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Effect of Row Spacing on Sorghum-Sudan Forage Yield and Utilization by Dairy Cows

AGRICULTURAL EXPERIMENT STATION
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CONTENTS

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SORGHUM-SUDAN HYBRIDS are widely used as pasture for dairy cows. Thus, it is important to follow management practices that make best use of the forage produced. Smith, et al. *(6)* found no difference in yield and quality of forage and performance of lactating cows when continuous and rotational grazing were compared on a representative sorghum-sudan, seeded in 8-inch rows. However, there was considerable forage loss from lodging and trampling under both management systems. Because of these results, grazing trials were conducted at the Black Belt Substation of Auburn University Agricultural Experiment Station System in the summers of 1965, 1967, and 1968 to determine the effect of row spacing on lodging and trampling of sorghum-sudan forage by grazing cows. The forage treatments were compared with respect to carrying capacity, forage chemical composition, forage digestibility and intake, and lactation performance of grazing cows. Drought conditions during the summer of 1966 prevented test.

Since sorghum-sudan hybrids are similar in growth and yield characteristics *(4)*, DeKalb SX-11, used in previous grazing management studies, was selected as the representative sorghum-sudan hybrid for this study.

EXPERIMENTAL PROCEDURE

DeKalb SX-11 was planted in a prepared seedbed on Sumter clay in rows spaced 8, 16, and 24 inches apart to provide two 2-acre paddocks of each spacing each year. Seeding rate was 25 pounds per acre for all row spacings. Row spacing on paddocks was rotated each year. Phosphorus and potassium ferti-

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lization was according to soil test. All forage was topdressed shortly after emergence with a single application of 75 pounds of nitrogen per acre. Planting dates were June 9, 1965; April 27, 1967, and July 1, 1968 (1968 crop was replanted without additional fertilization after April 14 planting gave poor stand).

Grazing was begun when forage was approximately 20 inches in height. All forage treatments were grazed continuously for these periods: July 5-August 15, 1965; June 5-July 16, 1967; and August 5-September 15, 1968. The time interval from planting until the beginning of grazing was 26 days in 1965, 39 days in 1967, and 35 days in 1968. After dry weather in May, rainfall was abundant during June and July of 1967. Cold, wet conditions following seeding in 1968 resulted in poor stands. This required reseeding, as reported earlier, and delayed beginning the test.

Twelve lactating Holstein and Jersey cows from the Substation herd were assigned to the 6-week test each year. Following a 10-day standardization period during which all cows grazed a common forage, they were grouped according to level of milk production, stage of lactation and gestation criteria, and assigned at random to the row-spacing treatments. Two lactating cows were assigned to each paddock, along with one non-lactating cow (which received no concentrate) that was permanently assigned and used to determine forage digestibility at weekly intervals *(5)*. Additional non-lactating cows managed on the put-and-take system were used in determining carrying capacity of the forage treatments. Adjustments in the number of animals per paddock were made in an attempt to use all available forage while assuring that the test animals would have adequate forage throughout each test period.

All lactating cows were fed 1 pound of a concentrate mixture (16 per cent protein) for each 3 pounds of 4 per cent fat-corrected milk (FCM) produced daily during the standardization period. No adjustment in rate of concentrate fed was made during the experimental periods. Amount of concentrate fed and refused by each cow was measured daily, and milk production of each cow was weighed and recorded daily at both milkings. Milk fat content was determined by the Babcock method on 2-day composite samples at end of the standardization period and at 2-week intervals throughout each trial. Milk yield was converted to FCM by the Gaines' formula *(2)*.

Forage intake was measured during the second and final week of each test period by the chromogen-chromic oxide method *(3)*, using the permanently assigned lactating and non-lactating cows. Fecal grab samples were collected at approximately 6 a.m. and 6 p.m. on the 7th through 10th day of chromic oxide administration by balling gun (10-gram capsule per cow at 6 a.m. daily).

Forage samples were collected from each replication, within treatments, at 7-day intervals throughout each trial by the hand-pluck method. These samples were oven-dried, ground, and their chemical composition determined *(1)*. Degree of lodging of the sorghum-sudan hybrid within each treatment was determined visually at weekly intervals.

Body weight of each permanently assigned cow was obtained on 3 consecutive days at the end of the standardization period and at the end of the experimental period.

RESULTS

Carrying Capacity

Carrying capacity (cows per acre per day) for row spacings and years showed only small and non-significant variations among row spacings, Table 1. However, carrying capacity for 1965 and 1967 was significantly higher than for 1968. Apparently, the less vigorous growth of the forages during 1968 resulted from sparse rainfall combined with the late season. In addition, there was a longer period between nitrogen application and grazing in 1968 because of the replanting after topdressing.

TABLE 1. CARRYING CAPACITY OF SORGHUM-SUDAN FORAGES, BY ROW SPACING AND YEARS

Row spacing	Cows per acre per day			
	1965	1967	1968	Means for row spacing
	No.	*No.*	*No.*	*No.*
8 inches	2.01	2.12	1.73	1.95[a]
16 inches	1.98	2.25	1.80	2.01[a]
24 inches	2.05	2.30	1.56	1.97[a]
Means for years[1]	2.01[a]	2.22[a]	1.70[b]	

[1] Least significant difference between means for row spacings and for years, P = 0.05 is 0.28 and P = 0.01 is 0.52. C. V. = 5.38 per cent. Means with like superscripts are not significantly different.

Lodging and Trampling

More lodging and trampling occurred on the 8- and 16-inch row spacings than on the 24-inch rows. When plants reached a

height of 20 inches or more, rows became indiscernible in the 8- and 16-inch spacings, and cows grazed without respect to row direction. In contrast, rows on the 24-inch spacing remained distinct, and cows grazed primarily with the rows. Some trampling occurred on the 24-inch spacing, however, as cows traversed the rows.

Forage Chemical Composition

Row spacing did not alter crude protein or fiber content of the forage, but crude protein content differed among years, Table 2. Crude protein content of the forage in 1967 was higher than that grown in 1965 ($P < 0.05$) and 1968 ($P < 0.01$). Also, the 1965 forage was higher in crude protein ($P < 0.05$) than that grown in 1968. The longer time interval between nitrogen application and forage sampling in 1968 resulting from replanting the crop may have influenced the protein content of the 1968 forage to some degree. The seasonal decline in forage protein, shown by the trends plotted in Figure 1, is in agreement with numerous data reported in the literature.

The mean fiber content of the hand-plucked forage samples is given by treatments in Table 3 and illustrated by weeks within years in Figure 2. Comparisons among years were not made because the analytical method used in 1965 (acid detergent fiber) differed from that used in 1967 and 1968 (Weende). Acid detergent fiber determinations generally yield values 10-20 per cent higher than those obtained using the conventional Weende method. Fiber contents of the forages collected at weekly intervals during the respective years varied, while those for row spacings within years were similar.

TABLE 2. MEAN CRUDE PROTEIN CONTENT OF HAND-PLUCKED SORGHUM-SUDAN FORAGE SAMPLES, BY ROW SPACING AND YEARS

Row spacing	Crude protein, dry basis			
	1965	1967	1968	Means for row spacing[1]
	Pct.	*Pct.*	*Pct.*	*Pct.*
8 inches	17.4	18.7	15.2	17.1[a]
16 inches	16.6	19.1	15.3	17.0[a]
24 inches	16.7	19.4	13.7	16.6[a]
Means for years[1]	16.9[a]	19.1[b]	14.7[c]	

[1] Least significant difference between means for row spacing and for years, $P = 0.05$ is 1.74 and $P = 0.01$ is 3.28. C. V. = 3.96 per cent. Means with like superscripts are not significantly different.

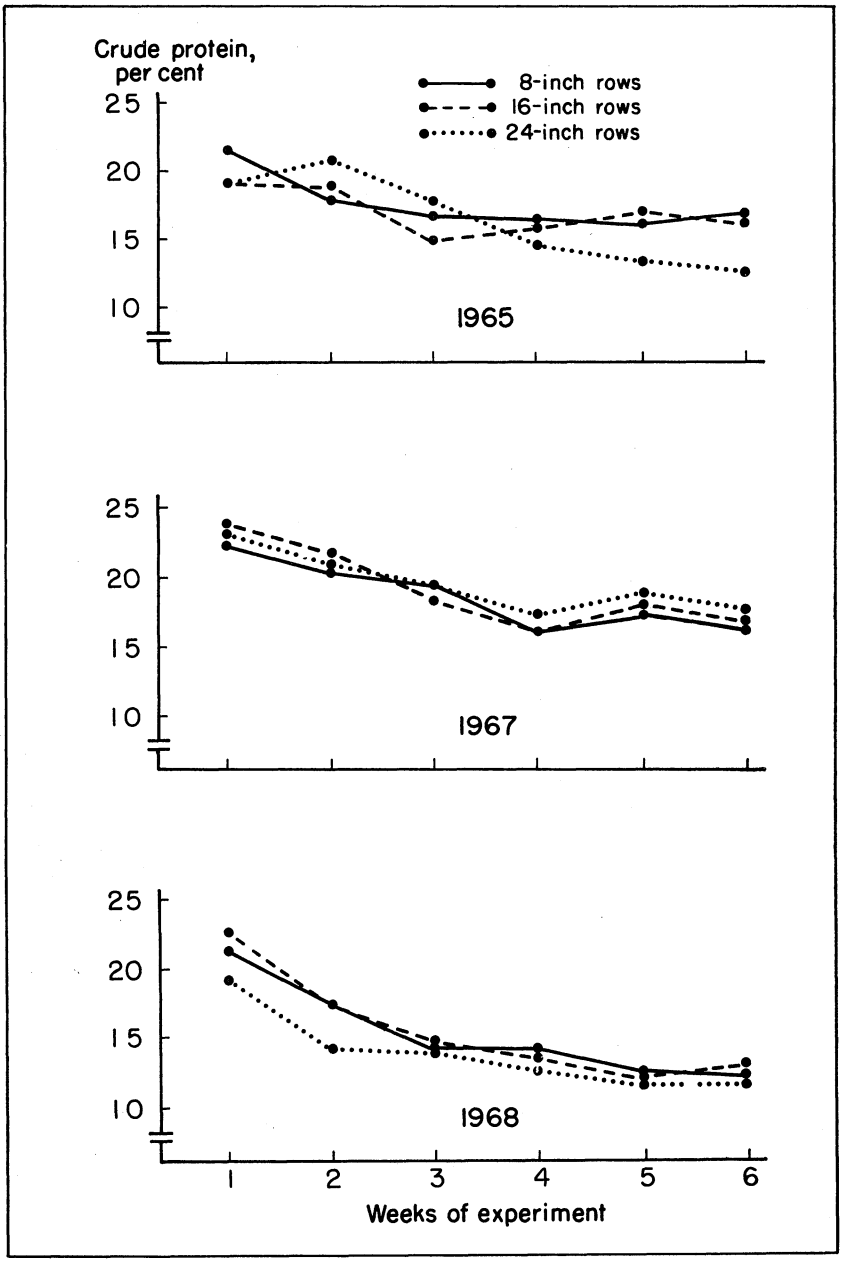

FIG. 1. Effect of row spacing on crude protein content of hand-plucked sorghum-sudan forage samples obtained at weekly intervals throughout the grazing periods (1965, July 5-August 15; 1967, June 5-July 16; 1968, August 5-September 15).

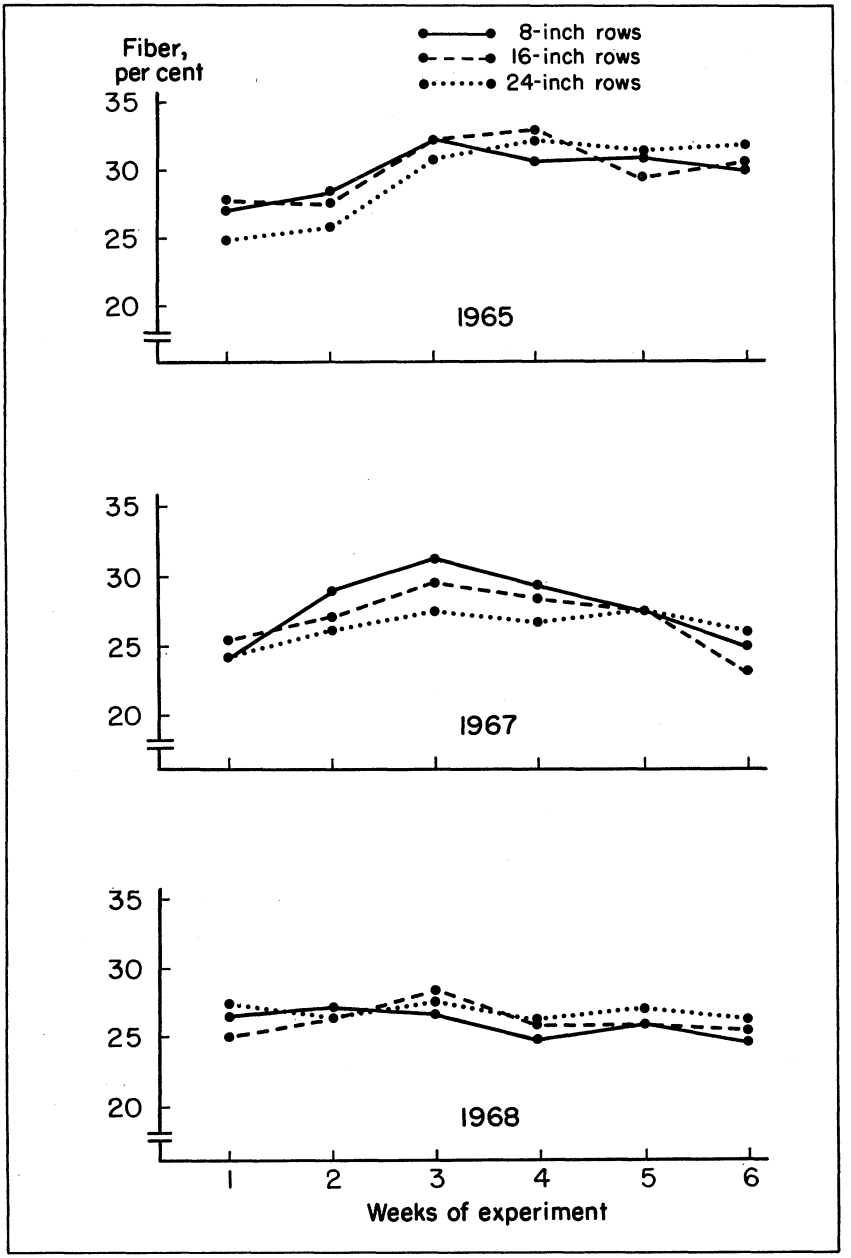

FIG. 2. Effect of row spacing on fiber content of hand-plucked sorghum-sudan forage samples obtained at weekly intervals throughout the grazing periods (1965, July 5-August 15; 1967, June 5-July 16; 1968, August 5-September 15).

TABLE 3. MEAN FIBER CONTENT OF HAND-PLUCKED SORGHUM-SUDAN FORAGE SAMPLES, BY ROW SPACING AND YEARS

Row spacing	Fiber, dry basis[1]			
	1965	1967	1968	Means for row spacing[2]
	Pct.	*Pct.*	*Pct.*	*Pct.*
8 inches	30.1	27.2	25.6	27.7[a]
16 inches	30.3	26.6	26.0	27.6[a]
24 inches	29.7	26.4	26.6	27.6[a]

[1] Values for 1965 determined by acid detergent method; for 1967 and 1968 by Weende method.

[2] Least significant difference between means for row spacings, P = 0.05 is 1.20 and P = 0.01 is 2.27. C. V. = 1.67 per cent. Means with like superscripts are not significantly different.

Forage Digestibility and Intake

Forage dry matter digestibility was not affected by row spacing, the 3-year mean for all treatments being approximately 65 per cent, Table 4. However, forage dry matter digestibility during 1968 was lower than in 1965 and 1967. Trends in forage dry matter digestibility determined weekly throughout the grazing periods show a decline as season advanced, Figure 3, which agrees with the general trend for maturing forage grasses.

TABLE 4. MEAN APPARENT DRY MATTER DIGESTION COEFFICIENTS FOR SORGHUM-SUDAN FORAGE, BY ROW SPACING AND YEARS

Row spacing	Digestion coefficients			
	1965	1967	1968	Means for row spacing[1]
	Pct.	*Pct.*	*Pct.*	*Pct.*
8 inches	66.4	66.8	62.0	65.1[a]
16 inches	67.4	66.6	61.8	65.2[a]
24 inches	66.4	66.0	61.6	64.7[a]
Means for years[1]	66.8[a]	66.5[a]	61.8[b]	

[1] Least significant difference between means for row spacing and for years, P = 0.05 is 0.75 and P = 0.01 is 1.05. Means with like superscripts are not significantly different.

Mean daily forage dry matter intake per hundredweight was not significantly different for the 8-, 16-, and 24-inch row spacings, Table 5. However, variability in intake among years was evident. Intake for 1965 was lower than in 1967 and 1968 ($P < 0.01$). There were no significant differences among row spacings in intake during the second and final weeks of each test period.

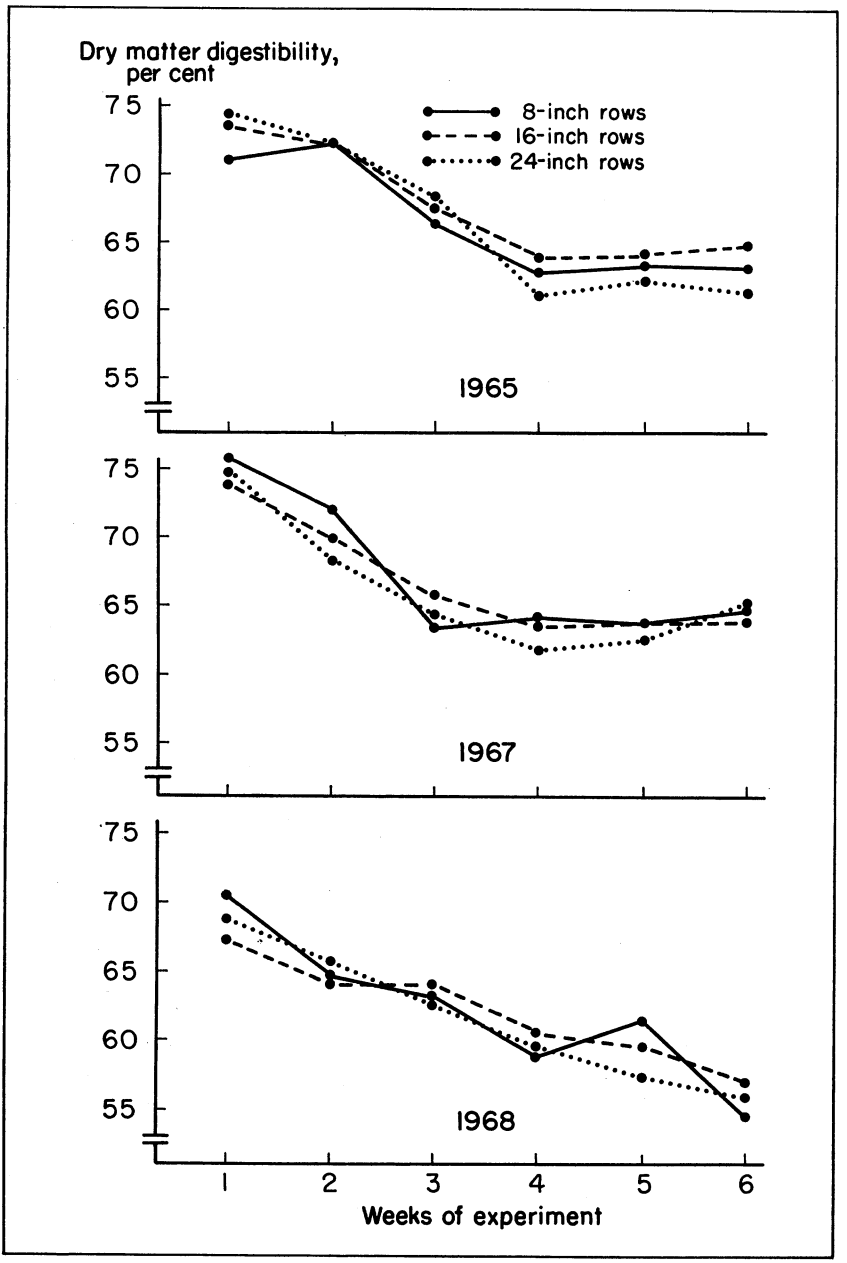

FIG. 3. Effect of row spacing on changes in apparent dry matter digestibility of sorghum-sudan forage throughout the grazing periods (1965, July 5-August 15; 1967, June 5-July 16; 1968, August 5-September 15).

TABLE 5. MEAN DAILY DRY MATTER INTAKE OF SORGHUM-SUDAN FORAGES BY LACTATING COWS

Row spacing	Intake per 100 pounds body weight			
	1965	1967	1968	Means for row spacing[1]
	Lb.	*Lb.*	*Lb.*	*Lb.*
8 inches	2.41	2.49	2.47	2.46[a]
16 inches	2.32	3.12	2.73	2.72[a]
24 inches	2.29	2.78	2.98	2.68[a]
Means for years[1]	2.34[a]	2.80[b]	2.73[b]	

[1] Least significant difference between means for row spacing and for years, P = 0.05 is 0.28 and P = 0.01 is 0.37. C. V. = 17.76 per cent. Means with like superscripts are not significantly different.

Milk Production

During the three grazing trials a total of 12 lactating cows completed a 42-day grazing period on each row spacing. Their lactation responses were evaluated on the basis of mean daily FCM production per cow and lactation persistency for the 42-day experimental periods. Lactation persistency is the mean daily FCM production for the entire 6-week period expressed as the per cent of that for the standardization period.

Mean daily FCM production data for the standardization periods and for each experimental period, along with lactation persistency, are summarized by treatment and years in Table 6.

TABLE 6. MEAN DAILY FCM PRODUCTION FOR THE STANDARDIZATION AND EXPERIMENTAL PERIODS AND LACTATION PERSISTENCY AS RELATED TO ROW SPACING AND YEARS

Row spacing	FCM produced daily			Lactation persistency[1]
	Standardization period	Experimental period	Adjusted means[1]	
	Lb.	*Lb.*	*Lb.*	*Pct.*
1965				
8 inches	40.6	39.2	39.0[a]	96.5[a]
16 inches	40.0	36.6	37.0[a]	91.5[a]
24 inches	40.7	39.9	39.6[a]	98.0[a]
1967				
8 inches	41.4	42.2	42.0[a]	102.1[a]
16 inches	40.5	40.5	40.8[a]	100.0[a]
24 inches	41.2	42.4	42.3[a]	103.0[a]
1968				
8 inches	46.9	41.1	40.7[a]	87.8[a]
16 inches	46.2	41.7	41.9[a]	90.1[ab]
24 inches	46.2	44.3	44.5[a]	95.9[b]

[1] Means within years with like superscripts are not significantly different, P = 0.05.

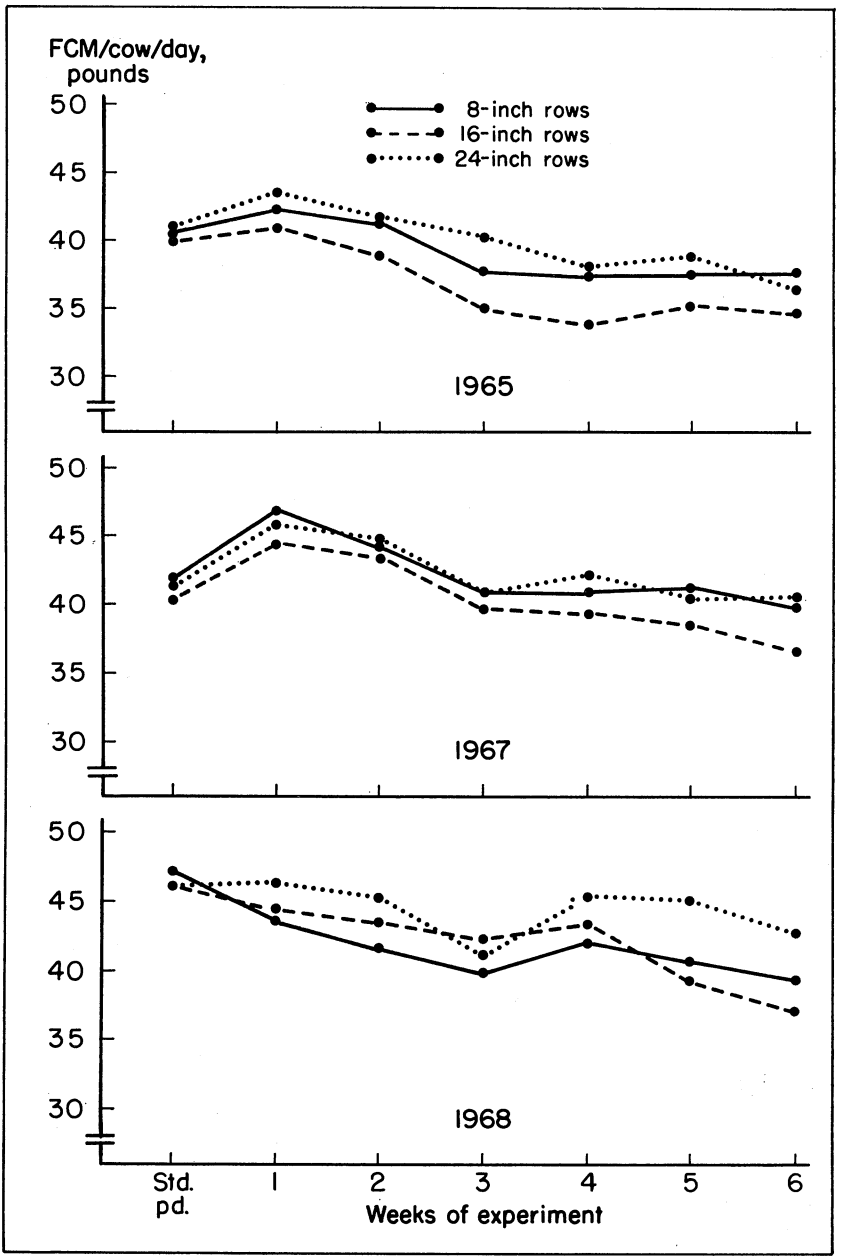

FIG. 4. Effects of row spacing on daily FCM production by weeks for lactating cows grazing sorghum-sudan forage. Grazing periods were: 1965, July 5-August 15; 1967, June 5-July 16; 1968, August 5-September 15.

TABLE 7. MEAN DAILY FCM PRODUCTION FOR THE STANDARDIZATION AND EXPERIMENTAL PERIODS AND LACTATION PERSISTENCY FOR THE THREE YEARS

Row spacing	FCM produced daily			Lactation persistency[1]
	Standardization period	Experimental period	Adjusted means[1]	
	Lb.	*Lb.*	*Lb.*	*Pct.*
8 inches	42.9	40.8	40.6^{ab}	95.7^{ab}
16 inches	42.2	39.6	39.9^{a}	93.9^{b}
24 inches	42.7	42.2	42.1^{b}	99.1^{a}

[1] Least significant difference between means for milk production, P = 0.05 is 1.83 and C. V. = 5.1 per cent; for persistency, P = 0.05 is 4.47. Means with unlike superscripts are significantly different.

When adjusted by convariance analysis to take into account levels of production during the standardization periods, FCM production associated with row spacings within years did not differ ($P > 0.05$). However, over the three test periods the cows grazing the 24-inch row spacing produced significantly more FCM daily ($P < 0.05$) than the cows grazing 16-inch rows, Table 7. Other comparisons were not different ($P > 0.05$).

Lactation persistency among row spacings and years, Table 6, ranged from a low of 87.8 to a high of 103.0 per cent. For comparison, the normally accepted lactation persistency range is 93-94 per cent for a 28-day period. Production persistency of cows grazing the 16-inch spaced forage was below "normal" in two of the three tests, whereas on the 8-inch treatment it was low one year. During 1967, a year of abundant rainfall during the June 5-July 16 grazing period, persistency was high on all row spacings. These rather unusual values were the result of a marked increase in milk production when the cows were changed from the standardization to the experimental forage. The 3-year average lactation persistencies for the 8-, 16-, and 24-inch row spacings are given in Table 7. Persistency of cows grazing the 24-inch row spacing was higher ($P < 0.05$) than that of cows on the 16-inch treatment.

The mean daily FCM data for the standardization and experimental periods by weeks, presented graphically in Figure 4, clearly depict the magnitude of differences among row spacings and years, particularly with respect to the grazing periods.

Body Weight Change

There were no differences in body weight changes with respect to treatments. Gain or loss in weight was quite variable among

TABLE 8. MEAN WEIGHT CHANGE PER ANIMAL AND THE RANGE AMONG ANIMALS, BY ROW SPACING AND YEARS

Row spacing	Body weight change					
	1965		1967		1968	
	Mean	Range	Mean	Range	Mean	Range
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
8 inches	22	−5 to +47	5	−15 to +14	2	−40 to +30
16 inches	8	−7 to +63	14	−12 to +55	−14	−40 to +25
24 inches	−3	−50 to +47	19	−2 to + 65	−11	−58 to +25
Mean	9		13		−8	

lactating cows within row spacings in all years. The mean weight gain or loss per animal and the range among animals by row spacings and years is given in Table 8.

Relationships Studied

Relationships between certain criteria and animal performance were evaluated by simple correlation analysis, Table 9. Significant positive relationships existed between forage dry matter intake and FCM production, and between forage digestible dry matter and forage crude protein per cent. These relationships are as normally expected. Other correlations were not significant ($P > 0.05$).

TABLE 9. RELATIONSHIP BETWEEN CERTAIN CRITERIA AND PERFORMANCE OF LACTATING COWS AS INDICATED BY CORRELATION ANALYSIS

Relationship evaluated[1]	Correlation coefficients	Variance associated with criteria[2]
	r	*Pct.*
Dry matter intake and carrying capacity	0.009	0.008
Dry matter intake and crude protein (pct.)	0.055	0.3
Dry matter intake and digestible dry matter (pct.)	−0.299	8.9
Dry matter intake and FCM (lb.)	0.675[3]	45.6
Digestible dry matter and crude protein (pct.)	0.680[3]	46.2
FCM (lb.) and crude protein (pct.)	−0.475	22.6
FCM (lb.) and digestible dry matter (pct.)	−0.607	36.8

[1] Dry matter intake, crude protein, and digestible dry matter refer to forage only.
[2] Variance associated with criteria = $r^2 \times 100$.
[3] P, 0.05 = 0.632.

ECONOMIC APPRAISAL

There were no economic differences in the agronomic practices for the various row spacings. Therefore, an economic appraisal

is confined to milk production on a per acre basis. Daily returns per acre for the respective treatments were calculated using the 3-year adjusted means for daily milk production, Table 7, the mean daily carrying capacity, Table 1, and a blend-price value of $6.50 per hundredweight of milk. Such calculations reveal a return per acre per day for milk of $5.15, $5.21, and $5.39 for the 8-, 16-, and 24-inch row spacings, respectively. While these differences are small, they would accumulate to noticeable differences in economic return per acre among the respective row spacings, and could amount to sizeable returns where large acreages are grown.

SUMMARY

Grazing trials were conducted at the Black Belt Substation in the summer of 1965, 1967, and 1968 to determine effect of row spacing on lodging and trampling of sorghum-sudan forage by grazing cows, and to compare the forage treatments with respect to carrying capacity, forage chemical composition, forage digestibility and intake, and lactation performance of grazing cows.

Lodging and trampling were less on 24-inch than on 8- and 16-inch row spacing, but row spacing had no effect on carrying capacity, chemical composition, digestibility and intake of the forage, or on body weight change of grazing animals. For the 3-year period, milk production and lactation persistency of cows grazing the 24-inch row spacing were significantly higher ($P < 0.05$) than that of cows grazing the 16-inch row spacing.

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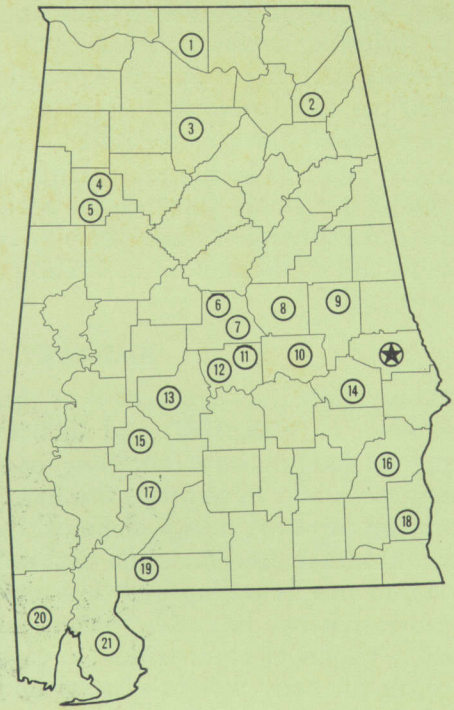

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.