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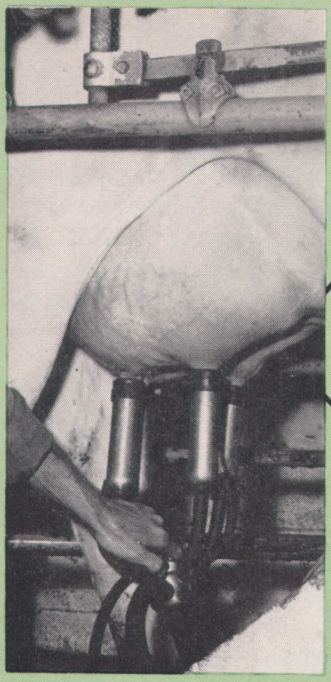

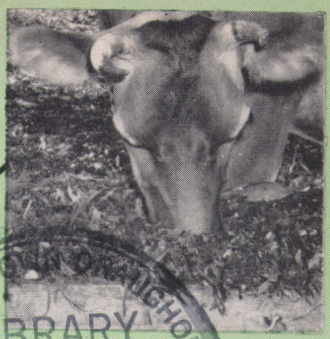

FORAGE SYSTEMS *compared for* HIGH PRODUCING COWS

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SUMMARY

An experiment covering approximately 5 years was conducted to compare an all-pasture forage system with an all-harvested forage system for supplying roughage needs of dairy cattle. The all-pasture system utilized oats, rye, ryegrass-crimson clover, millet, and dallisgrass-white clover permanent pastures to provide grazing. The harvested forage system utilized corn silage and alfalfa hay, both fed to appetite.

Average chemical composition, digestibility of dry matter, and intake of the pasture forages indicated that quality of forage grazed was high except during May, late September, and October each year. Although there was some variation in quality of the alfalfa hays and corn silages fed during the 5-year period, quality of both was relatively high at all times.

The results of the study show that:

1. In central Alabama, pastures were not a reliable source of roughage on a year-round basis. The pasture group of cows had grazing available an average of 86 per cent of the time, but there was a range of 62 to 100 per cent between years. Carrying capacity of the cool season forages averaged 69.4 cow days per acre with a range of 30 to 147 days. Length of the cool season grazing varied from 113 to 221 calendar days and averaged 168 days. During the warm season, carrying capacity of millet pastures averaged 81.5 cow days of grazing per acre with a range of 63 to 132 days. The grazing season for millet ranged from 102 to 141 days and averaged 121 days.

2. Yields of harvested roughage per acre were variable. Corn silage averaged 8.7 tons and ranged from a low of 6.0 to a high of 11.5 tons per acre. Alfalfa hay yields averaged only 2.1 tons, ranging from a low of 1.4 to a high of 3.2 tons per acre.

3. Average daily FCM production of cows during the 224-day experimental period for each lactation was 33.84 pounds for the harvested forage group and 33.86 pounds for the pasture group. During the first 12 weeks in which cows grazed cool season forages, daily FCM production averaged 40.1 pounds as compared with 39.2 pounds when fed harvested forage during the same period in alternate years.

4. Lactation trends were similar for cows fed harvested roughages and for those grazing pastures during the spring and summer months. However, the average month-to-month persistency of FCM production was lower for cows starting their experimental lactation in late March and producing through the summer months than for all cows.

5. There was an indication that the fat percentage in milk was lower during the years in which cows grazed cool season pastures and millet pastures than in alternate years when they were fed harvested forage.

CONTENTS

FIRST PRINTING 3½ M, DECEMBER 1965

Forage Systems Compared for High Producing Cows

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MOST ALABAMA DAIRYMEN use a forage program consisting principally of pasture during the warm months and harvested forage plus limited grazing during the remainder of the year. In recent years, however, dairymen have shown an increasing interest in feeding programs that use only harvested forages or all pasture.

An all-harvested forage program has both advantages and disadvantages. The advantages include: (a) a more uniform quality of feed throughout the year; and (b) higher yields of feed nutrients per acre, thereby increasing the number of cows that may be fed from the same acreage. Major disadvantages of the all-harvested program over a combination of harvested forage and pasture are the increase in costs of labor for handling feed and manure, and for the extra feed storage capacity needed.

A 5-year study was made to compare a harvested forage program based on corn silage and alfalfa hay with an all-pasture system using ryegrass, crimson clover, oats, rye, and millet for milk production.

EXPERIMENTAL PROCEDURE

The dairy herd at the Piedmont Substation of Auburn University Agricultural Experiment Station System provided test animals for the study. This herd is principally crossbred Holstein cows averaging approximately 1,200 pounds in body weight and producing an average of 11,000 pounds of milk annually.

[1] The authors acknowledge the valued cooperation of Joseph Lott and John Sandy, former assistant superintendents of the Piedmont Substation, in the conduct of this experiment.

The herd was divided into two experimental roughage groups. One group was fed corn silage and alfalfa hay and is identified in this report as the harvested forage group. Cows in the other group grazed the highest quality pasture available and they are referred to as the pasture group.

Annual pasture crops were relied on to furnish grazing for the pasture group. Rye and ryegrass-crimson clover pastures were planted in early fall of 1958 and 1959 and oats and ryegrass-crimson clover in the fall of 1960, 1961, and 1962 to provide grazing from November through May each year. Millet was planted in April and at subsequent intervals during late spring and summer each year to furnish grazing from June to October. There were short intervals each year when annual forages were inadequate. During these times the pasture cows were grazed on a permanent pasture of dallisgrass and white clover or were fed corn silage plus alfalfa hay.

Alfalfa hay and corn silage were grown on the Piedmont Substation each year and fed to the harvested forage group. Corn silage yields averaged 8.7 tons per acre and alfalfa produced an average of 2.1 tons of hay per acre.

In the original assignment of cows, the groups were balanced according to stage of lactation, stage of gestation, and level of milk production. Thereafter, cows entering the experiment for the first time were assigned alternately to the pasture and harvested forage groups. Before assignment to experimental forage groups, all cows were standardized for 60 days on a roughage ration of alfalfa hay and corn silage. Each cow remained on the assigned forage from the end of her standardization period until the lactation was completed. During their dry periods all cows were assigned to the same type of pasture being grazed by the lactating cows of the pasture group. This was done to balance the 60 days of standardized feeding on harvested forages at the start of each lactation. Following parturition and standardization, cows that had completed one experimental lactation were assigned to the other forage group for their second lactation to minimize individual cow differences. This annual alternation between forage groups continued as long as the cow remained in the experiment.

Cows assigned to harvested forage were fed alfalfa hay and corn silage to appetite. Likewise, pasture cows were on the highest quality grazing available except during the two milking

periods daily. Cows on both roughage rations were fed a 17.5 per cent protein concentrate mixture (corn, oats, and cottonseed meal). During the first month on experiment, concentrate feeding for each cow was based on her average daily milk production during the last 2 weeks of the standardization period. (Feeding rate was 2 pounds for the first 20 pounds of 4 per cent fat-corrected milk (FCM) plus 1 pound for each additional 2.5 pounds FCM, which averaged approximately 1 pound for each 4 pounds of FCM produced.) Concentrate allowances were reduced by 6 per cent each 28 days during the experimental lactation. Milk weights were recorded for each milking and butterfat tests were made on a 48-hour milk composite during each 28 days, with FCM calculated by the Gaines formula (5).

Forage quality was measured by chemical analyses (2) of samples collected at intermittent intervals during the grazing and feeding periods, by periodic intake and digestion trials, and by milk production level of cows consuming the forage. Digestibility and intake of pasture forages were determined by the chromogen-(*16*) chromic oxide (*6*) ratio method, whereas conventional digestion trials were used for the harvested forages. Harvested forages required per cow were measured by difference between amounts of these feeds stored and that remaining at the end of each year.

RESULTS

Forage Crop Yields

The days during each calendar year that cows grazed each forage species are given in Table 1. As indicated by the schedule, pastures were grazed rotationally to utilize the highest quality of forage available for lactating cows. Dry cows and heifers gleaned residual forage after pastures had been grazed by the lactating cows.

During the 5-year experiment, the cows averaged grazing 86 per cent of the time. However, there was great variation between years, ranging from 62 to 100 per cent, Table 2. This shows that it is hazardous to depend on pastures as the sole source of roughage in central Alabama.

Average days of grazing each month on cool season (rye, oats, and ryegrass-crimson clover) pastures and on millet pastures are shown by Figure 1. Cool season pastures provided an average of

TABLE 1. DAYS IN WHICH EACH FORAGE WAS GRAZED ANNUALLY BY THE PASTURE GROUP DURING EACH CALENDAR YEAR

Dates	Forage grazed
1958	
Dec. 8-22	Abruzzi rye
Dec. 23-31	Italian ryegrass—crimson clover
1959	
Jan. 1-18	Italian ryegrass—crimson clover
Jan. 19-Feb. 15	Abruzzi rye
Feb. 16-Mar. 9	Italian ryegrass—crimson clover
Mar. 10-31	Abruzzi rye
Apr. 1-May 7	Italian ryegrass—crimson clover
May 8-June 6	Permanent pasture (dallisgrass—white clover)
June 7-Oct. 25	Starr millet
Oct. 26-Nov. 22	Abruzzi rye
Nov. 23-Dec. 20	Italian ryegrass—crimson clover
Dec. 21-31	Abruzzi rye
1960	
Jan. 1-10	Abruzzi rye
Jan. 11-31	Italian ryegrass—crimson clover
Feb. 1-14	Abruzzi rye
Feb. 15-Mar. 6	Italian ryegrass—crimson clover
Mar. 7-Apr. 14	Abruzzi rye
Apr. 15-June 12	Italian ryegrass—crimson clover
June 13-Sept. 30	Starr millet
Oct. 1-7	Permanent pasture
Oct. 8-23	Starr millet
Oct. 24-Dec. 10	Oats
Dec. 11-31	Italian ryegrass—crimson clover
1961	
Jan. 1-Feb. 10	Italian ryegrass—crimson clover
Feb. 11-Apr. 4	Oats
Apr. 5-May 31	Italian ryegrass—crimson clover
June 1-18	Permanent pasture (dallisgrass—white clover)
June 19-Oct. 20	Starr millet
Oct. 21-Dec. 3	None
Dec. 4-31	Oats
1962	
Jan. 1-10	Oats
Jan. 11-31	None
Feb. 1-11	Italian ryegrass—crimson clover
Feb. 12-Mar. 18	Oats
Mar. 19-May 21	Italian ryegrass—crimson clover
May 22-June 13	None
June 14-Sept. 23	Starr millet
Sept. 24-Nov. 13	None
Nov. 14-Dec. 15	Oats
Dec. 16-19	Italian ryegrass—crimson clover
Dec. 20-31	None
1963	
Jan. 1-Mar. 19	None
Mar. 20-May 14	Italian ryegrass—crimson clover
May 15-29	None
May 30-Sept. 26	Starr millet
Sept. 27-Oct. 31	None

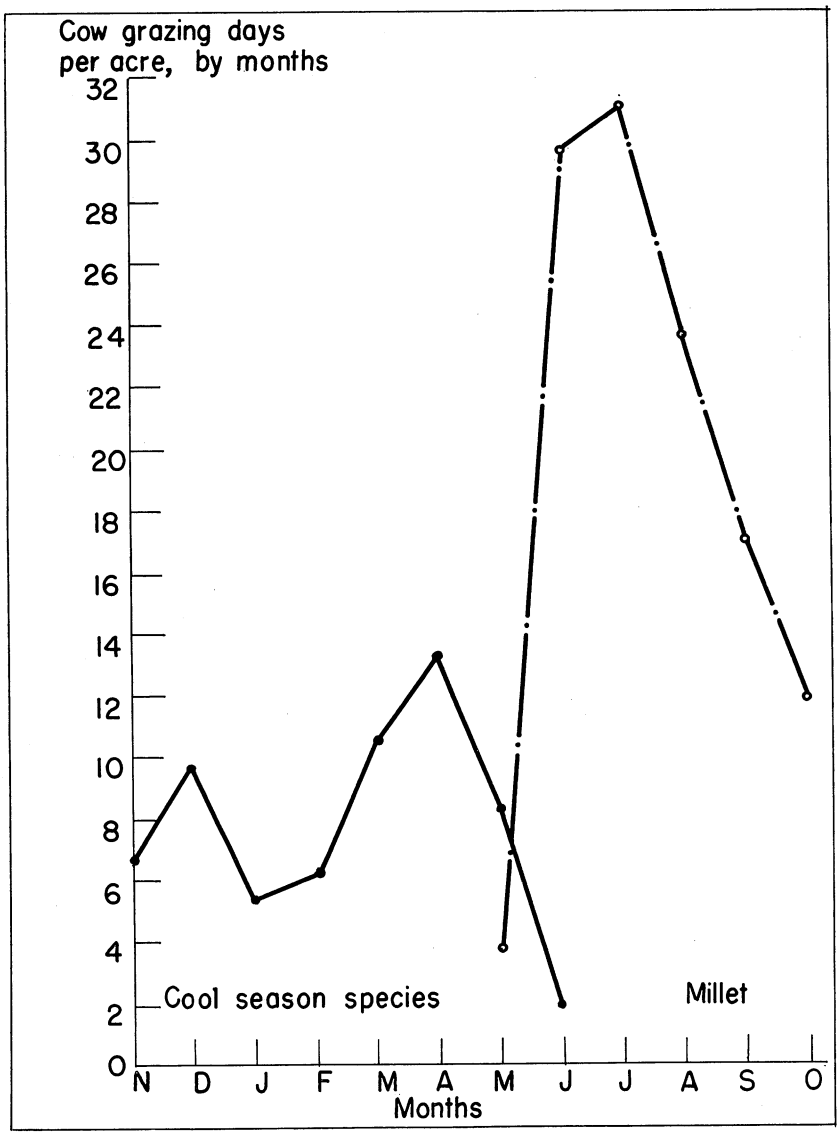

FIG. 1. Average number of standard cow days of grazing per acre per month on cool season (rye, oats, and ryegrass-crimson clover) and millet pastures.

8.5 standard cow days of grazing per acre per month from November 1 to May 31, inclusive. During November the average was 6.6 standard cow days. Cow grazing days per acre increased in December, decreased to low levels of approximately 6.0 days

TABLE 2. NUMBER OF CALENDAR DAYS IN WHICH FORAGE FROM EACH SPECIES WAS GRAZED DURING EACH CROP YEAR BY COWS ASSIGNED TO THE PASTURE GROUP

Crop year	Days of grazing per year					
	Rye	Ryegrass-crimson clover	Oats	Millet	Permanent pasture	Percentage of time on pasture
	No.	*No.*	*No.*	*No.*	*No.*	*Pct.*
Dec. 8, 1958-Oct. 31, 1959	71	86	----	140	29	100
Nov. 1, 1959-Oct. 31, 1960	96	153	----	116	----	100
Nov. 1, 1960-Oct. 31, 1961	----	93	100	124	37	97
Nov. 1, 1961-Oct. 31, 1962	----	87	70	102	----	71
Nov. 1, 1962-Oct. 31, 1963	----	73	32	120	----	62
AVERAGE	84	98	67	120	33	86

in January and February, then increased to 13.1 during April and declined to 8.3 during May.

There was a high degree of variation among cool season pasture species in amount of grazing per acre, as shown by data in Table 3. Rye and oat pastures had relatively high carrying capacities during November and December. There was a decline in this carrying capacity during January or February, followed by a second peak during March. The carrying capacity of ryegrass-crimson clover pastures was low throughout fall and winter, in-

TABLE 3. AVERAGE STANDARD COW DAYS OF GRAZING PER ACRE ON COOL SEASON PASTURE SPECIES BY MONTHS

Month	Cow days grazing per acre			
	Rye	Ryegrass-crimson clover		Oats
	1958-59 av.	1958-59 av.	1960-62 av.	1960-1962 av.
	No.	*No.*	*No.*	*No.*
October	3.5	0.0	0.0	0.8
November	11.0	6.6	0.0	10.5
December	10.8	11.3	3.3	14.0
January	8.6	12.4	2.6	3.5
February	5.2	10.1	2.8	9.1
March	8.7	14.6	6.7	14.4
April	3.6[1]	30.6	27.2	1.5
May	2.9[1]	22.2	16.8	0.0
June	1.3[1]	15.4	0.0	0.0
TOTAL	55.6	123.2	59.4	53.8

[1] The forage grazed on the rye pastures during April, May, and June was predominantly volunteer crimson clover.

creased during March, and reached a peak in April. During May the average cow days of grazing per acre on ryegrass-crimson clover pasture was 22.2 during the first 2 years and 16.8 during the last 3 years. This was five to seven times the grazing furnished by small grains during May.

The highest number of cow days of grazing per acre obtained from one paddock of each forage during a single month was: rye, 34.4 in March 1959; oats, 40.5 in December 1961; and ryegrass-crimson clover, 48.1 in April 1961. However, as indicated by data in Table 3, the highest carrying capacity for a single month was not representative of grazing furnished by all species over a period of 2 to 5 years. Carrying capacity of the cool season pastures was affected adversely by dry weather during the fall months and by extreme cold during January and February.

No direct comparisons can be made of oats and rye since they were not used during the same years. Total cow days of grazing per acre from ryegrass-crimson clover pastures during 1958-59 crop years was more than double that of rye, whereas for the 1960-62 crop years ryegrass-crimson clover produced only slightly more grazing than oat pastures. The distribution of grazing from ryegrass-crimson clover and small grain pastures differed markedly.

As shown by Figure 1, millet provided an average of 29.9 and 31.2 cow days of grazing per acre in June and July, respectively, during the 5-year period. This declined during August, September, and October to a low of 12.0 cow days per acre. The average values for millet appear somewhat low. In arriving at these carrying capacity data, total cow days of grazing during the month was divided by total number of acres planted to millet. Thus, the data do not reflect the maximum carrying capacity of the forage, but indicate the average number of cow days of grazing per acre from all land assigned to the production of this pasture crop. The highest number of cow days of grazing per acre obtained from a millet pasture during each month was: June 1959, 53; July 1961, 54; August 1962, 101; September 1963, 48; and October 1960, 67.

Acres of annual forage crops required to provide full time grazing for one cow during each month of the year is given graphically in Figure 2. The largest acreage, 5.6, was required during January and the lowest, 1.0, during June and July. These are average values and do not indicate that there were several

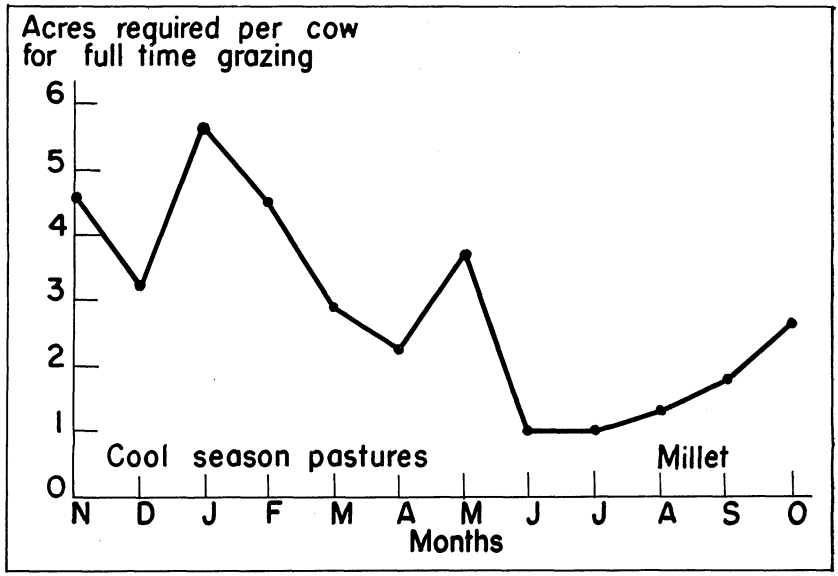

FIG. 2. Number of acres of annual pastures that were required to provide full time grazing for one cow during each month of the year during the experiment.

periods during which the cool season pastures and the millet pastures provided no grazing, as shown by data in Table 1. Thus, it is not feasible to depend on pasture as the only source of roughage for dairy cows in central Alabama because of adverse weather during fall and winter of some years. Differences in soils and weather conditions throughout Alabama limit the applicability of the pasture yield data, which may apply only to the Piedmont area.

Based on differences between amounts of corn ensiled and hay stored and amounts remaining at the end of each year, it was necessary to store 13.4 tons of corn silage and 2.2 tons of hay to feed each cow 365 days. With the low yields obtained in this experiment, 1.54 acres of corn and 1.03 acres of alfalfa were needed to supply the harvested forage required by one cow for 365 days.

Forage Quality and Consumption

Average crude protein, crude fiber, and ash contents of the three cool season annuals and millet (a summer annual) during months they were grazed are given in Figure 3, 4, and 5. All

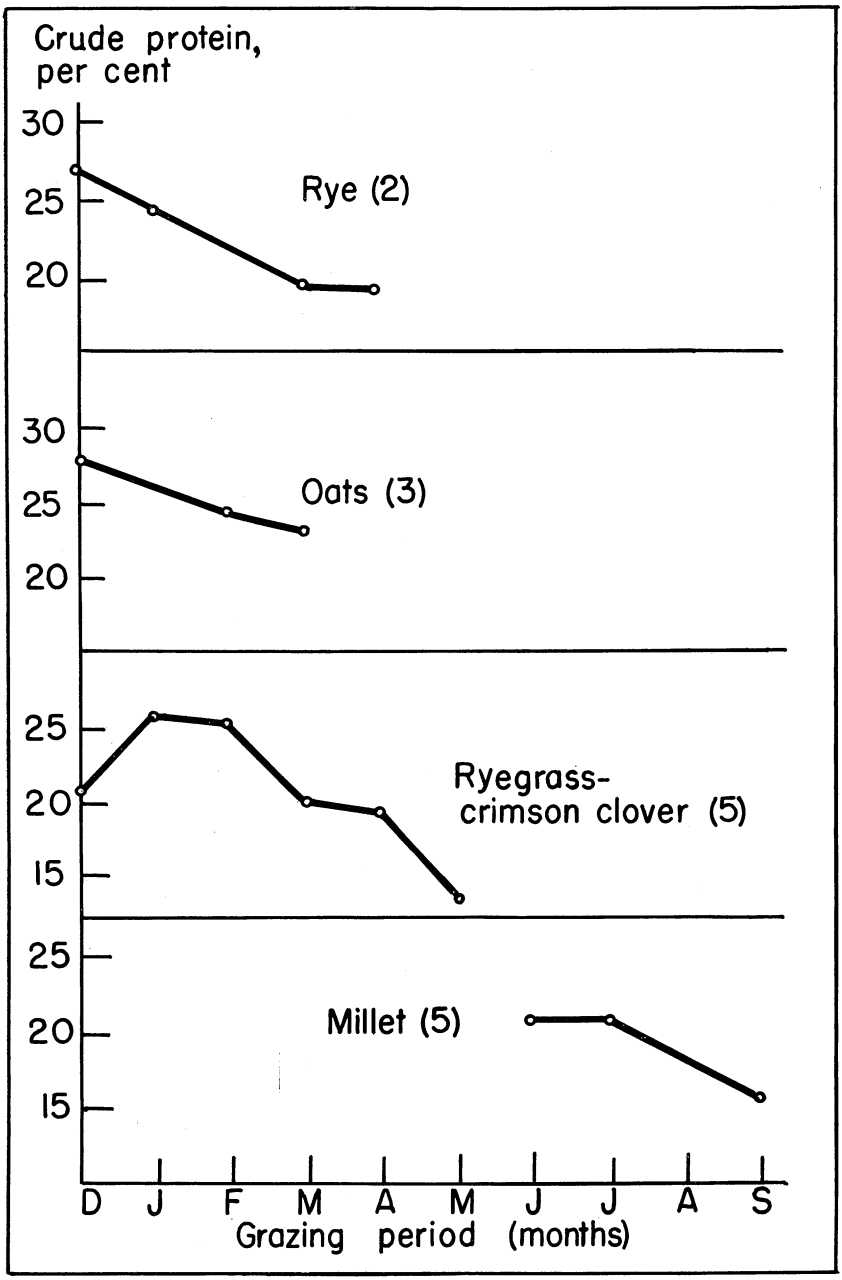

FIG. 3. Average seasonal trend in crude protein content of cool season and warm season annuals at intermittent intervals during their respective grazing periods. Numbers shown in parenthesis represent years that the forage was studied.

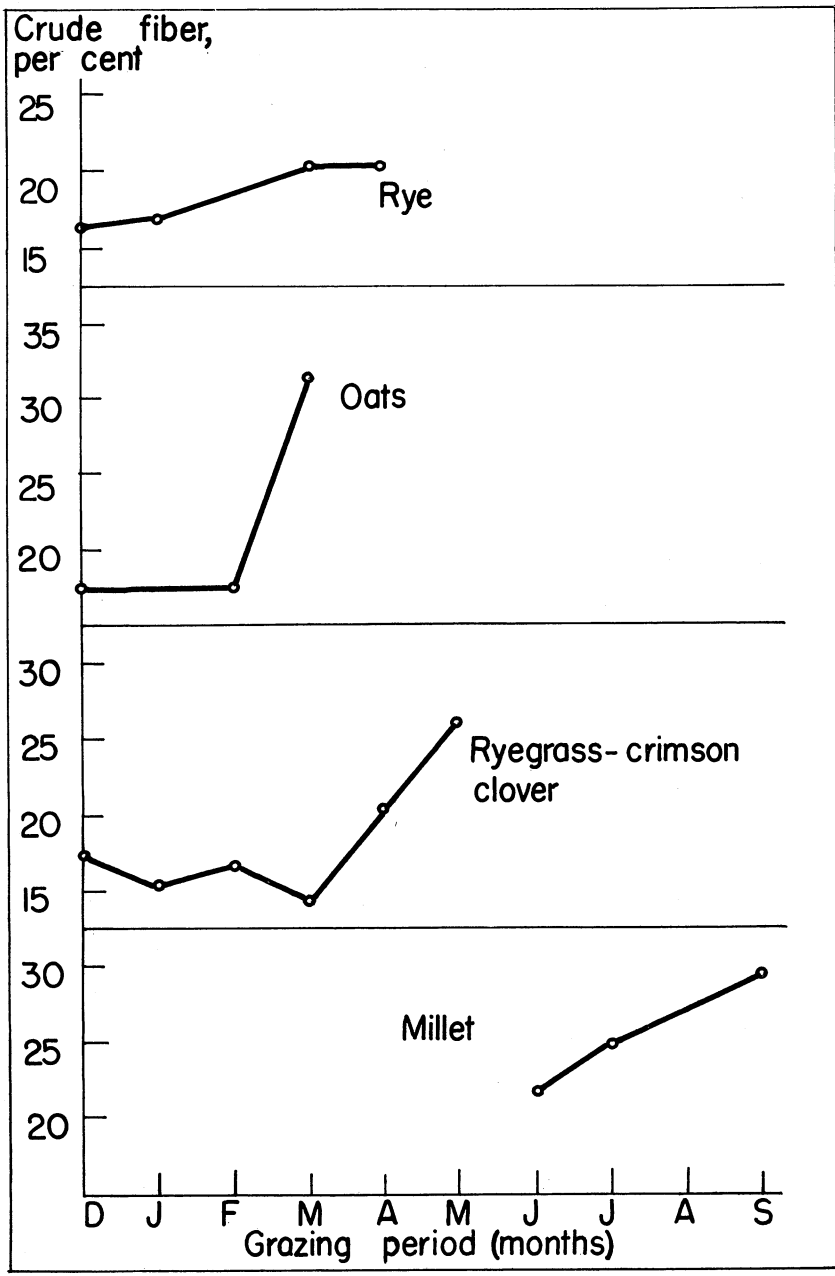

FIG. 4. Average seasonal trend in crude fiber content of cool season and warm season annuals at intermittent intervals during their respective grazing periods. The oats pasture in this test was contaminated with crimson clover.

samples were hand plucked, and composition data are expressed on the dry matter basis.

The crude protein content of rye, oats, and ryegrass-crimson clover was high in the early portion of the grazing period and remained relatively high through April each year, Figure 3. Average seasonal crude protein content of rye, oats, and ryegrass-crimson clover was 22.5, 25.5, and 20.8 per cent, respectively. Nevertheless, there was a marked decrease in crude protein content of all the cool season annuals between the first and final sampling period, reflecting the effect of advancing maturity. The range in crude protein content of these cool season forages was from 30.5 to 5.8 per cent. Similar decreases near the end of the growing season have been reported by others (*4,8,13,15*).

Crude fiber content of the cool season annuals was low from beginning of the grazing season in December through the middle of February for oats and rye and through the middle of March for ryegrass-crimson clover each year, Figure 4. However, rye and ryegrass-crimson clover pastures remained relatively low in crude fiber even in late April. The high crude fiber content of oats in March occurred on previously grazed forage that was in an advanced stage of maturity. The ranges in crude fiber contents by species were: rye, 15.7 to 23.6 per cent; oats, 17.1 to 31.4 per cent; and ryegrass-crimson clover, 14.2 to 30.2 per cent. Based on results of this and other research (*4,13*), an increase in crude fiber content of cool season forages can be expected during the latter part of the growing season. This will vary with forage species and location, but usually occurs from March 15 to May 15.

Ash content of rye and oats, Figure 5, was somewhat erratic throughout the grazing season, fluctuating from 7.5 to 12.0 per cent, whereas that of ryegrass-crimson clover forage followed a rather definite trend, decreasing from 14 per cent to about 8 per cent as grazing season and stage of maturity advanced. Highest ash values may have resulted from some contamination of the sample by soil.

There was evidence that the cows selectively grazed the leaves and left the stems of millet pasture. Therefore, the chemical composition data reflect the quality of forage that was available rather than that consumed. Nevertheless, the decrease in crude protein content of the millet as the grazing season advanced showed a trend similar to that found in other studies (*1,10*). Composition data obtained over the 5 years and summarized in

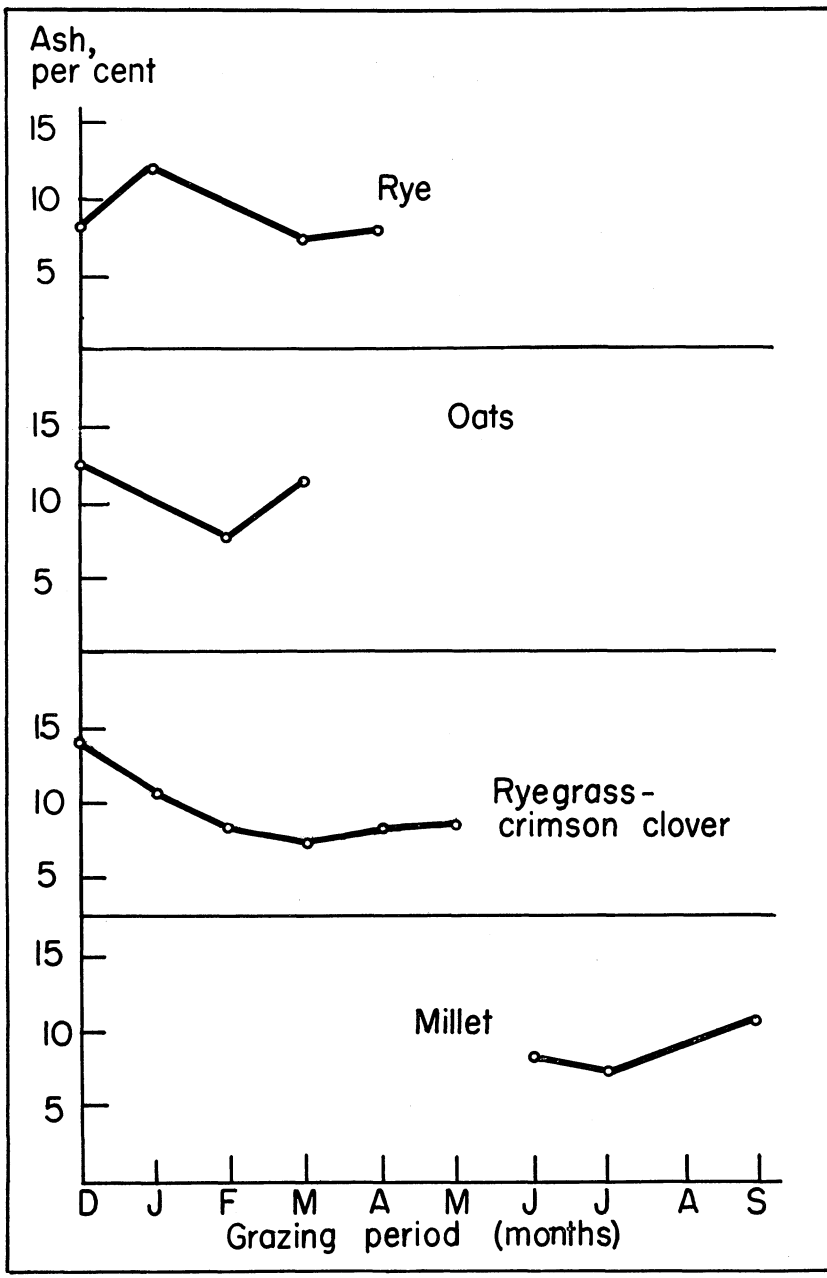

FIG. 5. Average seasonal trend in ash content of cool and warm season annual pastures at intermittent intervals during their respective grazing periods.

Figure 3, 4, and 5 indicate that the crude protein content of the millet forage available for grazing decreased with advancing maturity, while crude fiber and ash contents increased. During the five grazing seasons, the ranges in crude protein and crude fiber contents of millet samples were 24.2 to 9.5 per cent and 20.0 to 31.8 per cent, respectively.

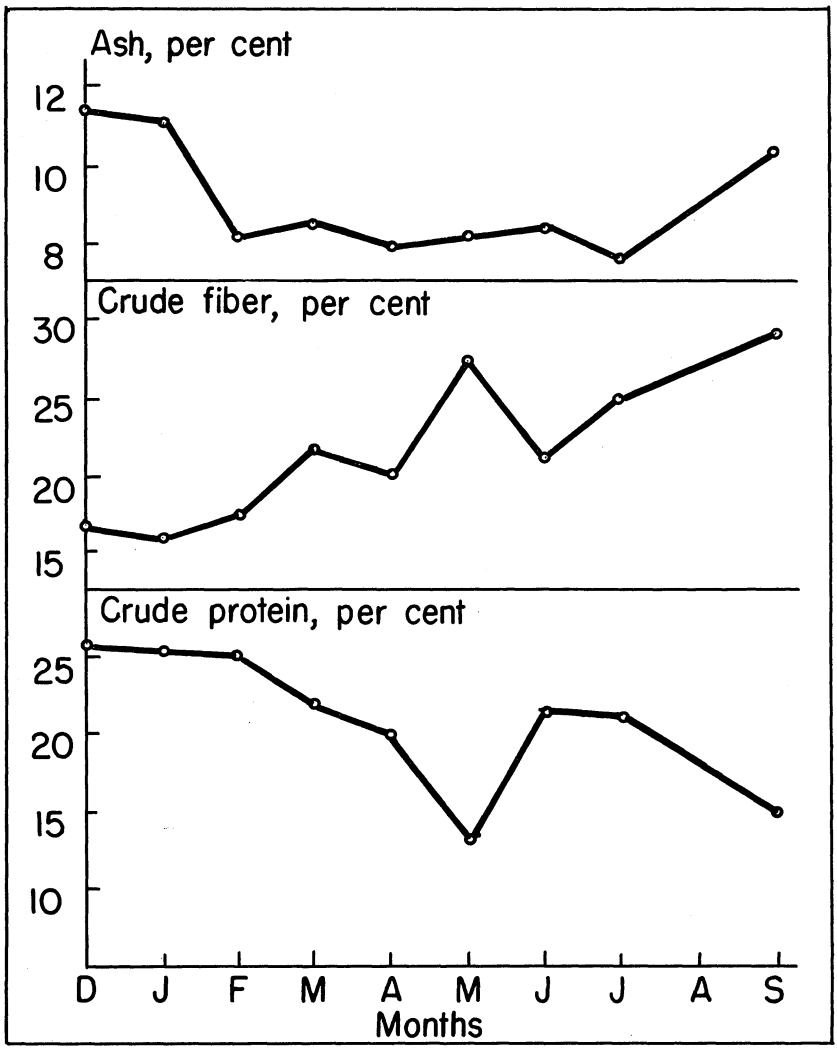

FIG. 6. Overall trend in crude protein, crude fiber, and ash contents of forages grazed throughout the year. Each value is a composite of values obtained from the various forages over the 5-year period for the respective months.

Since the pasture cows grazed two cool season annuals during winter and spring along with millet in summer and fall during each of the 5 years, it was of interest to know the average chemical composition of forage available to the cows throughout the year. Thus, crude protein, crude fiber, and ash data on each forage species grazed during each month over the 5-year experiment were combined to give average composition throughout the year, Figure 6. The relatively high crude protein and low crude fiber content of the forages grazed from early December through September indicate that high quality forage was available to the pasture group throughout most of the year. As pointed out earlier, however, there is evidence that quality of all the forages was lowest at the end of the grazing season.

Digestibility trials conducted each year confirmed that quality of the pasture forages was high except for ryegrass-crimson clover grazed during May and millet grazed during September and October. Dry matter digestibility of each forage was determined at intervals during each year's grazing period, with at least three cows utilized for each determination. The range of mean dry matter digestibility of the three cool season annuals was from 65.0 to 75.5 per cent throughout their grazing periods, Figure 7.

Digestible dry matter of rye and oat pastures was higher than that of ryegrass-crimson clover pastures, which reached a low of 58.8 per cent during May of one year. The absence of significant decreases in digestibility of rye and oat forage toward the end of the grazing season probably was due to grazing management and to contamination of the pastures with volunteer crimson clover that made rapid growth during late March and early April. All pastures were grazed rotationally, and digestibility determinations were made during the first 2 weeks in each rotation. Thus, the last determinations of the digestibility of rye and oat forage dry matter were made during late March and early April. In contrast, ryegrass-crimson clover digestibility was determined during May each year. From results of other studies (*8,13,15*), it would be expected that the digestibility of rye and oat forage available during middle and late April would decrease rapidly.

The average digestibility of millet pastures varied from 63.8 to 74.5 per cent in June and July for the 5-year study. Dry matter digestibility values of 72.7, 74.5, and 73.6 per cent obtained in June and July of 1961 and 1963 were the highest observed for this forage. These occurred on immature pastures that were only

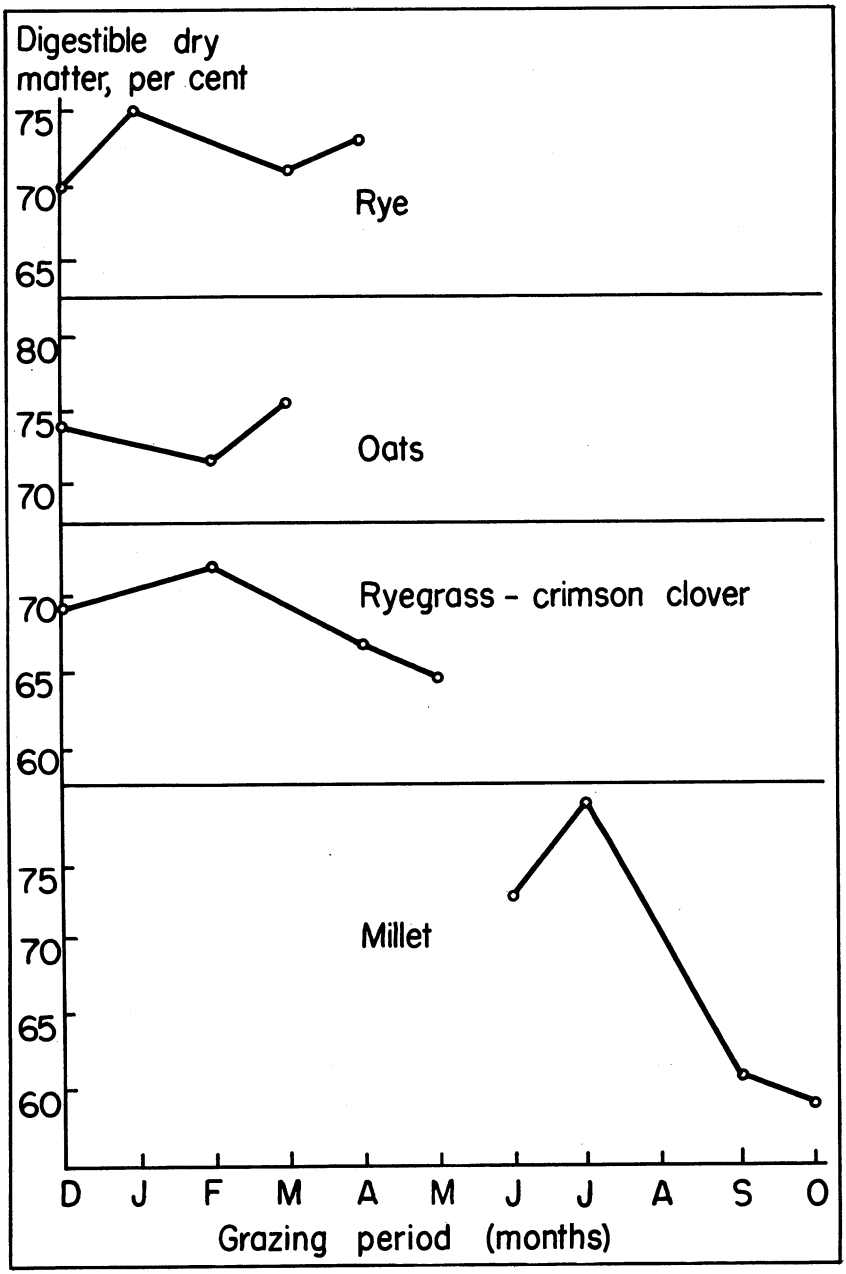

FIG. 7. Seasonal trend in dry matter digestibilities of cool season and warm season annual pasture crops during their respective grazing seasons.

12 to 14 inches in height. The lowest millet digestibility (about 55 per cent), recorded in September and October, was from mature, previously grazed pastures that were making slow growth during the digestion trials. The high average digestibility of millet forage dry matter by months indicates that, by making several plantings, high quality millet pastures can be maintained throughout the growing season if rainfall is adequate.

Dry matter digestibility coefficients of the individual forage species were combined to show the average annual trend by months over the 5 years. Both the digestibility data, Figure 8, and the composition data, Figure 6, show that the forage grazed in May, September, and October was relatively low in quality.

Dry matter intake of rye by lactating dairy cows during 1958, 1959, and 1960, Table 4, averaged 2.40 pounds per 100 pounds of body weight, as compared with 2.38 by cows grazing oats during comparable periods in 1960, 1961, and 1962. These intake levels were relatively high (*8,12,13*), similar to that reported in another study (*17*) of oat forage dry matter intake. Forage dry matter intake equal to average values reported for this study can be expected only when quality of forage available is high and the quantity is adequate. Variation in intake of rye within and between years was small as compared with other forages.

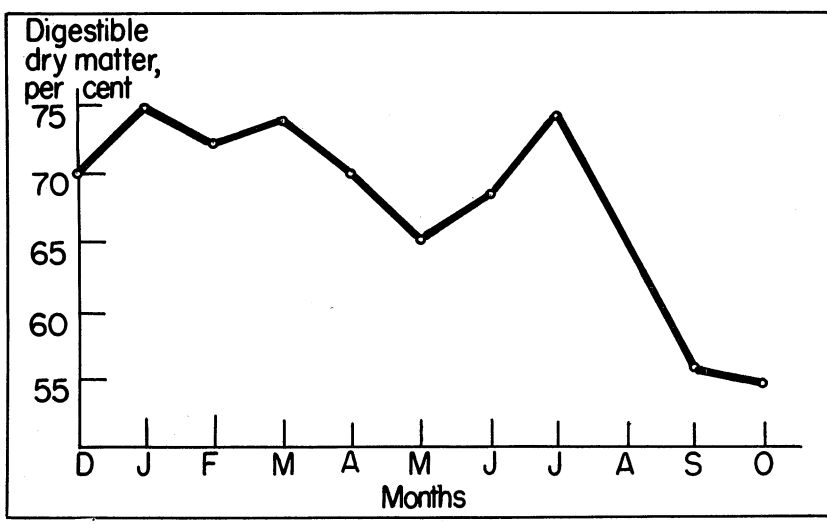

FIG. 8. Mean dry matter digestibility of annual forages grazed throughout the year. Each value plotted is the average of all values obtained from the various forages over the 5-year experimental period for the respective months.

TABLE 4. FORAGE DRY MATTER INTAKE PER 100 POUNDS BODY WEIGHT BY COWS IN PASTURE GROUP GRAZING ANNUAL FORAGES

Date of test	Intakes of forages grazed, per 100 pounds weight			
	Oats	Rye	Ryegrass-crimson clover	Millet
	Lb.	*Lb.*	*Lb.*	*Lb.*
Dec. 15-18, 1958	----	2.27	----	----
Feb. 23-26, 1959	----	----	2.12	----
Mar. 16-19, 1959	----	2.30	----	----
Apr. 20-23, 1959	----	----	1.69	----
June 29-July 2, 1959	----	----	----	1.76
Oct. 12-15, 1959	----	----	----	1.43
Dec. 7-10, 1959	----	----	2.44	----
Jan. 4-7, 1960	----	2.60	----	----
Apr. 11-14, 1960	----	2.43	----	----
May 2-5, 1960	----	----	2.02 (1.90)[1]	----
June 17-30, 1960	----	----	----	1.87 (0.94)
Sept. 26-29, 1960	----	----	----	2.31 (1.31)
Dec. 5-8, 1960	1.77	----	----	----
Dec. 17-20, 1960	----	----	1.72	----
Mar. 27-31, 1961	2.30 (1.67)	----	----	----
May 1-4, 1961	----	----	2.74 (1.46)	----
June 26-29, 1961	----	----	----	3.10
Dec. 11-14, 1961	3.61 (1.58)	----	----	----
Feb. 19-22, 1962	2.41 (2.31)	----	----	----
Apr. 23-26, 1962	----	----	2.59 (1.97)	----
June 26-29, 1961	----	----	----	1.82 (1.29)
Dec. 3-6, 1962	1.82 (2.39)	----	----	----
Apr. 1-4, 1963	----	----	2.06 (1.47)	----
May 6-9, 1963	----	----	1.95 (1.37)	----
July 6-9, 1963	----	----	----	2.09 (1.77)
Sept. 23-26, 1963	----	----	----	1.64 (1.18)
AVERAGE	2.38 (1.99)	2.40	2.15 (1.63)	2.00 (1.30)

[1] Values in parenthesis are mean intakes of nonlactating cows receiving no concentrate.

Mean intake of ryegrass-crimson clover forage dry matter, 2.15 pounds per 100 pounds of body weight over the 5 crop years, was lower than that of the small grains grazed during the same years. Ryegrass-crimson clover intakes ranged from a high of 2.74 pounds per 100 pounds body weight during the May 1961 test to a low of 1.69 pounds for the April 1959 test.

Consumption of millet forage during the test periods varied from a high of 3.10 pounds of dry matter per 100 pounds of body weight on immature forage in June 1961, to a low of 1.43 pounds on mature forage in October 1959. The 5-year average was 2.00 pounds. In 1959 and 1963 intakes of millet were highest during the June and July test periods and lowest in September and October. However, the relationship reversed in 1960 when cows

consumed more forage dry matter during September than in late June, yet digestibility of forage grazed was 10.5 per cent higher in June than during September. Insufficient millet forage in late September and October 1961 and 1962 prevented collection of intake data during these periods.

Apparent forage dry matter intake per 100 pounds of body weight was significantly different between lactating and non-lactating cows. In 14 of the trials during 1960-63, the intake of oat, ryegrass-crimson clover, and millet forage dry matter averaged 2.24 pounds for lactating cows and 1.64 pounds for dry cows grazing the same forage at the same time. No doubt these differences simply reflect the increased nutrient requirement of the lactating animal. However, they are of practical importance in determining carrying capacity of a pasture forage and in making an economic evaluation of forage systems.

The average chemical composition of the alfalfa hays and corn silages fed to the harvested roughage group throughout the study are given in Table 5. Average quality of the alfalfa hays fed was high, as shown by the high crude protein (22.1 per cent) and relatively low crude fiber (24.7 per cent) and lignin (8.7 per cent) contents. Corn silages fed to the cows averaged 8.8 per cent crude protein, 22.1 per cent crude fiber, and 7.5 per cent lignin. Some variation in quality of the alfalfa hays and corn silages fed was indicated by the standard deviations (S.D.) for crude protein, crude fiber, and lignin.

The total digestible nutrients (TDN) content of alfalfa hays fed during the experiment averaged 58.7 per cent and corn silages

TABLE 5. AVERAGE DIGESTIBILITY AND CHEMICAL COMPOSITION OF ALFALFA HAY AND CORN SILAGE FED TO HARVESTED ROUGHAGE GROUP THROUGHOUT THE EXPERIMENT, DRY MATTER BASIS

Unit	Resultant			
	Alfalfa hay		Corn silage	
	Averages	S.D.[1]	Averages	S.D.[1]
	Pct.	*Pct.*	*Pct.*	*Pct.*
Total digestible nutrients	58.7		68.1	
Digestible protein	15.3		4.3	
Crude protein	22.1	±2.1	8.8	±0.4
Ether extract	3.2	±1.0	3.5	±1.1
Crude fiber	24.7	±4.0	22.1	±2.8
Nitrogen-free extract	42.5	±2.4	61.0	±3.3
Ash	7.7	±1.7	4.7	±2.4
Lignin	8.7	±0.7	7.5	±3.0

[1] S.D. is standard deviation.

averaged 68.1 per cent, on the dry matter basis. Digestible protein in the alfalfa hays averaged 15.3 per cent, which is relatively high. The 4.3 per cent digestible protein content of corn silages is similar to values reported from other experiments.

MILK PRODUCTION COMPARED

During the 5-year experiment 50 lactations were completed on each forage system. The lactation responses of cows on the two forage systems were evaluated by three procedures: (a) total FCM production during the first 12 weeks on the experiment, (b) FCM production and persistency of production during each 28-day period, and (c) daily FCM production for the experimental lactations. Average total FCM production of cows during the final 2 weeks of the 60-day standardization period and during the first 12 weeks of the experimental period for the entire 5 years are given in Table 6. When adjusted by covariance analysis to take into account differences in initial levels of production of individual cows during the first 12 weeks on the experiment, those in the harvested forage group produced an average of 3,272 pounds of FCM as compared with 3,273 pounds by cows in the pasture group ($P > 0.05$).

Possibly a more accurate evaluation of how nutritive quality of the annual pasture forages and the harvested forages affected level of milk production is given in Tables 7 and 8. Persistency of FCM production over the eight 28-day experimental periods for the 5 years, Table 6, averaged 93.6 per cent for cows fed harvested forage and 93.8 per cent for those on pasture, Table 7. These average values for both groups are within the so-called normal persistency range of 92 to 94 per cent. During the standardization period, cows in the harvested roughage group pro-

TABLE 6. TOTAL FCM PRODUCTION OF COWS DURING THE FINAL 2-WEEK STANDARDIZATION AND FIRST 12 WEEKS OF EXPERIMENTAL PERIODS AS RELATED TO ROUGHAGE FED OR GRAZED

Roughage system	FCM per cow, standardization period	FCM per cow, first 12 weeks on experiment	
		Actual	Adjusted[1]
	Lb.	*Lb.*	*Lb.*
Harvested forage	588	3,281	3,272
Pasture	585	3,265	3,273

[1] Least significant difference between treatment averages, $P = 0.05$ is 111.8, and C.V. = 8.7 per cent.

TABLE 7. AVERAGE DAILY FCM PRODUCTION AND PERSISTENCY OF FCM PRODUCTION OVER EIGHT[1] ANNUAL 28-DAY EXPERIMENTAL PERIODS AS RELATED TO THE FORAGE FED OR GRAZED

Month of lactation	Average per cow production[2]			
	Harvested forage group		Pasture group	
	FCM	Persistency	FCM	Persistency
	Lb.	*Pct.*	*Lb.*	*Pct.*
Standardization period[3]	42.3		41.5	
Experimental periods				
First	41.0	96.9	40.5	97.6
Second	39.4	96.1	38.6	95.3
Third	37.6	95.4	37.4	96.9
Fourth	35.8	95.2	35.2	94.1
Fifth	33.7	94.1	33.5	95.2
Sixth	31.5	93.5	31.1	92.8
Seventh	28.9	91.7	28.3	91.0
Eighth	24.8	85.8	24.7	87.3
AVERAGE	34.1	93.6	33.6	93.8

[1] Persistency is the production for each 28-day period expressed as a per cent of production during the previous 28-day period.

[2] Each value represents the average for 50 cows.

[3] All cows in both groups received the harvested forages during the standardization period.

TABLE 8. AVERAGE DAILY FCM PRODUCTION OF COWS DURING THE 224-DAY EXPERIMENTAL LACTATIONS OVER THE 5 YEARS AS RELATED TO FORAGE FED OR GRAZED

Roughage system[1]	FCM per cow daily, by periods		
	Standardization	Experimental	
		Actual	Adjusted[2]
	Lb.	*Lb.*	*Lb.*
Harvested roughage	42.3	34.1	33.84
Pasture	41.5	33.6	33.86

[1] Fifty cows per roughage group.

[2] Least significant difference between treatment averages, P = 0.05 is 2.24, and C.V. = 16.6 per cent.

duced 42.3 pounds of FCM daily as compared with 41.5 pounds by cows in the pasture group. This small difference persisted throughout the 224-day experimental periods, with production averaging 34.1 and 33.6 pounds for harvested roughage and pasture groups, respectively. Adjustment of average daily FCM production to account for initial differences between the harvested forage and pasture groups removed the small differences, Table 8. These data indicate, therefore, that FCM production on the two forage systems was equal.

The two forage systems had almost identical trends in average

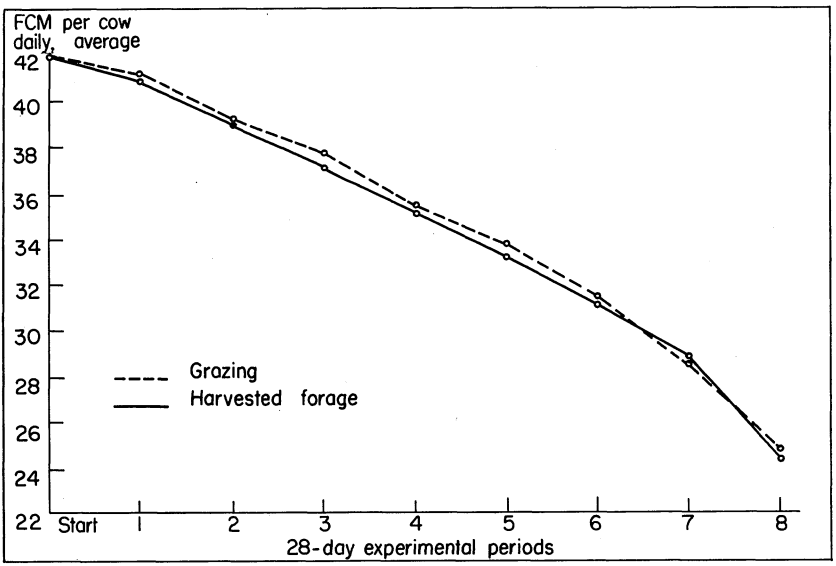

FIG. 9. Average daily milk production of cows in each forage group during the 224-day experimental lactations, beginning 61 days after calving.

daily FCM production, when adjusted to the same initial level of production, Figure 9.

A depression in milk production frequently occurs during the summer months. From information available it has been impossible to determine whether these production slumps resulted from inadequate nutrition or heat stress. To evaluate the effect of forage system on milk production through the spring and summer periods, lactation trends of cows with similar calving dates and entering the experimental feeding period near the end of March were used. The trend in FCM production during the spring and summer was slightly in favor of the pasture group, Figure 10, but the difference was not significant. Average persistency of FCM by cows starting on the experimental forage systems in late March or early April was 90.9 and 92.2 per cent for those on harvested roughage and pasture, respectively. In comparison with average persistency of all lactations, those starting in the spring were lower by 2.1 per cent. This probably resulted from relatively low levels of intake of forage during the hot summer months.

To obtain a direct comparison of cool season pastures with harvested roughages, records made by cows during the first 12

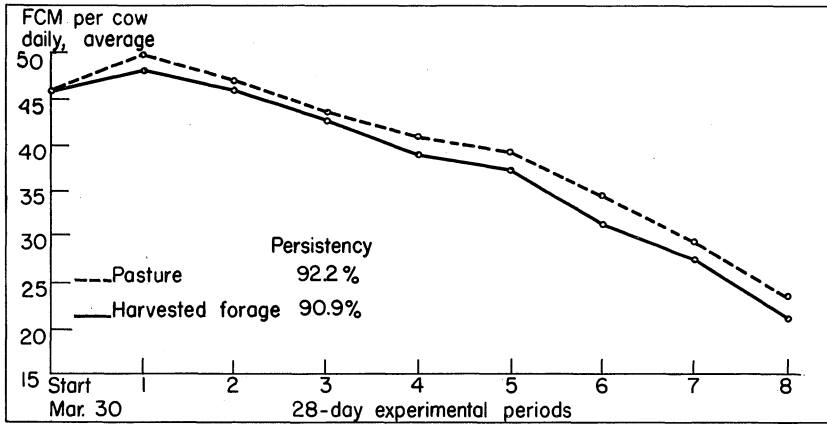

FIG. 10. Average daily milk production during summer on each forage system.

weeks they were on cool season pastures were compared with their records on alternate years during the first 12 weeks on harvested roughages. During the year(s) the cows grazed cool season pastures, they produced an average of 40.1 pounds of FCM daily during the first 12 weeks as compared with 39.2 pounds during the year(s) they were fed harvested forage, Table 9. This represents 19 records from 15 cows on each type of forage. The difference of 0.9 pound of FCM per cow daily on the two forage systems was not significant. These findings differ from results of other research in which cows grazing oats (*7*) or ryegrass and crimson clover supplemented with Kobe lespedeza hay (*9*) produced more FCM than cows fed harvested forage. The different responses observed in these studies probably were related to differences in quality of harvested forages fed. Also, it has been reported (*18*) that feeding a combination of corn silage and alfalfa hay resulted in greater milk production than when corn silage was the only forage.

EFFECT OF FORAGE ON FAT CONTENT

The fat percentage in milk produced by cows during the first 12 weeks on cool season pastures was significantly lower than in milk produced by the same cows fed harvested forages during alternate years, Table 9. The difference resulted from an increase in fat percentage of milk from cows fed harvested roughage, since milk from cows turned on cool season pastures showed little

TABLE 9. MEAN DAILY FCM PRODUCTION AND MILK FAT PER CENT OF COWS IN ALTERNATE YEARS DURING THEIR FIRST 12 WEEKS ON COOL SEASON PASTURES AND ON HARVESTED FORAGE

Roughage	FCM	Milk fat
	Lb.	*Per cent*
Harvested	39.2	4.11
Cool season pastures	40.1	3.84
Least significant difference, P = 0.05	2.1	0.19

change in fat percentage from that recorded during the standardization period. In similar studies one investigator reported a depression in milk fat per cent of cows grazing immature oats (*11*), whereas another found that immature oats had no effect on per cent fat (*3*). It is known that the type and amount of concentrate fed affects milk fat percentage. Therefore, any depression when cows are grazing cool season pastures would be expected to be greatest when concentrates are fed at high levels or in pelleted form.

The effect of millet on milk fat percentage was evaluated by two procedures. In the first, milk fat data from seven cows that went directly from the standardization ration to millet grazing show a drop of 0.20 per cent during the first 8 weeks of grazing, Table 10; the decrease for cows fed harvested forages was 0.13 per cent during the same period. The other procedure evaluated the change in milk fat percentage of 25 cows during the first 8 weeks on millet grazing and during the same period of alternate years while fed harvested forages. Some of the cows went to millet grazing from the standardization ration, whereas others went from grazing cool season pastures. During the first 8 weeks on millet, fat percentage in milk from these 25 cows averaged

TABLE 10. ADJUSTED MEAN FAT CONTENT OF MILK DURING THE FINAL MONTH OF STANDARDIZATION AND THE FIRST 2 MONTHS OF THE EXPERIMENTAL PERIODS AS RELATED TO FORAGE FED OR GRAZED

Forage consumed	Milk fat content		
	Standardization	Experimental period	
		Actual	Adjusted[1]
	Pct.	*Pct.*	*Pct.*
Millet	3.44	3.24	3.22
Alfalfa hay-corn silage	3.37	3.24	3.26

[1] Least significant difference between treatment averages, P = 0.05 is 0.327 and C.V. = 8.68 per cent. (Each value represents composite of values from seven animals.)

3.46 per cent, as compared with 3.74 per cent immediately before grazing millet. In contrast, during the same 8-week period on alternate years when fed harvested forage there was no change in the fat content (average of 3.81 per cent.) This evaluation, involving a much larger number of cows than the first, indicated that grazing millet depressed milk fat significantly. However, magnitude of the depression was less than that reported by others (*14*).

LITERATURE CITED

(1) ACHACOSO, A. S., MONDART, C. L., JR., BONNER, F. L., AND RUSOFF, L. L. Relationship of Lignin to Other Chemical Constituents in Sudan and Millet Forages. J. Dairy Sci., 43:443. 1960. (Abstract).

(2) ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official Methods of Analysis. 9th ed., A.O.A.C., Washington, D.C. 1960.

(3) CULLITY, M., AND MILLER, I. The Influence of Grazing Green Oats on the Butterfat Content of Milk. J. Agr., Western Australia, 27:394. 1950.

(4) FAIRES, E. W., DAWSON, J. R., LAMASTER, J. P., AND WISE, G. H. Experiments with Annual Pasture Crops and Permanent Pasture to Provide Grazing for Dairy Cows in the Sandhill Region of the Southeast. U.S.D.A., Tech. Bul. 805. 1941.

(5) GAINES, W. L. The Energy Basis of Measuring Milk Yield in Dairy Cows. Ill. Agr. Expt. Sta., Bul. 308. 1928.

(6) HARDISON, W. A., AND REID, J. T. Use of Indicators in the Measurement of the Dry Matter Intake of Grazing Animals. J. Nutrition, 51:35. 1953.

(7) HAWKINS, G. E., AND AUTREY, K. M. Young Oat Forage – A High Quality Dairy Feed. Auburn Univ. Agr. Expt. Sta., Leaf. 55. 1957.

(8) ---------- AND ROLLINS, G. H. Changes in Digestibility of Cool Season Forages During the Spring Grazing Season. Paper presented to Sou. Div., ADSA, Jackson, Miss., Feb. 6-8, 1961.

(9) LAMASTER, J. P., KING, W. A., AND MITCHELL, H. H. Ryegrass and Crimson Clover for Winter Pasture. S.C. Agr. Expt. Sta., Bul. 380. 1950.

(10) MARSHALL, SIDNEY P., SANCHEZ, A. B., SOMERS, H. L., AND DIX ARNOLD, P. T. Value of Pearl Millet Pasture for Dairy Cattle. Fla. Agr. Expt. Sta., Bul. 527. 1953.

(11) MCCLYMONT, G. L., AND PAXTON, R. The Effect of Grazing Oats on Butterfat Content of Milk. Agr. Gazette, 58:551. 1947.

(12) MCCULLOUGH, M. E. The Use of Indicator Methods in Measuring the Contribution of Two Forages to the Total Ration of the Dairy Cow. J. Dairy Sci., 36:445. 1953.

(13) ----------, BAIRD, D. M., AND SELL, O. E. The Relationship Between Forage Dry Matter Digestibility and Weight Gain by Dairy Heifers on Three Winter Grazing Crops. J. Dairy Sci., 37:1435. 1954.

(14) MILLER, R. W., WALDO, D. R., OKAMOTO, M., HEMKEN, R. W., VANDERSALL, J. H., AND CLARK, N. A. Feeding of Potassium Bicarbonate or Magnesium Bicarbonate to Cows on Sudangrass or Pearl Millet. J. Dairy Sci., 46:621. 1963.

(15) OWEN, F. G. Oat Pasture for Lactating Cows. J. Dairy Sci., 47:95. 1964.

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

(17) ROARK, D. B., LUSK, J. W., COWSERT, W. C., AND WATERS, R. E. Pasture for Dairy Cattle. A Summary of Three Years Grazing Trials. Miss. Agr. Expt. Sta., Bul. 507. 1953.

(18) WAUGH, R. K., MOCHRIE, R. D., MURLEY, W. R., POSTON, H. A., AND LUCAS, H. L. Milk Production and Dry Matter Intakes From Different Combinations of Hay and Corn Silage. N. C. State College, Animal Ind. Dept., Rpt. 14-DHis. 1955.