionic, and each of the three acids were altered both by cultivar and among planting and harvesting treatments within cultivars.

Only two treatments each of Pioneer 3098 (Evaluation 1, Table 12.4) and Brandies sorghum (Evaluation 2, Table 12.4) were evaluated, and steers preferred the early harvest over the late (Treatment 16 versus 17). In the case of forage sorghum, no preference was noted. In comparing the preference for temperate corn (Treatment 1) or tropical corn (Treatment 8) with forage sorghum (Treatments 18 and 19), no differences were noted (Evaluations 3 and 4, Table 12.4).

Within the three tropical corns ensiled both early and late (Treatments 4 through 15), steers showed no difference in preference for Dekalb 678C, although the dry matter intake for silage from Treatment 6 did approach significance ($P = 0.10$, Table 12.5) for the late-planting/early-harvest treatment. On the other hand, steers preferred the late-planting/late-harvest treatment within the Pioneer X304C silage and the late-planting/early-harvest treatment within the Dekalb 660XL silage.

When comparing the steer preference for temperate corn silage to tropical silages, and among tropical silages planted and harvested on comparable dates (Evaluations 8, 9, and 10, Table 13.6), no significant differences were noted until the late-planted/late-harvested treatments (Treatments 3, 7, 11, and 15), in which temperate corn silage was preferenced ($P < 0.01$) over the tropical silages (Evaluation 10, Table 13.6). No differences were noted, however, among the silages of the three tropical cultivars.

Summary and Conclusion

- All temperate and tropical cultivars varied appreciably in morphology, but all fermented well with silage pH measures of ≤ 4.0.
- The forage sorghum evaluated also fermented well with a silage pH of < 3.8.
- Of the 10 preference evaluations conducted, only four evaluations revealed a preference for a particular silage: (1) greatest preference for an early harvest versus a late harvest of the tropical corn silage Pioneer 3098, (2) greatest for the late-planted/early harvest of tropical corn Pioneer X304C, (3) greatest for a late-planted/early harvest of tropical corn Dekalb 660XL, and (4) greatest for temperate compared with three tropical corn silages planted late and harvested late.

Table 12.1. Description of treatments designating early (E) and late (L) dates for both planting and harvesting of each cultivar used in preference evaluations.

Forage	Treatment		Plant		Harvest	
	No.	Description[1]	Early	Late	Early	Late
Temperate corn:						
Pioneer 3156	1	E/E	Apr 20	-	Aug 16	-
	2	L/E	-	June 1	Aug 23	-
	3	L/L	-	June 1	-	Sept 6
Tropical corn:						
Dekalb 678C	4	E/E	May 25	-	Aug 30	-
	5	E/L	May 25	-	-	Sept 21
	6	L/E	-	June 15	Sept 14	-
	7	L/L	-	June 15	-	Oct 6
Pioneer X304C	8	E/E	May 25	-	Aug 30	-
	9	E/L	May 25	-	-	Sept 21
	10	L/E	-	June 15	Sept 14	-
	11	L/L	-	June 15	-	Oct 6
DeKalb 660XL	12	E/E	May 25	-	Aug 30	-
	13	E/L	May 25	-	-	Sept 21
	14	L/E	-	June 15	Sept 14	-
	15	L/L	-	June 15	-	Oct 6
Pioneer 3098	16	L/E	-	June 20	Sept 6	-
	17	L/L	-	June 20	-	Oct 6
Forage sorghum:						
Brandies	18	E/E	May 26	-	Sept 14	-
	19	E/L	May 26	-	-	Oct 19

[1]E = early and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late."

Table 12.2. Height, yield and morphological components of corn and sorghum cultivar used in silage evaluations (dry matter basis).

Forage	Treatment		Height	Yield	Forage						Ear	
	No.	Desc.[1]			Leaf	Stalk	Tassel	Husk	Dead	Ear (Head)	Grain	Cob
			ft	tons/ac	—————————— % of total dry matter ——————————						— % of Ear —-	
Temperate corn:												
Pioneer 3156	1	E/E	9.2[2]	6.3	3.2	28.2	0.5	8.1	7.7	52.3	83.3	16.7
	2	L/E	8.3	4.6	24.3	35.6	1.2	16.3	0.1	22.5	47.4	52.6
	3	L/L	8.0	5.3	18.3	48.1	0.4	11.7	0.3	21.2	57.9	42.1
Tropical corn:												
Dekalb 678C	4	E/E	9.3	5.1	22.6	46.5	1.2	15.2	0.6	13.9	40.9	59.1
	5	E/L	7.6	7.1	17.9	32.4	0.8	12.1	0.9	35.9	71.3	28.7
	6	L/E	7.6	4.1	21.3	40.0	1.4	17.1	0.6	19.6	48.8	51.2
	7	L/L	8.6	5.5	12.7	26.7	0.6	13.4	1.6	45.0	78.3	21.7
Pioneer X304C	8	E/E	11.1	5.1	21.2	55.0	1.2	12.5	2.0	8.1	45.2	54.8
	9	E/L	10.0	7.8	14.7	46.0	1.0	10.1	3.5	24.7	75.0	25.0
	10	L/E	9.5	5.2	18.8	48.6	1.7	13.0	1.3	16.6	50.2	49.8
	11	L/L	10.4	7.0	9.7	35.8	1.0	9.8	4.4	39.3	80.0	20.0
Dekalb 660XL	12	E/E	8.8	4.8	24.3	47.9	1.5	13.1	2.9	10.3	44.4	55.6
	13	E/L	7.7	6.9	18.2	36.5	1.1	10.9	4.4	28.9	73.3	26.7
	14	L/E	7.6	4.5	20.4	31.9	1.6	17.1	0.6	28.4	66.7	33.3
	15	L/L	9.0	6.2	13.6	28.4	1.1	10.5	2.6	43.8	83.0	16.3
Pioneer 3098	16	L/E	7.9	3.5	21.7	44.9	2.3	16.6	0.5	14.0	41.1	58.9
	17	L/L	8.9	4.2	13.7	31.2	1.2	10.2	1.8	41.9	79.0	21.0
Forage sorghum:												
Brandies	18	E/E	7.4	4.8	19.5	75.6	-	-	3.5	(1.4)	-	-
	19	E/L	9.2	7.1	13.2	72.8	-	-	2.7	(11.3)	-	-
Significance (*P*):												
Treatment			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01(0.02)	<0.01	<0.01
MSD[3]			0.5	1.1	3.4	6.5	0.4	2.9	8.0	5.5	14.5	8.5

[1] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[2] Each value is the average of five stalks and the mean of three replicates.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 12.3. Dry matter (DM) and fermentation characteristics of each silage used in preference evaluations (DM basis).

Silage	Treatment		DM	pH	Alcohols		Fatty Acids				
	No.	Desc.[1]			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
			%		%						
Temperate corn:											
Pioneer 3156	1	E/E	42.4[2]	4.0	0.82	0.02	0.79	0.03	2.97	0.29	0.01
	2	L/E	23.7	3.7	4.66	0.05	1.99	0.12	8.15	0.01	0.00
	3	L/L	27.3	3.8	3.86	0.03	1.65	0.12	7.51	0.00	0.01
Tropical corn:											
Dekalb 678C	4	E/E	19.9	3.7	3.03	0.06	1.67	0.08	9.72	0.01	0.00
	5	E/L	27.7	3.8	1.25	0.03	1.94	0.01	7.80	0.00	0.00
	6	L/E	20.6	3.8	3.76	0.03	1.40	0.07	8.71	0.00	0.00
	7	L/L	27.6	3.8	1.05	0.02	1.56	0.00	6.80	0.00	0.00
Pioneer X304C	8	E/E	19.3	3.7	3.01	0.05	2.19	0.09	9.69	0.02	0.00
	9	E/L	27.3	3.8	1.88	0.03	2.24	0.04	7.53	0.00	0.00
	10	L/E	21.3	3.8	2.73	0.00	1.50	0.09	8.61	0.00	0.02
	11	L/L	30.7	3.8	1.95	0.01	1.61	0.06	6.45	0.00	0.00
Dekalb 660XL	12	E/E	20.2	3.7	2.22	0.05	2.40	0.04	10.59	0.01	0.01
	13	E/L	27.5	3.8	1.55	0.03	1.73	0.04	8.11	0.00	0.00
	14	L/E	23.6	3.8	2.48	0.04	2.44	0.06	9.30	0.04	0.00
	15	L/L	30.7	3.8	0.97	0.03	1.93	0.01	6.51	0.00	0.00
Pioneer 3098	16	L/E	19.6	3.7	2.56	0.02	1.97	0.00	9.48	0.00	0.00
	17	L/L	25.5	3.8	1.30	0.00	1.67	0.03	7.46	0.00	0.00
Forage sorghum:											
Brandies (Sweet)	18	E/E	16.4	3.7	6.43	0.00	2.33	0.10	12.29	0.00	0.00
	19	E/L	22.1	3.7	5.21	0.00	2.92	0.11	8.02	0.00	0.03
Significance (*P*):											
Treatment			<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.58
MSD[3]			1.8	0.07	1.10	0.05	0.56	0.05	0.88	0.04	0.05

[1][4]Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[2 4]Each value is the mean of three replicates.

[3 4]MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 12.4. Preference evaluations (Evaluations 1 thru 4) comparing either two or three temperate and tropical corn or forage sorghum silages at a time (dry matter basis)

Silage	Treatment		Evaluation 1			Evaluation 2			Evaluation 3			Evaluation 4		
	No.	Desc.[1]	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
			g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:														
Pioneer 3156	1	E/E							232[3]	5.3	34.0			
Tropical corn:														
Pioneer X304C	8	E/E										146[3]	2.3	47.1
Pioneer 3098	16	L/E	492[3]	6.6	76.1									
Pioneer 3098	17	L/L	22	0.4	14.5									
Forage sorghum:														
Brandies	18	E/E				428[3]	5.5	84.3	206	3.5	59.7	400	5.6	56.5
Brandies	19	E/L				158	1.8	53.0	168	2.4	73.4	112	0.6	35.6
Significance (*P*):														
Treatments			<0.01	<0.01	0.04	0.15	0.11	0.25	0.88	0.48	0.24	0.30	0.21	0.87
MSD[4]			-	-	-	-	-	-	352	6.2	55.6	484	6.7	107.3

[1] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[2] DMI = dry matter intake

[3] Each value is the mean of five steers.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 12.5. Preference evaluations (Evaluations 5 thru 7) comparing four tropical corn silages within each of three tropical corn cultivars[1] (dry matter basis)

Silage	Treatment		Evaluation 5			Evaluation 6			Evaluation 7		
	No.	Desc.[2]	DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
			g	min	g/min	g	min	g/min	g	min	g/min
Tropical Corn:											
Dekalb 678C	4	E/E	256^{ab}	5.5^{a}	77.0^{a}						
	5	E/L	298^{ab}	5.8^{a}	142.7^{a}						
	6	L/E	494^{a}	6.6^{a}	72.3^{a}						
	7	L/L	48^{b}	0.2^{a}	100.5^{a}						
Pioneer X304C	8	E/E				154^{b}	1.4^{b}	35.4^{a}			
	9	E/L				24^{b}	0.5^{b}	17.1^{a}			
	10	L/E				274^{ab}	4.0^{ab}	59.3^{a}			
	11	L/L				598^{a}	8.4^{a}	56.6^{a}			
Dekalb 660XL	12	E/E							28^{b}	0.4^{b}	56.4^{a}
	13	E/L							16^{b}	0.1^{b}	28.3^{a}
	14	L/E							554^{a}	7.7^{a}	71.2^{a}
	15	L/L							110^{b}	2.0^{b}	11.7^{a}
Significance (*P*):											
Treatments			0.10	0.32	0.74	0.05	0.03	0.40	<0.01	<0.01	0.40
MSD[4]			396	9.5	199	431	5.6	72.5	256	3.3	98.8

[1] Each value is the mean of five steers and means with same superscript are similar.

[2] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[3] DMI = dry matter intake.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 12.6. Preference evaluations (Evaluations 8 thru 10) comparing four silages consisting of one temperate and three tropical corn silages[1] (dry matter basi

Silage	Treatment		Evaluation 8			Evaluation 9			Evaluation 10		
	No.	Desc.[2]	DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
			g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:											
Pioneer 3156	1	E/E	454[a]	6.3[a]	43.2[ab]						
	2	L/E				178[a]	2.4[a]	110.6[a]			
	3	L/L							750[a]	9.3[a]	82.0[a]
Tropical corn:											
Dekalb 678C	5	E/L	222[a]	3.2[a]	71.9[a]						
	6	L/E				448[a]	6.9[a]	91.5[a]			
	7	L/L							250[b]	3.2[b]	43.8[a]
Dekalb X304C	9	E/L	6[a]	0.1[a]	1.0[b]						
	10	L/E				90[a]	0.7[a]	26.6[a]			
	11	L/L							12[b]	0.1[b]	69.0[a]
Dekalb 660XL	13	E/L	160[a]	1.7[a]	36.1[ab]						
	14	L/E				144[a]	1.5[a]	37.7[a]			
	15	L/L							36[b]	0.4[b]	18.2[a]
Significance (*P*):											
Treatments			0.30	0.26	0.12	0.18	0.11	0.27	<0.01	<0.01	0.62
MSD[4]			594	7.9	66.0	413	6.1	123.4	329	4.3	142

[1] Each value is the mean of five steers and means with same the superscript are similar.

[2] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[3] DMI = dry matter intake.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 12.7 In vitro true dry matter disappearance (IVTD) and nutritive value[1] of the silages used in preference evaluations (dry matter basis).

Silage	Treatment		IVTD	CP	NDF	Fiber Fractions			
	No.	Desc.[2]				ADF	HEMI	CELL	Lignin
			%						
Temperate corn:									
Pioneer 3156	1	E/E	86.9[3]	5.9	30.4	14.1	16.4	13.5	1.2
	2	L/E	74.0	10.9	58.9	31.5	27.3	29.6	3.0
	3	L/L	75.5	10.6	51.0	26.4	24.6	24.6	2.7
Tropical corn:									
Dekalb 678C	4	E/E	73.0	9.8	61.8	34.6	27.2	32.2	3.4
	5	E/L	78.6	8.9	47.0	24.8	22.2	23.3	2.5
	6	L/E	74.6	8.9	58.6	32.6	25.9	30.4	3.2
	7	L/L	79.4	8.3	40.9	21.3	19.6	19.5	2.0
X304C	8	E/E	67.7	9.3	65.2	37.7	27.5	34.2	3.9
	9	E/L	74.9	8.4	51.6	27.6	24.0	25.4	3.0
	10	L/E	73.5	8.7	59.2	33.1	26.1	30.7	3.3
	11	L/L	77.4	7.5	44.2	22.9	21.3	21.3	2.3
Dekalb 660XL	12	E/E	70.6	10.4	63.0	35.9	27.0	33.2	3.5
	13	E/L	76.8	9.6	49.1	26.3	22.9	24.3	2.6
	14	L/E	75.6	9.8	54.0	29.5	24.5	27.8	2.7
	15	L/L	80.2	9.0	39.2	20.2	19.0	18.6	1.8
Pioneer 3098	16	L/E	73.1	10.1	61.7	34.9	26.8	32.5	3.3
	14	L/L	76.1	8.9	46.7	25.4	21.3	22.6	2.7
Forage sorghum:									
Brandies	18	E/E	73.5	8.1	62.4	36.2	26.2	33.8	3.4
	19	E/L	77.3	5.9	50.7	28.6	22.1	26.4	2.9
Significance (*P*):									
Treatments			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[4]			3.0	1.0	4.0	2.4	2.1	2.0	0.3

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 12.1 for details.

[3] Each value is the mean of three replicates.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Experiment 13. Temperate or Tropical Corn Silages Ensiled at Four Maturities: Steer Preference

As noted in Experiment 12, the morphology and nutritive value of forages change with advancing maturity. Further, forages that produce a grain component and are ensiled can have their ensiling characteristics appreciably altered, resulting in differing fermentation products and possibly different quality of the resulting silage. This dynamic is likely to occur with corn during ear formation and filling. Our objectives in this experiment were to compare temperate and tropical corn cultivars and maturities within each cultivar during ear development, and to determine any effect on fermentation characteristics, nutritive value, and preference by steers.

Materials and Methods

A small-plot experiment was conducted consisting of four forages planted in 14-foot wide by 25-foot long plots in a randomized complete block design with three replicates, which provided the experimental forages. The plots were planted and harvested by conventional methods and packed into miniature silos using standard procedures (Appendix GP-1). The silos were stored under cover being undisturbed for at least 60 days prior to opening, and the silages were used in a series of preference evaluations.

The forages evaluated consisted of the temperate corn Pioneer 3156 and the tropical corn cultivars Dekalb 678C, Pioneer X304C, Dekalb 660XL, and Pioneer 3098. Each cultivar was planted early and late and each planting harvested early and late, resulting in a total of 20 treatment combinations as delineated in Table 13.1 The early-harvested corn was ensiled in the early-milk stage and the late-harvested corn ensiled in the late-dent stage. At time of harvest, estimates of forage height (10 measurements per plot) and dry matter yields (10-foot strip) were obtained and intact stalks (five per plot) were separated into morphological components.

A series of short-term preference evaluations were conducted with steers weighing 500 to 800 pounds (Appendix GP-5). Each evaluation was conducted as a randomized complete block design with five steer replicates. Each evaluation was conducted for 30 minutes, silage intake and time devoted to eating were recorded, and total dry matter intake and intake rate (grams/minute) were determined.

At feeding, the silos were opened and any surface mold removed. A sample of each silage replicate (miniature silo) was obtained and analyzed for dry matter, fermentation characteristics, and nutritive value (Appendix GP-6). Data were analyzed statistically according to the experimental design (Appendix GP-7). When more than two treatments were compared in an evaluation, a minimum significant difference was determined and included in the data table to separate differences among treatment means (Appendix GP-7).

Results and Discussion

The adapted temperate corn cultivars and the four tropical cultivars subjected to the four management strategies of early and late planting and early and late harvesting (Table 13.1) resulted in considerable variation. Dry matter at harvest ranged from 21.1% to 38.1%, cultivar height from 7.1 to 11.2 feet, and dry matter yields from 3.6 to 7.5 tons per acre (Table 13.2). In general, the temperate cultivar was shorter and had least dry matter yield compared with the tropical cultivars—consistent with expectations. The nutritive value of the whole plant at harvest and the in vitro true dry matter digestion, crude protein, and neutral detergent fiber of the morphological components of the forage at harvest (prior to fermentation) are reported in Appendix Tables (AT)1, 2, 3, and 4, respectively, for the interested reader and will not be discussed further.

All silages fermented well with pH measures of ≤ 3.9, although dry matter concentrations ranged from 19.9 to 35.2% (Table 13.3). Alcohol was present with ethanol dominating and ranging from 0.6 to 5.8%, with some presence of methanol (ranging from 0.04 to 0.08%). The major fatty acid produced was lactic followed by acetic, with propionic, butyric, and isobutyric acid concentrations being variable—ranging from a trace to about 0.1%. These factors all contributed to stable silages.

Preference demonstrated by steers when offered the silage from each of the four early and late management options within each cultivar was not altered (Table 13.4). This indicates that the early- and late-planted and early- and late-harvested strategies were not of major concern for subsequent silage acceptance.

A comparison of preference among the adapted temperate cultivar (Pioneer 3156) and three of the four tropical cultivars (Dekalb 678C, Pioneer X304C, and Dekalb 660XL), within each of the four management strategies, revealed no difference in dry matter intake for the two early-planted treatments (Table 13.5). However, the two late-planted treatments had greatest dry matter intake for the adapted temperate corn, whether harvested early or late (Table 13.5). In the late-planted and early-harvested treatment, steers consumed less but similar amounts of the tropical cultivar Dekalb 660XL.

When the same cultivars were compared, but with Pioneer 3098 included and Dekalb 678C omitted, no difference in silage preference was noted for the early-planted/early-harvested management, but differences were noted in the other three managements (Table 13.6). The temperate corn silage was preferred over the tropical cultivars in the other three managements, but preference was similar to the tropical cultivar, Dekalb 660XL.

Examination of the nutritive value of the various silages indicated that the temperate adapted corn (Pioneer 3156) was greater in in vitro true dry matter disappearance and lesser in neutral detergent fiber and its fiber constituents than the tropical corn silages, which is consistent with demonstrated steer preference (Tables 13.7, 13.5, and 13.6). This difference in nutritive value is attributed mainly to the larger proportion of the temperate plant consisting of ears. The nutritive value of the tropical cultivars (Table 13.7) also varied among the cultivars but generally had little influence on steer preference.

Summary and Conclusion

- Adapted temperate corn was shorter and yielded less dry matter per acre than the tropical cultivars, but had a greater proportion of total ear.
- All corn cultivars ensiled well in miniature silos, regardless of planting and harvest managements, with pH measures of ≤ 3.9 upon opening.
- Management strategies evaluated within each corn cultivar did not alter steer preference for the resulting silage.
- In the silage from cultivars compared in the early-planted and late-harvested and late-planted managements, animal preference differed, with the adapted temperate cultivars generally preferred over the tropical cultivars. But preference for the temperate cultivar was not always significantly greater compared to the tropical Dekalb 660XL.
- The corn cultivars evaluated provide considerable management flexibility in production systems. Temperate corn silage, however, is generally of greater nutritive value compared with tropical corn but will yield lesser in dry matter produced per acre.

Table 13.1. Description of treatments designating early (E) and late (L) planting and harvesting dates for each cultivar used in preference evaluation.

Forage	Treatment		Plant[1]		Harvest	
	No.	Description[2]	Early	Late	Early	Late
Temperate corn:						
Pioneer 3156	1	E/E	Late April	-	July 29	-
	2	E/L	Late April	-	-	Aug 11
	3	L/E	-	Early June	Aug 11	-
	4	L/L	-	Early June	-	Aug 25
Tropical corn:						
Dekalb 678C	5	E/E	Late May	-	Aug 25	-
	6	E/L	Late May	-	-	Sept 18
	7	L/E	-	Mid June	Sept 9	-
	8	L/L	-	Mid June	-	Oct 7
Pioneer X304C	9	E/E	Late May	-	Aug 25	-
	10	E/L	Late May	-	-	Sept 23
	11	L/E	-	Mid June	Sept 9	-
	12	L/L	-	Mid June	-	Sept 30
DeKalb 660XL	13	E/E	Late May	-	Aug 25	-
	14	E/L	Late May	-	-	Sept 8
	15	L/E	-	Mid June	Sept 9	-
	16	L/L	-	Mid June	-	Oct 7
Pioneer 3098	17	E/E	Late May	-	Aug 25	-
	18	E/L	Late May	-	-	Sept 8
	19	L/E	-	Mid June	Sept 9	-
	20	L/L	-	Mid June	-	Sept 30

[1]Plant dates are approximate, but dates are close to those reported in Table 12.1.

[2] E = early and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late."

Table13.2. Height, dry matter (DM) yield and morphological description of temperate and tropical corn cultivars evaluated (DM basis).

Forage	Treatment		DM[3]	Height[4]	Yield[3]	Forage[1]						Ear (Head)[1]	
	No.	Desc.[2]				Leaf	Stem	Tassel	Husk	Dead	Ear (Head)	Grain	Cob
			%	ft	tons/acre	——————— % of total dry matter ———————						— % of Ear total —	
Temperate corn:													
Pioneer 3156	1	E/E	27.8	7.3	4.3	11.0	29.3	0.6	13.4	0.9	44.8	77.0	23.0
	2	E/L	26.8	8.0	5.3	7.8	22.1	0.3	8.9	3.8	57.1	83.1	16.9
	3	L/E	26.0	7.1	3.6	19.8	40.8	0.9	11.0	0.3	27.2	68.4	31.6
	4	L/L	36.4	8.2	5.1	12.1	34.1	0.7	10.4	2.2	40.5	77.3	22.7
Tropical corn:													
Dekalb 678C	5	E/E	24.0	9.3	4.9	19.0	50.1	1.7	15.6	1.4	12.2	36.4	63.6
	6	E/L	30.2	9.1	7.5	16.7	45.0	1.3	14.1	5.2	17.7	70.3	29.7
	7	L/E	21.1	9.4	4.5	17.9	52.3	1.3	15.9	0.3	12.3	39.4	60.6
	8	L/L	34.0	9.3	6.8	10.3	34.5	0.9	13.2	4.4	36.7	74.5	25.5
Pioneer X304C	9	E/E	27.2	10.3	6.0	20.0	63.8	2.3	6.3	6.1	1.5	-	-
	10	E/L	33.8	10.5	6.8	10.5	55.7	1.1	10.0	9.9	12.8	64.7	35.3
	11	L/E	21.8	11.2	5.1	16.7	62.8	1.7	11.1	0.7	7.0	25.5	74.5
	12	L/L	34.8	10.9	7.2	10.1	50.3	1.2	9.1	6.5	22.8	69.1	30.9
DeKalb 660XL	13	E/E	29.7	10.1	5.7	18.8	59.5	1.9	9.0	4.8	6.0	42.2	57.8
	14	E/L	31.4	10.2	7.0	16.1	53.6	1.9	10.0	9.6	8.8	64.8	35.2
	15	L/E	23.9	9.2	5.0	19.2	48.2	1.6	13.4	0.8	16.8	57.1	42.9
	16	L/L	33.7	9.0	5.8	10.8	40.2	1.4	9.5	8.3	29.8	77.6	22.4
Pioneer 3098	17	E/E	30.0	10.2	6.8	17.2	51.4	2.2	11.3	5.6	12.3	52.6	47.4
	18	E/L	34.0	9.7	7.0	12.9	42.7	1.7	8.9	8.6	25.2	73.7	26.3
	19	L/E	25.3	10.1	6.0	18.0	58.0	1.8	9.6	2.5	10.1	52.1	47.9
	20	L/L	38.1	10.2	7.2	9.1	46.3	1.5	9.0	7.8	26.3	72.9	27.1
Significance (*P*):													
Treatment			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[5]			3.8	0.8	1.1	3.4	7.8	0.4	3.1	2.7	7.9	10.7	10.7

[1] Each value is the average of five stalks per plot and the mean of three replicates.

[2] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[3] Each value is the mean of three replicates.

[4] Each value is the average of 10 measurements per plot and the mean of three replicates

[5] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 13.3. Dry matter (DM) and fermentation characteristics of each silage used in preference evaluation (DM basis).

Silage	Treatment		DM	pH	Alcohols		Fatty Acids				
	No.	Desc.[1]			Ethanol	Methanol	Acetic	Propionic	Lactic	Butyric	Isobutyric
			%		%						
Temperate corn:											
Pioneer 3156	1	E/E	27.1[2]	3.7	4.02	0.07	2.01	0.05	7.43	0.01	0.01
	2	E/L	30.4	3.8	2.21	0.05	1.78	0.02	5.97	0.13	0.02
	3	L/E	21.3	3.7	6.07	0.08	1.94	0.00	10.05	0.01	0.01
	4	L/L	34.5	3.8	2.09	0.04	1.16	t	5.94	0.02	0.02
Tropical corn:											
Dekalb 678C	5	E/E	24.8	3.7	1.26	0.07	1.78	0.00	9.53	0.01	0.02
	6	E/L	28.7	3.8	0.91	0.07	1.83	0.00	6.87	0.01	0.01
	7	L/E	19.9	3.7	4.86	0.09	2.13	0.02	10.08	0.04	0.01
	8	L/L	35.2	3.8	2.64	0.04	1.24	0.00	6.21	t	t
Pioneer X304C	9	E/E	26.4	3.7	1.02	0.07	2.06	0.00	8.58	0.04	0.02
	10	E/L	31.7	3.8	2.89	0.05	1.47	0.00	6.65	0.01	0.01
	11	L/E	21.5	3.7	2.78	0.05	1.77	0.00	8.86	0.01	t
	12	L/L	31.1	3.8	1.21	0.05	1.75	t	7.73	0.01	0.01
DeKalb 660XL	13	E/E	27.7	3.8	1.25	0.07	1.56	0.01	7.57	0.02	0.02
	14	E/L	30.2	3.7	3.83	0.05	1.36	t	7.23	0.01	0.01
	15	L/E	22.8	3.8	3.67	0.08	1.61	0.01	8.92	t	0.01
	16	L/L	33.1	3.8	5.76	0.06	1.77	0.00	6.19	t	0.01
Pioneer 3098	17	E/E	27.8	3.8	1.19	0.07	1.62	0.00	7.95	0.085	0.01
	18	E/L	32.3	3.8	1.86	0.06	1.24	t	7.06	0.02	0.01
	19	L/E	23.6	3.8	3.21	0.07	1.48	t	8.88	0.01	0.01
	20	L/L	34.6	3.9	0.62	0.04	1.33	t	6.26	t	0.01
Significance (*P*):											
Treatment			<0.01	<0.01	<0.01	<0.01	<0.01	0.41	<0.01	<0.01	<0.01
MSD[3]			1.6	0.04	1.13	0.02	0.45	0.05	0.68	0.05	0.01

[1] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[2] Each value is the mean of three replicates.

[3] t = trace

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 13.4. Preference evaluation of silages among the four management strategies within each cultivar[1] (dry matter basis).

Treatment[2]	Temperate			Tropical											
	Pioneer 3156			Dekalb 678C			Pioneer X304C			Dekalb 660XL			Pioneer 3098		
	DMI[3]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
E/E	288	3.4	38.7	243	2.9	113.5	222	3.1	69.7	139	1.7	68.6	205	2.2	64.9
E/L	43	0.3	132.9	126	1.7	86.3	216	2.4	76.0	155	1.7	17.9	193	2.3	53.2
L/E	200	2.1	68.6	60	0.8	83.0	241	2.6	78.5	288	3.8	69.4	278	2.8	149.4
L/L	386	3.5	113.1	359	4.3	50.2	87	0.8	77.0	201	2.7	30.7	165	1.8	42.9
Significance (*P*):															
Treatment	0.31	0.39	0.31	0.27	0.34	0.47	0.78	0.61	0.99	0.85	0.81	0.21	0.91	0.96	0.44
MSD[4]	468	5.5	136.8	402	5.1	104.7	471	6.2	114.2	534	6.9	72.1	473	5.7	190.7

[1] Each value is the mean of five steers.

[2] E = early and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[3] DMI = shor*t*-term dry matter intake.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 13.5. Preference evaluation of silages from a temperate and three tropical corn cultivars within each of four management strategies[1] of early planting (E-plant), early cutting (E-cut), late planting (L-plant) and late cutting (L-cut) (dry matter basis).

Treatment	E-plant/E-cut			E-plant/L-cut			L-plant/E-cut			L-plant/L-cut		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:												
Pioneer 3156	272[2]	2.6	62.8	298[a]	2.4[a]	98.3[a]	472[a]	4.7[a]	100.1[a]	552[a]	4.8[a]	121.9[a]
Tropical corn:												
Dekalb 678C	55	0.6	51.3	132[a]	1.1[b]	51.1[a]	0[b]	0.0[b]	0.0[b]	49[b]	0.7[b]	65.7[a]
Pioneer X304C	264	3.1	94.7	76[a]	0.8[b]	64.7[a]	52[b]	0.7[b]	60.9[ab]	13[b]	0.1[b]	23.5[a]
Dekalb 660XL	327	3.8	70.3	405[a]	4.7[a]	89.8[a]	297[a]	3.1[a]	78.9[a]	40[b]	0.5[b]	70.6[a]
Significance (*P*):												
Treatment	0.29	0.20	0.57	0.14	0.05	0.60	<0.01	<0.01	0.02	<0.01	<0.01	0.28
MSD[3]	375	3.7	86.4	358	3.1	107.3	193	1.7	61.2	106	1.3	124.5

[1] Each value is the mean of five steers, and means with the same superscript are similar.

[2] DMI = dry matter intake.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 13.6. Preference evaluation of silages from a temperate and three tropical corn cultivars within each of four management strategies[1] involving early planting (E-plant), early cutting (E-cut), late planting (L-plant) and late cutting (L-cut) (dry matter basis).

Treatment	E-plant/E-cut			E-plant/L-cut			L-plant/E-cut			L-plant/L-cut		
	DMI[2]	Time	Rate	DMI	Time	Rate	DMI	Time	Rate	DMI	Time	Rate
	g	min	g/min	g	min	g/min	g	min	g/min	g	min	g/min
Temperate corn:												
Pioneer 3156	299	2.2	98.4	437^{a}	3.5^{ab}	96.1^{ab}	382^{a}	4.7^{a}	83.3^{a}	517^{a}	4.9^{a}	106.6^{a}
Tropical corn:												
Pioneer 3098	245	2.9	93.4	39^{b}	0.4^{bc}	39.1^{b}	63^{b}	0.7^{b}	69.2^{a}	0^{b}	0.0^{b}	0.0^{b}
Pioneer X304C	84	1.0	17.5	44^{b}	0.3^{c}	234.3^{a}	50^{b}	0.6^{b}	30.5^{a}	10^{b}	0.1^{b}	45.8^{ab}
Dekalb 660XL	105	1.1	70.1	272^{ab}	3.7^{a}	77.6^{ab}	122^{b}	1.3^{b}	95.8^{a}	165^{b}	2.0^{b}	68.0^{ab}
Significance (*P*):												
Treatment	0.61	0.67	0.35	0.05	0.04	0.08	0.01	<0.01	0.32	<0.01	0.04	0.15
MSD[3]	517	5.0	127.5	350	3.1	170.3	176	1.7	91.2	270	3.5	103.5

[1] Each value is the mean of five steers, and means with same the superscript are similar.

[2] DMI = dry matter intake.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Table 13.7 In vitro true dry matter disappearance (IVTD) and nutritive value[1] of the experimental silages used in preference evaluations (dry matter basis).

Forage	Treatment		IVTD	CP	NDF	Fiber Fractions			
	No.	Desc.[2]				ADF	HEMI	CELL	Lignin
			%						
Temperate corn:									
Pioneer 3156	1	E/E	77.7[3]	7.9	40.7	23.8	16.8	19.9	1.0
	2	E/L	77.7	7.4	40.7	22.8	17.9	18.8	0.9
	3	L/E	72.4	9.9	50.2	29.2	20.9	25.7	1.6
	4	L/L	75.3	9.0	44.4	24.1	20.3	21.3	1.1
Tropical corn:									
Dekalb 678C	5	E/E	71.0	7.5	56.4	34.1	22.3	30.0	2.4
	6	E/L	68.5	7.8	55.2	31.5	23.7	27.5	2.2
	7	L/E	67.5	9.3	59.5	36.3	23.2	31.7	2.8
	8	L/L	71.2	7.6	49.0	27.8	21.2	24.2	2.2
Pioneer X304C	9	E/E	66.5	7.0	59.4	35.7	23.7	31.3	2.4
	10	E/L	61.6	6.9	60.9	35.4	25.5	30.4	3.3
	11	L/E	64.5	7.6	61.6	37.4	24.2	32.2	3.3
	12	L/L	62.5	7.4	57.1	33.9	23.2	28.9	3.6
DeKalb 660XL	13	E/E	66.6	7.0	59.5	35.9	23.6	31.6	2.4
	14	E/L	64.9	6.5	60.4	35.1	25.3	30.7	2.9
	15	L/E	68.6	8.7	60.8	36.6	24.2	32.4	2.4
	16	L/L	67.2	8.6	54.1	31.5	22.6	27.2	2.7
Pioneer 3098	17	E/E	67.9	6.7	61.3	35.9	25.5	31.7	3.0
	18	E/L	68.6	6.7	56.0	62.1	23.9	27.6	3.1
	19	L/E	66.0	8.1	61.4	36.9	24.4	32.3	3.2
	20	L/L	67.5	7.8	54.6	31.3	23.5	27.3	3.0
Significance (*P*):									
Treatments			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[4]			2.9	0.8	3.6	2.3	1.5	1.9	0.5

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Desc. = description, E = early, and L = late, which refers to plant/harvest sequence; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[3] Each value is the mean of three samples.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Appendices

I. General Standard Procedures of Experimentation

Each general procedure (GP) followed in conducting the various experiments presented in this bulletin are noted below and are not repeated elsewhere. Departure or specific details related to any one experiment are noted under the Materials and Methods section of each experiment with reference to the appropriate general procedures outlined below. Animal experiments were conducted primarily in the months of October through April, but occasionally an experiment was extended into May. This practice avoided the potential negative influences of elevated temperatures on animal behavior during the hot summer months.

GP-1. Planting and Ensiling Process

All plantings were conducted similarly using conventional procedures. Row-crop plantings were top-dressed at establishment according to soil test and side dressed with 80 to 100 pounds of nitrogen per acre. Small grain seedings were also top-dressed at establishment and received 70 pounds of N per acre to initiate spring growth. In experiments in which estimates of dry matter intake or dry matter digestibility were obtained, the cultivars to be evaluated were planted in adjacent fields using conventional procedures. When only preference estimates were obtained, the experimental cultivars were planted in small plots measuring 14 feet wide by 24 feet long. The small plots were laid out in a randomized complete block design with three field replicates. Generally the warm-season annual forages were ensiled in the hard-dough or dent stage. In experiments where planting and harvesting dates were variables, the late-planted/early harvested treatments were cut in the late-milk stage and the early-planted/late-harvested treatments cut in the hard-dough stage.

Forages in the field plantings were harvested with a conventional field chopper, blown into a self-unloading wagon, and transported to the NC State University Forage Animal Metabolism Unit, Raleigh, NC, for ensiling in upright experimental silos. The fiberglass silos were lined with plastic, the forage packed by tramping, and the plastic liner tied off at the top.

Forages from the small plots were cut by hand (random 10-foot-long sample from each replicate), passed through a conventional field chopper, mixed, and placed in miniature silos. These consisted of plastic buckets 11 inches in diameter and 14 inches deep. The forage was packed by tramping and capped with a plastic lid fitted with a gas-release valve. These miniature silos were then stored in a barn until opened at feeding.

Both the upright silos and the miniature silos remained undisturbed for at least 60 days after ensiling to accommodate complete fermentation. At initiation of an experiment, the appropriate silos were opened and any surface mold removed in preparation for feeding.

GP-2. Dry Matter Intake and Apparent Whole-tract Digestibility

Silages were evaluated using steers at the NC State University Forage-Animal Metabolism Unit, Raleigh, NC, in an animal facility consisting of a metal structure partitioned into three areas. On one end is a feed preparation area. The middle is an enclosed, but well-ventilated central area equipped with digestion crates. This area has temperature control designed to keep the ambient air between 50°F and 85°F. The third section, on the opposite end from the feed preparation area, is fitted with a raised, basket weave, metal platform equipped with electronic gates (American Calan Inc., Northwood, NH) to control animal access to mangers for individual intake measurements. This intake area is beneath an extension of the roof with three open sides. In the intake phase, each animal wore a collar electronically keyed to allow access to only one manger, but each had free access to trace mineralized salt and water and could lounge with other animals. Prior to each experiment, animals were conditioned to the electronic gates

before random assignment to the appropriate silage treatment.

The intake phase of an experiment consisted of a 28-day period, allowing the first 14 days for adjustment to potential differences in fermentation characteristics of the silage and the last 14 days to estimate daily dry matter intake (Burns et al., 1994). A recorded weight of silage was fed twice daily allowing about 13% to 15% in excess. A daily sample of the fed silage (as-fed) was obtained for each animal, and composites were made on a weekly basis. The unconsumed silage (weighback) was weighed twice daily, saved separately for each animal-treatment combination, and composited each week.

The digestibility phase consisted of 12 days when immediately following an intake period (steers previously adjusted to the diet) or 19 days for a separate digestibility evaluation. In either case, animals were moved into digestion crates and the digestibility phase was initiated. The digestibility phase consisted of a 14-day adjustment period followed by a 5-day total fecal and urine (if applicable) collection (Cochran and Galyean, 1994). A recorded weight of silage was fed twice daily at about 15% excess. A daily sample of the fed silage was obtained, and weighback saved separately for each animal-treatment combination, frozen, and the daily samples composited for the 5-day collection period.

Feces were collected on a plastic sheet placed on the floor immediately in back of each digestion crate. Feces were removed periodically throughout the day, and the daily total weight of feces recorded for each of five consecutive days. Feces were thoroughly mixed daily, and 5% of the fresh weight was placed in a freezer (5°F). When part of the experimental objectives, a second sample was obtained, placed in a freezer for freeze-drying, and subsequent particle size was determined as explained in GP-4.

The weekly silage samples from the 14-day intake phase, the 5-day composite silage and fecal samples from the digestibility phase, and the associated weighback samples from the intake and digestibility phases were first thawed and prepared for subsampling. The samples were thoroughly mixed, and those to be analyzed for fermentation characteristics were subsampled and extracted while wet. Silages for nutritive value determination were freeze-dried, and fecal samples for chemical composition were oven-dried. Dry matter determinations were obtained at drying when appropriate. The samples were then thoroughly mixed and a 300- to 500-gram subsample ground in a Wiley Mill to pass a 1-mm screen and stored in a freezer (silage samples) or at room temperature (fecal samples) until analyzed. The samples for feces particle-size determination remained in the freezer (5°F) until freeze-dried and were dry sieved as noted below for the masticate.

In experiments using a randomized complete block design, the digestion phase followed the intake phase and completed the experiment for each animal. However, in Latin square-designs, once animals completed one period, they returned to the intake facility following the digestion phase to begin the next period.

GP-3. Masticate Collection and Processing.

Mature, esophageally-fistulated, grade British-bred steers (800 to 1,400 pounds) were generally used and fed a standard silage about five days before initiation of an experiment. After adjustment to treatments (offered the previous afternoon), collections generally occurred about 9:00 a.m. and 3:00 a.m. on two consecutive days. Animals were offered about 10 pounds of silage at each collection. The esophageal cannulas were removed and boluses collected by hand to ensure complete collection. The first five to six boluses were discarded, and the following 10 to 15 were collected. If chewing behavior was determined, the chews per bolus were recorded and each bolus was handled separately, and a fresh- and freeze-dried weight was obtained of each bolus prior to mixing. Otherwise the boluses were placed on a large plastic tray, gently mixed, placed into two plastic bags, and immediately quick-frozen in liquid nitrogen (-319°F). The boluses were stored in a freezer (5°F) until freeze-dried and then returned to the freezer until analyzed. The dried boluses were sampled for chemical analyses and for particle-size determination.

GP-4. Particle Size Determination

Particle size estimates of the boluses were obtained by passing two subsamples of 15 grams each through a Fritsch Vibrator system (Fritsch Analysette, the Tekmor Co., Cincinnati, OH). Nine particle sizes were weighed consisting of dry matter retained on 5.60-, 4.00-, 2.80-, 1.70-, 1.00-, 0.50-, 0.25-, and 0.125-mm sieves and that which passed through the 0.125-mm sieve (<0.125 mm). The dry weight was recorded for the material retained on each sieve and that which passed through the 0.125-mm sieve, and percentage of cumulative particle weight oversize was determined and used to calculate median particle size (Fisher et al., 1988). Samples were composited across days and feeding times for each sieve size. Particle size estimates of feces were also determined as noted above for masticates, except only one subsample was passed through the sieves. Sieved samples of both masticate and feces were stored either separately by individual sieve size, or composites were made to form three particle-size classes of large (≥1.7 mm), medium (<1.7 and ≥0.50 mm), and small (<0.50 mm) prior to chemical analyses. The composite samples were ground in a cyclone mill (Udy Corp., Fort Collins, CO) to pass a 1-mm screen and stored in a freezer until analyzed.

GP-5 Preference Determination

Preference experiments were conducted in pens using individual steers. Prior to an experiment, animals were offered a meal of each of the experimental silages to allow an association of each silage with any post-ingestive feedback produced by the forage.

In each preference evaluation comparing two silages, steers were fed in pens (8 ×13 feet) and offered about 15 pounds of each of the two silages for about 30 minutes. A maximum of four mangers could be accommodated within a larger pen (16 × 26 feet) allowing the maximum of four silages to be evaluated at any one time. The silages were randomized at presentation. The left-right position was also randomized when fed in pairs, or all positions were randomized when fed in groups of three or four. A video recorder was used to estimate total time spent at each feeder in order to calculate intake rate, which was determined by dividing weight of silage consumed by minutes at a feeder. In all preference evaluations, care was taken to collect representative samples of the as-fed silage and weighback and also to prevent total consumption of the more preferred silages from the manger.

GP-6. Laboratory Analysis

Nutritive value for all as-fed, weighback, masticate, and feces samples, as appropriate for the various experiments, was analyzed either fresh or after drying (freeze-drying or oven-drying, as appropriate) by wet chemistry and reported, or used to develop calibration equations in association with the prediction of nutritive value using near-infrared reflectance spectroscopy (NIRS).

Fermentation characteristics of the silages were determined on preserved (frozen) samples according to Burns and Fisher (2012). In vitro dry matter disappearance was determined using a modification of the method by Tilley and Terry (1963), and in vitro true dry matter disappearance was determined by 48-hour fermentation in a batch fermentation vessel (Ankom Technology Corp., Fairport, NY) with artificial saliva and rumen inoculum according to Burns and Cope (1974). In vitro fermentation was terminated with neutral detergent solution in an Ankom 200 fiber analyzer (Ankom Technology Corp., Fairport, NY) to remove the residual microbial dry matter. Ruminal inoculum was obtained from a mature rumen-fistulated steer generally fed a mixed alfalfa (*Medicago sativa* L.) and orchardgrass (*Dactylis glomerat*a L.) hay. Total nitrogen was determined colorimetrically (AOAC, 1990) with a Technicon Autoanalyzer (Bran and Luebbe, Buffalo, IL), and crude protein was estimated as 6.25 times the nitrogen concentration. Fiber fractions, consisting of neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, and ash, were estimated using reagents according to Van Soest and Robertson (1980). Hemicellulose was determined by difference (NDF minus ADF) as was cellulose, depending on procedures used.

GP-7. Statistical Analysis

The data from the intake, digestion, and masticate phases and from preference evaluations for the various experiments were analyzed and generally presented as least square means. These were obtained from the application of mixed model or generalized least squares methodology, as appropriate, based on the design for the particular experiment. Particle sizes, when determined, were expressed as percentages of cumulative particle weight oversize (sum of dry matter weight on each sieve vs. weight from all larger sieves) and were used to determine mean and median particle size (Fisher et al., 1988). Means for all variables found significant in each intake and digestibility and mastication experiment were compared by either trend analysis with a set of polynomial orthogonal contrasts or by a set of meaningful comparisons using orthogonal contrasts, as appropriate, within the mixed model analysis of variance. A minimum significant difference was frequently included to assist the reader in determining differences between individual treatments. When comparisons exceeded two in the preference evaluations, differences were based on the minimum significant difference value.

II. References and Recent Related Publications

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Recent Related Publications

Huntington, G.B., and J.C. Burns. 2007. Afternoon harvest increases readily fermentable carbohydrate concentration and voluntary intake of gamagrass and switchgrass baleage by steers. J. Anim. Sci. 85: 276-284.

Huntington, G.B., and J.C. Burns. 2008. The interaction of harvest time of day of switchgrass hay and ruminal degradability of supplemental protein fed to beef steers. J. Anim. Sci. 86:159-166

III. Supplemental Data

Appendix Table AT13.1. Nutritive value[1] of the whole plant of temperate and tropical corn silage prior to ensiling (dry matter basis).

Forage	Treatment		IVTD	CP	NDF	Fiber Fractions			
	No.	Desc.[2]				ADF	HEMI	CELL	Lignin
			%						
Temperate corn:									
Pioneer 3156	1	E/E	81.7[3]	6.9	50.7	24.6	26.1	22.1	2.3
	2	E/L	79.2	8.3	54.0	25.9	28.1	23.5	2.5
	3	L/E	81.9	6.4	47.2	22.3	24.9	19.8	2.1
	4	L/L	79.8	7.9	50.7	23.3	27.4	20.7	2.2
Tropical corn:									
Dekalb 678C	5	E/E	71.5	7.2	63.7	33.6	30.1	30.0	3.5
	6	E/L	71.3	8.1	64.2	33.7	30.5	29.7	3.5
	7	L/E	70.4	6.8	62.5	31.2	31.3	27.4	3.2
	8	L/L	73.2	6.7	59.3	29.1	30.2	25.6	3.0
Pioneer X304C	9	E/E	68.3	6.2	65.1	35.5	29.6	31.4	3.7
	10	E/L	67.1	6.3	64.5	36.2	28.3	31.3	4.2
	11	L/E	67.8	5.9	62.9	32.8	30.1	28.8	3.6
	12	L/L	67.6	6.4	60.2	32.3	27.9	27.9	3.7
DeKalb 660XL	13	E/E	72.0	5.9	63.5	33.4	30.1	30.0	3.4
	14	E/L	71.9	7.8	63.9	32.6	31.3	28.7	3.4
	15	L/E	68.2	5.6	64.3	33.9	30.4	30.1	3.6
	16	L/L	70.7	7.3	61.6	31.3	30.3	27.5	3.4
Pioneer 3098	17	E/E	72.0	6.1	66.1	35.5	30.6	31.5	3.9
	18	E/L	71.9	7.1	66.4	35.8	30.6	31.6	4.1
	19	L/E	68.2	6.6	62.3	32.1	30.2	28.2	3.5
	20	L/L	70.7	6.9	61.3	32.0	29.3	28.1	3.6
Significance (*P*):									
Treatments			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[4]			2.9	0.9	2.9	2.1	1.6	1.8	0.3

[1] CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEMI = hemicellulose; CELL = cellulose.

[2] Desc. = description, E = early and L = late, which refers to planting/harvesting sequences; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[3] Each value is the mean of three samples.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Appendix Table AT13.2. In vitro true dry matter disappearance of the morphological components of temperate and tropical corn forages prior to ensiling (dry matter basis).

Forage	Treatment		Forage				Ear	
	No.	Desc.[1]	Leaf	Stem	Husk	Dead	Grain	Cob
			%					
Temperate corn:								
Pioneer 3156	1	E/E	79.2[2]	68.4	81.5	74.3	97.7	70.9
	2	E/L	77.3	64.2	74.7	67.7	96.9	66.9
	3	L/E	78.5	70.9	82.9	69.1	97.7	77.3
	4	L/L	77.5	71.1	74.8	63.8	96.5	67.7
Tropical corn:								
Dekalb 678C	5	E/E	77.8	63.4	79.7	69.0	95.1	81.3
	6	E/L	73.5	64.2	71.0	65.7	94.4	68.7
	7	L/E	76.9	61.3	84.2	71.7	96.9	86.2
	8	L/L	73.7	58.3	71.4	70.7	96.4	66.2
Pioneer X304C	9	E/E	76.1	63.9	82.7	69.8	-	95.6
	10	E/L	73.0	62.2	70.2	69.4	91.4	73.6
	11	L/E	74.2	60.3	82.5	73.1	96.3	85.9
	12	L/L	71.8	57.9	69.6	67.8	95.1	68.7
DeKalb 660XL	13	E/E	77.4	67.3	81.6	72.2	97.9	86.8
	14	E/L	74.6	63.9	74.1	63.1	87.8	83.5
	15	L/E	80.8	60.1	80.0	76.8	96.9	81.6
	16	L/L	74.6	54.5	71.9	72.3	96.7	70.8
Pioneer 3098	17	E/E	76.8	58.9	82.1	73.2	97.0	84.5
	18	E/L	73.5	58.3	72.2	66.8	94.7	69.3
	19	L/E	79.4	59.2	85.9	69.9	96.9	84.1
	20	L/L	73.2	56.7	73.8	68.2	96.0	71.5
Significance (*P*):								
Treatments			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MSD[3]			2.2	3.7	2.9	4.8	6.6	6.3

[1] Desc. = description, E = early and L = late, which refers to planting/harvesting sequences; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[2] Each value is the mean of three replicates.

[4] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Appendix Table AT13.3. Crude protein concentration of the morphological components of temperate and tropical corn forages prior to ensiling (dry matter basis).

Forage	Treatment		Forage				Ear	
	No.	Desc.[1]	Leaf	Stem	Husk	Dead	Grain	Cob
			%					
Temperate corn:								
Pioneer 3156	1	E/E	14.5[2]	2.9	4.0	7.6	10.0	3.9
	2	E/L	10.2	2.4	3.1	4.4	9.1	2.8
	3	L/E	15.3	4.5	5.3	6.5	11.5	7.7
	4	L/L	13.3	4.5	4.9	9.0	11.8	4.1
Tropical corn:								
Dekalb 678C	5	E/E	13.8	3.8	6.0	6.	15.6	11.5
	6	E/L	11.1	4.1	4.6	5.7	14.0	5.9
	7	L/E	16.3	4.4	6.5	8.0	16.1	12.8
	8	L/L	11.4	3.6	3.2	7.0	11.6	3.0
Pioneer X304C	9	E/E	11.8	4.3	7.5	4.5	-	14.6
	10	E/L	9.5	3.9	5.1	5.6	14.2	7.6
	11	L/E	14.2	3.5	5.6	5.9	17.7	12.4
	12	L/L	10.3	4.2	3.8	6.6	13.1	4.9
DeKalb 660XL	13	E/E	11.8	3.6	6.0	4.6	13.1	9.4
	14	E/L	10.2	3.9	5.3	4.3	10.3	8.6
	15	L/E	14.9	4.2	5.5	7.7	14.5	8.9
	16	L/L	11.0	4.3	4.7	6.9	12.5	5.2
Pioneer 3098	17	E/E	11.7	3.6	4.6	4.6	13.0	8.9
	18	E/L	10.3	3.7	4.0	5.1	12.9	6.2
	19	L/E	13.7	4.5	5.5	5.1	15.3	9.7
	20	L/L	9.7	4.5	3.6	6.1	13.7	5.3
Significance (*P*):								
Treatments			<0.01	0.01	<0.01	<0.01	<0.01	<0.01
MSD[3]			1.7	1.3	1.0	1.9	2.4	2.7

[1] Desc. = description, E = early, and L = late, which refers to planting/harvesting sequences; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[2] Each value is the mean of three replicates.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

Appendix Table AT13.4. Neutral detergent fiber concentration of the morphological components of temperate and tropical corn forages prior to ensiling (dry matter basis).

Forage	Treatment		Forage				Ear	
	No.	Desc.[1]	Leaf	Stem	Husk	Dead	Grain	Cob
			%					
Temperate corn:								
Pioneer 3156	1	E/E	61.8[2]	66.9	68.1	67.9	18.5	75.6
	2	E/L	62.4	72.2	77.2	73.2	18.5	78.5
	3	L/E	62.6	61.2	59.5	71.5	18.7	68.0
	4	L/L	61.5	58.7	70.2	66.4	22.3	75.9
Tropical corn:								
Dekalb 678C	5	E/E	64.5	65.4	67.7	72.8	29.8	61.2
	6	E/L	65.2	63.5	73.7	73.9	30.0	73.5
	7	L/E	64.7	68.3	64.5	66.1	23.3	57.1
	8	L/L	64.7	69.6	79.3	70.8	25.3	78.3
Pioneer X304C	9	E/E	65.3	64.6	62.1	75.0	-	36.0
	10	E/L	64.2	64.6	73.2	73.6	25.6	67.1
	11	L/E	66.3	65.7	63.6	71.5	30.1	53.9
	12	L/L	62.4	63.7	76.1	71.2	27.3	71.4
DeKalb 660XL	13	E/E	66.1	63.7	64.1	74.0	20.7	54.6
	14	E/L	64.7	62.3	69.5	81.8	42.2	53.0
	15	L/E	64.1	69.7	68.9	69.0	27.3	62.8
	16	L/L	66.7	72.7	77.4	75.1	24.3	74.1
Pioneer 3098	17	E/E	66.4	70.1	69.2	74.3	24.6	58.4
	18	E/L	65.9	69.3	79.2	77.1	25.5	71.5
	19	L/E	64.2	70.2	66.4	78.7	26.9	61.2
	20	L/L	65.0	67.2	80.3	75.1	25.6	72.1
Significance (*P*):								
Treatments			<0.01	<0.01	<0.01	<0.01	0.07	<0.01
MSD[3]			2.5	3.5	3.4	4.8	16.4	10.1

[1] Desc. = description, E = early, and L = late, which refers to planting/harvesting sequences; i.e., E/L is read "planted early and harvested late." See Table 13.1 for details.

[2] Each value is the mean of three replicates.

[3] MSD = minimum significant difference from the Waller-Duncan k-ratio (k = 100) *t*-test and can be used to compare any two treatments.

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