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University of Tennessee Agricultural Experiment Station

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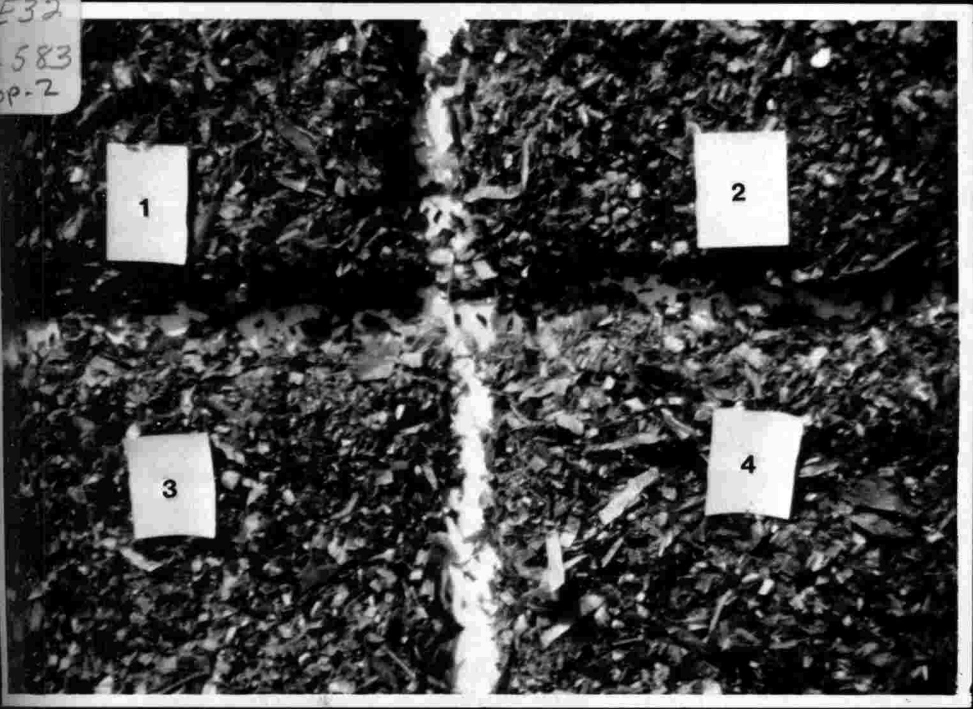

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FOREWORD

This bulletin is the result of interdisciplinary cooperation among several departments: agronomic data were obtained by the Department of Plant and Soil Science; silage scores by Plant and Soil Science Extension; and feedlot, carcass, and digestibility data by the Department of Animal Science. The research was conducted at the Tobacco Experiment Station, Greeneville, Tennessee, and in the laboratories of the Departments of Animal Science and of Plant and Soil Science at Knoxville, Tennessee.

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Front Cover: Samples of the four maturity stages of silages used in this study: 1) late milk; 2) early dough; 3) late dough; and 4) mealy endosperm.

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Corn Silage Maturity and Beef Heifer Performance

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INTRODUCTION

The question "When should I cut my corn for silage?" is asked repeatedly by Tennessee farmers. This study attempts to provide information relative to finishing beef heifers with corn cut at various stages of maturity and preserved as corn silage.

Three major criteria have been used to determine when to harvest corn for silage. The first deals with the maximum dry matter yield per acre. Work by Johnson *et al.* (1966) and by Johnson and McClure (1967) indicated that maximum dry matter yield was obtained when corn was harvested for silage between the dent and the glazed stages of maturity. Conversely, Gay (1966) and Keeney *et al.* (1967) found that harvest during the late dent-hard dough stage resulted in maximum dry matter yield. Pratt, Conrad, and Triplett (1964) found no measurable difference in dry matter yield between a late milk-early dough stage and a well-dented stage, but Geasler, Henderson, and Hawkins (1967) reported a decrease in dry matter yield with increasing maturity.

The second criterion is the amount of silage dry matter consumed daily by cattle. Maximum dry matter consumption was found to occur with corn harvested in the early dent stage by Noller *et al.* (1963); Huber, Graf, and Engel (1963) and Gay (1966) found that the largest consumption occurred at the hard dough stage; and Chamberlain *et al.* (1968) found higher air dry matter consumption by heifers at the early and late dough stages than at the late milk and mealy endosperm stages. Still other workers—such as Geasler *et al.* (1967), Bryant, Huber, and Blaser (1965), and Johnson *et al.* (1965)—showed that dry matter consumption increased with increasing maturity.

A third criterion for determining harvesting time has been digestibility. Various stages of maturity have been compared, ranging from the blister stage to the very mature stage of kernel development,

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with most experiments concentrating on the milk, dough, and dent stages. In general, digestibility of most nutrients increased up to the dough stage and decreased thereafter (Pratt *et al.*, 1964; Gordon *et al.*, 1968; Johnson and McClure, 1968; Goering *et al.*, 1969 and Colovos *et al.*, 1970). Perry *et al.* (1968) reported no significant differences in digestibility of the various stages.

Other practical criteria influence the timing of corn silage harvest. Labor availability and work required by other farm production activities often modify corn silage harvesting dates. Tobacco and cotton harvest or small grain planting are activities that compete for labor and equipment at the time that silage should be harvested.

The objectives of this experiment were: 1) to determine the differences in chemical and botanical (plant parts) composition of corn ensiled at various stages of maturity; 2) to determine whether differences in maturity affect digestibility and consumption of these silages by beef heifers, and their performance; and 3) to determine if nutrient composition, digestibility, or visual scores of corn silage can be related to animal performance.

EXPERIMENTAL PROCEDURE

Agronomic Management Practices

The corn for this 3-year experiment was grown on a field comprised of 80% Huntington silt loam (fine-silty, mixed, mesic, Fluventic Hapludalfs) and 20% Linside silt loam (fine-silty, mixed, mesic Fluvaquentic Eutrochrepts). Each fall, the area was planted with small grain following silage harvest. This crop was used as pasture for beef cows or heifers during the wintering period as weather permitted. The field was top-dressed in the spring with 50 pounds of nitrogen and about 24 tons of cattle manure per acre. The fertilizer and manure were plowed under with the small grain residue. Before planting, 160 pounds of nitrogen, 30 pounds of phosphorus, and 50 pounds of potassium per acre were applied in accordance with soil test recommendations. Weed control was accomplished by using atrazine or simazine as preemergence herbicides.

The corn varieties used were hybrids recommended for silage production at the time of this test. During the 3-year period the plant population varied between 15,000 and 20,000 plants per acre. The corn was planted the last week of April or the first week in May.

Stages of Maturity at Harvest

The silage was harvested at four stages of grain maturity subsequently referred to as 1) late milk or first cutting, 2) early dough or second cutting, 3) late dough or third cutting, and 4) mealy endosperm or fourth cutting. These stages were selected to encompass a wide range in time or physiological stage of maturity during which corn might be ensiled. The first stage was earlier than had been recommended when this study was initiated. The dough stage was the usual recommendation, with most recommendations indicating the late dough stage. The fourth cutting was later than had been recommended for the harvesting of corn silage in Tennessee. Harvest dates of the silage are presented in Table 1. The color photo on the cover shows the differences in the silages as they were fed.

The **late milk** stage had about 10% of the kernels dented. There was considerable juice in the kernel and very few kernels were in the dough stage. The shuck was green and there was generally not more than 5% firing of the bottom leaves.

At the **early dough** stage, practically all of the kernels were dented. Numerous kernels were still soft or in a very early dough stage. The shucks were beginning to lose some green color. The firing of the lower leaves had increased to as much as 10%.

In the **late dough** stage the endosperm was rather firm. The kernels contained approximately 50% moisture. Nearly half of the color had been lost from the shuck and the firing of the lower leaves had increased to about 20%.

In the **mealy endosperm** stage the grain had about 35% moisture. Nearly all color had disappeared from the shucks. The endosperm was mealy, indicating a high degree of starch development, and the firing of the leaves sometimes was as high as 50%.

Table 1. Harvesting dates for corn silage.

Stages of maturity	First year	Second year	Third year
Late milk	Sept. 9	Aug. 18	Aug. 28[a]
Early dough	Sept. 16	Aug. 25	Aug. 31
Late dough	Sept. 21	Sept. 1	Sept. 7
Mealy endosperm	Oct. 5	Sept. 21	Sept. 18

[a]This cutting, originally scheduled for August 17, was delayed because of rain.

Separation of the corn plant into the parts: stalk, leaf, and ear.

Agronomic Data

As corn of each maturity was cut and ensiled, agronomic data were collected from a minimum of 16 representative row sections, each 18 feet long, in the following manner from each row section: 1) number of plants; 2) number of dead and lodged plants; 3) average plant height; 4) ears (grain and cobs only, the shuck was left on the stalk) were removed, weighed, separated into ears and nubbins, counted, and a 5- to 8-pound subsample was taken; 5) the ears in the subsample were oven-dried for not less than 48 hours at 65°C, air equilibrated, and weighed; 6) the standing plants (stalk, leaf, and shuck) were cut at the stubble height left by the field chopper, and weighed; 7) 5-10 stalks, weighing about 12-15 pounds, were randomly selected, and the leaf blades and shucks removed from the stalks; 8) the leaf blades and shucks were placed in bags, oven-dried, air-equilibrated, and weighed; 9) the stalks (minus leaves and shucks) were cut into 3-4 inch sections to facilitate drying, placed in bags, oven-dried, air-equilibrated, and weighed; 10) cobs and grain were separated, and moisture content was determined for each fraction; 11) fractional composition of the plant (stalk, leaf, cob, and grain) was computed on both green and dry weight bases. The agronomic data thus secured are shown in Table 2.

Table 2. Agronomic characteristics of corns used for silage

Characteristics	First year				Second year				Third year			
	Late milk Sept. 9	Early dough Sept. 16	Late dough Sept. 21	Mealy endo-sperm Oct. 5	Late milk Aug. 18	Early dough Aug. 25	Late dough Sept. 1	Mealy endo-sperm Sept. 21	Late milk Aug. 28	Early dough Aug. 31	Late dough Sept. 7	Mealy endo-sperm Sept. 18
Height, feet	10.9	10.4	10.8	–	10.0	10.0	9.8	9.9	8.8	9.0	9.3	8.9
Plants per acre	20,230	18,080	18,875	18,515	19,690	17,980	19,260	19,480	16,185	15,330	15,320	14,860
Lodging, %	8.0	10.2	10.7	27.0	2.9	6.0	8.9	19.0	1.4	1.6	0.3	2.3
Number of ears per acre	19,980	18,185	17,180	14,445	16,325	17,080	17,850	16,430	20,500	19,005	19,220	19,175
Ears per 100 plants	99.1	100.3	91.4	79.3	83.1	97.0	93.3	84.9	128.7	125.2	128.2	130.8
Nubbins, %	24.5	19.5	24.7	32.9	37.6	28.3	22.0	27.2				
Shelling %	74.2	76.6	82.2	80.2	71.3	78.3	81.4	84.0	75.5	77.5	79.3	81.5
Green weight, tons per acre												
Stalks	12.79	10.00	10.54	8.94	11.17	10.87	10.06	9.90	9.67	8.98	8.90	7.24
Leaves	6.62	5.00	4.63	2.85	6.83	6.74	5.66	3.66	8.07	7.16	6.18	4.33
Ears	5.25	4.79	4.94	4.53	5.19	5.97	5.78	5.63	6.77	6.17	6.15	5.84
Total	24.66	19.79	20.11	16.32	23.19	23.58	21.50	19.19	24.50	22.31	21.22	17.42
Green yields												
% stalks	51.3	49.5	52.3	54.5	48.3	46.0	46.9	51.6	39.6	40.2	42.0	41.6
% leaves	27.0	25.4	23.0	17.6	29.4	28.7	26.3	19.1	32.7	32.0	29.2	24.8
% ears	21.7	25.0	24.7	27.9	22.3	25.3	26.8	29.2	27.6	27.8	28.8	33.6
Leaf in green stover, %	34.6	34.1	30.6	24.5	37.8	38.4	36.0	27.0	45.3	44.4	41.0	37.4
Stalk in green stover, %	65.4	65.9	69.4	75.4	62.2	61.6	64.0	73.0	54.7	55.6	59.0	62.5
Dry weight, tons per acre												
Stalks	3.61	2.18	3.67	1.81	2.30	2.28	2.71	2.14	1.95	1.88	1.98	2.24
Leaves	2.02	1.40	1.58	1.32	1.49	1.56	1.44	1.32	1.86	1.68	1.72	1.65
Ears	1.87	2.18	2.80	3.00	1.86	2.76	3.08	3.45	3.12	3.05	3.31	3.51
Grain	1.40	1.68	2.30	2.41	1.33	2.17	2.51	2.90	2.36	2.37	2.63	2.86
Cobs	0.47	0.50	0.50	0.59	0.53	0.59	0.57	0.55	0.76	0.68	0.68	0.65
Total	7.50	5.75	8.00	6.14	5.65	6.60	7.23	6.91	6.93	6.61	7.01	7.40
Dry matter %												
Stalks	29.7	21.4	34.2	20.4	20.7	20.9	26.8	21.6	20.2	21.0	22.4	30.9
Leaves	30.6	27.8	34.6	47.6	22.1	23.2	25.6	36.4	23.2	23.7	28.0	38.5
Ears	35.6	45.2	56.8	66.2	35.6	46.3	53.1	61.3	46.0	49.3	53.7	59.9
Moisture in grain, %	–	–	48	38	59	48	42	34	60	44	40	34
Moisture in silage, %	68.9	71.0	60.2	62.4	75.6	72.0	66.4	64.0	71.7	70.4	67.0	57.5
Dry yields												
% stalks	46.9	36.7	44.7	29.6	40.5	34.4	37.1	31.0	28.3	28.3	28.5	30.1
% leaves	27.5	24.4	19.6	21.6	26.6	23.8	20.2	19.2	26.7	25.6	24.7	22.4
% ears	25.6	38.9	35.6	48.8	32.9	41.9	42.8	49.7	45.0	46.1	46.9	47.5
% grain	19.0	29.8	29.4	39.2	23.5	32.8	34.8	41.8	34.0	35.8	37.2	38.7
% cobs	6.5	9.1	6.2	9.6	9.4	9.1	7.9	7.9	11.0	10.4	9.7	8.8
Leaf in dry stover, %	37.1	40.3	31.0	42.3	39.3	41.0	35.5	38.2	48.5	47.5	46.5	42.9
Stalk in dry stover, %	62.9	59.7	69.0	57.7	60.7	59.0	64.5	61.7	51.5	52.5	53.5	57.1
Number of observations (18-foot row)	19	20	20	18	18	21	20	21	20	20	16	20

Yearly Environmental Conditions

The first year was a relatively poor silage year. Only two rains of consequence occurred in the 2-month period preceding the harvest of the first maturity stage, and essentially no rain fell between the first and the third cuttings. The dry weather was accompanied by relatively high temperatures (above 85°F). Thus, the silage produced the first year had a higher percentage of leaf firing than that from either the second or the third year.

The second year was an above-average year for silage production. July had slightly above average rainfall and over 3.3 inches of rain fell in August before the first harvest (Table 1). In addition, considerable rain fell between the third and fourth cuttings.

The third year was an average silage year. Precipitation in July was slightly above normal, and close to normal during the August harvesting period.

Silos used to store silage and the cattle feeding sheds.

Harvesting and Ensiling

The field cutter was set to give about a ½-inch cut on the harvested plant material. Each wagon load of plant material was weighed to obtain the weight of the plant material placed in the silo. These values were compared during the second and third years to the potentially harvestable yield obtained by hand cutting in the field, thus allowing calculation of the percentage of field harvest loss. These data are presented in Figure 1.

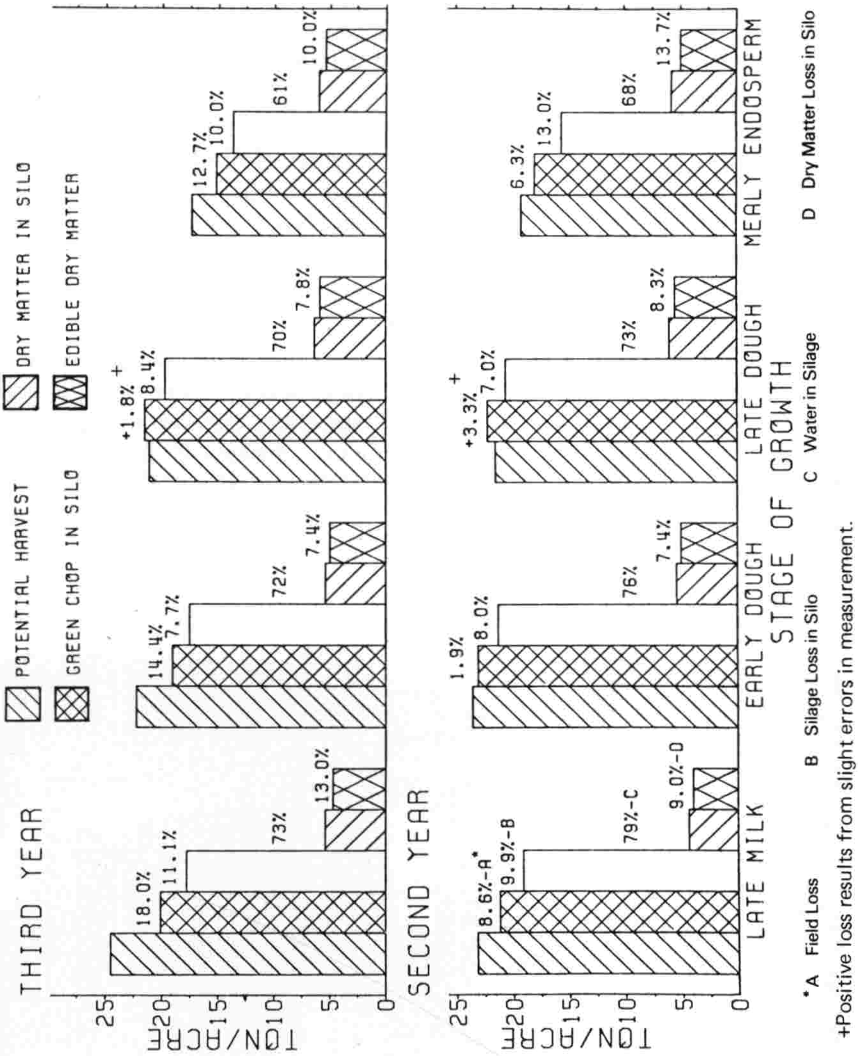


Figure 1. Silage harvested, stored, and fed.

Two 6- x 30-foot upright silos of 10-11 tons capacity were filled with chopped corn plants from each maturity stage studied. They were normally filled in a single day, and the plant material was allowed to settle overnight. Silos were refilled the following morning, capped with plastic and a layer of sawdust to reduce spoilage. The silage was normally allowed to ferment at least 30 days after the fourth cutting before it was fed to cattle. About a week elapsed between the first and second field cuttings, and another week between the second and the third. About two additional weeks were required to reduce the moisture content of the grain to 35% for the fourth cutting. Thus, the total time span between the first and fourth cuttings was about 1 month.

In the last 2 years of the experiment, spoiled material from the top was weighed so that spoilage losses could be calculated. These data, as well as the unaccounted losses (fermentation, gas, and seepage), are presented in Figure 1.

Silage Scoring

In an attempt to relate feeding values with silage scores and chemical composition, the silages were scored individually several times during the feeding period, using standard Tennessee Agricultural Extension Service silage score sheets (Figure 2 Before Study). Samples of the silage as it was fed were taken periodically for chemical analysis. The yearly and 3-year average data from these analyses are given in Table 3 on an as-fed basis. It was on the basis

Heifers during the adjustment phase, between purchase and starting on silage.

Figure 2. Silage scoring sheet, Tennessee Agricultural Extension Service

	Before Study	After Study
I. GRAIN CONTENT (Total 40)		
1. High	36-40	36-40
2. Medium	28-35	28-35
3. Low	16-27	16-27
4. None (either no ears developed or ears removed)	0-15	0-15
II. COLOR (Total 12)		
1. **Desirable**—Slightly brownish	9-12	9-12
2. **Acceptable**—Dark green to yellowish green or yellow to brownish	5-8	5-8
3. **Undesirable**—Deep brown or black indicating excessive heating or putrefaction. Predominantly white or gray indicating excessive mold development	0-4	0-4
III. ODOR (Total 28)		
1. **Desirable**—Light, pleasant odor with no indication of putrefaction.	22-28	24-28
2. **Acceptable**—Fruity, yeasty, musty, which indicates a slightly improper fermentation. Slight burnt odor. Sharp vinegar odor	11-21	11-23
3. **Undesirable**—Strong burnt odor indicating improper fermentation. A very musty odor indicating excessive mold which is readily visible throughout silage	0-10	0-10
IV. MOISTURE	**(Total 20)**	**(Total 10)**
1. No free water when squeezed in hand. Well preserved silage	17-20	9-10
2. Some moisture can be squeezed from silage or silage dry and musty.	9-16	5-8
3. Silage wet, slimy or soggy, water easily squeezed from sample. Silage too dry with a strong burnt odor	0-10	0-4
V. CHOP		**(Total 10)**
1. Small, uniform, sharp angled pieces of silage.		9-10
2. Silage uniform in cut, but slightly stringy, some large pieces of shucks, cobs, and stalks		5-8
3. Silage stringy, puffy or large variable sized pieces		0-4

Total Score

Scoring:	90 and above	Excellent silage
	80-89	Good silage
	65-79	Fair silage
	Below 65	Poor silage

Table 3. Chemical composition of corn silage harvested at four stages of maturity—as-fed basis

	Dry matter	Crude protein	Crude fiber	NFE
	percent			
First year				
Late milk	23.8	2.5	6.2	13.1
Early dough	27.8	3.1	7.2	15.1
Late dough	29.8	3.0	6.9	17.4
Mealy endosperm	31.5	3.3	8.7	16.8
Second year				
Late milk	20.8	2.2	5.2	11.5
Early dough	23.6	2.4	5.0	13.7
Late dough	26.8	2.6	5.5	16.3
Mealy endosperm	31.9	3.3	6.8	19.0
Third Year				
Late milk	26.6	2.0	6.0	16.5
Early dough	28.3	2.0	6.2	17.9
Late dough	29.6	2.2	6.5	18.8
Mealy endosperm	39.1	2.9	8.1	25.4
Three-year average				
Late milk	23.7	2.3	5.8	13.7
Early dough	25.6	2.5	6.1	15.5
Late dough	28.7	2.6	6.3	17.5
Mealy endosperm	34.2	3.1	7.9	20.4

of these chemical analyses that 1½ pounds of protein supplement were added to the ration to meet the NRC standards for heifers of this weight and desired growth rate.

Feeding Trials

Each year, approximately 45-50 heifers of Angus and Hereford breeding weighing 450 to 500 pounds and grading Good, were purchased at graded feeder calf sales. They were allowed 2-3 weeks to adjust to each other and to the station conditions, and were observed for possible illnesses or abnormalities. Following this adjustment period, the animals were graded with respect to type and condition. Then they were allotted into eight uniform groups on the basis of weight, grade, and weight changes during the adjustment period. Two groups were randomly assigned to each of the four corn silage maturity treatments.

In the silage phase, heifers were fed corn silage free choice *(ad lib)* once a day, plus 1½ pounds of cottonseed meal per head per day placed over the top of the silage, and 2 pounds of hay per head per day. Alfalfa-orchardgrass hay classified as good quality was used. In order to measure differences due to stages of maturity of the silage, no concentrate other than the protein supplement was fed. The heifers were fed the silages for 98 days for each of the first 2 years and for 112 days in the third year. The silage-feeding phase was followed by a full-fed concentrate phase. There was a transition period of 1 to 2 weeks during which the silage was reduced gradually and the concentrate portion increased gradually.

The heifers were weighed on 2 consecutive days at the beginning of the silage feeding phase and at the end of the concentrate phase. They were weighed every 28 days between the beginning and end of the test. To minimize "shrink and fill" differences in weight, the heifers were taken off feed and water at about 6:00 p.m. on the evening before the weigh day, and were weighed the following morning around 8:00 a.m.

Treatment of heifers for external parasites.

Marketing and Carcass Data

Cattle were trucked from Greeneville to Knoxville, a distance of about 70 miles, when the visual grade of the cattle in the experiment averaged USDA high good. After slaughter, hot carcass weight was obtained. Carcasses were chilled and allowed to remain in the cooler for 48 hours. At that time they were graded by a USDA grader for official carcass grade, marbling score, maturity grade, and percent kidney fat. In addition, measurements of backfat and loin eye area were made according to procedures outlined by the American Meat Science Association (Schnoonover *et al.*, 1967).

Statistical Analysis

The statistical analysis was performed according to methods described by Harvey (1960). The independent variables included in the model were year, stage of maturity, and the year X maturity interaction. Variation between pens treated alike was considered to be an appropriate error term for this model. The year X cutting interaction was not significant and was deleted in the final analysis. When significant differences ($P \leq .05$) were found, Duncan's (1955) multiple range test as modified by Kramer (1956) was used for mean separation.

Digestion Trials with Steers

During each of the last 2 years, an *in vivo* total-collection digestion trial was conducted. In both years, 12 Hereford steer calves of similar type and condition and weighing approximately 600 pounds were used. The steers were placed in metabolism stalls described by Hobbs *et al.* (1950) and three were assigned randomly to each of the four corn silage rations. Ten-day preliminary periods and 7-day collection periods were used. Collection of the fecal material started 2 days after accounting for feed intake.

Each steer was fed a daily ration consisting of 2 pounds of alfalfa hay, 1.5 pounds of cottonseed meal, and as much of one of the four corn silages as they had consumed voluntarily in the preliminary period. Equal parts of the daily ration were fed in the morning and in the evening. Fecal material and feed refusal (if present) were collected once daily. Fecal samples were refrigerated under thymol, and all samples were analyzed for proximate constituents according to A.O.A.C. (1965) procedures. Digestion coefficients and total digestible nutrients (TDN) were calculated. Possible significant differences among digestion coefficients and percent total digestible nutrients were determined by an analysis of variance test. When significant differences were found, Duncan's (1955) multiple range test as modified by Kramer (1956) was used for mean separations.

In Vitro Digestibility

The corn silages of the third year were used to determine *in vitro* digestible dry matter of the various plant parts according to the Tilley and Terry (1963) procedure. Representative portions of the frozen corn silages were separated by hand into 1) leaves including shucks, 2) stalks, 3) cobs, and 4) kernels. All silage fractions were freeze-dried in a "Del-Vac" freeze dryer for 24 hours and ground. Rumen liquid was obtained from a rumen-fistulated beef steer 4-5 hours after feeding a ration of corn silage, corn, and cottonseed meal. Three successive *in vitro* runs were conducted on duplicate samples of each determination.

RESULTS AND DISCUSSION

Agronomic and Silage Data

In the first 2 years the number of plants per acre was between 18,000 to 20,000 with an average height of about 10 feet; in the third year, the population was slightly lower (about 15-16,000) and average plant height was 9 feet (Table 2). In general the percent of lodged stalks in the first 2 years gradually increased from the first to the fourth cutting. In the third year, there was little difference in the lodging percentage, although the trend to increased lodging in the fourth cutting was evident. During the first 2 years there was slightly under one ear per plant while in the third the ratio was about 1¼ ears per plant. This was probably due to the change in corn varieties, both of which were recommended for silage production.

Green weight, as measured by sampling 18 feet of row at harvest, gradually decreased from the first to the fourth cutting. This was due to the increasing maturity of the plant and the gradual reduction of moisture within plant tissues. In the first 2 years, stalks represented about 50% of the total green weight of the plant, leaves about 25-30%, and ears 20-25%. In the third year, stalks represented about 40% of the green weight, leaves 25-30%, and ears 25-30%. This decrease in stalk percentage and increase in ear percentage the third year reflected the increase in ears per stalk. The dry matter in the ear increased consistently from the first to the fourth cutting in all years. This increase indicated deposition of starch and reduction in grain moisture as the plant approached maturity.

Although every attempt was made to harvest the corn silage at the same physiological condition each year, there was variability. Environmental variation of such factors as rainfall and temperature played an important part in influencing composition and quality of silage as it was harvested. This variation was emphasized by the variability in harvesting dates of the silage (Table 1) which was due primarily to environmental conditions. In the third year, harvesting was delayed due to heavy rains which left the field unsuitable for harvesting equipment. Yearly variation will be discussed further when discussing the feeding values of the various corn silages.

The potential harvestable yield of silage, the amount of chopped material that went into the silo, and the amounts that were fed during the second and third years are presented in Figure 1. Since the quantity of top spoilage was not determined for the first year, these values could not be determined for that year. Potential harvestable yields were calculated from the standing crop row samples weighed in the field immediately before machine harvest. The chopped material per acre actually put in the silo was determined by weighing each wagon load of silage as it was emptied into the silo. The edible silage represents the amount taken out of the silo and fed to cattle. The percentage of potentially harvestable yield of silage in the silo was determined by dividing the actual chopped material per acre that went into the silo by the potentially harvestable yield. The late dough or third cutting had slightly more chopped material put into the silos than would be predicted. Possible explanations for this are error in sampling the row samples, or in weighing the corn plants cut from the row samples.

The percentage of edible silage fed in relation to the potentially harvestable yield was slightly higher for the two middle cuttings, i.e. the early and the late dough stages. The percentages for the first and fourth cuttings were slightly less than for the two middle cuttings.

Although the total tonnage ensiled was quite similar for the first three cuttings (Figure 1), the dry matter yield for the first cutting was slightly less than for the last three cuttings. The reason for this is apparent from the data in Table 3 which describe the nutrient composition of the silage as fed. The first cutting had the lowest dry matter percentage, with dry matter percentages increasing with subsequent cuttings. This is further reflected in quantity of edible silage dry matter per acre, which represents the actual silage fed.

The field loss (Figure 1) represents the differences between the potential harvestable yield and the amount that actually went into the silo. Several factors affect this loss: header losses on the chopper, the positioning of the blower relative to the wagon, wind, the amount of turning, evaporation losses, and perhaps others. The third year data show higher field losses than those for the second year. Increased firing of the lower leaves and higher wind velocities during harvesting are possible explanations.

The loss that occurred in the silo represents the difference between the amount placed in the silo and the amount actually fed. This includes 1) the top spoilage which consistently was in the 2-3% range, 2) the unaccounted losses such as those due to fermentation, gas production, loss of fluids in runoff, and 3) the inedible material at the bottom of the silo. The higher loss figure for the first cutting was undoubtedly due to greater moisture content and consequently the increased amounts of fluids lost from the silo. The increase in loss in the fourth cutting may be explained partly because this silage was drier, had a higher percentage of fired leaves, and consequently did not pack as tightly as the material from the two previous cuttings. These data would indicate that the total loss was smaller for the middle cuttings and larger for the first and the fourth. In the small silos used, this total loss was probably higher, percentagewise, than would be encountered in a larger silo.

The detailed yearly silage scores and the mean total silage scores placed on these silages are given in Table 4. In all 3 years, scores of the two middle cuttings were consistently higher than those for the first and fourth cuttings. This was particularly true during the first 2 years. Much of this difference is accounted for by the low score given to grain content in the first 2 years on the first cutting. This corn was in the milk stage and much of the fluid from the kernel seeped into the silage and could not be seen as grain. The first cutting

Table 4. Silage scores

	Stage of maturity			
Category	Late milk	Early dough	Late dough	Mealy endosperm
First year[a]				
Grain content	28	35	35	34
Color	9	9	9	7
Odor	20	22	22	17
Moisture	13	16	17	15
Total[b]	70	82	83	74
Second year[a]				
Grain content	27	34	35	36
Color	11	9	7	6
Odor	20	21	20	14
Moisture	15	16	16	15
Total[b]	72	80	79	72
Third year[c]				
Grain content	34	35	35	35
Color	9	8	8	6
Odor	22	23	22	21
Moisture	15	16	16	16
Total	80	82	82	78
Three-year average total score	74	81	81	75

[a]Average of three scores.
[b]The individual scores do not always add up to the total due to rounding errors.
[c]Single score.

in the third year had a higher grain score because of a 10-day delay in harvesting due to rain and wet field conditions which prevented harvesting at the desired stage of maturity.

There was no apparent relation between the silage scores (Table 4) and the chemical composition of the corn silage on an as-fed basis (Table 3). The only consistent differences in chemical composition of the silage were the lower protein content and higher NFE values on the as-fed basis the third year, as compared to the first 2 years. This higher NFE content can be accounted for, in part, by the fact that the corn averaged 1¼ ears per stalk in the third year rather than slightly less than one ear per stalk in each of the first 2 years.

The silage score card was revised (Figure 2: column, After Study) to reflect some of the findings of this report. The moisture score was reduced from 20 on the original form (column, Before Study) to 10, and the other 10 points were allocated to fineness and uniformity of chop to reflect the effectiveness of chopping on the ensiled corn plant.

Feeding area for the heifers inside the barn.

Animal Performance and Feed Consumption

Silage Phase

Animal performance and feed consumption data are presented by years in Table 5 and summarized for the 3 years in Table 6. The tables include data for both the silage and the full-fed phase. There was a yearly difference in the gains made during the silage feeding phase (Table 5). The lowest gains during the silage phase were obtained the first year, and the highest in the second.

However, in all 3 years there was a consistent pattern in average daily gain (ADG) among treatments. The ADG's of heifers fed the first three stages of maturity were similar and significantly higher ($P \leq .05$) than that of the cattle fed silage from the fourth stage of maturity. These yearly differences in ADG point out the influence of environmental conditions during the growing season on the feeding value of silage produced each year. While there may have been differences among the cattle themselves each year, the heifers purchased presumably represented those available to feeders in Tennessee. Inasmuch as there were decided yearly differences in environmental conditions during the growth of the silage crop, it was felt that most of the yearly differences observed in the ADG's were due to the influence of environmental conditions on the growth of corn rather than to differences in the cattle.

Silage scores (Table 4) and nutrient composition (Table 3) did not correspond to the observed differences in ADG. Silage scores and nutrient content might suggest that ADG of cattle fed first-cutting silage would be below those of the two middle cuttings. However, this was not the case.

The lowest ADG's were obtained with cattle fed the fourth maturity stage (Tables 5 and 6), indicating physiological changes in the plant may have affected its feeding value. Although there was a marked increase in NFE (Table 3) due to the increased deposition of starch in the ear, there was also a marked increase in the maturity of both leaf and stalk as reflected by the large firing percentage. This was not accompanied, however, by a marked increase in crude fiber content of the plant (Table 3). Although the NFE tended to increase with increasing maturity on the as-fed basis it did not show a similar increase when converted to a dry matter basis (Table 9).

Average daily corn silage consumption per head on an as-fed and on an air dry matter basis for the 3 years are shown in Table 6. The largest consumption each year (Table 5) on an as-fed basis was from the first maturity stage. The consumption of silage from the two middle maturity stages was similar, and the lowest consumption was from the fourth maturity stage. However, when these data were converted from an as-fed to an air-dry matter basis, the relationship changed. Silage dry matter consumption was higher ($P \leq .05$) for the

Table 5. Animal performance and feed consumption

	Silage phase				Full fed phase			
	Late milk	Early dough	Late dough	Mealy endo-sperm	Late milk	Early dough	Late dough	Mealy endo-sperm
				FIRST YEAR				
No. animals/year[1]	10	9	10	10	10	9	10	10
Average weight and gain/head								
Initial	467.	469.	467.	467.	619.	633.	623.	587.
Final	619.	633.	623.	587.	772.	776.	777.	733.
Total	152.	164.	156.	120.	153.	143.	154.	146.
Avg. Daily Gain	1.55[a][2]	1.67[a]	1.59[a]	1.23[b]	1.83	1.70	1.83	1.74
Average daily feed intake/head (lb.)								
Corn silage—as fed	30.4[a]	27.2[a]	27.4[a]	20.8[b]	14.0	13.7	14.0	13.9
Corn silage—ADM[3]	7.2[ac]	7.6[ab]	8.2[b]	6.6[c]	3.6	4.2	5.4	4.7
Hay	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cottonseed meal	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Corn					12.5	12.4	12.2	12.7
Total ADM	10.7[a]	11.1[a]	11.7[b]	10.1[c]	16.1	16.0	15.8	16.3
Grades[4]								
Initial type	10.7	10.6	10.7	10.6	10.7	10.6	10.7	10.6
Initial condition	8.4	8.5	8.4	8.5	8.4	8.5	8.4	8.5
Intermediate condition					8.4	8.9	8.8	8.4
Final condition	8.4	8.9	8.8	8.4	11.2	11.3	10.9	10.7
Carcass					10.2	10.0	10.2	10.1
				SECOND YEAR				
No. animals/year[1]	10	10	10	10	10	10	10	10
Average weight and gain/head								
Initial	485.	475.	478.	478.	698.	686.	678.	658.
Final	698.	686.	678.	658.	827.	828.	787.	786.
Total	213.	211.	200.	180.	129.	142.	109.	128.
Avg. Daily Gain	2.17[a]	2.15[a]	2.04[a]	1.84[b]	1.54[b]	1.69[a]	1.30[c]	1.52[b]
Average daily feed intake/head (lb.)								
Corn silage—as fed	40.8[a]	39.4[a]	35.5[a]	26.4[b]	18.7	18.7	18.7	18.7
Corn silage—ADM	8.9[a]	10.0[b]	10.3[b]	9.3[a]	4.1	4.7	5.4	6.5
Hay	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Table 5. (Continued)

Cottonseed meal	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Corn					16.2	16.2	15.3	16.0
Total ADM	12.4^{a}	13.5^{b}	13.8^{b}	12.8^{a}	19.7	19.7	18.8	19.5
Total ADM	5.8	6.2	6.7	6.9	12.4^{b}	11.4^{b}	14.0^{a}	12.5^{b}
Grades								
Initial type	9.0	9.3	9.3	9.2	9.0	9.3	9.3	9.2
Initial condition	7.2	7.2	7.4	7.4	7.2	7.2	7.4	7.4
Intermediate condition					8.9	9.0	9.2	8.8
Final condition	8.9	9.0	9.2	8.8	10.3	10.8	10.1	10.2
Carcass					9.3	9.3	9.5	9.6
THIRD YEAR								
No. animals/year[1]	10	10	10	10	10	10	10	10
Average weight and gain/head								
Initial	477.	477.	478.	479.	673.	681.	672.	664.
Final	673.	681.	672.	664.	797.	812.	816.	819.
Total	196.	204.	194.	185.	124.	131.	144.	155.
Avg. Daily Gain	1.75^{a}	1.82^{a}	1.73^{a}	1.65^{b}	1.63^{c}	1.72^{bc}	1.90^{ab}	2.04^{a}
Average daily feed intake/head (lb.)								
Corn silage—as fed	34.7^{a}	33.3^{a}	30.5^{a}	24.8^{b}	15.6	15.6	15.2	14.6
Corn silage—ADM	9.8^{ab}	10.1^{ac}	9.6^{ac}	10.3^{c}	4.4	4.7	4.8	6.1
Hay	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cottonseed meal	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Corn					14.6	14.6	14.6	14.6
Total ADM	13.3^{ab}	13.6^{bc}	13.1^{a}	13.8^{c}	18.1	18.1	18.1	18.1
Grades								
Initial type	9.6	9.8	9.8	9.7	9.6	9.8	9.8	9.7
Initial condition	7.5	7.6	7.6	7.5	7.5	7.6	7.6	7.5
Intermediate condition					7.9	8.7	8.8	8.6
Final condition	7.9	8.7	8.8	8.6	10.1	10.1	10.5	10.2
Carcass					11.2	10.4	11.7	10.6

[1]Two replications.
[2]Means on the same line accompanied by a different letter are different at ($P \leq .05$).
[3]Air Dry Matter.
[4]8 = High Standard; 9 = Low Good; 10 = Average Good; 11 = High Good; 12 = Low Choice.

Table 6. Animal performance and feed consumption: 3-year means

	Silage phase				Full fed phase			
	Late milk	Early dough	Late dough	Mealy endo-sperm	Late milk	Early dough	Late dough	Mealy endo-sperm
Average weight and gain/head[1]								
Initial	476.	474.	473.	474.	663.	667.	658.	636.
Final	663.	667.	658.	636.	799.	805.	793.	779.
Total	187.	193.	185.	162.	136.	138.	135.	143
Avg. Daily Gain	1.81^{a}	1.87^{a}	1.80^{a}	1.57^{b}	1.70	1.73	1.69	1.79
Average daily feed intake/head (lb.)								
Corn silage—as fed	35.3^{a}	33.3^{a}	31.1^{a}	24.0^{b}	16.1	16.0	16.1	15.7
Corn silage—ADM[2]	8.6^{a}	9.4^{b}	9.4^{b}	8.7^{a}	4.0	4.5	4.9	5.8
Hay	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cottonseed meal	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Corn					14.4	14.4	13.0	14.4
Total ADM	12.1^{a}	12.7^{b}	12.9^{b}	12.2^{a}	17.9	17.9	16.5	17.9
Grades[3]								
Initial type	9.9	9.9	9.9	9.8	9.8	9.9	9.9	9.8
Initial condition	7.7	7.8	7.8	7.8	7.7	7.8	7.8	7.8
Intermediate condition					8.4	8.9	8.9	8.6
Final condition	8.4	8.9	8.9	8.6	10.5	10.7	10.5	10.4
Carcass					10.2	9.9	10.5	10.1

[a,b,c]Different letters on the same line denote significant differences ($P \leq .05$).

[1]Five animals/lot, replicated twice; the early dough stage, started with 10 animals and one animal had to be removed the first year.

[2]ADM = air dry matter.

[3]8 = High standard; 9 = Low good; 10 = Average good; 11 = High good; 12 = Low choice.

second and third stages as an average of all years (Table 6). Nevertheless, the lower ADG of heifers fed the fourth maturity stage cannot be accounted for only by a corresponding reduction in air dry matter (ADM) intake. Heifers fed the first maturity stage consumed similar amounts of air dry matter, but gained significantly faster than those consuming the fourth maturity stage, suggesting that there are factors other than ADM consumption which influence ADG.

The data indicate that the low ADM consumption in the first year (Table 5) may have been partly responsible for the low ADG in the first year during the silage phase. ADM consumption in the second and third years was similar, yet there was an average difference of about ¼ pound a day between the ADG of the cattle for the 2 years. This again suggests the possibility that environmental factors before ensiling do influence the feeding value of a silage.

In Table 7, ADG, ADM in the silage as fed, daily intake of ADM, and ADM per pound of gain are compared. ADG's within each of the 3 years were similar among the first three stages of maturity and lower for the fourth stage of maturity. ADM in the silage increased consistently with increasing maturity. Daily ADM intake did not show the consistent pattern exhibited by ADG and ADM content, indicating that there were factors involved in ADM intake other than the quantity of ADM which the animal can eat.

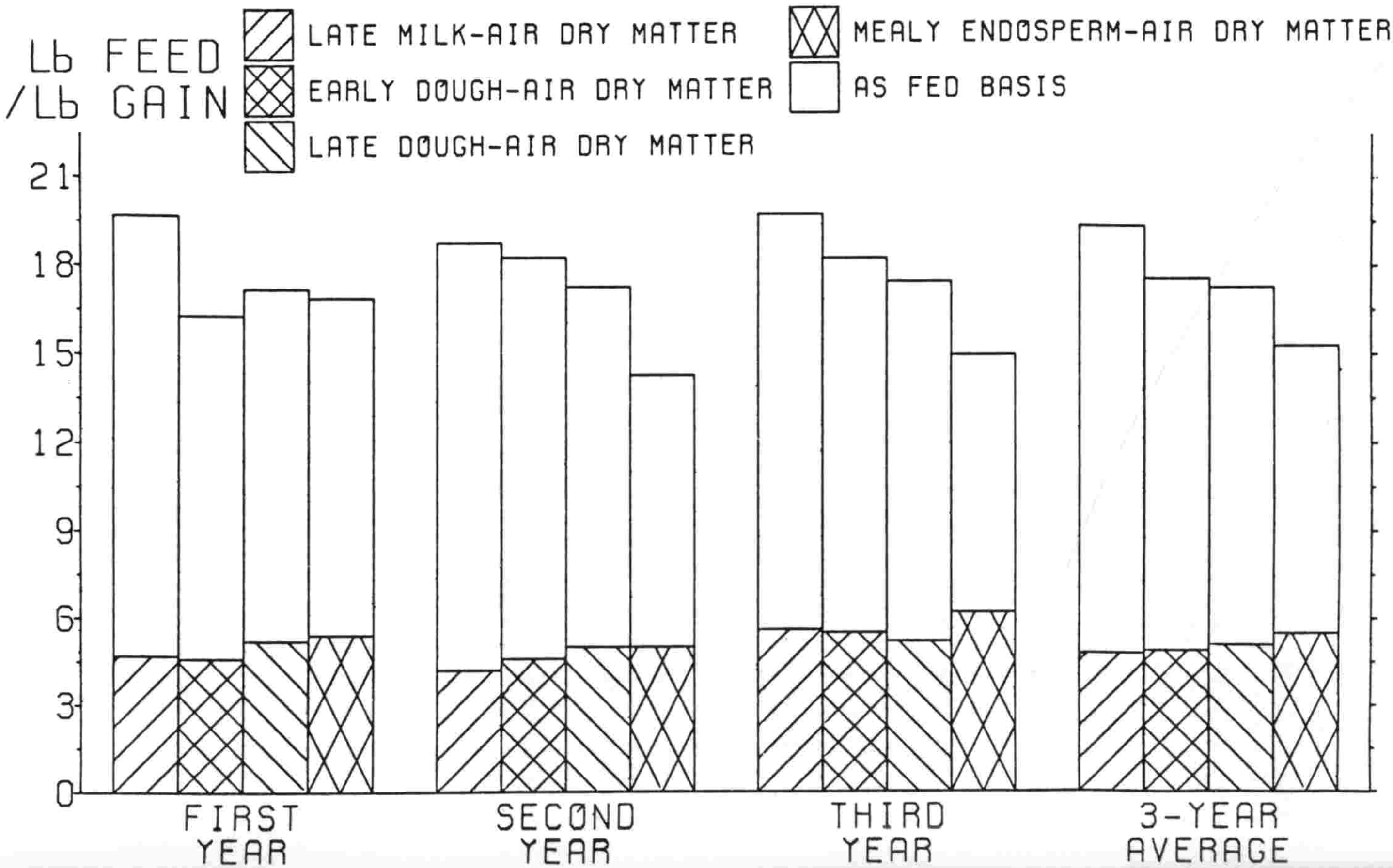
On an as-fed basis, feed efficiency (pounds of feed per pound of gain) tended to improve (smaller number) with increasing maturity (Figure 3). However, when these data were compared on a dry matter basis, the pounds of dry matter required per pound of gain

Table 7. Yearly average daily gains, moisture content of silage, daily air dry matter intake, and feed efficiency of silages during the silage phase

		Maturity stage			
	Year	Late milk	Early dough	Late dough	Mealy endosperm
Average daily gain, pounds	First	1.55^{b}	1.67^{b}	1.59^{b}	1.23^{a}
	Second	2.17^{b}	2.15^{b}	2.04^{b}	1.84^{a}
	Third	1.75^{b}	1.82^{b}	1.73^{b}	1.65^{a}
Air dry matter in silage as fed, percent	First	23.8	27.8	29.8	31.5
	Second	20.8	23.6	26.8	31.9
	Third	26.6	28.3	29.6	39.1
Daily air dry matter intake, pounds per day	First	7.2^{ba}	7.6^{bc}	8.2^{c}	6.6^{a}
	Second	8.9^{a}	10.0^{b}	10.3^{b}	9.3^{a}
	Third	9.8^{ba}	10.1^{bc}	9.6^{a}	10.3^{c}
Air dry matter intake, pounds per pound of gain	First	4.7^{a}	4.6^{a}	5.2^{b}	5.4^{b}
	Second	4.2^{a}	4.6^{ab}	5.0^{b}	5.0^{b}
	Third	5.6^{a}	5.5^{a}	5.5^{a}	6.2^{b}

[a,b,c]Different letters on the same line denote significant differences ($P \leq .05$).

Figure 3. Feed efficiency.



tended to increase slightly with increasing maturity. This suggests a decreasing efficiency in ADM utilization with increasing plant maturity, again suggesting that factors other than ADM intake influence ADG.

Visual condition grades increased an average of about one third of a condition grade—from high Standard to low Good (Table 6)—during the silage feeding period. The change in condition grade was related to ADG. The first year there was very little change in grade when the ADG was the lowest (Table 5); it was nearly two-thirds of a grade higher the second year when the ADG was the highest, and intermediate the third year.

Heifers at the end of the finishing phase.

Full Fed Phase

There was no consistent pattern among treatments in the gains obtained in the full-fed phase (Tables 5 and 6). There were some yearly differences in the second and third years (Table 5). The cattle fed silage cut in the late dough stage had the lowest gain the second year in the full-fed phase and the second highest gain in the third year. Thus, when all 3 years of data are considered, there was no difference. This range in ADG (1.69-1.79) for the 3 years would suggest that the rate of gain during the full fed phase was largely independent of the rate of gain during the silage phase.

The final visual condition grades of the cattle for the first 2 years were approximately 1/3 of a condition grade above the actual carcass grades (Table 5). In the third year, the carcass grade was nearly 1/3 of a grade higher than the final visual condition grade. Considering the year-by-year data (Table 5) rather than the 3-year summary (Table 6), yearly variation among cattle and their response to feed is apparent.

The 3-year summary shows that the silage feeding phase tended to increase the visual condition of the cattle by approximately 1/3 of a grade, from a grade of nearly 8 (high Standard) to a grade of nearly 9 (low Good). The final condition grade of the cattle was a little above 10 (average Good). Thus, the feeding regime of 98 or 112 days of silage feeding followed by a full fed phase of about 56 days resulted in increasing the weight from about 475 to 800 pounds and improved the condition of the cattle nearly one full grade from high standard to high Good. There were no significant ($P \leq .05$) differences in dressing percentages, which ranged from 56.2% to 58.1%.

Beef Production Per Acre of Forage Land

All the data necessary to calculate beef production per acre were not obtained the first year, so the data given in Table 8 are for the second and third years only. Beef yields per acre of forage land (silage and hay) were calculated on the basis of the actual tonnage of silage produced per acre and on the average yield of alfalfa hay per acre (Table 8). They do not take into account the quantity of cottonseed meal (CSM) used with the silage and hay to meet the protein requirements of the heifers. The CSM required is given separately and not expressed on an acreage basis.

Table 8. Beef produced per acre from forage land

	Year	Late milk	Early dough	Late dough	Mealy endo-sperm
Pounds of beef per acre of forage land[1]	Second	1484	1777	1777	1634
	Third	1400	1482	1600	1386
	avg.	1442	1629	1688	1510
Supplemental CSM required to produce the beef/forage acre above cottonseed meal	Second	1439	1243	1315	1342
	Third	1190	1214	1375	1261
	avg.	1315	1224	1345	1302

[1]Includes land used to produce silage and hay[a] but does not include the CSM.
[a]Alfalfa hay yields used were 7,000 lb/acre—Robert M. Ray and Herbert N. Walch, 1978, Farm Planning Manual, EC 622, Agric. Ext. Serv., Univ. of Tenn.

The beef produced per acre of forage land increased from the milk through the late dough stage, and then decreased at the mealy endosperm stage. The late dough stage consistently produced the most beef per acre. This would be expected, since it produced the most TDN per acre also (Table 9). Silage harvested in the early dough stage per forage acre produced almost as much beef as the late dough stage (Table 8). The beef produced per forage acre from the mealy endosperm silage follows the dough stages, and the silage from the late milk stage produced the least beef per forage acre. These findings are consistent with the TDN produced per acre (Table 9). Attention is called to the harvesting dates of the silages (Table 1). Much of the land used for corn silage production is double-cropped with small grains. The earlier corn silage harvesting dates would permit earlier planting of small grains. The increased forage production from small grains planted earlier would be a factor to consider in determining corn silage harvesting time.

Proximate Composition and Digestion Trials

The chemical composition and digestion coefficients on a dry matter basis of the experimental corn silages used in the digestion trials are presented in Table 10 for the second and third years.

In the first digestion trial (second year), no statistical difference was found among the digestion coefficients of the various silage ration components. With the exception of ether extract, it was noted that the digestibility numerically decreased as maturity advanced from the late milk to the late dough and then appeared to increase slightly at the mealy endosperm stage.

Apparent digestibility of the silages in the second digestion trial (third year) was different from that in the first trial. The coefficients for the second digestion trial generally increased with advancing maturity until the late dough stage, after which a large decrease was noted. The silages harvested at the late dough stage that year were significantly higher in digestibility of dry matter, organic matter, ether extract, and nitrogen-free extract than those harvested at the mealy endosperm stage.

The late milk and early dough stages had slightly higher digestibilities in the first digestion trial (second year), while silage harvested at the late dough stage was the most digestible in the second trial (third year).

The results within each year agreed with those by Nevens *et al.* (1954) who found the optimum time to harvest silage to be when the forage contained 25 to 30% dry matter. In the present study, this corresponded with the late milk and early dough stages in the second year, and with the two dough stages in the third year.

The digestible nutrient contents of the silage rations, both on

Table 9. Digestible nutrients of rations consisting of corn silage of various maturities, hay, and cottonseed meal

	Second year				Third year			
	Late milk	Early dough	Late dough	Mealy endo-sperm	Late milk	Early dough	Late dough	Mealy endo-sperm
As-fed basis,%								
Crude protein	2.4	2.5	2.7	3.1	2.5	2.5	3.2	3.3
Crude fiber	3.4	3.5	3.7	4.8	2.6	2.6	2.9	3.2
Ether extract	.3	.4	.5	.4	.3	.3	.4	.4
N-free extract	9.5	10.7	12.2	12.7	8.0	9.6	11.3	12.8
Total digestible nutrients	16.1	17.6	19.9	21.8	13.7	15.4	18.7	20.3
Dry-matter basis, %								
Crude protein	10.5^{a}	9.8^{b}	9.1^{c}	9.6^{d}	11.9^{a}	10.8^{b}	11.9^{a}	10.3^{c}
Crude fiber	14.5^{a}	13.7^{ab}	12.4^{b}	14.8^{a}	12.4^{a}	11.1^{ab}	11.0^{ab}	10.0^{b}
Ether extract	1.3	1.5	1.6	1.3	1.2	1.4	1.6	1.2
N-free extract	40.9	41.2	41.0	38.9	38.3^{a}	41.3^{b}	42.3^{b}	39.7^{ab}
Total digestible nutrients	68.9	68.0	66.7	66.6	65.4^{ab}	66.3^{ab}	69.7^{a}	62.8^{b}
TDN Yield, tons per acre	3.08	3.25	4.10	3.40	2.44	2.71	3.37	2.78

^{a,b,c}Means within the same year with a different superscript letter are significantly different at ($P \leq .05$).

Table 10. Composition of silages (dry matter basis) and digestibility of silage rations by steers.

	Second year				Third year			
	Late milk	Early dough	Late dough	Mealy endo-sperm	Late milk	Early dough	Late dough	Mealy endo-sperm
	percent							
Composition of silages								
Crude protein (N X 6.25)	11.1	11.1	10.5	9.7	9.7	9.3	9.0	9.3
Ether extract	1.4	1.6	1.3	1.2	2.4	2.7	3.0	3.0
Crude Fiber	24.7	23.7	24.1	27.7	23.0	19.9	19.0	19.4
Ash	5.9	6.2	5.7	7.1	6.0	5.8	5.1	5.1
N-free extract	56.8	57.6	57.5	54.3	58.7	62.3	63.8	63.2
Dry matter	30.4	29.1	39.8	37.6	24.4	28.0	33.6	36.0
Digestibility of silage rations[1]								
Dry matter	68.9	68.0	66.4	66.7	67.4[ab]	68.0[ab]	70.8[a]	64.1[b]
Organic matter	70.8	69.2	67.5	68.1	68.6[ab]	69.2[ab]	71.9[a]	65.3[b]
Crude protein (N X 6.25)	66.2	63.3	60.8	63.9	68.5	67.1	72.5	63.0
Crude fiber	61.9	60.2	56.7	59.8	58.8	57.4	58.2	52.5
Ether extract	67.4	68.9	70.2	68.0	60.1[a]	61.8[a]	66.1[a]	51.0[b]
N-free extract	76.1	75.5	74.3	74.8	72.8[b]	74.1[ab]	77.2[a]	70.9[b]
Energy	68.0	67.7	64.9	65.8	–	–	–	–

[ab]Means within the same year with a different superscript letter significantly are different at ($P \leq .05$).

[1]The experimental silages were fed free choice. Two pounds of alfalfa hay and 1.5 pounds of cottonseed meal per steer per day were fed also.

Cattle in digestion stalls during in vivo digestion trials.

as-fed and dry-matter basis, are shown in Table 9. On a dry matter basis, digestible crude protein in both years was significantly higher in the late milk stage than in the mealy endosperm stage. In general, digestible crude protein content appeared to decrease with advancing maturity, except for the mealy endosperm stage in the second year and the late dough stage in the third year. Digestible crude fiber also tended to decrease with advancing maturity, except for an increase at the mealy endosperm stage in the second year. There was only a slight increase in digestible ether extract until the late dough stage both years and a decrease thereafter, while digestible nitrogen-free extract increased until the early or late dough stage and then decreased as the plants matured.

On a dry matter basis, the TDN in the second year decreased with each advancing stage of maturity, while in the third year it increased until the late dough stage and decreased thereafter (Table 9). This decrease in TDN from the late dough to the mealy endosperm stage was statistically significant.

When the results on a dry-matter basis for both trials were pooled (data not shown), digestible crude protein and digestible crude fiber in the earliest stage of maturity were significantly higher than in the later stages. Digestible ether extract and nitrogen free extract on a dry matter basis increased significantly until the early dough stage and then decreased at the late dough stage. No significant differences in TDN on the dry-matter basis were observed. However, the means were similar for the first two stages, larger at the late dough stage, and much less at the mealy endosperm stage.

On the as-fed basis, TDN values increased considerably with each maturity stage in both years (Table 9). This increase was mainly due to the large decrease in moisture with advancing maturity. Cattle compensated for the higher moisture content of the less mature and higher moisture silages by consuming more of these higher moisture silages (Tables 5 and 6). The resulting TDN intake per head per day in both years increased from the late milk, to the early dough and the late dough stage. At the mealy endosperm stage, there was a decrease in TDN intake. This was a result of the lowered ADM intake (Table 7) and the lowered percentage of TDN on the dry-matter basis (Table 9) and could account for the lower ADG (Tables 5 and 6). This is consistent with the beef production per forage acre mentioned previously.

Silages harvested at the late milk and early dough stages resulted in the largest TDN intakes during the second year, and at the early dough stage in the third year. The mean of the two trials indicated that either of the two dough stages would be acceptable for harvesting silages as far as nutritive values were concerned. The lower TDN intake during the third year accounted for the lower gains made by the heifers during that year.

In general, the late dough stage appeared to be the best stage to harvest corn for silage, since this maturity stage produced the highest TDN yield of edible silage per acre in the last 2 years (Table 9), and resulted in the greatest production of beef per acre (Table 8).

In Vitro Digestibility of Silages and Their Components

Samples of the silages were separated into their various components, i.e. stalks, leaves including shucks, cobs, and kernels. *In vitro* digestible dry matter (IVDDM) was determined on each portion to ascertain whether differences in amount and digestibility of these components might explain differences in dry matter digestibility of the silages. In addition, cottonseed meal and hay were added to the various components in the same ratio as they had been added to the complete silage, since their presence in the fermentation mixture would be expected to alter the digestibility of the silage components (Prigge, 1968). Proportions of these components in the four silages and the dry matter of these components are presented in Table 11. As the silages became more mature, the stalks, leaves, and cob decreased and the kernels increased when measured as dry silage components.

The IVDDM of the silage components with cottonseed meal and hay is presented in Table 11. Digestibility of stalks was sig-

Table 11. Dry matter content, proportion in whole silage, and *in vitro* digestibility of silage components

	Late milk	Early dough	Late dough	Mealy endosperm
	percent			
Dry matter, %				
Stalks	17.2	18.3	19.0	24.5
Leaves[1]	22.4	21.4	24.1	28.0
Cobs	29.6	31.4	35.8	36.0
Kernels	43.5	46.4	45.1	55.8
Dry silage components, % of whole silage				
Stalks	43.6	43.0	37.3	33.3
Leaves[1]	33.4	25.7	24.0	23.0
Cobs	19.9	15.0	11.3	7.3
Kernels	9.1	16.3	27.4	36.4
In vitro dry matter digestibility, %				
Stalks	63.3[a]	60.1[b]	62.6[a]	58.0[c]
Leaves[1]	63.2	64.6	64.1	64.7
Cobs	62.9	63.3	63.8	62.8
Kernels	72.6[a]	77.3[b]	73.9[ab]	76.8[b]
In vitro digestible dry matter, % contributed by each component to total				
Stalks	27.6	25.8	23.4	19.3
Leaves[1]	21.1	16.6	15.4	14.9
Cobs	8.8	9.7	7.2	4.6
Kernels	6.6	12.6	30.5	27.9
Sum of components[2]	64.0	64.6	66.5	66.7
Complete ration	63.9	65.6	66.3	64.6

[a,b,c]Means within a different superscript are significantly different at ($P \leq .05$).

[1]Husks are included with the leaves.

[2]In the same proportion as added in the steer digestion trial.

nificantly lower in the mealy endosperm stage than in all the other stages. The digestibility of the leaves and cobs was similar in all four stages of plant maturity.

In vitro dry matter digestibility of the kernels was much higher than that of the other silage components. The kernels from the least mature silage (late milk) were the least digestible, probably because much of the immature starch had escaped from the ruptured seed coat and the identifiable kernels thus contained a higher percentage of seed coats. Digestibility of the kernels from the three other silages were high and not different from each other.

The percentage IVDDM contributed by each component in the presence of cottonseed meal and hay was calculated from the amount of dry matter that each component contributed to the dry matter of the complete silage (Table 11) and from the digestibility of the individual silage components. These calculations were performed to determine whether changes in either amount or digestibility of individual components might explain changes in digestibility of the complete silage rations. The percentage of IVDDM contributed by the stalks and leaves decreased with advancing maturity, while that contributed by the cobs increased up to the early dent stage and decreased thereafter. In contrast, IVDDM of kernels increased greatly with each advancing stage of maturity.

The sum of IVDDM contributed by the silage components with cottonseed meal and hay added was compared to the IVDDM of the complete ration (Table 11) and was found to be similar. This indicated that the digestibility determined from each silage component separately gave a good estimate of the digestibility of that component in the presence of the remaining silage components and could be used to explain the differences in IVDDM of the complete silage ration.

Increasingly higher digestibilities from the late milk to the early dough maturity can be attributed to the large increase in kernel digestible dry matter. Since kernels were more highly digestible than the other components, an increased percentage of kernels tended to increase the IVDDM of the complete ration. The decrease of IVDDM of the complete ration at the mealy endosperm stage was due partly to the decrease in digestibility of the stalks component. The increased IVDDM contributed by the kernels was not enough to compensate for this decrease.

SUMMARY AND CONCLUSIONS

The three objectives of this investigation were to 1) determine the effects of stages of maturity (late milk, early dough, late dough, and mealy endosperm) on corn silage yields; 2) determine the effect of corn silage harvested at these four stages of maturity on the performance of feeder heifers; and 3) determine whether visual silage scoring methods, nutrient composition, and digestibility could be of value in predicting animal performance.

The potentially harvestable corn plant yield tended to decrease as maturity increased. Expressed either as percentage of the potentially harvestable yield or on the basis of dry matter per acre, the quantity of green plant material ensiled tended to increase from the late milk through the early and late dough stages, and then to decrease at the mealy endosperm stage. Losses between potentially harvestable yield and the quantity ensiled, and unaccounted losses between the time of ensiling and feeding, were lowest for the early and late dough stages.

Average daily intake of as-fed silage decreased with increasing maturity. Consumption of the mealy endosperm silage was significantly less than that of the other three stages. However, when expressed on an air-dry basis, consumption was similar for all four stages of maturity.

Average daily gains of heifers fed late milk and early and late dough stages of silage were similar and significantly higher than gains obtained with heifers fed the mealy endosperm stage of silage. Pounds of feed required per pound of gain tended to decrease with increasing maturity on an as-fed basis. This was a reflection of increasing dry matter in the silage as the corn plant matured. However, when the pounds of feed per pound of gain were expressed on an air dry basis, the tendency was reversed.

No significant differences were found in 1) the live condition grades at the end of the silage phase, 2) the live condition grades at the end of the full fed phase, or 3) the carcass characteristics obtained following slaughter. Carcass grade tended to be slightly lower than condition grade. This was probably due to the strong influence of marbling score on carcass grade, whereas live condition grade is more closely associated with the amount of external finish.

The pounds of beef produced per acre of forage (silage + hay) were largest for the silage harvested at the late dough stage, followed closely by that harvested at the early dough stage. Silages harvested at the mealy endosperm and the late milk stages were similar but produced less beef per acre than the other two stages.

During the full-fed phase, no significant differences were found among treatments in either average daily gain or dry matter intake. This indicates that there was no carry-over effect from the silage phase to the full-fed phase. Although there were significant differences in animal performance from year to year, these differences could not be related to feed consumption on either an as-fed or dry matter basis, or to nutrient composition or silage scores. However, these differences could be partly explained by digestibility studies, since total digestible nutrient intake was considerably less the third year.

The overall results obtained in this 3-year experiment suggest that the most appropriate time to cut silages for feeding beef heifers is between the early and late dough maturity stages, and then in the late milk stage. These conclusions are similar to those obtained by Montgomery *et al.* (1974) with dairy cattle. This suggests, from a practical point of view, that if labor and equipment supplies are limited, it would be preferable to harvest silage at a somewhat earlier stage of maturity rather than to postpone harvest and allow silage to reach the later stages of maturity.

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