Summer Annual Forages for Livestock Production in Kansas

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SUMMER ANNUAL FORAGES FOR LIVESTOCK PRODUCTION IN KANSAS

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INTRODUCTION

Perennial grasses in many regions of the United States go dormant during the mid- to late-summer and pastures decline in both amount and quality of forage. Since profitability in ruminant livestock production depends largely upon the producer's ability to grow his own feed, profit margins may decrease as the need for purchasing hay and other feeds increase. Practical solutions to feed shortages encountered during the critical summer period may be supplemental pasture, greenchop, hay, or silage. Summer annuals, which grow best under warm soil and weather conditions, can be used to meet these feed shortages for dairy or beef cattle and sheep.

The primary disadvantage of summer annual grasses is the need for yearly establishment, which increases their production costs compared with warm season perennials. However, their timeliness of growth and potential to provide forage of high yield and quality may justify these costs.

Selection of the type or variety of summer annual to be grown should be based on adaptation, yield potential, and feeding value for a particular livestock program. Summer annuals show differences in growth rate, recovery after clipping, forage yield and quality, plant height, and leaf/stem ratio. Because of these differences, nutritive value can be maximized only by choosing production practices and harvest and conservation managements (greenchop, pasture, hay, or silage) that are suitable to each variety.

Frequently, variety recommendations are based solely on total seasonal dry matter (DM) production (Worker and Marble, 1968). However, yield is only one aspect of forage value and may not necessarily be the most important. An extremely low yield of high quality forage would be of limited value, as would forage of low quality and high yield (Holt, 1966). Few studies comparing the yield and quality of summer annual sorghums with pearl millet have been reported. Therefore, studies were conducted for 3 years at two locations, Manhattan and Hutchinson, to determine the nutritive value components and agronomic characteristics of six summer annual grasses (five sorghums and one pearl millet). In addition to laboratory tests to evaluate forage quality, 24 silages and hays from these summer annuals were fed to beef cattle and sheep in five trials to determine forage intake and animal performance.

MATERIALS AND METHODS

AGRONOMIC STUDIES

Cultural Practices

Treated, certified seeds of six summer annual grasses were planted with a Planet Junior seeder at the Manhattan and Hutchinson experimental fields. The two locations differed in soil types and climatic conditions. The Manhattan studies were seeded on Smolan silty-clay loam and the Hutchinson studies, on Clarkost fine loam. All studies were conducted for 3 years (1977-1979) with the fields planted in late May or June under warm soil and weather conditions (Tables 1 and 2). In 1978, the plots at Manhattan were planted on June 7 but seedlings in many plots were destroyed by chinch bugs and greenbugs. Therefore, another site with comparable soil characteristics was seeded on June 26.

The six summer annuals evaluated were 'Piper' sudangrass; Northrup King 'Trudan 6' hybrid sudangrass; *(Sorghum bicolor* (L.) Moench); Dekalb 'Sudax SX-11' and Ring Around 'Super Chow Maker 235' sorghum sudan hybrids (*Sorghum bicolor* (L). Moench); Northrup King 'Millex 23' hybrid pearl millet (Pennisetum typhoides (Burm) Stapf and C.E. Hubb.); DeKalb 'FS 25A' hybrid forage sorghum *(Sorghum bicolor* (L). Moench). The grass seeds were planted at a depth of 1½ inches at row spacings of 8 inches in plots 5 ft. × 20 ft., except forage sorghum, which was planted at row spacings of 30 inches in plots 10 ft. × 20 ft. Seeding rates (Ibs/acre) were: 12 each for 'Piper' sudangrass (Piper) and 'Trudan 6' hybrid sudangrass (Trudan); 25 for 'Sudax SX-11' (Sudax) and 'Super Chow Maker 235' (S. Chow) sorghum sudan hybrids; 10 for 'Millex 23' hybrid pearl millet (Millex); and 8 for 'FS 25A' hybrid forage sorghum (FS 25A).

Weeds were controlled by hand hoeing, except in 1978 and 1979 when Propazine® was applied (1.0 lb. of active ingredient/acre) at Manhattan. Furadan® was applied as needed in 1978 and 1979 (1.1 Ibs. of active ingredient/acre) to control chinch bugs and greenbugs at Manhattan.

Each experimental site was fertilized with nitrogen by broadcasting and discing in the fertilizer prior to planting. Nitrogen was applied as ammonium nitrate at the rates of 80, 60, and 80 Ibs N/acre at Manhattan and 0, 30, and 30 Ibs N/acre at Hutchinson for 1977, 1978, and 1979, respectively.

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Table 1. Mean monthly temperatures (°F) at Manhattan and Hutchinson, 1977-1979.

		Year					
		1977		1978		1979	
Location	Month	Average	Departure from normal*	Average	Departure from normal	Average	Departure from normal
Manhattan	March	49.5	7.5	40.8	−1.2	44.8	2.8
	April	60.3	4.8	58.0	2.5	53.2	2.3
	May	70.5	5.3	63.7	−1.5	63.6	−1.6
	June	76.5	2.2	75.7	1.4	73.6	−0.7
	July	82.0	2.9	81.1	2.0	77.9	−1.2
	August	76.6	−1.8	79.8	1.4	77.9	−0.5
	September	70.5	1.4	74.4	5.3	70.7	1.6
	October	58.2	−0.4	57.1	−1.5	59.9	1.3
Hutchinson	March	49.7	6.9	44.0	1.2	46.5	3.7
	April	58.3	2.6	58.2	2.4	54.2	−1.6
	May	68.1	2.7	63.4	−2.0	63.0	−2.4
	June	77.1	1.7	76.1	0.7	74.8	−0.6
	July	83.4	3.2	84.7	4.5	80.7	0.5
	August	77.3	−2.0	80.8	1.5	78.6	−0.7
	September	72.1	2.0	74.5	2.4	72.7	0.6
	October	59.9	0.6	59.6	0.3	63.2	3.9

*Determined from the mean monthly weather summary (1941-1970), Weather Data Library, Department of Physics, Kansas State University, Manhattan.

Table 2. Total monthly precipitation (inches) at Manhattan and Hutchinson, 1977-1979.

		Year					
		1977		1978		1979	
Location	Month	Total	Departure from normal*	Total	Departure from normal	Total	Departure from normal
Manhattan	March	2.38	0.53	1.79	−0.06	4.30	2.45
	April	3.85	0.85	1.46	−1.54	1.86	−1.14
	May	9.86	5.51	5.12	−0.77	2.74	−1.61
	June	11.55	5.71	4.79	−1.05	3.09	−2.75
	July	1.30	−3.08	3.14	−1.24	5.55	1.17
	August	7.25	3.65	1.23	−2.37	2.92	−0.68
	September	5.95	1.99	4.56	0.60	1.26	−2.70
	October	2.07	−0.65	0.24	−2.48	5.95	3.23
Hutchinson	March	3.13	1.58	1.40	−0.20	4.91	3.31
	April	3.86	1.15	1.98	−0.73	1.04	1.67
	May	7.63	3.77	6.38	2.52	3.73	−0.13
	June	8.15	3.13	2.50	−2.50	2.94	−2.08
	July	1.86	−2.23	0.85	−3.24	7.55	3.46
	August	9.55	6.38	1.85	−1.32	1.57	−1.50
	September	8.02	4.52	3.64	0.14	0.09	−3.41
	October	2.37	−0.06	0.15	−2.28	11.52	9.09

*Determined from the mean monthly weather summary (1941-1970), Weather Data Library, Department of Physics, Kansas State University, Manhattan.

Cutting Managements and Experimental Design

The forages were harvested at the vegetative, boot, and soft dough stages of maturity initially and each time regrowth on the respective plots reached the desired stage (Table 3). Before each harvest, six random height measurements were taken per plot in 1977 and 10 per plot in 1978 and 1979. The leaves and tops of plants were fully extended against a stick with 1-cm graduations and the height recorded was the point of the tallest leaf or plant part. All possible combinations of the six varieties and three cutting managements were arranged in a randomized complete block design with four replications at each field location.

Dry Matter Production and Laboratory and Statistical Analyses

A self-propelled Carter flail-type forage harvester was used to cut the forages, leaving a 6-inch stubble height. Forage production was determined by harvesting the center three feet of each plot, with the outside rows cut and discarded. Fresh weight of forage from each plot was taken immediately after harvesting and a representative subsample of the harvested material was oven-dried under forced ventilation at 150°F for 5 days for dry matter (DM) determination.

Dried samples were finely ground in a Wiley mill to pass through a 1-mm stainless steel screen and analyzed for crude protein (CP), *in vitro dry* matter digestibility (IVDMD), and acid-detergent fiber (ADF). No laboratory analyses were performed on forage samples taken at Hutchinson in 1978.

All field and laboratory data were subjected to analysis of variance and differences among treatment means were determined at the .05 probability level using the Duncan multiple range test (Duncan, 1955).

FORAGE CONSERVATION AND ANIMAL FEEDING TRIALS

At several field locations near Manhattan, four summer annuals (Trudan, Sudax, Millex, and FS 25A) were harvested at several stages of growth and conserved as hay or silage in 1977, 1978, and 1980. When conserved as hay, the grasses were swathed with a mower-conditioner, allowed to field wilt to 15 to 20% moisture (approximately 72 to 96 hours), baled in rectangular bales (70 to 80 Ibs), and stored under cover. Before being fed, all hays were chopped with a tub grinder fitted with a 2-inch recutter screen. When conserved as silage, the vegetative and boot stage grasses were allowed to field wilt to 65 to 75% moisture and ensiled in 10 ft. × 50 ft. concrete stave silos without additives. Soft dough stage forages were direct-cut and ensiled similarly.

The hays and silages were fed with the appropriate supplements so cattle or sheep nutrient requirements were met. Animal performance in the five trials was expressed as average daily gain, DM intake, and feed efficiency. Samples of the hays and silages fed were taken weekly during the respective trials and analyzed for CP and crude fiber. All feeding trials were conducted by the Department of Animal Sciences and Industry at Kansas State University in Manhattan.

RESULTS AND DISCUSSION

CLIMATIC INFLUENCE ON FORAGE YIELD AND QUALITY

Summer annuals grow best under warm conditions and require a soil temperature of 68-86°F. They produce forage even when the total annual precipitation is as low as 16-26 inches, but more moisture or irrigation enhances forage production (Fribourg, 1973). Mean temperatures and total precipitation were sufficient for good to excellent forage production at both locations in all years of these studies (Tables 1 and 2).

In each year, there were three vegetative stage cuttings at Hutchinson and four at Manhattan. For all growth stages and years, mean DM yield, plant height, and CP at Manhattan were significantly greater than at Hutchinson: 6.57 vs 5.63 tons per acre; 117 vs 114 cm; and 13.3 vs 9.0%, respectively. Conversely, DM and ADF contents were significantly higher at Hutchinson than at Manhattan: 29.6 vs 25.7% and 35.8 vs 34.5%, respectively. There was no significant difference in IVDMD between the two locations: 60.6 and 61.0% for Manhattan and Hutchinson, respectively.

Dennis et al. (1959) indicated that both the total and seasonal precipitation and distribution of moisture in soils are very important for forage production. The higher overall productivity and nutritive value of forages at Manhattan compared with Hutchinson may have resulted from better seasonal distribution of rainfall, especially in 1978 and 1979. Mean temperatures were also slightly higher at Hutchinson than at Manhattan (Table 1).

AGRONOMIC PERFORMANCE OF SUMMER ANNUALS

Growth Rates and Regrowth Potentials

Across years and forages, the lengths of time between planting and the first harvests at the vegetative, boot, and soft dough stages averaged 37, 59, and 114 days at Manhattan, and 43, 71, and 104 days at Hutchinson, respectively (Table 3). Thus, the average time intervals across both locations were 40, 65, and 109 days, for the vegetative, boot, and soft dough stages, respectively. These data confirm the recommendation that grazing of summer annuals should begin about 5 to 6 weeks after planting.

When averaged across all years, the regrowth potential of the forages (days between successive cuttings) at the vegetative stage was 27 days for most of the forages at both Manhattan and Hutchinson. The only exception was Millex, which at Manhattan required about 29 days between successive vegetative stage cuttings. At the boot stage, the lengths of time between successive cuttings differed markedly between Manhattan and Hutchinson. At Manhattan, Piper, Trudan, S. Chow, Sudax, Millex, and FS 25A required 39, 37, 39, 32, 37, and 59 days, respectively. At Hutchinson, the corresponding lengths of time for the first five of these forages were 51, 53, 57, 59, and 57 days, respectively. FS 25A was cut only once in each of the 3 years at Hutchinson.

Regrowth following defoliation depends upon plant morphology, the amount of stored food reserves at harvest, and the amount of photosynthetic or leaf area left for regrowth (Fribourg, 1963). When cut to a uniform stubble height, the regrowth potential of

Table 3. Planting and cutting dates for six summer annual forages at Manhattan and Hutchinson. 1977-1979.

	Planting dates	
Year	Manhattan	Hutchinson
1977	June 3	June 8
1978	June 26	June 8
1979	May 23	May 28

		Cutting dates												
		Manhattan							Hutchinson					
		Vegetative				Boot		Soft Dough	Vegetative			Boot		Soft Dough
Forage	Year	Cut 1	Cut 2	Cut 3	Cut 4	Cut 1	Cut 2	Cut 1	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1
Piper sudangrass	1977	7-8	8-3	8-26	9-22	7-22	8-26	9-22	7-19	8-8	9-8	8-8	10-22	9-8
	1978	7-25	8-18	9-14	10-12	8-18	9-28	9-12	7-18	8-17	10-14	8-1	9-9	9-9
	1979	7-10	8-3	8-31	10-11	7-20	8-31	9-10	7-16	8-8	9-6	7-29	9-6	9-6
Trudan sudangrass	1977	7-8	8-3	8-26	9-22	7-22	8-26	9-22	7-19	8-8	9-8	8-8	10-22	9-8
	1978	7-25	8-18	9-14	10-12	8-11	9-14	9-12	7-18	8-17	10-14	8-1	10-14	8-16
	1979	7-10	8-3	8-31	10-11	7-20	8-31	9-10	7-16	8-8	9-6	7-29	9-6	9-6
S. chow sorghum sudan	1977	7-8	8-3	8-26	9-22	8-3	9-7	9-22; 10-13	7-19	8-8	9-8	8-8	10-22	10-22
	1978	7-25	8-18	9-14	-	8-18	-	10-12	7-18	8-17	10-14	8-9	-	9-9
	1979	7-10	8-3	8-31	10-11	7-20	8-31	9-10	7-16	8-8	9-6	7-29	9-6	9-6
Sudax sorghum sudan	1977	7-8	8-3	8-26	9-22	8-3	8-26; 9-7	9-22	7-19	8-8	9-8	8-8	10-22	9-8
	1978	7-25	8-18	9-28	10-12	8-18	10-12	9-12	7-18	8-17	10-14	8-9	10-14	10-14
	1979	7-10	8-3	8-31	10-11	7-20	8-31	9-10	7-16	8-8	9-6	7-29	9-6	9-6
Millex pearl millet	1977	7-8	8-3	8-26	9-22	8-3	8-26; 9-7	9-22; 10-13	7-19	8-8	9-8	8-22	10-22	10-22
	1978	7-25	8-18	9-28	-	9-12	-	9-28	7-18	8-17	10-14	9-9	-	10-14
	1979	7-10	8-13	-	-	7-20	8-31	9-10	7-16	8-8	9-6	7-29	9-6	9-6
FS 25A forage sorghum	1977	7-8	8-3	8-26	9-22	8-3	9-7	9-22; 10-13	7-19	8-8	9-8	9-8	-	10-22
	1978	7-25	8-18	-	-	9-14	-	10-12	7-18	8-17	-	10-14	-	10-14
	1979	7-10	8-13	10-11	-	7-20	10-11	10-11	7-16	8-8	9-6	7-29	-	9-6

summer annuals varies among cultivars or hybrids within cultivars (Holt and Alston, 1968).

Sudangrass hybrids and sorghum sudangrasses often have faster growth and regrowth rates than the open-pollinated true sudangrass varieties (Holt, 1965). However, under the conditions of these studies, Piper, Trudan, S. Chow, Sudax, and Millex were similar in regrowth potential at the vegetative and boot stages. FS 25A had the poorest regrowth potential. FS 25A, S. Chow, and Millex were more adversely affected by frequent harvesting.

Dry matter yield of the forages decreased with successive cuttings at both vegetative and boot stages. The magnitude of these changes was greater at the boot stage than at the vegetative stage, which agrees with previous results of Edwards et al. (1971). These workers reported that under frequent cutting, carbohydrate restorage was only partially attained. Therefore, successive cuttings were associated with lower DM yields because of the reduction in stand vigor. Holt and Alston (1968) indicated that DM yields of successive boot stage cuttings were reduced drastically because carbohydrate restorage was low and regrowths originated mainly from the slower-growing basal buds.

Table 4. Analyses of variance for forage yields and extended plant heights of the six summer annual forages at three stages of maturity.

		Forage yields (T of DM/A)		Forage yields (T of 60% moisture forage/A)		Extended plant height (cm)	
Source	D.F.	M.S.	PR►F	M.S.	PR►F	M.S.	PR►F
Model	110						
Forage (F)	5	56.77	0.0001	392.84	0.0001	8126.71	0.0001
Stage (S)	2	395.81	0.0001	2878.18	0.0001	212078.85	0.0001
Location (L)	1	96.56	0.0001	577.16	0.0001	844.48	0.0012
Year (Y)	2	342.55	0.0001	4311.10	0.0001	385488.20	0.0001
Replication	3	7.71	0.0014	50.97	0.0025	331.88	0.0066
FxS	10	32.30	0.0001	234.09	0.0001	1463.97	0.0001
FxL	5	5.21	0.0033	42.24	0.0014	828.03	0.0001
FxY	10	37.23	0.0001	256.61	0.0001	3334.11	0.0001
FxSxL	10	2.63	0.0529	17.42	0.0836	723.02	0.0001
FxSxY	20	6.35	0.0001	51.69	0.0001	1244.26	0.0001
FxLxY	10	10.98	0.0001	80.79	0.0001	1822.75	0.0001
SxLxY	4	16.66	0.0001	126.69	0.0001	975.70	0.0001
SxL	2	46.24	0.0001	322.63	0.0001	2388.98	0.0001
SxY	4	47.83	0.0001	451.17	0.0001	8821.73	0.0001
LxY	2	60.30	0.0001	401.12	0.0001	6198.20	0.0001
FxSxLxY	20	3.06	0.0034	20.62	0.0075	533.45	0.0001
Error	321	1.43	—	10.35	—	76.47	—

D.F. means Degrees of Freedom.
M.S. means Mean Squares.
PR►F means Probability that a greater F value would occur due to chance alone.

Table 5. Analyses of variance for in vitro dry matter digestibility, crude protein and acid-detergent fiber contents of the six summer annual forages harvested at three stages of maturity.

		In vitro DM digestibility (%)		Crude protein (%)		Acid-detergent fiber (%)	
Source	D.F.	M.S.	PR►F	M.S.	PR►F	M.S.	PR►F
Model	74						
Forage (F)	5	79.47	0.0001	20.89	0.0001	15.34	0.0007
Stage (S)	2	3294.14	0.0001	1948.65	0.0001	754.95	0.0001
Location (L)	1	8.09	0.1247	1345.67	0.0001	103.49	0.0001
Year (Y)	1	30.51	0.0031	234.69	0.0001	486.49	0.0001
Replication	3	8.06	0.0707	1.05	0.5573	14.39	0.0062
FxS	10	34.11	0.0001	7.86	0.0001	25.17	0.0001
FxL	5	9.55	0.0178	6.45	0.0011	7.48	0.0531
FxY	5	4.90	0.2102	3.65	0.0366	5.95	0.1201
FxSxL	10	9.81	0.0022	1.86	0.2722	5.04	0.1421
FxSxY	10	5.01	0.1522	4.06	0.0040	10.81	0.0008
FxLxY	5	6.04	0.1185	3.74	0.0329	4.30	0.2743
SxLxY	2	42.01	0.0001	40.72	0.0001	2.13	0.5323
SxL	2	25.86	0.0007	41.27	0.0001	66.75	0.0001
SxY	4	186.55	0.0001	109.79	0.0001	97.22	0.0001
LxY	1	9.84	0.0907	32.36	0.0001	134.04	0.0001
FxSxLxY	10	16.43	0.0001	5.18	0.0003	5.66	0.0876
Error	213	3.41	—	1.51	—	3.60	—

D.F. means Degrees of Freedom.
M.S. means Mean Squares.
PR►F means Probability that a greater F value would occur due to chance alone.

Plant Heights

The forage × stage × location × year interaction was significant, as shown in Tables 4 and 5. Therefore, plant height, DM production, and nutritive value of the six forages are presented by stages of harvest, location, and year. Differences in the morphology of the summer annuals are shown in Figure 1 and by the plant height data in Tables 6 and 7. As expected, plant height increased significantly as harvesting was delayed from the vegetative to boot to soft dough stages.

At Manhattan, Millex was generally the shortest grass and S. Chow, the tallest. Piper and Trudan were similar in height and were taller than FS 25A, except at the dough stage in 1977 and 1979 and the boot stage in 1978. Sudax was significantly shorter than S. Chow at all stages except the dough stage in 1979, when the differences in height were not significant.

At Hutchinson, S. Chow and FS 25A were the tallest forages and Millex the shortest. FS 25A was significantly taller than S. Chow at the boot stage in 1977 and 1978 and at the dough stage in 1977; but S. Chow was taller at the dough stage in 1978 and 1979 and at the vegetative stage in 1979. Piper and Trudan were similar in height in all years, except at the boot stage in 1978, when Trudan was significantly taller than Piper. S. Chow was taller than Sudax except at the vegetative stage in 1977 and 1979 and the boot stage in 1979.

Table 6. Extended heights (cm) of six summer annual forages cut at three stages of maturity, Manhattan.*

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	106	160^{a}	181^{c}	87^{ab}	141^{c}	190^{a}	105^{a}	151^{c}	234^{b}
Trudan sudangrass	101	155^{a}	186^{c}	90^{ab}	146^{c}	205^{a}	87^{c}	165^{b}	244^{ab}
S. Chow sorghum sudan	107	161^{a}	226^{ab}	98^{a}	172^{a}	197^{a}	93^{b}	180^{a}	267^{a}
Sudax sorghum sudan	101	138^{bc}	184^{c}	82^{b}	150^{bc}	174^{b}	86^{c}	169^{b}	247^{ab}
Millex pearl millet	101	124^{c}	220^{ab}	67^{c}	113^{d}	96^{c}	88^{c}	143^{d}	232^{b}
FS 25A forage sorghum	95	153^{ab}	243^{a}	85^{b}	162^{ab}	171^{b}	72^{d}	162^{b}	257^{ab}
Stage mean	102	149^{b}	207^{a}	85^{c}	147^{b}	172^{a}	89^{c}	162^{b}	247^{a}

*For conversion to English units, 25 cm = 10 inches.

$^{a, b, c, d}$Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 7. Extended heights (cm) of six summer annual forages cut at three stages of maturity, Hutchinson.*

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	114^{a}	154^{c}	187^{de}	105^{ab}	114^{d}	157^{b}	100^{a}	134^{a}	194^{ab}
Trudan sudangrass	113^{a}	144^{c}	193^{cd}	111^{a}	127^{c}	166^{ab}	92^{ab}	123^{a}	194^{ab}
S. Chow sorghum sudan	126^{a}	179^{b}	238^{b}	89^{c}	139^{b}	176^{a}	80^{bc}	100^{b}	208^{a}
Sudax sorghum sudan	115^{a}	157^{c}	201^{c}	99^{bc}	128^{bc}	169^{ab}	86^{ab}	121^{a}	194^{ab}
Pearl millet	85^{b}	129^{d}	172^{e}	66^{d}	139^{b}	123^{c}	71^{c}	126^{a}	173^{c}
FS 25A forage sorghum	115^{a}	259^{a}	270^{a}	90^{c}	160^{a}	155^{b}	69^{c}	102^{b}	182^{bc}
Stage mean	111^{c}	171^{b}	210^{a}	93^{c}	134^{b}	158^{a}	83^{e}	118^{b}	191^{a}

*For conversion to English units, 25 cm = 10 inches.

$^{a, b, c, d, e}$Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Figure 1. Summer annual forages at different stages of maturity: Piper sudangrass, vegetative stage (top left); FS 25A forage sorghum, vegetative stage (top center); FS 25A forage sorghum, boot stage (top right); Piper sudangrass, anthesis (bottom left); Piper sudangrass, dough stage (bottom center); Millex pearl millet, dough stage (bottom right).

Table 8. Forage yields (tons of DM/acre) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	5.01^{ab}	6.53^{ab}	7.58^{d}	5.10^{a}	6.18^{c}	6.32^{b}	3.53^{bc}	4.52^{cd}	4.80^{d}
Trudan sudangrass	4.91^{ab}	6.32^{ab}	8.40^{d}	5.42^{a}	7.81^{b}	7.68^{b}	4.83^{ab}	4.99^{c}	7.16^{bc}
S. Chow sorghum sudan	5.13^{ab}	8.20^{a}	16.57^{a}	4.64^{a}	5.69^{c}	12.42^{a}	2.81^{c}	5.77^{bc}	7.38^{b}
Sudax sorghum sudan	5.44^{a}	6.86^{ab}	9.11^{dc}	5.50^{a}	9.63^{a}	8.00^{b}	4.32^{b}	5.53^{bc}	7.57^{b}
Millex pearl millet	6.11^{a}	7.44^{a}	13.38^{ab}	2.92^{b}	4.29^{d}	4.67^{c}	3.24^{bc}	6.90^{b}	5.16^{cd}
FS 25A forage sorghum	2.93^{b}	4.98^{b}	12.17^{bc}	2.47^{b}	5.46^{cd}	7.40^{b}	6.19^{a}	8.45^{a}	13.24^{a}
Stage mean	4.92^{c}	6.72^{b}	11.20^{a}	4.34^{c}	6.51^{b}	7.75^{a}	4.15^{c}	6.02^{b}	7.55^{a}

$^{a, b, c, d}$Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P◄.05).

Table 9. Forage yields (tons of DM/acre) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	5.08^{ab}	7.77^{c}	5.41^{e}	5.01^{a}	3.59^{b}	4.02^{ab}	3.22^{bc}	3.06^{c}	2.77^{d}
Trudan sudangrass	5.73^{a}	8.26^{c}	8.08^{d}	4.69^{a}	4.32^{ab}	5.24^{ab}	4.02^{b}	4.09^{b}	4.11^{c}
S. Chow sorghum sudan	5.83^{a}	10.04^{b}	15.66^{a}	3.99^{ab}	3.67^{b}	5.14^{ab}	3.28^{bc}	4.62^{b}	4.85^{bc}
Sudax sorghum sudan	5.85^{a}	12.36^{a}	10.96^{b}	4.84^{a}	5.16^{a}	4.71^{ab}	3.88^{bc}	4.72^{b}	5.35^{b}
Millex pearl millet	4.41^{ab}	7.01^{c}	8.38^{cd}	2.46^{c}	3.61^{b}	3.82^{b}	3.06^{c}	2.58^{c}	4.21^{c}
FS 25A forage sorghum	3.89^{b}	9.94^{b}	11.98^{b}	3.58^{bc}	5.08^{a}	5.53^{a}	5.06^{a}	7.36^{a}	8.98^{a}
Stage mean	5.13^{c}	9.23^{a}	10.08^{b}	4.09^{b}	4.26^{ab}	4.65^{a}	3.75^{c}	4.41^{b}	5.04^{a}

$^{a, b, c, d}$Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P◄.05).

Dry Matter Production

Dry matter yields of the six summer annual forages are presented in Table 8 (Manhattan) and Table 9 (Hutchinson).

Vegetative Stage

1977. When managed to simulate pasture utilization (vegetative stage), Millex and Sudax had significantly greater DM yields than FS 25A (Manhattan). The yield of FS 25A was similar to that of Piper, Trudan, and S. Chow. The yields of Piper, Trudan, S. Chow, Sudax, and Millex also were similar. At Hutchinson, DM yield was lowest for FS 25A. Trudan, S. Chow, and Sudax were similar in yield and exceeded Piper and Millex, though not significantly.

1978. Millex and FS 25A did not tolerate frequent cutting and produced the lowest yields. At Manhattan, there were three cuttings of Millex and only two of FS 25A at the vegetative stage. The other forages each were harvested four times and produced significantly more DM than Millex and FS 25A. At Hutchinson, FS 25A was affected more by frequent cutting and was cut twice versus three times for the other forages. The total vegetative stage DM yield of Millex was significantly lower than that of the other forages, except FS 25A where the difference was not significant. Piper, Trudan, S. Chow, and Sudax produced similar DM yields.

1979. At Manhattan, the DM yield of FS 25A was greater than that of the other forages except Trudan. S. Chow produced the lowest yield, but not significantly less than Piper, Sudax or Millex. The yield of Trudan was intermediate between that of FS 25A and Sudax. At Hutchinson, as at Manhattan, FS 25A outyielded all other forages. The yields of Piper, Trudan, S. Chow, and Sudax were similar and Millex was lower than Trudan.

Boot Stage

1977. When cut at boot stage, S. Chow had greatest DM production at Manhattan and FS 25A the least. The yields of Piper, Trudan, S. Chow, Sudax, and Millex were similar. Sudax DM yield was greater than that of the other forages at Hutchinson. Piper, Trudan, and Millex produced the lowest yields. Yields of S. Chow and FS 25A were similar and intermediate between Sudax and the other forages.

1978. As at the vegetative stage, Millex and FS 25A plus S. Chow did not regrow after clipping at the boot stage (Manhattan). They were harvested only once and produced the lowest DM yields. The yield of Sudax was greater than that of the other forages and Trudan outyielded Piper. At Hutchinson, Piper, Trudan, and Sudax were each cut twice, while S. Chow; Millex, and FS 25A were each cut only once. Trudan, Sudax, and FS 25A had the highest yields.

1979. Under boot stage management in Manhattan, FS 25A produced the highest DM yield and Piper the lowest. DM yield of Millex was greater than that of Piper and Trudan and similar to that of S. Chow and Sudax. Trudan outyielded Piper and S. Chow outyielded Sudax, but the differences were not significant. At Hutchinson, FS 25A was harvested only once versus twice for the other forages. The DM yield of Millex was the lowest and that of FS 25A the highest. Piper yielded more DM than Millex but the difference was not significant. The yields of Trudan, S. Chow, and Sudax were similar and all were superior to Piper.

Soft Dough Stage

1977. Under the single-cut management, S. Chow and Millex produced the most DM at Manhattan. DM yield of FS 25A was lower but not significantly different than that of Millex. The yields of Piper, Trudan, and Sudax were similar and lower than those of the other forages. At Hutchinson, S. Chow had the highest yield and Piper the lowest. The DM yields of Sudax and FS 25A were similar and greater than those of Trudan and Millex.

1978. At Manhattan, S. Chow produced the highest DM yield and Millex the lowest. DM yields of Piper, Trudan, Sudax, and FS 25A were intermediate and similar. At Hutchinson, FS 25A outyielded Millex. Although numerically higher, the yield of FS 25A was similar to those of Piper, Trudan, S. Chow, and Sudax.

1979. At Manhattan, FS 25A produced more DM than the other grasses. The yields of Trudan, S. Chow and Sudax were all similar and greater than that of Piper. S. Chow and Sudax outyielded Millex. The yields of Trudan and Millex were similar, as were those of Piper and Millex. At Hutchinson, as at Manhattan, FS 25A outyielded the other grasses. The DM yield of Piper was lower than the other forages while the yields of Trudan, S. Chow, and Millex were similar. Sudax outyielded Trudan and Millex but was similar to S. Chow in DM yield.

Summary

At Manhattan, DM yields of Piper and Trudan were statistically similar in seven of nine comparisons; Trudan significantly outyielded Piper only at the boot stage in 1978 and soft dough stage in 1979. S. Chow and Sudax were similar in DM yields at the vegetative stage in 1977 and 1978, boot stage in 1977 and 1979, and soft dough stage in 1979. S. Chow produced significantly more DM than Sudax at the soft dough stage in 1979; S. Chow produced significantly more DM than Sudax at the soft dough stage in 1977 and 1978, but less at the boot stage in 1978 and the vegetative stage in 1979.

At the vegetative and boot stages in 1977, Millex produced as much DM as S. Chow and Sudax. At the same stages, FS 25A produced the lowest DM yield. At the soft dough stage, however, FS 25A outyielded Piper, Trudan, and Sudax. In 1978 and 1979, Millex generally produced the lowest DM at all stages. At the vegetative and boot stages (1978) the DM yield of FS 25A was similar to that of Millex, but at the soft dough stage FS 25A outyielded Millex. In 1978, FS 25A produced the greatest DM yield at all stages of maturity.

At Hutchinson, the yields of Piper and Trudan were similar in six of nine comparisons (vegetative stage, 1977, 1978, and 1979; boot stage, 1977 and 1978; and soft dough stage, 1978). At the soft dough stage (1977 and 1979) and boot stage (1979), Trudan significantly outyielded Piper.

S. Chow and Sudax were similar in DM yield in all years, except at the boot stage in 1977 and 1978, when Sudax produced significantly more DM than S. Chow, and at the soft dough stage in 1977, when S. Chow outyielded Sudax. At all stages, except the vegetative and soft dough (1977) and soft dough (1979), Millex produced the lowest DM yield. Even in those three harvests, Millex was among the group of forages with the lowest DM yields. At the vegetative stage in 1977 and 1978, FS 25A was among the forages with the lowest yields, while at the boot and soft dough stages in 1977 and 1978, it was among the forages with the highest DM yields. In 1979, FS 25A significantly outyielded the other forages at all stages.

Dry matter yields increased with advancing maturity at Manhattan. However, at Hutchinson the increases in DM yield between boot and soft dough stages in 1977 and between vegetative and boot stages in 1978 were not significant. The lack of yield increase in these two cases resulted from declines in yields of Piper, Trudan, and Sudax in 1977, and of Piper, Trudan, and S. Chow in 1978.

Dry Matter Contents and Silage Production

Moisture content is one of the major factors influencing the stage of maturity at which to harvest forages and the method of conservation (Holt et al., 1963). The appropriate range for making acceptable silage is 60 to 75% moisture. As shown in Tables 10 and 11 summer annuals harvested at pre-dough stages would require field wilting for making either hay or silage. The loss of nutrients through seepage and extensive fermentation would be very high from forages ensiled with more than 75% moisture. On the other hand, wilting would be unnecessary if summer annuals were harvested for silage at the soft dough stage.

DM yields were linearly transformed to express silage production as tons/acre at 60% moisture (Tables 12 and 13). Silage yields therefore have the same comparative relationships among forages, locations, and stages of cutting as DM yields. Data in the tables allow easy comparison among these forages on a silage yield basis.

Table 10. Dry matter contents (%) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	23.3[a]	21.1	38.9[a]	23.7[a]	25.5[b]	40.0[a]	19.7[c]	25.1[a]	34.1
Trudan sudangrass	21.8[ab]	20.0	39.0[a]	21.5[a]	22.7[b]	43.4[a]	25.2[a]	23.0[c]	35.6
S. Chow sorghum sudan	20.3[ab]	21.4	39.4[a]	17.0[b]	20.7[b]	30.5[b]	17.0[d]	21.0[d]	31.8
Sudax sudan sorghum	21.1[ab]	20.7	31.6[b]	21.0[a]	22.7[b]	31.7[b]	25.7[a]	22.3[c]	38.3
Millex 23 pearl millet	17.3[b]	19.5	31.4[b]	15.9[b]	32.5[a]	20.1[c]	16.7[d]	19.5[e]	33.7
FS 25A forage sorghum	18.5[ab]	19.7	32.0[b]	16.3[b]	23.7[b]	29.8[b]	22.7[b]	24.1[b]	36.6
Stage mean	20.4[b]	20.4[b]	35.5[a]	19.2[c]	24.6[b]	32.6[a]	21.2[b]	22.5[b]	35.0[a]

[a, b, c, d, e]Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 11. Dry matter contents (%) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	23.3[a]	33.5[a]	34.1[bc]	29.4[a]	31.4[a]	44.2[a]	29.7	28.2[ab]	47.4[a]
Trudan sudangrass	22.2[ab]	29.8[ab]	35.5[ab]	26.3[ab]	30.7[a]	40.2[b]	27.8	25.1[b]	46.9[a]
S. Chow sorghum sudan	20.1[ab]	25.1[cd]	38.7[a]	26.4[ab]	20.9[c]	30.2[d]	27.0	31.2[a]	33.4[b]
Sudax sorghum sudan	20.0[ab]	29.1[ab]	30.2[c]	25.4[b]	24.0[bc]	34.4[c]	25.7	31.4[a]	43.7[a]
Millex pearl millet	20.3[ab]	27.3[bc]	37.4[ab]	23.6[b]	30.2[a]	29.6[d]	29.0	27.9[ab]	36.4[b]
FS 25A forage sorghum	17.9[b]	22.5[d]	30.5[c]	23.8[b]	26.4[b]	28.2[d]	25.8	26.7[b]	32.6[b]
Stage mean	20.6[c]	28.0[b]	34.4[a]	25.8[c]	27.2[b]	34.5[a]	27.0[b]	28.4[b]	40.1[a]

[a, b, c, d]Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 12. Forage yields (tons of 60% moisture forage/acre) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	14.3[a]	18.7[ab]	21.7[d]	12.8[a]	15.5[c]	15.8[b]	8.8[bc]	11.3[cd]	12.0[d]
Trudan sudangrass	14.0[a]	18.0[b]	24.0[cd]	13.6[a]	19.5[b]	19.2[b]	12.2[ab]	12.5[c]	17.9[bc]
S. Chow sorghum sudan	14.7[a]	23.4[a]	47.3[a]	11.6[a]	14.2[c]	31.1[a]	7.0[c]	14.2[bc]	18.5[b]
Sudax sorghum sudan	15.5[a]	19.6[ab]	26.0[c]	13.7[a]	24.1[a]	20.0[b]	10.9[b]	13.8[bc]	18.9[b]
Millex pearl millet	17.6[a]	21.2[ab]	38.2[b]	7.3[b]	10.7[d]	11.7[c]	8.2[c]	17.3[b]	12.9[cd]
FS 25A forage sorghum	8.4[b]	10.3[c]	34.8[b]	6.2[b]	13.7[cd]	18.5[b]	15.5[a]	21.1[a]	33.1[a]
Stage mean	14.1[c]	19.2[b]	32.0[a]	10.9[c]	16.3[b]	19.4[a]	10.4[c]	15.1[b]	18.9[a]

[a, b, c, d]Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 13. Forage yields (tons of 60% moisture forage/acre) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	14.5[ab]	22.2[c]	15.5[d]	12.5[a]	9.0[b]	10.0[ab]	8.0[bc]	7.7[c]	6.9[d]
Trudan sudangrass	13.4[a]	23.6[c]	23.8[c]	11.7[a]	11.3[ab]	13.1[ab]	10.0[b]	10.2[b]	10.3[c]
S. Chow sorghum sudan	16.7[a]	28.7[b]	44.7[a]	10.0[ab]	9.2[b]	12.9[ab]	8.2[bc]	11.6[b]	12.1[bc]
Sudax sorghum sudan	16.7[a]	35.3[a]	31.0[b]	12.1[a]	12.9[a]	11.8[ab]	9.7[c]	11.8[b]	13.4[b]
Millex pearl millet	12.6[b]	20.0[c]	23.9[c]	6.2[c]	9.0[b]	8.2[b]	7.7[c]	6.5[c]	10.5[c]
FS 25A forage sorghum	11.4[b]	28.4[b]	34.2[b]	9.0[bc]	12.6[a]	13.8[a]	12.7[a]	18.4[a]	22.5[a]
Stage mean	14.7[c]	26.4[b]	28.3[a]	10.2[b]	10.7[ab]	11.7[a]	9.4[c]	11.0[b]	12.6[a]

[a, b, c, d]Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 14. Crude protein contents (%) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	19.2^{b}	14.3^{c}	10.2^{a}	17.0^{b}	11.9^{b}	6.9^{c}	16.3^{ab}	14.8^{ab}	7.4^{ab}
Trudan sudangrass	17.8^{c}	15.6^{ab}	8.9^{bc}	16.4^{b}	12.5^{a}	5.8^{c}	15.5^{b}	13.1^{bc}	5.9^{ab}
S. Chow sorghum sudan	19.2^{b}	14.5^{bc}	8.3^{c}	17.5^{a}	12.0^{ab}	8.0^{bc}	17.8^{a}	12.1^{bc}	5.4^{ab}
Sudax sorghum sudan	20.1^{b}	12.6^{d}	9.9^{ab}	17.3^{ab}	13.7^{a}	7.3^{c}	15.6^{b}	15.2^{a}	7.9^{a}
Millex pearl millet	21.5^{a}	16.6^{a}	10.2^{a}	19.1^{a}	13.4^{a}	13.2^{a}	18.1^{a}	16.4^{a}	5.8^{ab}
FS 25A forage sorghum	19.7^{b}	12.5^{d}	8.7^{bc}	18.2^{a}	8.6^{c}	9.7^{b}	14.4^{b}	11.3^{c}	4.5^{b}
Stage mean	19.6^{a}	14.4^{b}	9.4^{c}	17.6^{a}	12.0^{b}	8.5^{c}	16.3^{a}	13.8^{b}	6.9^{c}

a, b, c, d Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 15. Crude protein contents (%) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year					
	1977			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	13.8^{b}	9.1^{bc}	6.6^{a}	10.2	11.7^{a}	4.5
Trudan sudangrass	14.2^{b}	8.6^{bc}	6.0^{a}	10.1	10.5^{a}	4.8
S. Chow sorghum sudan	13.8^{b}	8.3^{c}	3.3^{b}	10.4	8.9^{b}	5.4
Sudax sorghum sudan	14.9^{b}	10.3^{ab}	5.7^{a}	10.4	8.6^{b}	4.9
Millex pearl millet	14.8^{b}	11.1^{a}	3.9^{b}	10.0	11.8^{a}	6.0
FS 25A forage sorghum	17.3^{a}	7.9^{c}	4.0^{b}	10.4	8.7^{b}	4.6
Stage mean	14.8^{a}	9.2^{b}	4.9^{c}	10.3^{a}	10.0^{a}	5.0^{b}

a, b, c Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Table 16. In vitro dry matter digestibilities (%) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	67.3	63.1^{ab}	49.8^{b}	63.0	63.7^{ab}	56.5^{c}	64.1^{b}	61.6^{b}	54.1
Trudan sudangrass	67.6	61.8^{ab}	51.5^{ab}	63.9	65.0^{a}	57.3^{c}	64.4^{b}	64.3^{ab}	54.6
S. Chow sorghum sudan	66.1	62.6^{ab}	50.9^{ab}	64.1	64.5^{a}	63.3^{a}	64.7^{b}	62.4^{b}	55.5
Sudax sorghum sudan	65.1	61.0^{b}	50.3^{b}	63.4	62.0^{b}	59.7^{bc}	61.9^{c}	63.9^{b}	56.5
Millex pearl millet	67.4	63.9^{a}	52.8^{a}	64.2	63.2^{ab}	61.6^{ab}	68.1^{a}	66.8^{a}	56.1
FS 25A forage sorghum	65.6	58.6^{b}	53.1^{a}	63.8	64.4^{a}	64.6^{a}	62.9^{bc}	62.3^{b}	57.8
Stage mean	66.5^{a}	62.2^{b}	51.4^{c}	63.7^{a}	63.8^{a}	60.5^{b}	64.3^{a}	63.3^{a}	55.7^{b}

a, b, c Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P<.05).

Nutritive Value

Data for CP contents of the summer annual forages are shown in Tables 14 and 15; data for IVDMD, in Tables 16 and 17; and data for acid detergent fiber (ADF) content, in Tables 18 and 19.

Vegetative Stage

1977. When cut to simulate grazing at Manhattan, Millex contained more protein than the other grasses. Trudan was lower than the other forages in CP. Piper, S. Chow, Sudax, and FS 25A were all similar in CP, and were intermediate between Trudan and Millex. At Hutchinson, FS 25A was higher in protein than the other forages, which were all similar.

There were no significant differences among forages for IVDMD at Manhattan. At Hutchinson, the IVDMD of Millex was significantly higher than that of the other forages. Trudan, S. Chow, Sudax, and Piper were similar in digestibility and Trudan, S. Chow, and Sudax were significantly more digestible than FS 25A.

ADF content of Millex was significantly lower than the other forages in Manhattan and forages high-

Table 17. In vitro dry matter digestibility (%) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year					
	1977			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	66.2^{bc}	59.8^{cd}	50.9^{d}	63.4^{ab}	64.2^{ab}	49.7^{b}
Trudan sudangrass	68.2^{b}	62.9^{b}	51.3^{d}	65.0^{ab}	65.0^{a}	52.6^{b}
S. Chow sorghum sudan	67.4^{b}	62.3^{b}	53.9^{c}	62.9^{b}	63.1^{bc}	59.3^{a}
Sudax sorghum sudan	66.6^{b}	61.0^{bc}	56.3^{ab}	63.7^{ab}	61.8^{bc}	52.1^{b}
Millex pearl millet	70.8^{a}	65.8^{a}	55.3^{bc}	65.5^{a}	66.7^{a}	60.3^{a}
FS 25A forage sorghum	64.6^{c}	58.3^{d}	58.7^{a}	65.2^{ab}	61.2^{c}	58.9^{a}
Stage mean	67.1^{a}	61.7^{b}	54.4^{c}	64.2^{a}	63.9^{a}	55.5^{b}

a, b, c, d Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P◄.05).

Table 18. Acid-detergent fiber contents (%) of the six summer annual forages cut at three stages of maturity, Manhattan.

	Year								
	1977			1978			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	28.9^{ab}	30.7	36.7^{ab}	32.4^{b}	32.2^{bc}	39.2^{a}	35.1^{ab}	32.5^{ab}	43.9^{a}
Trudan sudangrass	28.1^{b}	31.9	36.5^{ab}	33.8^{a}	33.7^{b}	39.1^{a}	37.2^{a}	33.9^{ab}	40.6^{ab}
S. Chow sorghum sudan	30.4^{ab}	31.6	38.7^{a}	32.9^{ab}	33.0^{b}	34.5^{b}	35.3^{ab}	34.5^{a}	41.2^{ab}
Sudax sorghum sudan	28.8^{ab}	31.1	36.4^{ab}	33.4^{ab}	33.0^{bc}	33.2^{b}	37.1^{a}	31.9^{ab}	39.2^{ab}
Millex pearl millet	24.5^{c}	30.4	35.6^{b}	32.0^{b}	31.5^{c}	33.3^{b}	32.5^{b}	31.0^{b}	41.2^{ab}
FS 25A forage sorghum	30.8^{a}	32.2	34.9^{b}	34.7^{a}	36.7^{a}	33.7^{b}	35.5^{ab}	34.9^{a}	37.5^{b}
Stage mean	28.6^{c}	31.3^{b}	36.4^{a}	33.2^{b}	32.7^{b}	35.5^{a}	35.5^{b}	33.1^{c}	40.6^{a}

a, b, c Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P◄.05).

Table 19. Acid-detergent fiber content (%) of the six summer annual forages cut at three stages of maturity, Hutchinson.

	Year					
	1977			1979		
Forage	Vegetative	Boot	Soft dough	Vegetative	Boot	Soft dough
Piper sudangrass	31.4	37.0^{a}	38.1	34.4	32.9^{b}	43.4^{a}
Trudan sudangrass	31.8	35.4^{ab}	38.8	35.4	35.0^{ab}	40.6^{ab}
S. Chow sorghum sudan	32.5	34.2^{b}	38.4	35.0	35.2^{a}	35.8^{c}
Sudax sorghum sudan	30.3	33.0^{b}	36.4	35.0	36.7^{a}	40.8^{ab}
Millex pearl millet	31.1	33.5^{b}	37.8	34.8	34.3^{b}	38.3^{bc}
FS 25A forage sorghum	32.4	37.5^{a}	36.4	34.5	37.6^{a}	35.5^{c}
Stage mean	31.9^{c}	35.1^{b}	37.6^{a}	34.9^{b}	35.3^{b}	39.1^{a}

a, b, c Any two forage means within a column or stage means within a year followed by the same letter are not significantly different (P◄.05).

est in ADF were Piper, Trudan, S. Chow, and FS 25A. At Hutchinson, the forages were similar in ADF content.

1978. Millex contained the highest CP content and Piper and Trudan the lowest. However, S. Chow, Sudax, Millex, and FS 25A were similar in protein. The CP of Piper and Trudan were similar to that of Sudax, but lower than those of S. Chow, Millex, and FS 25A.

IVDMD of all forages were statistically similar at Manhattan and quality was not determined for the Hutchinson location.

FS 25A, Trudan, Sudax, and S. Chow had the highest fiber contents; Millex and Piper, the lowest. The lower group in ADF content was Millex, Piper, S. Chow, and Sudax while the higher group was FS 25A, Trudan, Sudax, and S. Chow.

1979. At Manhattan, the CP of Millex was highest and that of FS 25A lowest. However, Millex, S. Chow, and Piper were similar in CP, as were Piper, Trudan, Sudax, and FS 25A. There were no significant differences among forage CP contents at Hutchinson.

At Manhattan, the digestibility of Millex was significantly greater than that of the other forages. Piper, Trudan, S. Chow, and FS 25A were more digestible than Sudax. At Hutchinson, Millex was significantly higher in IVDMD than was S. Chow. Millex, FS 25A, Trudan, Piper, and Sudax were similar in IVDMD, as were Piper, Trudan, Sudax, S. Chow, and FS 25A.

Fiber contents of Trudan and Sudax were the highest and that of Millex the lowest. Piper, Trudan, S. Chow, and Sudax, had the highest fiber contents, while Piper, S. Chow, Millex, and FS 25A had the lowest (Manhattan). At Hutchinson, there were no significant differences in ADF among forages.

Boot Stage

1977. At Manhattan, Millex contained more CP than Piper, S. Chow, Sudax, and FS 25A, but was similar to Trudan. Sudax and FS 25A were similar in CP and lower than Piper, Trudan, and S. Chow. Piper and S. Chow were similar in CP content as were Trudan and S. Chow. The CP content of Millex was highest at Hutchinson but not significantly greater than Sudax. Piper, Trudan, S. Chow, and FS 25A were similarly low in CP content, with Piper, Trudan, and Sudax intermediate in CP.

When cut at the boot stage at Manhattan, Millex was significantly more digestible than Sudax and FS 25A, but was similar in digestibility to Piper, S. Chow, and Trudan. Piper, S. Chow, Trudan, Sudax, and FS 25A were similar in digestibility. At Hutchinson, the IVDMD of Millex was significantly greater than all other forages. FS 25A was the least digestible although it was statistically similar in IVDMD to Piper. Trudan, S. Chow, and Sudax were similar in IVDMD as were Sudax and Piper.

At Manhattan, there were no significant differences among forages for ADF. At Hutchinson, FS 25A and Piper were the most fibrous, and S. Chow, Millex, and Sudax the least.

1978. Trudan, Millex, Sudax, and S. Chow had the highest CP contents. The CP in FS 25A was significantly lower than that in the other forages, while Piper was significantly lower in CP than Trudan, Sudax, and Millex, but similar to S. Chow.

The IVDMD's of Trudan, S. Chow, and FS 25A were significantly greater than that of Sudax. Trudan, S. Chow, Piper, and Millex were similar in IVDMD as were Piper, Millex, and Sudax.

FS 25A contained significantly more fiber than the other forages. Millex contained the least fiber although not significantly less than Piper and Sudax. Piper, Sudax, S. Chow, and Trudan were similar in fiber content.

1979. When cut at the boot stage in Manhattan, Millex contained the highest CP value; FS 25A the lowest. The CP contents of Millex and Sudax were greater than that of Trudan, S. Chow, and FS 25A but similar to that of Piper. Piper was similar to Trudan and S. Chow, but higher than FS 25A. Trudan, S. Chow, and FS 25A were similar in protein. At Hutchinson, Piper, Trudan, and Millex were similar in protein content and were higher than S. Chow, Sudax, and FS 25A.

At Manhattan, Millex and Piper were the highest and lowest, respectively, in digestibility and Millex was similar to Trudan. Piper, Trudan, S. Chow, Sudax, and FS 25A were statistically similar for IVDMD. At Hutchinson, Millex and Trudan were significantly more digestible than S. Chow, Sudax, and FS 25A. The IVDMD's of Millex, Trudan, and Piper were similar, as were those of Piper, S. Chow and Sudax.

When cut twice per season, S. Chow and FS 25A were the most fibrous; Millex, the least, in Manhattan. FS 25A, Trudan, Piper, and Sudax were similar and higher in ADF than were Trudan, Piper, and Millex. At Hutchinson, FS 25A, Sudax, and S. Chow were the most fibrous; Piper and Millex, the least. Trudan, S. Chow, Sudax, and FS 25A were all similar in ADF as were Piper, Trudan, and Millex.

Soft Dough Stage

1977. The CP contents of Piper, Sudax, and Millex were similar and greater than Trudan, S. Chow and FS 25A in Manhattan. At Hutchinson, the highest three forages, Piper, Trudan, and Sudax contained greater CP than the lowest three, S. Chow, Millex, and FS 25A. Forages within each group were similar in CP.

The digestibilities of FS 25A and Millex were similar and statistically greater than those of Sudax and Piper (Manhattan). Trudan, S. Chow, Sudax, and Piper were similar in IVDMD. At Hutchinson, FS 25A was significantly more digestible than the other forages, except Sudax, and Piper and Trudan were the least digestible.

At Manhattan, S. Chow contained the highest level of fiber, while Millex and FS 25A contained the least fiber. The ADF contents of S. Chow, Sudax, Piper, and Trudan were statistically similar. Piper, Trudan, Sudax, Millex, and FS 25A also were statistically similar in fiber content. At Hutchinson, there were no significant differences among forages in fiber content.

1978. When harvested in the soft dough stage, Millex contained more CP than the other forages. The CP content of FS 25A was greater than that of Piper, Trudan, and Sudax but similar to that of S. Chow. S. Chow, Sudax, Piper, and Trudan were all similar in CP content.

The IVDMD's of S. Chow and FS 25A were the highest, those of Piper and Trudan the lowest. However, FS 25A, S. Chow, and Millex were similar in IVDMD as were Sudax, Trudan, and Piper.

Piper and Trudan were similar in fiber content but were significantly more fibrous than the other forages. S. Chow, Sudax, Millex, and FS 25A were similar in ADF content.

1979. At Manhattan the CP content of Sudax was greater than that of FS 25A. Although lower numerically, the CP content of FS 25A was statistically similar to those of Piper, Trudan, Millex, and S. Chow. There were no significant differences among forages for CP at Hutchinson.

There were no statistical differences among forages for IVDMD, when cut at the soft dough stage in

Manhattan, although the IVDMD of FS 25A was numerically the highest. At Hutchinson, Millex, Sudax, and FS 25A were higher in IVDMD than Piper, Trudan, and S. Chow.

The fiber content of FS 25A was significantly lower than that of Piper. However, Piper, Trudan, S. Chow, Sudax, and Millex were statistically similar in ADF as were Trudan, S. Chow, Sudax, Millex, and FS 25A (Manhattan). At Hutchinson, Piper contained the highest ADF and S. Chow and FS 25A the lowest. However, Piper, Trudan, and Sudax were statistically similar in ADF as were Trudan, Sudax, and Millex. S. Chow, Millex, and FS 25A also were similar in ADF content.

Summary

At Manhattan, Piper contained more crude protein than Trudan in two of nine comparisons (vegetative and dough stages, 1977), Trudan was better than Piper in two of nine comparisons (boot, 1977 and 1978) and the two forages were similar in CP in the remaining comparisons. Sudax was significantly higher than S. Chow in two of nine cases (dough stage, 1977; boot, 1979) and S. Chow than Sudax in two of nine instances (boot, 1977; vegetative, 1979). The two forages were similar in CP content in the other instances. At all stages during the 3 years, Millex contained either the highest or one of the highest levels of CP. The CP content of FS 25A was either the lowest or one of the lowest at all stages of growth.

At all stages at Hutchinson, the CP contents of Piper and Trudan and of S. Chow and Sudax were quite similar. Millex contained the highest CP content at the boot stage in both years, but at the other stages, the CP content of Millex was either lower than or similar to that of the other forages. FS 25A contained the highest CP at the vegetative stage in 1977, but at the other stages it contained either the lowest or one of the lowest CP values.

At both locations, Piper and Trudan were similar in digestibility, with the latter being slightly more digestible. S. Chow and Sudax also were similar in digestibility. At all stages of maturity, Millex was either highest or one of the highest in IVDMD.

As forages advanced in maturity, ADF content usually increased significantly. However, at Manhattan, ADF was unchanged between the vegetative and boot stages (1978) and was significantly higher at the vegetative than at the boot stage (1979). At Hutchinson there was no significant difference in ADF between the vegetative and boot stages in 1979. Nuwanyakpa et al. (1982) found high correlations between ADF and IVDMD ($r = -0.95$) and between ADF and CP ($r = -0.96$). Thus, the higher ADF values at the vegetative stage compared with the boot stage at Manhattan in 1979 are unexpected and difficult to explain.

FS 25A contained the least fiber at the soft dough stage, while Millex contained the least fiber at the vegetative and boot stages. The two sudangrasses generally were similar in fiber content, as were the two sorghum sudangrasses. The higher IVDMD and lower ADF content of FS 25A is likely due to its high grain content. Nuwanyakpa (1979) ranked these six summer annuals for grain production as FS 25A ► Sudax ► S. Chow ► Trudan ► Piper and Millex.

At both locations, CP contents declined more rapidly than did IVDMD or ADF as harvesting was delayed. Between the vegetative and boot stages, the decline in CP at Manhattan ranged from 52 to 62% while the decline in IVDMD ranged from 5 to 24%.

ANIMAL PERFORMANCE

Trial 1. Performance of steers fed the four summer annual silage rations is shown in Table 20. Steers fed early-cut sudangrass and sorghum sudan silages and forage sorghum silage had similar gains, but efficiency of gain was slightly better for the forage sorghum silage rations. Steers fed late-cut sorghum sudan silage (soft dough stage) gained significantly slower, consumed less feed, and were significantly less efficient than steers fed any of the other three silage rations.

Trial 2. Performance of the steers after 42 days is shown in Table 20. Steers fed sorghum sudan hay consumed 16% more feed than steers fed the companion sorghum sudan silage and 5 to 17% more feed than steers fed the other three silages. Steers receiving forage sorghum silage made the fastest and most efficient gains and pearl millet, sudangrass and sorghum sudan silages supported similar cattle performance.

Trial 3. Performance of the calves is shown in Table 20. Calves fed forage sorghum silage outperformed those fed sorghum sudan silage or hay, and calves fed sudangrass hay had the poorest performance. Feed consumption averaged 25% higher for the two summer annual hay rations than for the two silage rations. However, the hays were used much less efficiently than the silages.

Trial 4. Performance of the lambs is shown in Table 21. Lambs fed sudangrass or sorghum sudan silages gained faster than those fed sudangrass or sorghum sudan hays. Feed consumption of pearl millet silage was greater than that of sudangrass or sorghum sudan silages. Lambs fed sudangrass silage were more efficient than those fed sudangrass or sorghum sudan hay, but lambs fed pearl millet hay were more efficient than those fed pearl millet silage.

Trial 5. Performance of the lambs fed the pearl millet silages and hays is shown in Table 21. Lambs fed boot stage hay had the fastest gain and highest feed consumption. Performance of lambs fed vegetative or boot stage silages was much better than that of lambs fed soft dough silage or hay. In general, feedlot performance for all lambs was rather low, but this was due largely to the extremely cold temperatures during the trial and to the unusually low feed consumption and digestibility of the dough-stage forages.

Additional information about these five animal performance trials is presented in Kansas Agricultural Experiment Station Reports of Progress 320, 336, 365, 377, and 413.

Table 20. Cattle performance from summer annual silages and hays, Manhattan.

	Stage of maturity					
	Vegetative-boot			Soft dough		
Forage	ADG*	DMI*	F/G*	ADG	DMI	F/G
Trial 1: 70 days; 1977-78; yearling steers						
Sudangrass silage	2.41	22.8	9.5	—	—	—
Sorghum sudan silage	2.43	22.5	9.3	1.71	19.3	11.8
Forage sorghum silage	—	—	—	2.41	20.0	8.6
Trial 2: 42 days; 1978-79; yearling steers						
Sudangrass silage	1.67	21.3	12.8	—	—	—
Pearl millet silage	1.57	21.9	13.8	—	—	—
Sorghum sudan silage	1.71	20.2	11.8	—	—	—
Sorghum sudan hay	1.76	23.1	13.2	—	—	—
Forage sorghum silage	—	—	—	2.43	19.0	8.2
Trial 3: 80 days; 1980-81; steer and heifer calves						
Sudangrass hay	1.26	16.4	13.0	—	—	—
Sorghum sudan silage	1.57	13.3	8.5	—	—	—
Sorghum sudan hay	1.56	17.3	11.0	—	—	—
Forage sorghum silage	—	—	—	1.78	13.7	7.7

*ADG means average daily gain (lbs.), DMI means dry matter intake (lbs.); F/G means lbs. of feed dry matter/lb. of gain.

Table 21. Lamb performance from summer annual silages and hays, Manhattan.

Trial 4: 35 days; 1977-78; feeder lambs at 55 lbs. initial weight.

	Boot stage of maturity		
Forage	ADG*	DMI*	F/G*
Pearl millet silage	.34	2.83	8.1
Pearl millet hay	.36	2.58	7.4
Sudangrass silage	.39	2.36	6.4
Sudangrass hay	.29	2.48	8.5
Sorghum sudan silage	.35	2.48	7.1
Sorghum sudan hay	.27	2.41	9.2

Trial 5: 42 days; 1978-79; feeder lambs at 71 lbs. initial weight.

	Stage of maturity								
Pearl	Vegetative			Boot			Soft dough		
millet	ADG	DMI	F/G	ADG	DMI	F/G	ADG	DMI	F/G
Silage	.10	2.34	26.2	.12	2.27	21.1	.06	1.90	32.8
Hay	—	—	—	.22	2.85	13.0	.04	2.08	58.6

*ADG means average daily gain (lbs.); DMI means dry matter intake (lbs.); F/G means lbs. of feed dry matter/lb. of gain.

Recommended Uses of Summer Annual Forages

With few exceptions, Millex produced the lowest DM yield in these studies (Table 22). It was also one of the three forages most adversely affected by frequent cutting. However, Millex had the highest CP and IVDMD at all stages of growth and the least fiber at the vegetative and boot stages, which was likely due to its higher leaf to stem ratio.

Forage sorghum regularly produced very low DM yields at the vegetative and boot stages, because its regrowth potential was intolerant of repeated harvesting. The CP content of forage sorghum was usually the lowest or one of the lowest at all stages of maturity. However, its digestibility was often the highest and its fiber content was the lowest at the soft dough stage because of its higher grain production.

Piper and Trudan were best suited to multiple cuttings and were similar in DM yields and overall nutritive value components. Of the two sorghum sudan hybrids, S. Chow was more adversely affected by frequent cutting at the vegetative and boot stages. These two forages also were taller than Piper, Trudan, and Millex. Kilgore (1975) reported that sorghum sudans are quite stemmy, with more than 50% of the forage weight being stems. This low leaf to stem ratio also extends the field wilting time needed for hay production from sorghum sudans.

Table 22. Dry matter, crude protein, and crude fiber contents of the summer annual forages fed in the animal feeding trials.

Trial	Forage	Stage of maturity	Dry matter	Crude protein	Crude fiber
			%	— % of the DM —	
Trial 1	Sudangrass silage	vegetative-boot	30.0	14.8	28.9
	Sorghum sudan silage	vegetative-boot	32.3	12.5	28.9
	Sorghum sudan silage	soft dough	39.5	6.5	33.0
	Forage sorghum silage	soft dough	28.0	9.1	26.9
Trial 2	Sudangrass silage	vegetative-boot	36.0	13.4	—
	Pearl millet silage	vegetative-boot	28.6	14.8	—
	Sorghum sudan silage	vegetative-boot	26.0	14.4	—
	Sorghum sudan hay	vegetative-boot	88.6	12.9	—
	Forage sorghum silage	soft dough	29.0	6.3	—
Trial 3	Sudangrass hay	vegetative-boot	90.5	12.0	25.0
	Sorghum sudan silage	vegetative-boot	32.4	14.7	27.8
	Sorghum sudan hay	vegetative-boot	90.1	12.5	25.9
	Forage sorghum silage	soft dough	28.8	9.4	25.3
Trial 4	Pearl millet silage	boot	26.8	19.3	26.0
	Pearl millet hay	boot	86.2	20.9	23.8
	Sudangrass silage	boot	25.8	17.8	28.2
	Sudangrass hay	boot	87.9	18.8	26.3
	Sorghum sudan silage	boot	34.2	14.8	26.8
	Sorghum sudan hay	boot	88.1	14.7	29.0
Trial 5	Pearl millet silage	vegetative	29.7	14.7	31.0
	Pearl millet silage	boot	33.4	11.8	30.0
	Pearl millet hay	boot	87.5	11.1	27.1
	Pearl millet silage	soft dough	34.4	7.3	35.2
	Pearl millet hay	soft dough	86.5	5.3	35.0

Previous recommendations were that sudangrass varieties and hybrid sudan, pearl millet, and sorghum sudan hybrids could be used for pasture, greenchop, hay, or silage while forage sorghum was best suited for silage. However, many of these recommendations were based solely on DM yields. Considering results from both agronomic characteristics and nutritive value components in these trials, sudangrass and pearl millet appear to be best suited for pasture (grazing) or hay and sorghum sudans and forage sorghum best for silage.

The decision to conserve summer annual forages as hay or silage will likely be determined by weather conditions, existing harvest equipment and storage facilities, farmer preference, and intended purpose (farm use or sale).

SUMMARY

Six summer annual forages, ‘Piper’ sudangrass, ‘Trudan 6’ hybrid sudangrass, ‘Sudax SX-11’ and ‘Super Chow Maker 235’ sorghum sudan hybrids, ‘Millex 23’ hybrid pearl millet, and ‘FS 25A’ hybrid forage sorghum, were grown in 1977, 1978, and 1979, at Manhattan and Hutchinson, and harvested at the vegetative, boot, and soft dough stages of maturity. At each harvest stage, the forages were compared for agronomic characteristics (growth rate, plant height, DM content and yield, and silage yield) and for nutritive value components (crude protein, *in vitro* dry matter digestibility, and acid detergent fiber).

Across years and forages, the first cuttings at the vegetative, boot, and soft dough stages were made at 37, 59, and 114 days; and 43, 71, and 104 days after planting at Manhattan and Hutchinson, respectively. Averaged across locations and years, the time intervals for the first cuttings at the vegetative, boot, and soft dough stages were, therefore, 40, 65, and 109 days after planting, respectively. These data indicate that *grazing of summer annuals should begin about 5 to 6 weeks after planting.*

At the vegetative stage, the rate of regrowth (days between successive cuttings) was similar for all forages (27 to 29 days). However, at the boot stage, rate of regrowth differed between the two locations, ranging from 32 to 49 days at Manhattan, and from 51 to 59 days at Hutchinson. The slower regrowth of forages at Hutchinson than at Manhattan may have been due to poorer moisture distribution at Hutchinson. At both locations, hybrid forage sorghum (FS 25A) had the slowest regrowth. FS 25A was also the most adversely affected by frequent cutting, followed by Millex and S. Chow.

Dry matter content increased with advancing forage maturity. Dry matter yield increased likewise, even though more cuttings were made at the vegetative stage. Across years and forages, the ranges in DM content were 20 to 25%, 23 to 28%, and 34 to 36%, for the vegetative, boot, and soft dough stages, respectively. The corresponding ranges in DM yield were 4.3 to 4.5, 6.0 to 6.4, and 6.6 to 8.8 tons/acre.

In contrast to DM content and yield, *nutritive value of the grasses was reduced by delayed harvesting.* Across years and locations, the ranges in crude protein (CP) contents were 13 to 18%, 10 to 13%, and 5 to 9%, for the vegetative, boot and soft dough stages, respectively. The corresponding mean values for *in vitro* dry matter digestibility (IVDMD) and acid detergent fiber (ADF) were 66, 63, and 56%; and 32, 34, and 38%, respectively.

The significant forage × stage × location × year interactions for the agronomic and nutritive value components measured indicate that *no forage was superior at both experimental sites for all characteristics.* In general, Piper and Trudan were similar in DM yield, IVDMD, CP, and ADF contents at all stages as were S. Chow and Sudax. The DM yields of Millex and FS 25A were frequently lower than the other forages at the vegetative and boot stages. The CP content of FS 25A was either the lowest or one of the lowest at all stages. On the contrary, the IVDMD of FS 25A was generally higher and ADF lower at the soft dough stage than were corresponding values for the other forages.

Considering both agronomic characteristics and nutritive value components, the *summer annual forages best suited for pasture (grazing) and for hay production* are pearl millet and sudangrass, *and for silage production,* hybrid forage sorghum and sorghum sudans. Primarily because of lower yield, summer annuals should not be harvested for silage or hay at the early vegetative stage.

Several feeding recommendations can be made from results of the three cattle trials and two lamb trials.

1. Forage sorghum silage made in the soft dough stage generally gave better cattle performance than the other three summer annual silages made in the vegetative or boot stage.

2. The overall feeding values of sudangrass, pearl millet, and sorghum sudan forages are similar when they are harvested in the vegetative or boot stage. However, harvesting and feeding any of these three summer annuals in the soft dough stage will likely result in poor rates and efficiencies of gain in cattle and lambs.

3. Hays and silages made from summer annuals harvested at the same maturity have similar overall feeding values for cattle and lambs. Hays tend to be consumed in greater amounts while silages tend to support more efficient gains.

4. Early harvested summer annuals will contain 1 1/2 to 2 times more crude protein (12 to 16%) than typical silages made from whole plant corn or sorghum (6 to 9%). Thus, considerably less supplemental protein needs to be fed in summer annual hay or silage rations.

5. The decision to conserve summer annual forages as hay or silage will likely be determined by weather conditions, existing harvest equipment and storage facilities, farmer preference, and intended purpose (farm use or sale).

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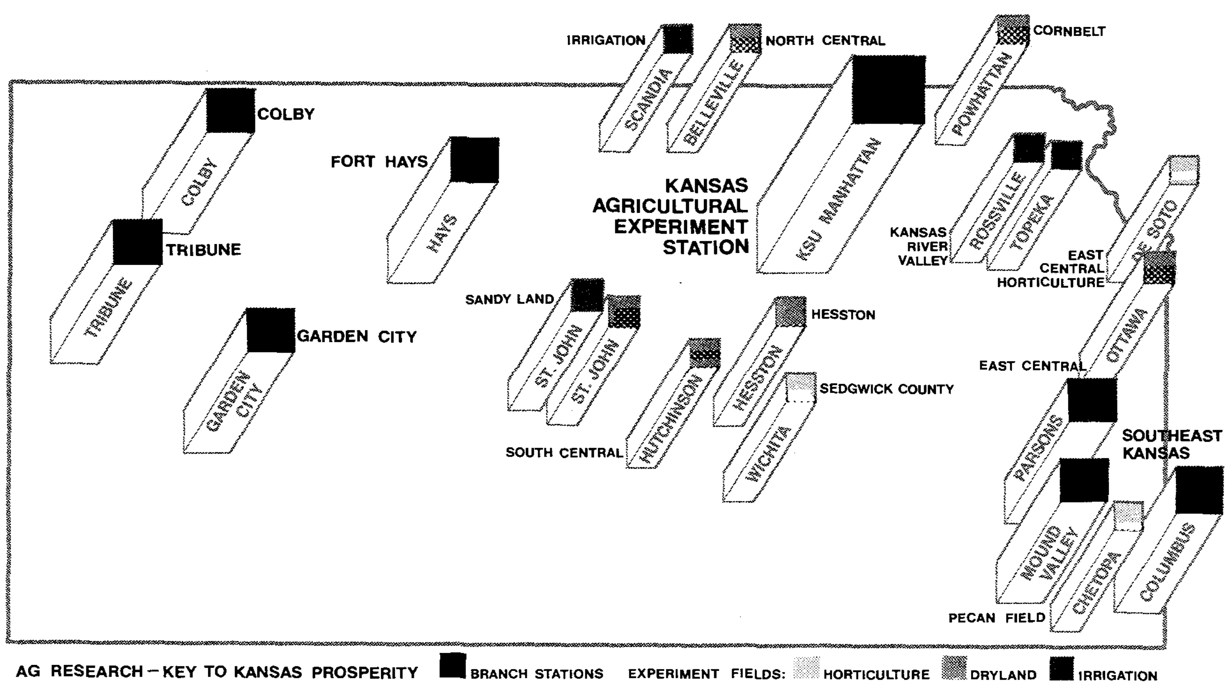

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