BULLETIN 389 APRIL 1969

MANAGING JOHNSONGRASS FOR DAIRY COWS

Relative Efficiency of Several Methods of Utilizing Forage Determined in Alabama Research

Agricultural Experiment Station
AUBURN UNIVERSITY
E. V. Smith, *Director* Auburn, Alabama

CONTENTS

First Printing 3.5M, April 1969

MANAGING JOHNSONGRASS FOR DAIRY COWS

Relative Efficiency of Several Methods of Utilizing Forage Determined in Alabama Research

GEORGE E. HAWKINS, *Professor of Dairy Science*
L. A. SMITH, *Superintendent, Black Belt Substation*
HAROLD GRIMES, *Assistant Superintendent, Black Belt Substation*
R. M. PATTERSON, *Professor, Research Data Analysis*
J. A. LITTLE, *Instructor of Dairy Science*
C. A. ROLLO, *Associate Professor of Agricultural Engineering*

IN RECENT YEARS the number of dairy herds in Alabama has decreased while average herd size was increasing. Increases in herd size have created the need for more efficient ways of utilizing forage crops than by conventional pasturing.

Johnsongrass is an important forage crop occupying an estimated 200,000 acres in the Black Belt area of Alabama. Previous work has shown that management practices that deplete root reserves in late summer or early autumn tend to decrease forage yield and persistency of johnsongrass stands. The 4-year study reported here compared the effects of continuous grazing, 1-day strip grazing, rotational grazing, and soiling (green chopping) of johnsongrass forage on: (1) chemical composition, intake, and digestibility of the forage by dairy cows, and (2) productivity of the forage as indicated by carrying capacity (cow days per acre) and milk production of cows utilizing the forage.

GENERAL EXPERIMENTAL PROCEDURES

The study was conducted at the Black Belt Substation, using a balanced incomplete block design. Three of the four systems of management (continuous grazing, 1-day strip grazing, rotational grazing, and soiling) were compared each year, Table 1. There was a total of six replications for each system during the 4-year experiment. The johnsongrass was fertilized with about 30 pounds of P (75 pounds P_2O_5), 60 pounds K (75 pounds K_2O), and 50 pounds N per acre annually. The P and K fertilizer was applied to a winter legume during the fall preceding each test. Starting

TABLE 1. SIZE OF PADDOCK ALLOCATED AND METHODS OF UTILIZING JOHNSONGRASS DURING EACH OF FOUR YEARS, BLACK BELT SUBSTATION

Year	Land area per paddock[1], by management method			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Acres	*Acres*	*Acres*	*Acres*
First	2.50	1.70	----	1.70
Second	2.50	----	1.70	1.70
Third	2.50	1.70	1.70	----
Fourth	..	1.675	1.675	1.45

[1] There were two paddocks per method of utilization each year in which each system was evaluated.

date of the study was determined each year by the availability of forage on experimental paddocks (when it reached a height of approximately 15 inches). The beginning dates for the 4 years were June 14, May 18, July 28, and June 15, respectively. Because of shortage of forage, the fourth year's test consisted of two phases, June 15 to July 13 and July 28 to August 24.

In this report the methods of utilizing johnsongrass forage are defined as follows: (1) **Continuous grazing**—cows were confined to the assigned paddock throughout the experimental period and had access to the entire paddock at all times. (2) **One-day strip grazing**—the cows were allowed a new strip of fresh grass each day and were confined to the strip by an electric fence. To provide all the forage the cows would eat and still minimize waste, area of the strip was varied according to quantity of forage available and ranged from 1,000 to 1,760 square feet per cow per day. (3) **Rotational grazing**—paddocks were divided into four subpaddocks of equal size. Cows grazed each subpaddock 6 to 7 days, depending on amount of forage available, and then were rotated to the next subpaddock. (4) **Soiling**—the johnsongrass forage was cut daily with a forage chopper set for a cut of about 1 inch in length and fed to the assigned cows. The cows were fed slightly more than they ate to assure that intake would not be limited by the quantity fed. Except during the first year, growth accumulation on the subareas representing one-fourth of each paddock was clipped about 4, 3, 2, or 1 week(s) before the tests were begun. The pre-test clippings were made to ensure near uniform maturity of forage as fed or grazed.

Experimental Animals

Cows, mainly of Jersey breeding, in the Black Belt Substation dairy herd were used as test animals. Most were in the middle to

TABLE 2. MEAN BODY WEIGHTS OF EXPERIMENTAL COWS DURING FOUR TEST YEARS

Year	Mean weight, by management system			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Lb.	*Lb.*	*Lb.*	*Lb.*
First	821	862	------	802
Second	852	------	824	826
Third	889	831	882	------
Fourth	------	899	918	898
Means	854	864	875	842

late stage of lactation and up to the fifth month of gestation at the start of each year's 8-week test period. Average daily production of 4 per cent fat-corrected milk (FCM) per cow at the start of the tests was 31.8 pounds, and the range was 20.4 to 48.1 pounds.

Within years the cows assigned to the different methods of utilizing johnsongrass forage were balanced as evenly as practicable on the basis of body size, Table 2, stage of gestation, and daily level of FCM production during the 10 to 14 days of standardization preceding the test. The number of lactating cows assigned to each experimental paddock of johnsongrass forage varied from two to three. Therefore, milk yields from only the two highest producers per paddock were used to evaluate lactation responses. When forage was adequate, non-lactating cows were added and used in the digestion trials for comparing digestibility of forage consumed by lactating cows (fed grain) and non-lactating cows (fed no grain).

Feeding and Management of Experimental Cows

Cows assigned to the experiment had access to johnsongrass forage at all times except during the two milking periods daily. With one exception, the cows were fed 1 pound of concentrate daily during the 56-day tests for each 5 pounds of FCM they had produced daily during the 10- to 14-day standardization period. The one exception was during the first year, when the concentrate allowance was reduced 6 per cent during the second 28 days of the test.

Water and shade were available in each grazing paddock and in each lot used for cows assigned to the soiling treatment. Alleys were provided to permit cows on 1-day strip grazing or rotational grazing to return for shade or water as desired.

Sampling and Analyses

Milk produced at each milking throughout the standardization and experimental periods was weighed and recorded. Fat content of milk from individual cows was determined by the Babcock method on 2-day composites at 2-week intervals. Milk yields were converted to 4 per cent FCM by the Gaines *(8)* formula, i.e., 4 per cent FCM = (0.4 $\times$ pounds of milk) + (15 $\times$ pounds of milk fat).

Forage from each test paddock was sampled periodically for chemical composition and total growth by caging or by the mower strip method. Studies of chemical composition of forage by years included: first year—none; second year—proximate analysis and lignin; third year—proximate analysis; and fourth year—crude protein. Proximate analysis and lignin were determined by procedures described in Official Methods *(1)*.

Intakes and digestibilities of forages were determined by the ratio method employing chromogen *(25)* and chromium sesquioxide *(4,19)*. A 6-day preliminary feeding of chromium sesquioxide preceded a 4-day collection of feces from all cows in each management group. Feces were collected by the grab method between 6 and 7 a.m. and between 3 and 4 p.m. During the 10-day intake and digestion trials a chromium sesqui-oxide capsule, commercially filled as containing 10 grams, was administered between 6 and 7 a.m. daily to each cow. For the first year, chromium sesqui-oxide concentration in a 4-day composite of feces from each cow was determined by the method of Bolin *(4)* and for subsequent years by the method described by Kimura and Miller *(19)*. Chromogens in the feces were measured by the procedure developed by Reid, et al. *(25)*.

RESULTS AND DISCUSSION

Within-year comparisons of crude protein, crude fiber, and lignin contents of johnsongrass forage available for grazing are presented in Figures 1, 2, and 3, respectively. In addition, the average proximate composition of forage before and after strip and rotational grazing and from caged and non-caged areas on the continuous grazing paddocks is given in Table 3.

During each year for which data are available, the crude protein content of forage available for grazing or soiling decreased

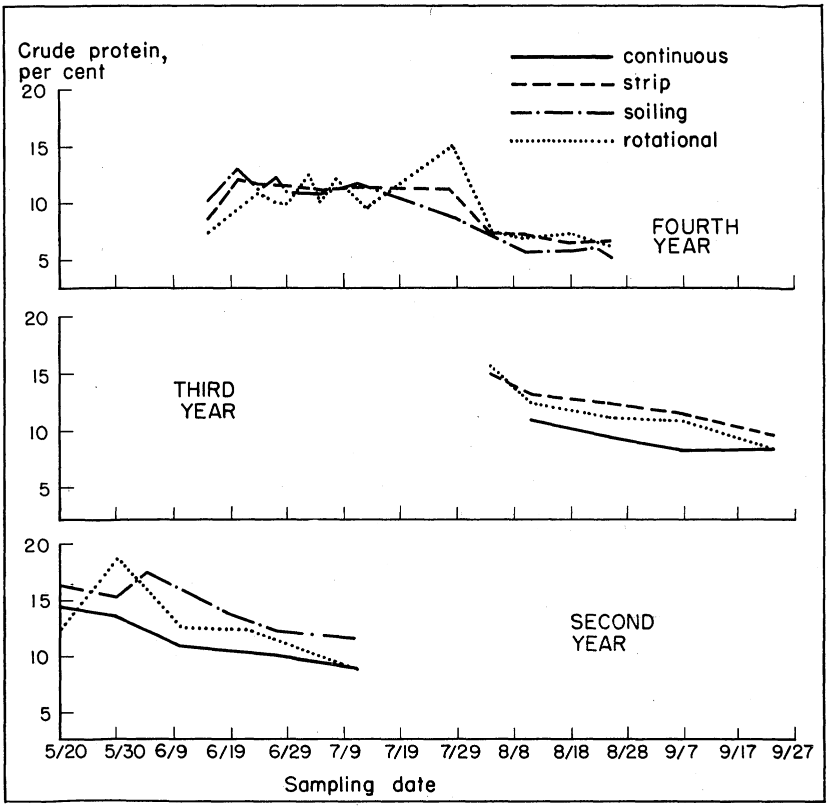


FIG. 1. Crude protein content of johnsongrass forage available for grazing at different dates under the four systems of management.

as the season progressed, Figure 1. Comparisons within the second and third years showed that crude protein content of continuously-grazed johnsongrass forage dry matter averaged lower than that of rotational grazing, strip grazing, or soiling. There was no clear-cut difference in crude protein content of the forage during the fourth year, that could be attributed to method of forage utilization.

Within the second and third years of the test, the crude fiber content of continuously-grazed forage usually was highest and that of strip grazed or soilage johnsongrass usually was lowest, Figure 2. During both years, forage crude fiber content increased as the season progressed.

The lignin content (dry matter basis) of johnsongrass forage available for grazing on the continuously-grazed paddocks in-

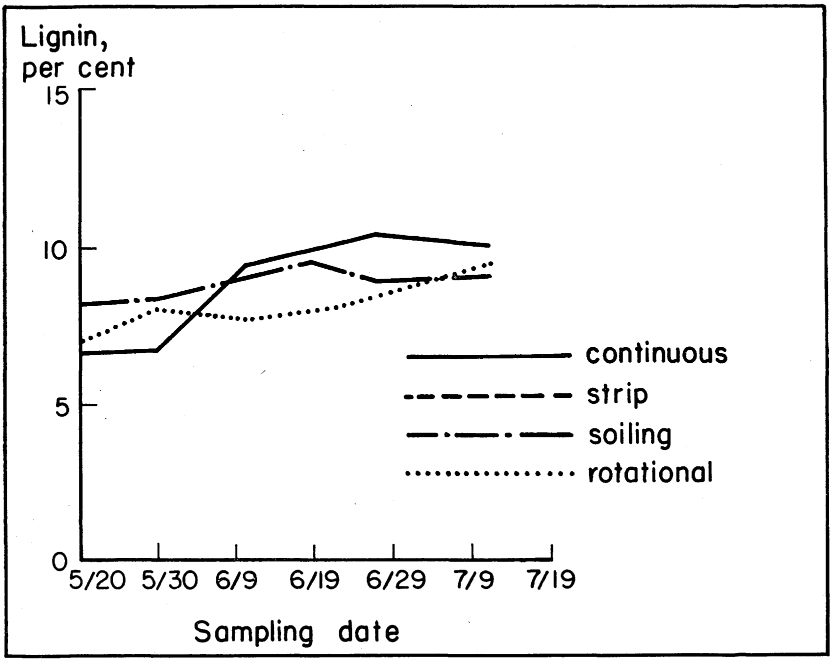


FIG. 2. Lignin content of johnsongrass forage available for grazing at different dates under the four management systems.

creased from 6.6 per cent on May 20 to 10.1 per cent on July 12, Figure 3. During this same interval, rotationally-grazed forage increased from 7.0 to 9.6 per cent lignin, and that of johnsongrass cut and fed green from 8.3 to 9.4 per cent.

Forage available for continuous grazing was lower in quality than that from strip or rotational grazing or soiling, and quality deteriorated as the grazing period progressed, Figures 1, 2, 3. Data in Table 3 show that forage crude protein was higher and crude fiber lower in caged areas than on grazed areas of continuously-grazed johnsongrass. Similarly, forage crude protein percentages were higher and crude fiber percentages were lower before than after strip or rotational grazing. Thus, data in Table 3 show that the cows selectively grazed the forage containing the highest percentage of crude protein and lowest percentage of crude fiber. This selective grazing of johnsongrass is similar to results reported by Guthrie, et al. *(10)* and Hardison, et al. *(12)* in which forage consumed by cattle was higher in quality than the average of total herbage available for grazing.

The small differences in crude protein and crude fiber per-

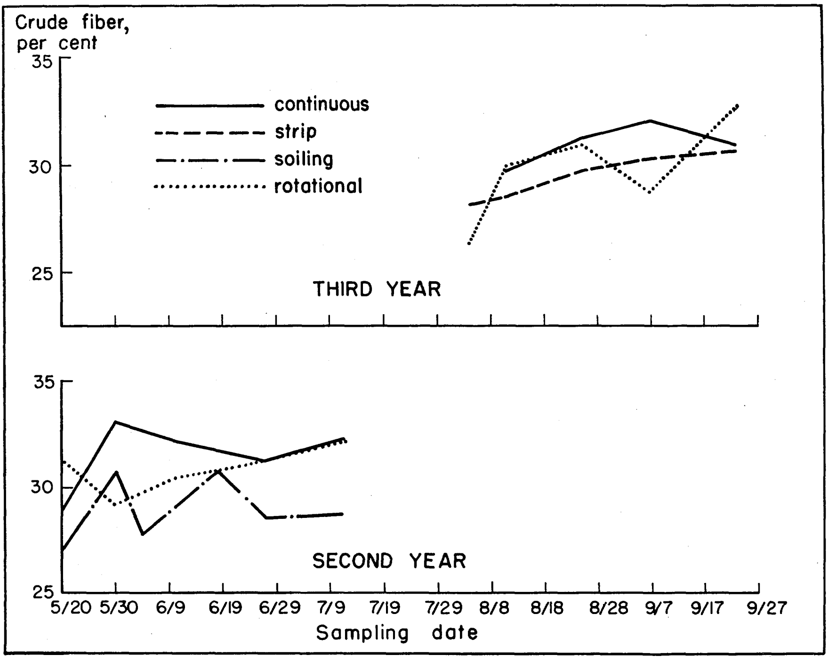


FIG. 3. Crude fiber content of johnsongrass forage available for grazing at different dates under the four systems of management.

centages of forage associated with method of using johnsongrass should not be considered as reflecting true differences in the composition of forage consumed. As shown in Figure 4, cows grazing johnsongrass in strips selectively ate the leaves and left the stems.

TABLE 3. MEAN COMPOSITION OF FORAGE, DRY MATTER BASIS, BEFORE AND AFTER GRAZING DURING THE THIRD YEAR AS RELATED TO METHOD OF JOHNSONGRASS UTILIZATION

Forage component	Mean content, before and after grazing					
	Continuous grazing[1]		Strip grazing[2]		Rotational grazing[2]	
	Caged	Grazed	Before	After	Before	After
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Crude protein	11.0	9.4	12.5	10.8	12.5	10.6
Ether extract	2.6	2.5	2.7	2.4	2.6	2.5
Crude fiber	30.7	31.0	29.1	29.7	29.8	30.9
Nitrogen-free-extract	49.9	51.4	50.0	51.4	50.1	50.1
Ash	5.8	5.7	5.7	5.7	5.7	6.1

[1] Forage from caged area was not available to cows but that from grazed area was available until the sample was taken.
[2] Before and after refer to time of sampling in relation to time the areas were grazed.

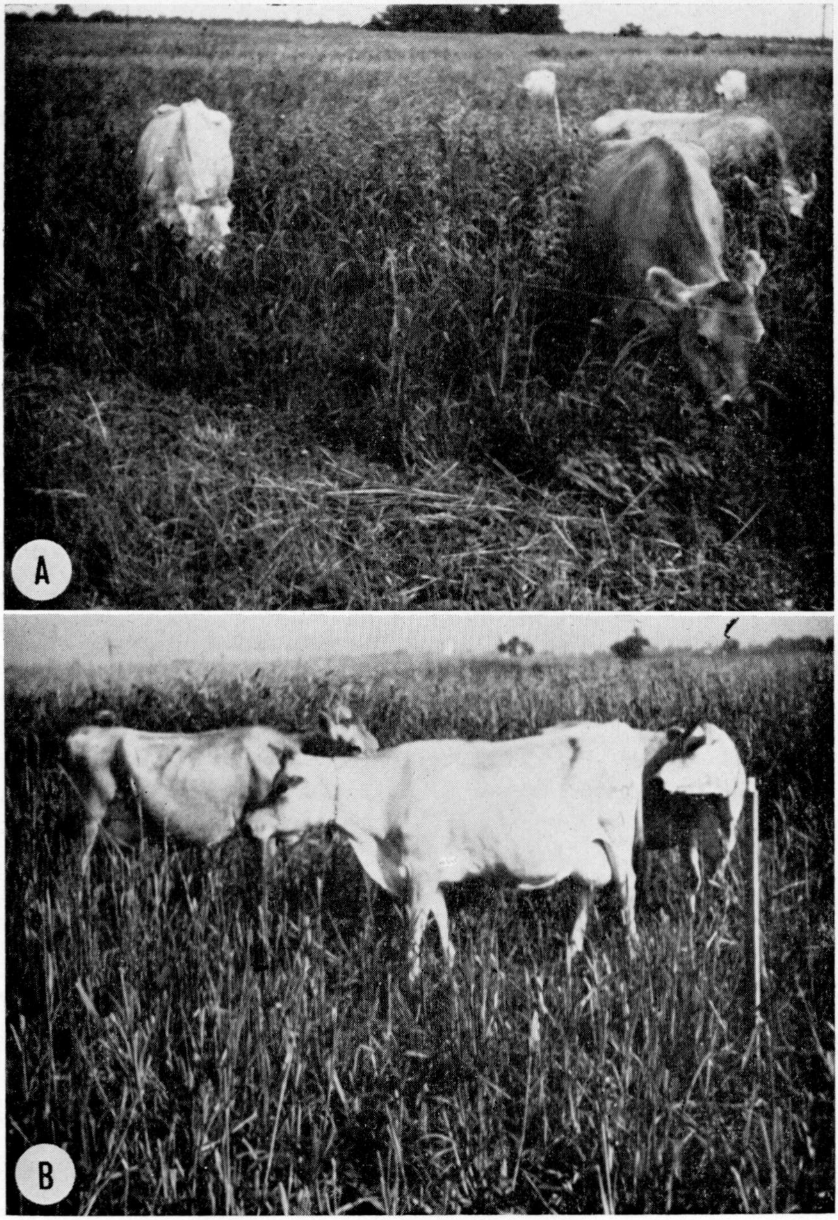


FIG. 4. Strip-grazed johnsongrass paddock during third week of the test, first year: (A) early in the day, and (B) near end of the day.

FIG. 5. This rotationally-grazed johnsongrass, shown after 5 days of grazing in the second-year test, illustrates how cows grazed selectively.

Cows grazing johnsongrass rotationally, Figure 5, or continuously, Figure 6, nipped the tops of the plants, but did not completely denude the stem as was observed for the strip grazing treatment. Thus, both the uneaten leaves and stems of continuous and rotationally-grazed johnsongrass continued to mature and probably accounts for the small differences in composition shown in Table 3.

TABLE 4. MEAN COMPOSITION OF JOHNSONGRASS FORAGE DRY MATTER AVAILABLE FOR GRAZING OR SOILING AS RELATED TO METHOD OF UTILIZATION DURING THE FINAL THREE YEARS OF THE EXPERIMENT

Forage component	Mean forage composition			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Pct.	*Pct.*	*Pct.*	*Pct.*
Crude protein	10.7	11.1	11.4	11.9
Ether extract	2.3	2.7	2.5	2.6
Crude fiber	31.3	29.1	30.4	29.0
Nitrogen-free-extract	49.4	51.4	49.5	49.3
Ash	6.3	5.7	6.2	7.2
Lignin	8.70	----	8.73	8.93

FIG. 6. Johnsongrass grazed continuously is shown during different periods of the test: (A) at beginning, (B) near middle, and (C) near end.

There was a 1.2 per cent range in crude protein and a 2.3 per cent range in crude fiber content of forage available for grazing or soiling during the last 3 test years, Table 4, but these differences probably do not reflect the quality of forage eaten by the cows. The average composition of forage available for soiling was similar to that of the soilage eaten, since the cows apparently were unable to select out the leaves and refuse the stems of the chopped forage.

The general quality of forage available for soiling is illustrated in Figure 7. During the first year some of the forage used for soiling had reached shoulder height and was blooming, Figure 7C. Regrowth on soiling during the first year, Figure 7A, was not adequate for cutting until the seventh and eighth weeks of the test. For the second and fourth years, excessive maturity of soiling forage was avoided by clipping subareas of the paddocks at 4, 3, 2, or 1 week(s) before the expected date of starting the test. As indicated by data in Table 4, the pre-test clipping of soiling areas controlled the maturity of forage available for chopping and feeding to the test cows. In summary, chemical composition data on the johnsongrass available for use by the four methods of management suggest that the continuously-grazed forage was the lowest in quality.

In contrast to the chemical composition data, digestibility data show that the johnsongrass selected by cows on paddocks continuously grazed was equal or superior to that of forage eaten on strip or rotationally-grazed paddocks and superior to that from the soiling method, Table 5. Although the differences were nonsignificant for years in which direct comparisons could be made, the digestibility of both continuously and rotationally-grazed

TABLE 5. DIGESTIBILITY OF FORAGE DRY MATTER AS RELATED TO METHOD OF JOHNSONGRASS UTILIZATION

Year	Forage digestibility			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Pct.	*Pct.*	*Pct.*	*Pct.*
First	63.0	62.8	----	54.3
Second	65.3	----	64.9	58.7
Third	62.4	61.6	63.7	----
Fourth	----	59.8	61.2	55.9
Means	63.6	61.4	63.3	56.3
Adj. means[1]	63.1[a]	62.1[a]	63.1[a]	56.2[b]

[1] Means were adjusted to take into account the year effects. Values followed by unlike superscripts differ significantly ($P < 0.05$).

FIG. 7. Soilage johnsongrass illustrating problem of maintaining high quality, immature forage: (A) 3½ to 5 weeks recovery since first chopping, (B) third week of first year, and (C) too mature for soiling, end of eighth week.

forage averaged slightly higher than that of strip-grazed forage. The consistency of these small differences suggest that the cows on continuous and rotational grazing were more selective in the forage eaten than cows on strip grazing. These apparent differences in selective grazing are similar to those observed by others *(5,12,24)* in which the degree of selective grazing increased as the area available per cow increased. The low digestibility values for the soiling treatment are striking contrasts to the high digestibility of johnsongrass that was continuously, rotationally, or strip grazed, and these differences reflect an absence of selectivity in chopped forage eaten by the cows. The similar digestibility of johnsongrass forage dry matter by continuous and rotational grazing cows follows the same trend as results obtained with continuous and rotational grazing of Coastal bermudagrass *(13)*.

The 4-year adjusted mean daily intake of johnsongrass forage dry matter per 100 pounds of cow body weight did not differ significantly, Table 6. It ranged from 2.58 pounds for those on the continuous grazing treatment to 2.73 pounds for those on 1-day strip grazing. The lack of a detectable difference in johnsongrass forage dry matter intake differs from findings with a sorghum-sudan hybrid, another tall-growing plant, in which cows grazing continuously consumed more forage than those grazing rotationally *(21)*. Levels of forage dry matter intake, given in a preliminary report *(14)*, appeared to be unusually high. Comparison of forage dry matter intake determined from chopped forage fed and refused by the soiling group showed that the ratio method overestimated intakes for the second and fourth years. The apparent cause of this earlier overestimation of intake was

TABLE 6. MEAN DAILY FORAGE DRY MATTER INTAKE PER COW PER 100 POUNDS OF BODY WEIGHT, DETERMINED BY RATIO TECHNIQUE, AS RELATED TO METHOD OF JOHNSONGRASS UTILIZATION

Year	Intake per 100 pounds of body weight			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Lb.	*Lb.*	*Lb.*	*Lb.*
First	2.8	2.7	----	2.6
Second	2.5	----	2.7	2.7
Third	2.6	2.8	2.9	----
Fourth	----	2.7	2.5	2.4
Means	2.63	2.67	2.70	2.57
Adj. means[1]	2.58	2.73	2.72	2.60

[1] Means were adjusted to take into account the year effects. There were no significant differences ($P > 0.05$).

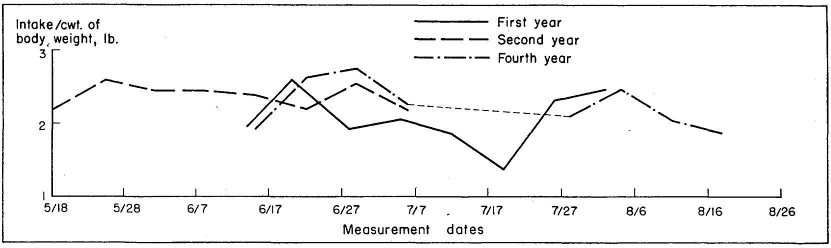


FIG. 8. Mean daily intake of freshly chopped johnsongrass forage dry matter by cows per 100 pounds of body weight.

incomplete oxidation and recovery of the chromium sesqui-oxide indicator in the feces. The intake values have been recalculated with appropriate correction factors, Table 6, and give a valid comparison of relative intakes as affected by method of forage utilization.

As shown in Figure 8, the measured intake of johnsongrass forage dry matter by cows (per 100 pounds of body weight) decreased at an essentially linear rate as each experimental period progressed. Increasing maturity of the first-year soiling forage, from the first through the sixth week, is reflected in the progressive decrease in forage intakes from the second through the sixth week. Also, the relatively high intake of regrowth forage, Figure 7A, during the seventh and eighth weeks of the first year emphasize the importance of providing immature forage to increase forage intake levels. The high quality regrowth forage tended to overcome what appeared to be a decline of intake associated with season.

When pastures are stocked at the optimum rate, cow days of grazing per acre is a good measure of pasture output or produc-

TABLE 7. COW-DAY UNITS PER ACRE OF JOHNSONGRASS FORAGE UNDER FOUR METHODS OF MANAGEMENT DURING 56-DAY TESTS

Year	Grazing per acre			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Cow days	*Cow days*	*Cow days*	*Cow days*
First	74.7	98.9	----	93.8
Second	74.0	----	85.0	83.4
Third	89.0	105.0	105.0	----
Fourth	----	84.8	84.8	90.3
Means	79.2	96.2	91.6	90.8
Adj. means[1]	76.9[a]	93.8[b]	92.4[b]	92.8[b]

[1] Means adjusted to take into account year effects. Values followed by unlike superscripts differ significantly ($P < 0.05$).

tivity. As shown by data in Table 7, continuously-grazed pastures yielded significantly fewer cow days of grazing than strip or rotational grazing or soiling methods. It should be remembered, however, that the difference in forage output per acre as measured by cow days of grazing per acre may be influenced more by stocking rate than by method of grazing management (3). Hence, the accuracy of judgment of the researcher in adjusting stocking rate influences the reliability of cow days of grazing per acre as a measure of forage productivity.

The estimated forage dry matter consumed per acre by cows on continuous grazing was lowest and that eaten by cows on strip grazing was highest, Table 8. These forage intake data were

TABLE 8. ESTIMATES OF JOHNSONGRASS FORAGE DRY MATTER EATEN PER ACRE BY COWS UNDER FOUR METHODS OF UTILIZATION[1] DURING 56-DAY PERIODS

Year	Forage consumed per acre				
	Continuous grazing	Strip grazing	Rotational grazing	Soiling	
				Ratio	Actual
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
First	1,717	2,299	----	2,060	1,645
Second	1,502	----	1,891	1,860	1,618
Third	2,057	2,443	2,686	----	----
Fourth	----	2,058	1,946	1,946	1,819
Means	1,759	2,267	2,174	1,955	1,804
Adj. means[2]	1,703[a]	2,187[b]	2,186[b]	2,079[b]	

[1] Forage dry matter eaten was estimated from intake data determined by the ratio method and cow days of grazing. In addition, forage eaten by soiling groups was determined from weighed amounts fed and refused (actual).

[2] Means adjusted to take into account year effects. Values followed by unlike superscripts differ significantly ($P < 0.05$).

TABLE 9. ESTIMATES OF MEAN FORAGE DRY MATTER FED TO OR EATEN BY COWS, DRY FORAGE HARVESTED MECHANICALLY, RESIDUE AT END OF TESTS AND TOTAL FORAGE DRY MATTER ACCOUNTED FOR BY THESE MEANS FROM START OF GROWTH TO END OF TEST

Measure	Forage dry matter estimates			
	Continuous grazing	Strip grazing	Rotational grazing	Soiling
	Lb.	*Lb.*	*Lb.*	*Lb.*
Eaten	1,759	2,267	2,174	1,955[1]
Surplus harvested[2]	163	332	----	746
Residue	1,987	1,352	2,451	918[3]
Mean recoverable yield	3,909[4]	3,951	4,625	3,629

[1] Cows were fed 2,058 pounds.

[2] Does not include pre-grazing clippings during years 2, 3, and 4.

[3] Two-year average; residue was not determined the first year.

[4] Agronomic estimates indicated that an average of 7,172 pounds of forage dry matter was produced annually.

combined with quantities of surplus forage harvested as hay and with residual forage to obtain an estimate of forage output, Table 9. The combined data indicate that total forage production was greatest for rotationally grazed, similar for strip and continuously grazed, and least for soiling. The low value for the soiling treatment probably resulted from the complete defoliation approximately once each month, which caused some reduction of organic food reserves and reduction in light intercepted by the plant.

According to the cage difference method of estimating forage yields, growth of johnsongrass on continuously-grazed paddocks averaged 7,172 pounds of dry matter annually, footnote 4, Table 9. This yield represented growth from the beginning of the season to the end of each experimental period. These data indicate

TABLE 10. MEAN DAILY FCM PRODUCTION BY INDIVIDUAL COWS ASSIGNED TO FOUR METHODS OF UTILIZING JOHNSONGRASS FORAGE

Year	Mean daily FCM: Continuous grazing, Before test	Continuous grazing, During test	Strip grazing, Before test	Strip grazing, During test	Rotational grazing, Before test	Rotational grazing, During test	Soiling, Before test	Soiling, During test
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
First	20.4	20.9	31.3	28.6	----	----	29.4	22.9
	23.5	23.2	24.7	21.4	----	----	24.6	14.8
	26.0	27.2	28.5	26.3	----	----	30.0	23.5
	26.5	26.3	28.2	28.8	----	----	28.7	22.7
Means	24.1	24.4	28.2	26.3	----	----	28.2	21.0
Second	42.1	36.3	----	----	38.7	38.1	38.7	31.2
	27.5	23.6	----	----	30.1	28.0	30.8	24.4
	35.3	36.2	----	----	36.0	33.4	36.7	38.9
	33.5	30.2	----	----	31.2	30.6	26.9	23.0
Means	34.6	31.6	----	----	34.0	32.5	32.8	29.4
Third	30.9	28.6	32.2	25.8	31.7	30.9	----	----
	25.9	23.5	36.0	24.4	26.6	27.3	----	----
	32.5	29.9	31.4	29.1	31.3	27.0	----	----
	28.0	26.0	27.5	26.2	28.0	24.7	----	----
Means	29.3	27.0	31.8	26.4	29.4	27.5	----	----
Fourth	----	----	36.2	33.0	34.1	29.8	34.2	24.7
	----	----	35.1	28.9	42.0	37.0	34.2	28.8
	----	----	35.4	29.4	33.6	31.3	31.4	22.0
	----	----	35.6	32.8	37.4	33.6	48.1	36.0
Means	----	----	35.6	31.0	36.8	32.9	37.0	27.9
Means	29.3	27.7	31.0	31.0	33.4	30.9	32.8	25.3
Adj. means[1]	----	29.4[a]		28.4[a]	----	29.8[a]	----	25.0[b]

[1] Adjusted means followed by unlike superscripts differ significantly ($P < 0.05$).

that only 24.4 per cent of the growth was utilized by the cows, and only 54.5 per cent of the total forage growth could be accounted for on continuous grazing as eaten, harvested, and residue. The efficiency of utilization of the total forage grown or accounted for was low under all methods of management. In general, the residue for each method of grazing management was stemmy and relatively low in quality as indicated by composition of forage available for grazing at or near the end of each test period, Figures 1, 2, and 3.

Mean daily FCM production by cows assigned to the four methods of johnsongrass utilization per 56-day test is presented in Table 10 and Figure 9. Persistency of FCM production throughout the test periods is presented in Figure 10. Interpretation of FCM production by cows on each treatment is based on the adjusted means, which take into account year effects and

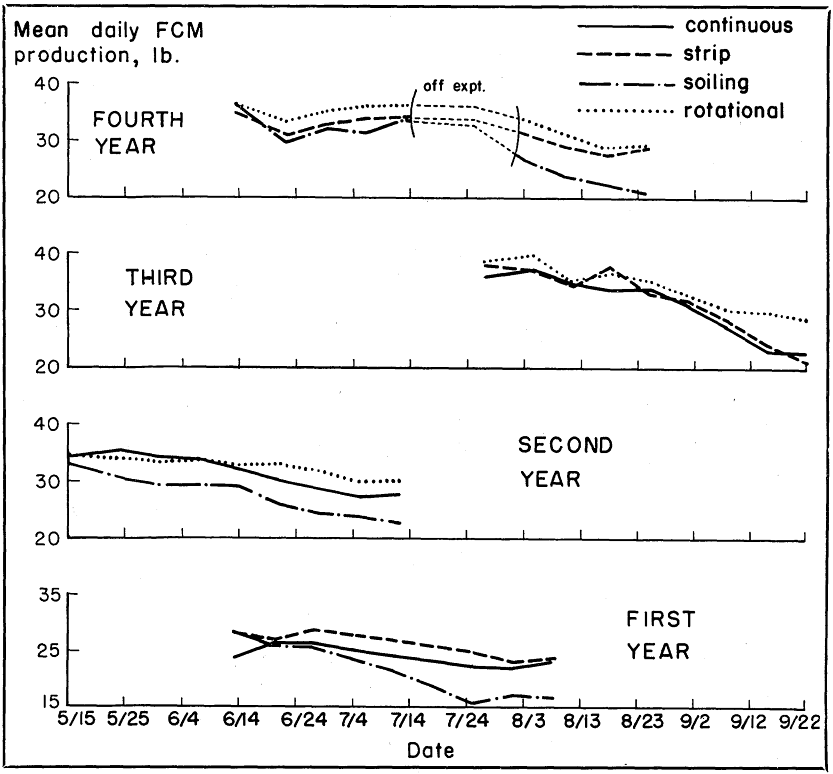


FIG. 9. Mean daily FCM production at weekly intervals during each test year.

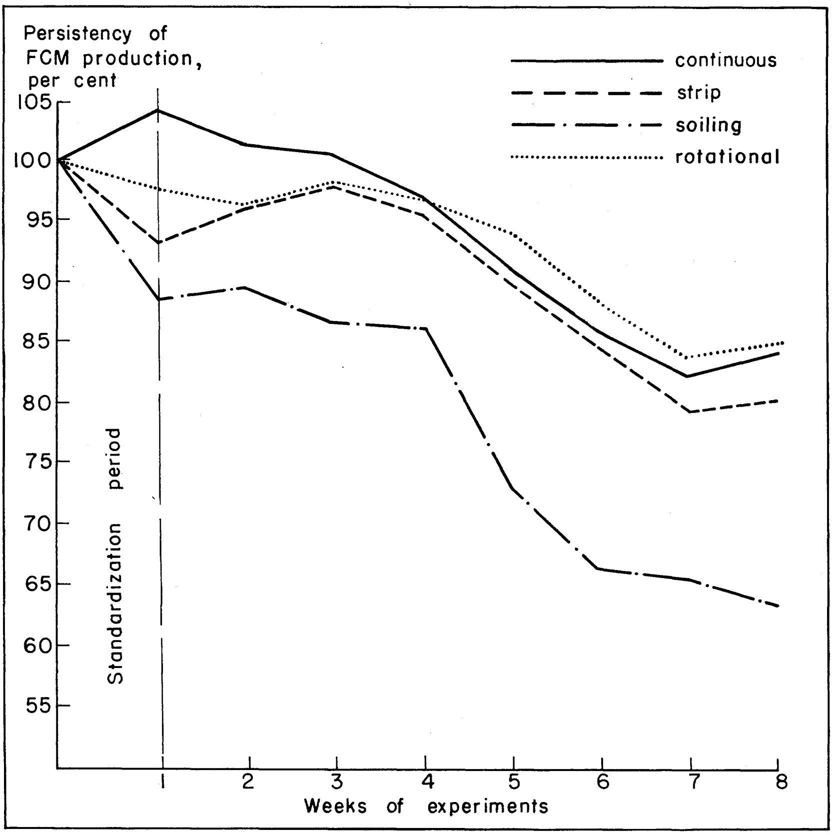


FIG. 10. Persistency of daily FCM production per cow by weeks as related to method of johnsongrass ultilization.

pre-experimental differences in production per cow. The adjusted means indicate that FCM production by cows on continuous, strip, and rotational grazing was superior to that of cows on johnsongrass managed by the soiling method, Table 10. The 28.4 pounds daily production per cow on strip grazing did not differ significantly from the 29.4 pounds on continuously-grazed or the 29.8 pounds for cows on rotationally-grazed johnsongrass.

The mean daily FCM production of cows at weekly intervals shows essentially the same trend, Figure 9, as indicated by summary data in Table 10. In each of the 3 years in which soiling was evaluated, FCM production decreased more rapidly throughout the test than on other methods of forage management.

Persistence of average daily FCM production, Figure 10, shows the 3-year average at weekly intervals expressed as a percentage of daily production immediately before the cows went on test. Persistency of FCM production by cows on continuous grazing increased during the first week of each test then declined at a rather uniform rate to the seventh week, when it leveled off. In contrast, persistency of production decreased during the first week of the test for cows on rotational, strip grazing, and soiling with the greatest loss occurring in the soiling group. After the initial marked decrease in FCM persistency by cows on johnsongrass managed by the soiling method, there was a 3-week leveling off; this was followed by precipitous decreases during the fifth and sixth weeks, with a lower rate of decrease the seventh and eighth weeks. In contrast, cows on strip and rotationally-grazed johnsongrass showed greater persistency during the third week than during the first. By the fifth test week, the average persistency of FCM for cows on the rotationally-grazed johnsongrass was slightly higher than for the continuously-grazed johnsongrass, and this slight difference was maintained during the remainder of the experiment. Although the persistency curves for cows on strip and rotationally-grazed johnsongrass showed great similarity throughout the experiment, the FCM persistency curve of strip-grazed cows remained below that of cows on rotationally and continuously-grazed pastures.

Summary data on cow performance presented indicate a close relationship between forage digestible dry matter (DDM) intake and FCM production, Table 11. Forage DDM intake ranged from a low of 12.4 pounds per cow daily for the soiling treatment to a high of 14.9 pounds for cows grazing johnsongrass rotationally. The low forage DDM intake by the soiling group reflected the relatively low digestibility (56.2 per cent) of the soiling forage, whereas the high forage DDM intake by cows on rotational

TABLE 11. SUMMARY EVALUATION OF COW PERFORMANCE BY METHOD OF JOHNSONGRASS UTILIZATION

Method of utilization	DDM intake/acre[1]	DDM intake/ cow/day[1]	FCM/acre[1]	FCM/lb. forage DDM[1]
	Lb.	*Lb.*	*Lb.*	*Lb.*
Continuous grazing	1,070[a]	13.9	2,211[a]	2.07
Strip grazing	1,357[b]	14.4	2,675[b]	1.99
Rotational grazing	1,381[b]	14.9	2,727[b]	2.01
Soiling	1,176[a]	12.4	2,326[a]	2.00

[1] Values were adjusted to take into account year effects. Values followed by unlike superscripts differ significantly ($P < 0.05$).

grazing resulted from both high total forage intake (2.73 pounds dry matter per 100 pounds of body weight) and highly digestible forage (63.1 per cent).

The low FCM yields per acre for continuously-grazed johnsongrass resulted primarily from the relatively low cow days per acre for this treatment. Low production from the soiling method of management, on the other hand, resulted primarily from a lowered level of production per cow.

Milk production per pound of forage DDM intake was slightly lower for strip grazing and slightly higher for continuous grazing, based on adjusted FCM means. To convert to an estimated net energy (ENE) basis, it was assumed that DDM percentage was equal to TDN percentage. On this basis the average FCM produced (by the 12 cows per treatment used to evaluate milk production) per megacalorie of forage ENE intake was: continuous grazing, 2.452 pounds; strip grazing, 2.385 pounds; rotational grazing, 2.382 pounds; and soiling, 2.585 pounds and did not differ significantly.

Performance of cows on johnsongrass that was continuously, strip, or rotationally grazed agree with a conclusion by Blaser *(3)* that method of forage utilization had little influence on performance if the animals were not starved, but did have a decided effect on milk production per acre. On johnsongrass managed by the soiling method, performance of cows was relatively low as measured by digestibility of the forage and by FCM yields. Low FCM yields appear to be characteristic of cows fed green-chopped, tall-growing, stemmy plants. Autrey, et al. *(2)* reported higher FCM production when grazing Star millet, a tall-growing stemmy plant, than when it was fed green-chopped. The principal reason for low FCM production by cows fed johnsongrass soilage or Starr millet soilage was that the cows were forced to eat the entire plant. In the case of johnsongrass, the soilage forage was only 88 to 91 per cent as digestible as the selectively eaten johnsongrass by cows under the three grazing methods.

The difference between digestibility of johnsongrass soilage and grazed johnsongrass is similar to the relationship observed with other forages *(11,22,23)* in which selectivity was varied. In addition, soiling created a problem in maintaining high quality forage for chopping, which is a problem observed with other forages *(18)*. For these reasons the soiling method of utilizing johnsongrass appears to be the least desirable of the four management methods tested. In contrast, many reports *(3,9,15,26,27)* show that soiling is a highly efficient method of utilizing several forages. Although soiling of johnsongrass forage appeared to be less efficient than the three methods of grazing, soiling does enable using forage from fields that are long distances from the milking barn. If soiling of johnsongrass is to be practical, however, cows will need more nutrients from concentrates than were fed in this experiment.

The slightly lower FCM production and digestibility of forage dry matter by cows on strip-grazed johnsongrass than those on continuously or rotationally-grazed johnsongrass suggest that the daily forage allowance on the strips was inadequate. Generally, digestibility of forage dry matter has decreased as the intensity of grazing increased *(24)*, which is the condition that seems to have existed on strip grazing. An increased carrying capacity seemed to be the only advantage of strip grazing over continuous grazing of johnsongrass. The results pointed out some of the problems associated with strip grazing: (1) extra labor and extra fencing are required as compared with the continuous or rotational systems of grazing; (2) a skilled herdsman is needed to determine the daily change in area required to provide nutrient needs of the cows without excess waste. As pointed out in a review *(17)*, some studies show up to a 45 per cent increase in milk yield per acre from strip grazing compared with rotational grazing *(6,20)*. Other investigations *(7,16)*, however, agree with the findings in this johnsongrass study that strip grazing gave no gain over rotational grazing.

Continuous grazing of pastures requires less management and less fencing than rotational grazing. Nevertheless, continuous grazing of johnsongrass over long periods tends to reduce the stand. Therefore, the 15.7 per cent increase in cow days of grazing per acre for rotational grazing over that from continuous grazing would appear to justify the extra fencing costs and the greater attention to management that is needed with rotational grazing. Particularly, the rotational method would be favored if land area was limited. Usually three to four pastures in a rotation, with grazing periods of approximately 1 week per pasture, should give good results with rotational grazing of johnsongrass. However, the length of time each johnsongrass pasture provides high quality grazing probably will vary in the range of at least 5 to 10 days. The practice of using a fixed interval for rotation has resulted in cows walking the fence during the last few days of the rotation *(18)*, which is a sign of inadequate forage.

SUMMARY

A 4-year study was made to determine the most efficient method of utilizing johnsongrass forage by lactating dairy cattle. Each method—continuous, strip, and rotational grazing, and soiling (green chop)—was evaluated during 3 out of the 4 years.

Grazing cows exercised selectivity in the forage consumed, as shown by comparison of chemical composition of forage before and after grazing for strip and rotational methods and of caged and grazed johnsongrass for the continuous method. On the other hand, cows on soilage johnsongrass were forced to eat both leaves and stems. The soilage forage was lower in digestibility of dry matter (56.2 per cent) than grazed forages (62.1 to 63.1 per cent). Also, milk production per cow daily was greater for cows on continuous (29.4 pounds), strip (28.4 pounds), and rotational (29.8 pounds) grazing than for those fed johnsongrass soilage (25.0 pounds).

Digestible forage dry matter eaten per acre and milk production per acre were greater for strip and rotationally-grazed johnsongrass than for continuously-grazed or soilage johnsongrass. Low milk yields per acre for continuous grazing resulted from low carrying capacity, whereas low milk production per acre for the soiling method was caused by low digestibility of the forage dry matter. Production of FCM per pound of digestible forage dry matter consumed was similar on all treatments.

Rotational and strip grazing were equal or superior to continuous grazing or soiling for each criteria employed to measure quality and productivity of johnsongrass forage. Rotational grazing required less fencing and less supervision than strip grazing. For these reasons, rotational grazing of johnsongrass approximately 1 week out of each 3 to 4 weeks seems to be the best method of utilizing this forage with lactating dairy cows.

REFERENCES

(1) ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1965. Official Methods of Analysis. 10th ed. Assoc. Off. Agr. Chem. Washington, D.C.

(2) AUTREY, K. M., J. H. BLACKSTONE, AND HAROLD YATES. 1965. Managing Starr Millet for Dairy Cows. Highlights of Agr. Res. Vol. 12, No. 1. Auburn Univ. (Ala.) Agr. Exp. Sta.

(3) BLASER, R. E., H. T. BRYANT, C. Y. WARD, R. C. HAMMES, JR., R. C. CARTER, AND N. H. MCLEOD. 1959. Symposium on Forage Evaluation. VII. Animal Performance and Yields with Methods of Utilizing Pasturage. Agron. J., 51:238.

(4) BOLIN, D. W., R. P. KING, AND E. W. KLOSTERMAN. 1952. A Simplified Method for the Determination of Chromic Oxide (Cr_2O_3). Science, 116:634.

(5) BRYANT, H. T., R. E. BLASER, R. C. HAMMES, JR., AND W. A. HARDISON. 1961. Method for Increasing Milk Production with Rotational Grazing. J. Dairy Sci., 44:1733.

(6) DEGEUS, J. AND M. L. HART. 1952. The Production and Behavior of Pasture Plants Under Rotational Grazing. Proc. 6th Int. Grassland Cong., 1:371.

(7) FOOT, A. S. AND C. LINE. 1960. Dairy Production from Pasture: A Comparison of Controlled Grazing at Two Rates of Stocking. J. British Grassland Soc., 15:155.

(8) GAINES, W. L. 1928. The Energy Basis of Measuring Milk Yield in Dairy Cows. Ill. Agr. Exp. Sta. Bull. 308.

(9) GULLICKSON, T. W. AND C. L. WILCOX. 1956. Soilage or Rotational Grazing. Minn. Farm and Home Sci., 13:18.

(10) GUTHRIE, L. D., G. H. ROLLINS, AND G. E. HAWKINS. 1968. Evaluation of the Esophageal-Fistula Cannula and Hand-Clip Methods for Sampling Coastal Bermudagrass Pastures. J. Dairy Sci., 51:710.

(11) HARDISON, W. A., J. T. REID, AND C. M. MARTIN. 1951. Degree of Selective Grazing by Steers as Evidenced by Fecal Composition. J. Anim. Sci., 11:1070.

(12) ——————, AND P. G. WOOLFOLK. 1954. Degree of Herbage Selection by Grazing Cattle. J. Dairy Sci., 37:89.

(13) HAWKINS, GEORGE E. AND G. H. ROLLINS. 1960. Intake and Digestibility of Coastal Bermudagrass and Bahiagrass as Affected by Management. J. Dairy Sci., 43:444.

(14) ——————, L. A. SMITH, R. M. PATTERSON, AND J. A. LITTLE. 1963. Managing Johnsongrass for Highest Possible Milk Production. Highlights of Agr. Res., Vol. 10, No. 2. Auburn Univ. (Ala.) Agr. Exp. Sta.

(15) HENDERSON, B. W., J. W. CABBLE, AND H. J. COOK. 1957. Soilage Feeding of Dairy Cattle. R.I. Agr. Exp. Sta. Bull. 336.

(16) HOLMES, W., R. WAITE, D. L. FERGUSON, AND J. I. CAMPBELL. 1950. Studies in Grazing Management. I. Comparison of the Production Obtained in Close Folding and Rotational Grazing with Dairy Cows. J. Agr. Sci., 40:381.

(17) HUFFMAN, C. F. 1959. Summer Feeding of Dairy Cattle. A Review. J. Dairy Sci., 42:1495.

(18) KENNEDY, W. K., J. T. REID, AND M. J. ANDERSON. 1959. Evaluation of Animal Production Under Different Systems of Grazing. J. Dairy Sci., 42:679.

(19) KIMURA, F. T. AND V. L. MILLER, 1957. Improved Determination of Chromic Oxide in Cow Feed and Feces. J. Agr. Food Chem., 5:216.

(20) LARSEN, H. J. 1959. Methods of Forage Utilization in the Midwest. J. Dairy Sci., 42:574.

(21) LITTLE, J. A., G. E. HAWKINS, L. A. SMITH, AND H. W. GRIMES. 1966. Managing Sorghum-Sudan Hybrids for Best Dairy Pasture. Highlights of Agr. Res., Vol. 13, No. 1. Auburn Univ. (Ala.) Agr. Exp. Sta.

(22) LOFGREEN, G. P., J. H. MEYER, AND M. L. PETERSEN. 1956. Nutrient Consumption and Utilization from Alfalfa Pasture, Soilage, and Hay. J. Anim. Sci., 15:1158.

(23) MEYER, J. H., G. P. LOFGREEN, AND J. L. HULL. 1957. Selective Grazing by Sheep and Cattle. J. Anim. Sci., 16:766.

(24) MILLER, J. W., E. R. BEATY, AND L. M. UNDERWOOD. 1958. A Comparison of Tift Sudan and Starr Millet for Dairy Cows by Several Techniques. Ga. Agr. Exp. Sta., Tech. Bull. NS16.

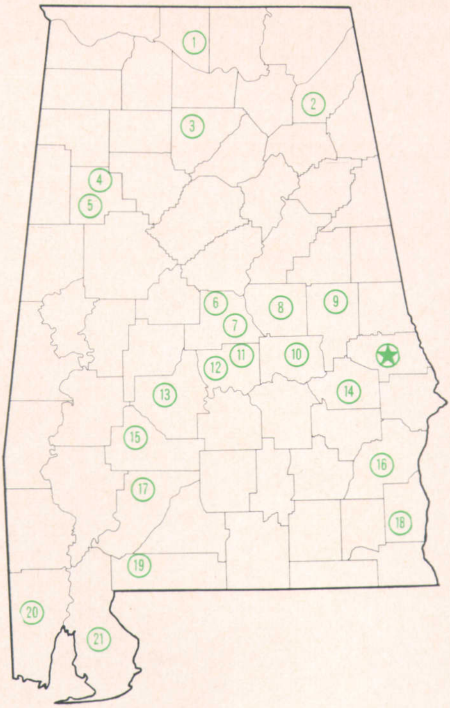
(25) REID, J. T., P. G. WOOLFOLK, W. A. HARDISON, C. M. MARTIN, A. L. BRUNDAGE, AND R. W. KAUFMANN. 1952. A Procedure for Measuring the Digestibility of Pasture Forage Under Grazing Conditions. J. Nutrition, 46:255.

(26) SMITH, E. P. AND E. A. KEYES. 1959. A Comparison of Three Pasture Plans with Grasses for Dairy Cows. J. Dairy Sci., 42:137.

(27) SWANSON, E. W., J. B. MCLAREN, AND E. J. CHAPMAN. 1959. A Comparison of Milk Production and Crop Utilization from Strip Grazing Versus Green Chop Feeding. Tenn. Agr. Exp. Sta. Bull. 292.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



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.