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To the Graduate Council:

I am submitting herewith a thesis written by Robert T. Vickers entitled "Effects of Corn Plant Maturity at Ensiling on the Performance of Feeder Heifers." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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EFFECTS OF CORN PLANT MATURITY AT ENSILING ON THE PERFORMANCE OF FEEDER HEIFERS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Robert T. Vickers

August 1971

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ABSTRACT

The three objectives in this investigation were to (1) determine the effects of the four stages of maturity on silage yields and losses; (2) to evaluate both a visual method of silage scoring and chemical analysis; and (3) to determine the effects of corn silage harvested at four stages of maturity (late milk, early dough, late dough, and mealy endosperm) on the performance of feeder heifers.

Theoretical green chop yield had a tendency to decrease as maturity increased. The tonnage of green chop ensiled was similar for the first three stages of maturity and higher than for the fourth stage. Expressed either as a percent of the theoretical yield or as dry matter per acre, the quantity of green chop ensiled increased through the third stage. Edible silage expressed as tons of dry matter per acre, increased through the third cutting. Losses between the theoretical values and the quantity ensiled were lower for the two middle stages of maturity as were the unaccountable losses between the time of ensiling and the actual quantity fed.

Total visual score was closely associated with animal performance with the second and third stages of maturity, but was not as good an indicator for the first and fourth stages of maturity. It was a good indicator of the daily air dry intake of silage by the animals.

Individual components of the chemical analysis, on an "as fed" basis, had a tendency to increase with increasing maturity in the three year summary. Chemical analysis was not closely associated with animal performance.

Animal performance showed yearly differences in silages which were not indicated by (1) chemical analysis, (2) by consumption on either an "as fed" or dry matter basis, or (3) the silage scores. Neither could the differences be explained by the digestibility studies conducted on the same silages by Prigge (1968).

Average daily silage intake "as fed" decreased with increasing maturity, with the fourth stage of maturity being significantly less ($P < .05$) than the other three. However, in the three year summary expressed on an air dry basis, it was significantly higher ($P < .05$) for the middle stages of maturity than for the first and fourth stages.

Average daily gains of the heifers during the silage phase for the late milk, early dough, and late dough stages were similar, but significantly higher ($P < .05$) than the gains obtained with the mealy endosperm stage.

Pounds of feed required per pound of gain on an "as fed" basis had a tendency to decrease with increasing maturity. However, expressed on an air dry basis the trend reversed.

No significant ($P < .05$) differences were found in (1) the live condition grades taken at the end of the silage phase, (2) the final live condition grades, and (3) the carcass characteristics obtained at the end of the full fed phase.

Pounds of beef produced per acre of silage was highest for the late dough stage, and followed in decreasing order by the early dough, mealy endosperm, and late milk stages.

In the full fed phase no significant ($P < .05$) differences were found in average daily gain or air dry matter intake indicating no "carry over" effects from the silage phase to the full fed phase.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	3
	Effects of Plant Maturity on the Yields of Corn Silage	3
	Effects of Plant Maturity on Losses of Corn Silage	4
	Harvesting and handling losses	5
	Storage losses	5
III.	Effects of Plant Maturity on Chemical Composition of Corn Silage	6
	Effects of Plant Maturity on Animal Performance	8
	Silage consumption	8
	Rate of gain, feed required per hundredweight of gain, and carcass quality	9
III.	EXPERIMENTAL PROCEDURES	11
	Corn Silages	11
	Production of the silage	11
	Stages of maturity	13
	Silage losses	20
	Silage scoring	22
	Chemical analysis of the silage	25

CHAPTER PAGE

Feeding Trial 28
Description of heifers 28
Carcass data 28
Statistical Analysis of the Data 29
IV. RESULTS AND DISCUSSION 30
Corn Silages 30
Silage yields 30
Silage losses 32
Visual silage scores 34
Chemical analysis on an "as fed" basis 38
Chemical analysis on a dry matter basis 40
Animal Performance 42
Average daily feed intake per head 42
Average daily gains 51
Pounds of feed per pound of gain 53
Carcass data 55
Pounds of beef produced per acre of silage 56
V. SUMMARY AND CONCLUSIONS 58
LITERATURE CITED 61
VITA 65

LIST OF TABLES

TABLE		PAGE
I.	Effects of Maturity and Urea-Limestone Additions on the Composition of Corn Silage	7
II.	Agronomic Characteristics of Corn Used for Silage in 1965	14
III.	Agronomic Characteristics of Corn Used for Silage in 1966	16
IV.	Agronomic Characteristics of Corn Used for Silage in 1967	18
V.	Harvesting Dates for Corn Silage	21
VI.	Silage Yields	31
VII.	Silage Losses	33
VIII.	Silage Scores	35
IX.	Chemical Composition of Corn Silage on an "As Fed" Basis Harvested at Four Stages of Maturity	39
X.	Chemical Composition of Corn Silage on a Dry Matter Basis Harvested at Four Stages of Maturity	41
XI.	Animal Performance and Feed Consumption for 1965	43
XII.	Animal Performance and Feed Consumption for 1966	45
XIII.	Animal Performance and Feed Consumption for 1967	47
XIV.	Three Year Summary of Animal Performance and Feed Consumption	49
XV.	Yearly Average Daily Gain, Moisture Content of Silages, Daily Air Dry Matter Intake, and Feed Efficiency of Silages During the Silage Phase	52

TABLE PAGE

XVI. Beef Production Per Acre 57

CHAPTER I

INTRODUCTION

Today, in our ever changing world there is an increasing need for new ideas and technology. This is especially true of the animal industry. As a result of new ideas and technology, new methods of producing, harvesting, and ensiling corn silage have evolved. This has contributed to the increasing importance of corn silage as a ruminant feed. The USDA Crop Production Report (1965) shows that the corn acreage used for silage almost doubled during the 20 year period from 1946 to 1965. In Tennessee, according to the Tennessee Crop Reporting Service (1970), the tonnage of corn silage has increased from 483,000 tons in 1960 to 1,275,000 tons in 1969.

Due to its large yields of high quality, low cost nutrients corn silage has a place on nearly every cattle farm, whether beef or dairy, where suitable soils are available for its production. For these reasons corn silage has become the standard by which other forages are measured.

According to the USDA Statistical Reporting Service (1970), between 1960 and 1969 the number of beef cattle in Tennessee has increased from 1,076,000 to 1,786,000. The Tennessee Department of Agriculture (1970) reported that during the same period the number of calves sold through the organized feeder calf sales increased from 17,466 to 33,188 head. Beef cattle producers are interested in producing the highest quantity of the desired market quality beef, at the lowest cost in order to maximize profits. Therefore, this has increased the interest in the use of corn silage to reduce the cost of producing marketable beef.

The main objective of this investigation was to determine the effects of certain stages of corn plant maturity on the yields of beef per acre and animal performance. Other objectives were to determine the effects of corn plant maturity on the losses of silage from the amount that is actually produced in the field to the amount that is actually fed. A score card method of determining silage value was also evaluated.

CHAPTER II

REVIEW OF LITERATURE

I. EFFECTS OF PLANT MATURITY ON THE YIELDS OF CORN SILAGE

Corn silage provides a highly palatable and economic source of nutrients for ruminants. Research conducted with corn silage has been extensive, yet there is still a great deal of controversy as to the best time to harvest corn silage in order to obtain maximum nutrient yield, minimum loss, and maximum animal performance.

Results of studies conducted to determine the best time of harvest in order to obtain maximum yield have varied considerably. Work reported by Johnson et al. (1965) and Johnson et al. (1966) suggested that the best time to harvest silage for maximum dry matter yields and digestible energy per acre was between the dent and glaze stages. Keeney et al. (1967) also concluded that the late dent stage was the best time to obtain maximum dry matter yields. Perry et al. (1967) indicated that corn which was harvested in the hard dent stage and after the silk was brown and entirely dry (171 days after planting) gave maximum yields in total dry matter. However, work by Gay (1966) found that corn ensiled in the hard dough stage of maturity gave maximum yields of dry matter per acre. Research by Pratt, Conrad, and Triplett (1964) indicated that there were slightly greater but non-significant increases in dry matter yields in the late milk to early dough stage compared to the well-dented stage. Suter (1966) and Bryant

et al. (1966) also found that dry matter yields per acre increased with increasing maturity. Henderson (1968) reported that harvesting between the late dough and early dent stages resulted in maximum tonnage yield and animal digestibility, and that dry matter yields per acre increased with maturity until the first killing frost, after which it declines at a rapid rate due to loss of leaves, tassels, and lodged plants. Further, there was no advantage in delaying harvest after the plants had reached 35 percent dry matter. However, other work by Geasler, Henderson and Hawkins (1967) indicated that dry matter per acre decreased with increasing maturity. They reported that silage harvested in Michigan on September 18, October 17, and November 14, produced 5.11, 4.57, and 4.06 tons of dry matter per acre, respectively.

Contrary to previously stated findings, work by Perry (1968) suggested that once corn has matured (October or later) age of the plants did not have much effect on the last possible harvest date or dry matter yields. He also reported that in 1965 harvests for maximum yields ranged from September 7 to November 30, and in 1966 they ranged from September 6 to November 15.

Possible explanation for these variations could be geographical, soil, variety, growing season (temperature and/or rainfall), and fertilization among others.

II. EFFECTS OF PLANT MATURITY ON LOSSES OF CORN SILAGE

Research involving corn silage losses occurring between field production and the quantity fed has been very limited. The most probable

sources of the loss are believed to be due to either harvesting and handling, or to seepage and spoilage in the silo.

Harvesting and Handling Losses

Boyce (1968) indicated that the large majority of the loss which takes place during harvesting and handling is not due to machinery loss, but to the human element. He suggested the loss which occurs in the machinery would be practically nil if the machinery was used in the proper way. In studies conducted to determine the amount of harvest loss Gordon, Derbyshire, and Humphrey (1966) found a dry matter loss of 18.7 percent was incurred when harvesting was delayed from September 21, to November 9, in 1964, and a loss of 27.2 percent between September 8, and November 8, in 1965. In similar studies Byers and Ormiston (1966) harvested 15.66 metric tons of dry matter per hectare on September 27, and 13.93 tons of dry matter on November 11. This represents a loss of 11 percent of the dry matter. Hoglund (1964) estimated a 4 percent field and harvest loss for corn silage when the total plant at ensiling time was 30 to 35 percent dry matter.

Storage Losses

According to Gordon (1967) the three categories of storage losses were seepage, spoilage, and gaseous or fermentation. He also stated that dry matter was the common denominator of storage losses although energy losses may be more important from the animal standpoint. In other studies of storage losses, Suter (1966) and Gay (1966) both agree that losses decreased with increasing maturity. Suter (1966) concluded that with silage above the 70 percent moisture level, seepage occurred, and

below 70 percent moisture the material was not sufficiently consolidated, and storage mold tended to develop in unsealed storage facilities. Ensiling at 32 to 35 percent dry matter was suggested by Hoglund (1964) to reduce seepage losses. According to Gay (1966) fermentation losses were found to be 5 to 10 percent under good conditions, and as high as 40 percent under poor conditions. The seepage losses were about 1 percent for silage containing less than 70 percent moisture, and as much as 15 percent in silage containing 80 percent or more moisture. Surface spoilage losses were practically zero in gas tight silos, about 5 percent in good tight conventional silos, and 8 to 16 percent in trench silos depending upon size and other factors. Gay further pointed out that losses in trench silos decreased as tonnage increased due to the decrease in surface area. However, Huber, Graf, and Engle (1965) found that losses were greatest with more matured silage. Component losses during silage fermentation were found to be quite variable by Keeney et al. (1967), but they reported no significant difference in total loss for silage harvested at various maturities.

III. EFFECTS OF PLANT MATURITY ON CHEMICAL COMPOSITION OF CORN SILAGE

In studying the effects of plant maturity on the chemical composition of corn silage, Bryant et al. (1966), Geasler et al. (1967), Huber et al. (1965), and Pratt et al. (1964) found the percent dry matter increased as maturity increased. Work by Johnson et al. (1965) further verified this trend as is shown in Table I. This increase in total dry matter was attributed to the increase in dry matter of the ear by Bryant

TABLE I

EFFECTS OF MATURITY AND UREA-LIMESTONE ADDITIONS ON THE COMPOSITION OF CORN SILAGE[a]

Harvest Date	Stage of Maturity	Treatment[b]	Dry Matter	Crude Protein
August 17	Blister	None	20.9	12.0
		UL	20.2	14.1
August 25	Early Milk	None	19.9	12.1
		UL	21.5	15.4
September 2	Milk-dough	None	21.9	10.8
		UL	23.9	14.8
September 9	Dough-dent	None	27.5	10.4
		UL	27.2	12.8
September 21	Glaze	None	33.5	9.4
		UL	34.6	--
October 6	Flint	None	45.4	9.0
		UL	47.2	11.5
October 15	Post Frost	None	49.2	8.7
		UL	50.8	10.6

[a] Johnson et al. (1965).

[b] None - nothing added to the corn silage as ensiled.
UL - 10# of urea and 10 pounds of limestone added per ton of green chop when ensiled.

et al. (1966). Bryant et al. (1966) and Johnson et al. (1965) have also studied the dry matter diztribution in the stalks, leaves, husks, and ears. With advanced maturity they found little difference in dry matter content of the stalks, a slight increase in dry matter content of the leaves, and a marked increase in the dry matter content of the husks and ears.

Bryant et al. (1966) and Pratt et al. (1964) found that the percent crude protein decreased with increased maturity. Similar results by Johnson et al. (1965) are shown in Table I. However, contradictory results were obtained by Huber et al. (1965) in which they found a non-significant increase in crude protein at the hard dough stage.

The percent of nitrogen-free extract (NFE) as it was affected by silage maturity was studied by Bryant et al. (1966) and Huber et al. (1965). They found that the percent of NFE increased as maturity increased from a milk to a hard dent stage.

IV. EFFECTS OF PLANT MATURITY ON ANIMAL PERFORMANCE

Silage Consumption

A study conducted by Johnson et al. (1965) indicated that dry matter consumption increased with increasing maturity. Similar results with dairy cattle were reported by Bryant et al. (1966), Huber et al. (1965), and Noller et al. (1963). Bryant et al. (1965) indicated that dry matter consumption by dairy cattle fed immature corn silage was significantly lower ($P < .01$) than those fed mature corn silage. The optimum harvest stage for maximum dry matter consumption was found by Huber, Graf, and Engle (1963) and Gay (1966) to be at the hard dough

stage while Noller et al. (1963) found it to be at the very early dent stage. However, Henderson (1968) and Huber, Thomas, and Emery (1967) found that cattle fed silage harvested in the late dent stage consumed less dry matter than those fed silage harvested earlier. Contrary to previously cited evidence, Perry (1968) indicated that maturity did not have much effect on acceptance by the animals. Similar results were reported by Coppock and Stone (1968) from research by H. K. Goering in which he found no significant difference in voluntary intake of dry matter by steers when offered 29.8 and 45.2 percent dry matter silages.

Rate of Gain, Feed Required per Hundredweight of Gain, and Carcass Quality

Corn silages harvested on September 18, October 17, and November 14 were studied by Geasler et al. (1967). They found average daily gain to be significantly ($P < .04$) higher for September harvested silage than for October or November harvested silage, but the October harvested silage was not significantly different from the November harvested silage. Geasler et al. (1967) and Henderson (1963) found feed required per hundredweight (CWT) of gain was significantly less ($P < .05$) for the earlier harvested silages than for the later harvested silages. Geasler et al. (1967) also found that cattle fed the September harvested silage produced significantly ($P < .04$) superior carcasses. These carcass comparisons were made for percent boneless, trimmed retail cuts; fat thickness; percent kidney, heart, and pelvic fat; cold carcass weight, and dressing percent.

Byers and Ormiston (1966) compared the feeding value of 36, 44, and 52 percent dry matter corn silages for lactating dairy cows. The

daily dry matter consumption averaged 12.8, 9.9, and 10.6 pounds per day with a fat corrected milk production of 39.7, 35.9, and 36.6 pounds per day, respectively. In another study involving dairy cattle Huber (1970) stated that in his previously published work milk yields were significantly lower ($P < .05$) for cows fed 44 percent dry matter corn silage than for cows fed similar silages containing 30 and 37 percent dry matter. These silages were treated with 0.5 percent urea at the time of ensiling. Maturity did not significantly ($P < .05$) affect the response to silages which had no urea added. He also reported that through acidification with formic acid, high dry matter corn silage could be treated with urea without depressing animal performance.

Geasler and Henderson (1970) used fistulated wether lambs to compare silages harvested on September 18 and October 19. These silages had 30.7 and 43.3 percent dry matter, respectively. The September harvested silage was found to have lower dry matter digestibility, nitrogen digestibility, and nitrogen retention. However, it was higher in nitrogen retention as a percent of the nitrogen absorbed. The stage of maturity had no effect on rumen volatile fatty acids and voluntary feed intake.

CHAPTER III

EXPERIMENTAL PROCEDURES

This study was conducted to determine the effects of the maturity of corn silage at harvesting on the silage yields and performance of beef heifers.

I. CORN SILAGES

Production of the Silage

In 1965 and 1966 Dixie 29, an early maturing hybrid corn, was used. In 1967 Pioneer 511A another hybrid recommended for silage production was planted. In all three years the plant population was 16,000 to 18,000 plants per acre. The corn was planted in the last week in April or the first week in May on Class I land which had 80 percent Huntington silt loam and 20 percent Lindside silt loam at the Tobacco Experiment Station, Greeneville, Tennessee. Each fall during the experiment small grains were planted after the silage harvest to be used for pasture. The field was top-dressed with 50 pounds of nitrogen and approximately 24 tons of cattle manure per acre in the spring of each year. This was plowed under along with the small grain residue. Prior to planting the corn, 160 pounds of nitrogen, 27 pounds of phosphorus, and 50 pounds of potassium per acre were applied. Weeds were controlled with Atrazine or Simazine used as a premerge.

Periodic observations were made as the desired stage of maturity approached. The desired stages of maturity at which the corn was ensiled will be discussed in detail later in this chapter. Agronomic data were

were collected as each maturity stage was ensiled. Two small silos of 10 by 30 feet were filled with approximately 10 tons of silage from each stage of maturity. The agronomic data were collected from a minimum of 15 representative row sections 18 feet long. The steps by which the agronomic data were collected were as follows:

1. Total of all the plants in each 18 foot row section were counted.
2. Dead and lodged plants were counted.
3. Average height of each row section was determined.
4. The ears (grain and cobs only, the shucks were left on the stalk) were removed, weighed, counted into ears and nubbins, and a subsample weighing between five and eight pounds was taken for each row section.
5. The subsample of the ears was then broken into two pieces by hand to facilitate drying, and placed in a previously weighed bag. The bag plus the ears was weighed, then oven dried for not more than 18 hours and air equilibrated.
6. The remainder of the plant (stalk, leaf, and shuck) which had been cut at approximately the same level as by the field chopper was weighed for each row section.
7. A sample of five to 10 stalks weighing approximately 12 to 15 pounds was taken from each row cut, and the leaf blades were removed from the stalks.
8. The leaf blades were placed in a previously weighed bag, and the bag plus the leaf was weighed. It was then oven-dried for at least 24 hours at 70 C., and weighed.

9. The stalks after they were stripped were cut with a knife into two to three inch sections to facilitate drying. They were then placed into previously weighed bags, weighed, dried for at least 60 hours at 70 C., and weighed again.
10. Samples were brought to Knoxville for drying and weighing.
11. Cobs and grain were separated and separate moisture determinations were made.
12. The percentages of the stalks, leaves, cobs, and grain were computed for both the green material and the dry matter.
13. Moisture content of the grain was determined at each cutting.

The agronomic data for all three years is given in Tables II, III, and IV, and were collected and furnished by Dr. H. A. Fribourg and N. C. Edwards, Jr. of the Agronomy Department.

The Stages of Maturity

The corn in this experiment was harvested at four stages of maturity subsequently referred to as late milk, early dough, late dough, and mealy endosperm (about 35 percent moisture in the grain), or also referred to as first, second, third, or fourth cuttings. These stages were selected to determine the range in time or physiological maturity during which corn can be ensiled and produce good silage. The first stage was earlier than has been recommended for harvesting silage. The second and third stages were within the usual recommendations, while the fourth stage was somewhat later than normally recommended. A description of each stage is as follows:

TABLE II

AGRONOMIC CHARACTERISTICS OF CORN
USED FOR SILAGE IN 1965[a]

	Harvest Dates							
	September, 9		September, 16		September, 21		October, 5	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Height	10.9	0.3	10.4	0.2	10.8	0.2	---	---
Plants per acre	20230	360	18080	490	18875	415	18515	440
Lodging, percent	8.0	1.6	10.2	1.8	10.7	1.6	27.0	3.7
Number of ears per acre	19980	705	18185	790	17180	470	14445	595
Ears per 100 plants	99.1	3.7	100.3	3.0	91.4	2.5	79.3	4.4
Nubbings, percent	24.5	1.4	19.5	2.0	24.7	1.9	32.9	2.4
Shelling, percent	74.2	1.2	76.6	0.7	82.2	0.6	80.2	3.9
Green weight, tons per acre								
Stalks	12.79	0.71	10.00	0.72	10.54	0.42	8.94	0.38
Leaves	6.62	0.28	5.00	0.27	4.63	0.24	2.85	0.12
Ears	5.25	0.20	4.79	0.20	4.94	0.14	4.53	0.16
Total	24.66	1.05	19.79	1.12	20.11	0.64	16.32	0.45
Green yields, percent								
Stalks	51.3	1.2	49.5	1.2	52.3	1.2	54.5	1.4
Leaves	27.0	0.5	25.4	0.5	23.0	0.9	17.6	0.7
Ears	21.7	0.8	25.0	1.0	24.7	0.6	27.9	0.9
Leaf in green stover, percent	34.6	0.9	34.1	0.9	30.6	1.3	24.5	1.3
Stalk in green stover, percent	65.4	0.9	65.9	0.9	69.4	1.3	75.4	1.3
Dry weight, tons per acre								
Stalks	3.61	0.37	2.18	0.20	3.67	0.27	1.81	0.07
Leaves	2.02	0.14	1.40	0.08	1.58	0.04	1.32	0.04
Ears	1.87	0.08	2.18	0.11	2.80	0.10	3.00	0.12
Grain	1.40	0.07	1.68	0.10	2.30	0.08	2.41	0.10
Cobs	0.47	0.01	0.50	0.02	0.50	0.03	0.59	0.03
Total	7.50	0.46	5.75	0.36	8.00	0.35	6.14	0.16

TABLE II (continued)

	Harvest Dates							
	September, 9		September, 16		September, 21		October, 5	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Dry matter, percent								
Stalks	29.7	3.0	21.4	0.6	34.2	1.7	20.4	0.3
Leaves	30.6	1.8	27.8	0.6	34.6	1.8	47.6	2.2
Ears	35.6	0.5	45.2	0.9	56.8	1.3	66.2	0.7
Moisture in grain , percent	----	---	----	---	48	---	38	---
Dry yields, percent								
Stalks	46.9	2.0	36.7	1.4	44.7	1.8	29.6	0.9
Leaves	27.5	1.7	24.4	0.5	19.6	0.7	21.6	0.4
Ears	25.6	0.9	38.9	1.5	35.6	1.3	48.8	1.2
Grain	19.0	0.8	29.8	1.2	29.4	1.2	39.2	1.0
Cobs	6.5	0.3	9.1	0.4	6.2	0.2	9.6	0.3
Leaf in dry stover, percent	37.1	2.4	40.3	1.1	31.0	1.6	42.3	0.6
Stalk in dry stover, percent	62.9	2.4	59.7	1.1	69.0	1.6	57.7	0.6
Number of observations (18 foot row)	19		20		20		18	

[a] These data were furnished by Dr. H. A. Fribourg and N. C. Edwards, Jr., the University of Tennessee Agronomy Department.

TABLE III

AGRONOMIC CHARACTERISTICS OF CORN
USED FOR SILAGE IN 1966[a]

	Harvest Dates							
	August, 18		August, 25		September, 1		September, 21	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Height	10.0	0.2	10.0	0.1	9.8	0.1	9.9	0.2
Plants per acre	19690	555	17980	630	19260	595	19480	345
Lodging, percent	2.9	1.0	6.0	0.9	8.9	1.6	19.0	3.1
Number of ears per acre	16325	595	17080	600	17850	545	16430	400
Ears per 100 plants	83.1	2.4	97.0	4.4	93.3	2.3	84.9	2.5
Nubbings, percent	37.6	2.8	28.8	3.0	22.0	1.8	27.2	1.7
Shelling, percent	71.3	0.4	78.3	0.3	81.4	0.3	84.0	0.3
Green weight, tons per acre								
Stalks	11.17	0.37	10.87	0.33	10.06	0.22	9.90	0.21
Leaves	6.83	0.32	6.74	0.17	5.66	0.18	3.66	0.11
Ears	5.19	0.21	5.97	0.22	5.78	0.18	5.63	0.19
Total	23.19	0.75	23.58	0.63	21.50	0.43	19.19	0.35
Green yields, percent								
Stalks	48.3	0.9	46.0	0.6	46.9	0.8	51.6	0.8
Leaves	29.4	0.8	28.7	0.4	26.3	0.6	19.1	0.5
Ears	22.3	0.5	25.3	0.5	26.8	0.5	29.2	0.7
Leaf in green stover, percent	37.8	1.1	38.4	0.6	36.0	0.9	27.0	0.7
Stalk in green stover, percent	62.2	1.1	61.6	0.6	64.0	0.9	73.0	0.7
Dry weight, tons per acre								
Stalks	2.30	0.12	2.28	0.09	2.71	0.18	2.14	0.05
Leaves	1.49	0.09	1.56	0.04	1.44	0.04	1.32	0.03
Ears	1.86	0.09	2.76	0.11	3.08	0.12	3.45	0.12
Grain	1.33	0.07	2.17	0.09	2.51	0.10	2.90	0.11
Cobs	0.53	0.02	0.59	0.02	0.57	0.03	0.55	0.02
Total	5.65	0.22	6.60	0.20	7.23	0.26	6.91	0.15

TABLE III (continued)

	Harvest Time							
	August, 18		August, 25		September, 1		September, 21	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Dry matter, percent								
Stalks	20.7	1.1	20.9	0.5	26.8	1.6	21.6	0.3
Leaves	22.1	1.1	23.2	0.2	25.6	0.7	36.4	0.8
Ears	35.6	0.5	46.3	0.5	53.1	1.2	61.3	0.8
Moisture in grain, percent	59		48		42		34	
Dry yields, percent								
Stalks	40.5	1.1	34.4	0.8	37.1	1.4	31.0	0.7
Leaves	26.6	1.5	23.8	0.4	20.2	0.6	19.2	0.5
Ears	32.9	1.0	41.9	0.9	42.8	1.2	49.7	0.9
Grain	23.5	0.8	32.8	0.7	34.8	1.0	41.8	0.9
Cobs	9.4	0.2	9.1	0.2	7.9	0.2	7.9	0.1
Leaf in dry stover, percent	39.3	2.0	41.0	0.8	35.5	1.3	38.2	0.7
Stalk in dry stover, percent	60.7	2.0	59.0	0.8	64.5	1.3	61.7	0.7
Number of observations (18 foot row)	18		21		20		21	

[a] These data were furnished by Dr. H. A. Fribourg and N. C. Edwards, Jr., of The University of Tennessee Agronomy Department.

TABLE IV

AGRONOMIC CHARACTERISTICS OF CORN
USED FOR SILAGE IN 1967[a]

	Harvest Dates							
	August, 28		August, 31		September, 7		September, 18	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Height	8.8	0.1	9.0	0.1	9.3	0.1	8.9	0.1
Plants per acre	16185	538	15330	395	15320	770	14860	565
Lodging, percent	1.4	0.7	1.6	0.6	0.3	0.3	2.3	0.9
Number of ears per acre	20500	860	19005	635	19220	855	19175	740
Ears per 100 plants	128.7	6.2	125.2	4.9	128.2	5.5	130.8	5.1
Nubbings, percent								
Shelling, percent	75.5	0.4	77.5	0.4	79.3	0.4	81.5	0.4
Green weight, tons per acre								
Stalks	9.67	0.34	8.98	0.33	8.90	0.33	7.24	0.32
Leaves	8.07	0.37	7.16	0.26	6.18	0.25	4.33	0.19
Ears	6.77	0.26	6.17	0.18	6.15	0.31	5.84	0.25
Total	24.50	0.87	22.31	0.71	21.22	0.82	17.42	0.65
Green yields, percent								
Stalks	39.6	0.8	40.2	0.6	42.0	0.6	41.6	0.9
Leaves	32.7	0.6	32.0	0.5	29.2	0.6	24.8	0.6
Ears	27.6	0.5	27.8	0.4	28.8	0.6	33.6	0.8
Leaf in green stover, percent	45.3	0.9	44.4	0.8	41.0	0.6	37.4	0.9
Stalk in green stover, percent	54.7	0.9	55.6	0.8	59.0	0.6	62.5	0.9
Dry weight, tons per acre								
Stalks	1.95	0.08	1.88	0.09	1.98	0.08	2.24	0.14
Leaves	1.86	0.10	1.68	0.05	1.72	0.06	1.65	0.07
Ears	3.12	0.13	3.05	0.11	3.31	0.17	3.51	0.16
Grain	2.36	0.10	2.37	0.10	2.63	0.14	2.86	0.13
Cobs	0.76	0.03	0.68	0.02	0.68	0.03	0.65	0.03
Total	6.93	0.26	6.61	0.23	7.01	0.29	7.40	0.30

TABLE IV (continued)

	Harvest Time							
	August, 28		August, 31		September, 7		September, 18	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Dry matter, percent								
Stalks	20.2	0.6	21.0	0.6	22.4	0.6	30.9	1.2
Leaves	23.2	0.8	23.7	0.5	28.0	0.6	38.5	1.1
Ears	46.0	0.4	49.3	0.8	53.7	0.5	59.9	0.3
Moisture in grain, percent	60		44		40		34	
Dry yields, percent								
Stalks	28.3	0.9	28.3	0.7	28.5	0.7	30.1	1.1
Leaves	26.7	0.8	25.6	0.4	24.7	0.4	22.4	0.6
Ears	45.0	0.8	46.1	0.7	46.9	0.9	47.5	1.1
Grain	34.0	0.7	35.8	0.6	37.2	0.8	38.7	0.9
Cobs	11.0	0.1	10.4	0.2	9.7	0.1	8.8	0.3
Leaf in dry stover, percent	48.5	1.4	47.5	0.8	46.5	0.7	42.9	1.2
Stalk in dry stover, percent	51.5	1.4	52.5	1.4	53.5	1.4	57.1	1.4
Number of observations (18 foot row)	20		20		16		20	

[a] These data were furnished by Dr. H. A. Fribourg and N. C. Edwards, Jr. of The University of Tennessee Agronomy Department.

1st stage: The late milk stage had about 10 percent of the kernels dented, and some juice in the kernel. At this stage the ear shuck had no loss of color and there was not more than 5 percent firing of the bottom leaves.

2nd stage: At the early dough stage practically all the kernels were dented, and there was no juice in the kernels although they were still soft. The shuck and ear were beginning to lose the green color, and there was about 5 to 10 percent firing of the bottom leaves.

3rd stage: In the late dough stage the endosperm was rather firm, and the kernels contained about 50 percent moisture. There was about 15 to 20 percent firing of the total plant, and about half of the color had turned on the shuck.

4th stage: This stage was harvested when the grain had approximately 35 percent moisture as determined by a moisture meter. The endosperm was mealy, firing of the leaves was as high as 50 percent, and nearly all color was gone from the shuck.

The dates on which each stage was harvested for the three years are given in Table V.

Silage Losses

Silage losses were divided into two main types of losses, harvesting and storage. Harvesting losses occurred between the field and the

TABLE V

HARVESTING DATES FOR CORN SILAGE

Stage of Maturity	1965	1966	1967
1st cutting	September 9	August 18	August 28[a]
2nd cutting	September 16	August 25	August 31
3rd cutting	September 21	September 1	September 7
4th cutting	October 5	September 21	September 18

[a] This cutting was originally scheduled for August 17, but was delayed due to rain.

silo as a result of mechanical and handling losses. However, according to Boyce (1968) the mechanical loss is nil providing the machinery is set properly. The storage losses were further divided into spoilage and unaccountable losses which occurred as a result of gas production, fermentation, and seepage.

To calculate these losses estimates of green field weight, the actual weight of green chop that went into the silo, weight of good silage removed from the silo, and the weight of any spoilage were obtained. Harvesting losses were calculated by subtracting the amount of green chop ensiled from the field yields estimated from the weight of row samples. Unaccountable storage losses were calculated by adding the amount of spoilage and the total amount of good silage fed, and subtracting this value from the amount of green chop that went into the silo. A comparison of these losses was then made to determine the effects of maturity and year.

Silage Scoring

Due to the increase in silage production in recent years a need has evolved for a subjective method of comparing or scoring silages. An attempt has been made by Joe D. Burns, Associate Agronomist at the University of Tennessee, to devise such a method with the use of a silage score card.

This silage score card was based on a possible 100 points. Out of this possible 100 points, 40 were allotted for grain content, 12 for color, 28 for odor, and 20 for moisture. A further breakdown and description of these four major categories are shown in Figure I. The score card was revised in January 1969 on the basis of these data and

Sample No. _____

	Possible Score	Score Given
I. GRAIN CONTENT (Total 40)		
1. High	36-40	
2. Medium	28-35	
3. Low	16-27	
4. None (either no ears developed or ears removed)	0-15	
II. COLOR (Total 12)		
1. Desirable - Slightly brownish	9-12	
2. Acceptable - Dark green to yellowish green or yellow to brownish	5-8	
3. Undesirable - Deep brown or black indicating excessive heating or putrefaction. Predominantly white or gray indicating excessive mold development	0-4	
III. ODOR (Total 28)		
1. Desirable - light, pleasant odor with no indication of putrefaction	22-28	
2. Acceptable - Fruity, yeasty, musty, which indicates a slightly improper fermentation. Slight burnt odor. Sharp vinegar odor	11-21	
3. Undesirable - Strong burnt odor indicating improper fermentation. A very musty odor indicating excessive mold which is readily visible throughout silage	0-10	

FIGURE 1

ORIGINAL CORN SILAGE SCORE CARD[a]

IV. MOISTURE (Total 20)

1. No free water when squeezed in hand. Well preserved silage	17-20	____
2. Some moisture can be squeezed from silage or silage dry and musty	9-16	____
3. Silage wet, slimy or soggy, water easily squeezed from sample. Silage too dry with a strong burnt odor	0-10	____
Total Score		____

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

FIGURE 1 (continued)

[a]Developed by Joe D. Burns, Associate Agronomist, University of Tennessee.

is shown in Figure II. Out of the possible 100 points, 40 were allotted to grain content, 12 to color, 28 to odor, 10 to moisture, and 10 to chop.

Chemical Analysis of the Silage

Chemical analyses of the corn silage were made according to A.O.A.C. (1965) recommendations. Duplicated samples of 500 grams each were taken from each treatment in each of the three years. These samples were dried at approximately 70 C. for three days, and air equilibrated for three days. They were then reweighed and the air dry matter (ADM) determined. The samples were then combined and ground through a Wiley Mill equipped with a two milimeter mesh screen and placed in airtight glass jars. A proximate analysis was then performed on these samples to determine their composition.

Sample No. _____

	Possible Score	Score Given
I. GRAIN CONTENT (Total 40)		
1. High	36-40	
2. Medium	28-35	
3. Low	16-27	
4. None (either no ears developed or ears removed)	0-15	
II. COLOR (Total 12)		
1. Desirable - Green to yellowish green	9-12	
2. Acceptable - Yellow to brownish	5-8	
3. Undesirable - Deep brown or black indicating excessive heating or putrefaction. Predominantly white or gray excessive mold development	0-4	
III. ODOR (Total 28)		
1. Desirable - Light, pleasant odor with no indication of putrefaction	24-28	
2. Acceptable - Fruity, yeasty, musty, which indicates a slightly improper fermentation. Slight burnt odor. Sharp vinegar odor	11-23	
3. Undesirable - Strong burnt odor indicating excessive heating. Putrid, indicating improper fermentation. A very musty odor indicating excessive mold which is readily visible throughout silage	0-10	

FIGURE 2

REVISED CORN SILAGE SCORE CARD[a]

IV. MOISTURE (Total 10)

1. No free water when squeezed in hand. Well preserved silage	9-10	____
2. Some moisture can be squeezed from silage or silage dry and musty	5-8	____
3. Silage wet, slimy or soggy, water easily squeezed from sample. Silage too dry with a strong burnt odor	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

FIGURE 2 (continued)

[a]Developed by Joe D. Burns, Associate Agronomist, University of Tennessee.

II. FEEDING TRIAL

Description of Heifers

Each year 40 beef heifer calves weighing 450 to 500 pounds were purchased at graded feeder calf sales. They were allowed two to three weeks to adjust to each other, station conditions, and to be observed for disease. In 1965 one heifer in the second treatment had to be removed due to sickness. These animals were graded with respect to type and condition, and were allotted to eight uniform lots on the basis of weight, grades, and weight change during the adjustment period. Two lots were randomly assigned to each of the four treatments. The heifers were fed corn silage free choice once a day plus 1.5 pounds of cottonseed meal and 2 pounds of good quality alfalfa-orchardgrass-clover hay per head per day for 98 days in 1965 and 1966, and 112 days in 1967. Following this period of silage feeding they were full-fed grain for 84 days in 1965 and 1966, and 76 days in 1967 prior to slaughter. At the end of the experiment each heifer was given a condition score. All of these heifers were weighed on two consecutive days at the beginning and end of the experiment, and at 28 day intervals throughout the experiment.

Carcass Data

At slaughter hot carcass weights, carcass grades, and marbling scores were obtained. Chilled carcass weights were calculated by shrinking the hot carcass weight by 2.5 percent. Length, maturity, percent kidney fat, backfat measurements, and loin eye area were all made according to procedures outlined by the American Meat Science Association. (Schoonover et al. 1967).

III. STATISTICAL ANALYSIS OF THE DATA

The statistical analyses were performed according to methods described by Harvey (1960). In a preliminary analysis the independent variables included in the model were year, stage of maturity, and year by maturity interaction. Variation among pens treated alike was considered to be the appropriate error term for this model. The interaction between year and cutting was not significant, and was deleted in the final analyses. When significant differences were found, Duncan's (1955) Multiple Range Test as modified by Kramer was used for mean separation.

CHAPTER IV

RESULTS AND DISCUSSION

I. CORN SILAGES

Silage Yields

Theoretical field yields of green chop in tons per acre were calculated from the agronomic data. These yields generally decreased as maturity increased. However, the yield of the second stage in 1966 had a slight increase over the first stage. In both years (1966 and 1967) the first three stages produced similar yields of green chop with the fourth stages being somewhat less. Green chop yields are presented in Table VI.

The actual quantity of green chop ensiled expressed in tons per acre did not have as definite a trend with increasing maturity as did the theoretical yields. The first three stages in both years had practically the same yield in tons per acre with a prominent decrease for the fourth stage. When the quantity ensiled was expressed as a percent of the theoretical yield, a trend was established. The percentage ensiled increased with increasing maturity through the third cutting with a definite decrease for the fourth cutting.

Tons per acre of edible silage were similar for the first three stages of maturity, and distinctly less for the fourth stage. When edible silage was expressed as a percent of the theoretical yields, there was a yearly variation. In 1966 there was an increase as maturity increased through the first three stages with the fourth stage being less

TABLE VI

SILAGE YIELDS

	1966				1967			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Theoretical yields, tons of green chop per acre	23.2	23.6	21.5	19.2	24.5	22.3	21.2	17.4
Silage in silos, tons of green chop per acre	21.2	23.1	22.2	18.0	20.1	19.1	21.6	15.2
Edible silage, tons of green chop per acre	19.1	21.3	20.6	15.6	17.8	17.6	19.8	13.7
Silage in silos, percent of theoretical yield	91.4	98.1	103.0[a]	93.7	82.0	85.6	101.8[a]	87.3
Edible silage, percent of theoretical yield	90.1	92.0	93.0	87.0	88.9	92.3	91.5	90.0
Silage in silos, tons of dry matter per acre	4.4	5.4	6.0	5.8	5.4	5.4	6.4	6.0
Edible silage, tons of dry matter per acre	4.0	5.0	5.5	5.0	4.7	5.0	5.9	5.4

[a] More silage was weighed into the silos than was predicted by the theoretical yields.

than the first stage. However, in 1967 the percentage of edible silage was maximum in the two middle stages, and slightly lower at the early and late maturity stages.

When the green chop ensiled and the amount of edible silage was expressed on a dry matter basis, the trends were similar. In both cases dry matter yields increased as maturity increased for the first three cuttings with the fourth cutting being between the second and third cuttings. Maximum dry matter yields were obtained with the late dough stage (third cutting) which was in agreement with results obtained by Gay (1966).

Silage Losses

The silage losses which were obtained for only two of the three years, 1966 and 1967, are presented in Table VII. The percent field loss decreased with increasing maturity for the first three stages. In both years there was more green chop ensiled with the late dough stage than estimated by the theoretical yields. This was probably due to sampling errors. Percent field loss for the fourth stage was between the losses for the first and second stages both years. Possible reasons for higher losses with the fourth stage were lodging, shattering, and wind loss in blowing the green chop into the wagons. Considerable yearly variation was noted.

Spoilage losses were not consistent. In 1966 the percent spoilage losses for the first three stages were similar with a higher loss in the fourth stage. In 1967 the percent spoilage losses were similar for the first, second, and fourth cuttings with a somewhat higher value for the third cutting. These differences were probably due to yearly variations.

TABLE VII

SILAGE LOSSES

	1966				1967			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Field loss, percent	8.6	1.9	+3.3[a]	6.3	18.0	14.4	+1.8[a]	12.7
Spoilage loss, percent	3.5	3.1	3.1	6.1	3.7	3.8	4.5	3.6
Unaccountable loss, percent	6.4	4.9	3.9	6.9	7.4	3.9	3.9	6.4
Total loss in silo, percent	9.9	8.0	7.0	13.0	11.1	7.7	8.4	10.0

[a] These figures are gains over the theoretical yields instead of losses, and are probably due to sampling errors.

All other losses were grouped under percent unaccountable losses which included fermentation, gaseous, and seepage losses. These losses were found to be the lowest in the two middle stages of maturity, and higher in the first and fourth stages. The higher loss for the first stage of maturity was probably due to the high moisture content which increased the seepage loss. The higher losses for the fourth stage of maturity was probably due to the lower moisture content which effected fermentation.

Visual Silage Scores

In this study an attempt was made to establish any trends that might exist between the visual silage scores and stage of maturity, chemical analysis, and animal performance.

The scores for each of the silages are given in Table VIII. The scores for 1965 and 1966 were averages from three scores while 1967 was a single score. An average of the scores for the three year period is also given in Table VIII. In all three years the trend was for the early dough and late dough stages to have the highest total scores. The total scores for these two cuttings were about the same. The total scores for the late milk and mealy endosperm were also similar, but lower than the two middle cuttings.

There was considerable yearly variation between the two high scores and the two low scores. In 1965, which was a relatively poor silage year, the variation was the greatest. The variation for 1967, an average silage year, was the least. The variation for 1966, which was an above average year, was intermediate, but closer to the values for 1965.

TABLE VIII

SILAGE SCORES

Category	Stage of Maturity: Late Milk	Early Dough	Late Dough	Mealy Endosperm
		1965[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
		1966[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
		1967[c]		
Grain Content	34	35	35	35
Color	9	8	8	6
Odor	22	23	22	21
Moisture	15	16	17	16
Total	80	82	82	78
		Summary		
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 procedures

[c] Single score

The grain content score of the silage was found to be lowest in the late milk stage, and approximately the same in the other three stages. One possible explanation for this apparent lack of grain content in the early milk stage was that individual kernels were broken, and being in the milk stage that a large percentage of the fluid was lost from the kernels, and therefore, did not appear as full grain kernels. This is one of the main factors that lowered the total score of the late milk stage. Conversely, the factors lowering the score of the mealy endosperm stage were lack of color due to the high percentage of firing, and lowered odor score due to mustiness. The grain content scores all fell in the medium category (Figure I, page 23) except for 1966 in which the late milk and the mealy endosperm stages fell in the low and high categories, respectively.

The desirable color scores of the silage decreased with increasing maturity except for 1965 in which the first three cuttings were the same, and the fourth was lower. The scores for the first cutting for all three years were in the desirable range while the scores for the fourth cutting were in the acceptable range (Figure I, page 23). The low color scores for the fourth stage of maturity was due to the high percent of firing which had occurred before harvesting. The scores for the second cutting in 1965 and 1966, and the scores for the third cutting in 1965 were in the desirable range with the remaining scores for both cuttings in the acceptable range.

The odor scores for the different stages of maturity were found to be about the same for the first three stages. The fourth stage had a lower odor score due to mustiness. However, none of these scores fell

below the acceptable range on the silage score card. In all three years the early dough stage had a high enough odor score to be placed in the desirable category. This was also true for the late dough stage in 1965 and 1967, but not in 1966.

The moisture content score increased slightly with increasing maturity through the third cutting, and then decreased slightly with the fourth cutting. There were only slight differences observed in 1966 due to the rainfall during the entire harvesting period. The differences in the moisture scores were highest in 1965 and 1967. The lower score for the first cutting was due to the higher moisture content, while the lower scores for the fourth cutting were due to insufficient moisture.

The only definite overall trend established with the individual components of these scores was between color and maturity. The color score decreased as maturity increased.

The most important trend established with the silage score was between the silage score and the average daily consumption of silage on an air dry basis by the test animals. Using the three year average, the consumption of silage on an air dry basis increased as the score increased thus illustrating that the total silage score was a good indicator of the air dry matter consumption.

Total silage scores obtained with the two center stages of maturity (early dough and late dough) were closely associated with animal performance. The problems were with the two extremes (late milk and mealy endosperm). The late milk stage was penalized for having too much moisture, and an apparent lack of grain content due to the collapsed kernels. The mealy endosperm stage was penalized for being too dry, and the resultant musty odor.

Another possible reason for the lack of trends is due to the narrow range in which these scores fell. They were all in the fair to low good categories.

Chemical Analysis on an "As Fed" Basis

The chemical analysis of these silages did not result in consistent patterns. The results for these analyses for dry matter, ether extract, crude fiber, ash, crude protein, and nitrogen free extract are summarized in Table IX.

The dry matter contents of these silages increased as maturity decreased. This was also the trend found by Bryant et al. (1966), Geasler et al. (1967), Huber et al. (1965), Pratt et al. (1964), and Johnson et al. (1965). Bryant et al. (1966) attributed this increase in dry matter to the increase in dry matter of the ear.

The percent ether extract also increased with increasing maturity, with the exceptions of the fourth stage of maturity in 1965, and the second maturity stage in 1967.

The percent crude fiber was similar for the first three stages in all three years with the fourth stage being somewhat higher.

The percent ash of these silages tended to increase with increasing maturity. However, the values for the second and third stages were similar.

The percent crude protein had a trend toward increasing with increasing maturity for all four stages. The exceptions to this were the second stage in 1965, and the second stage in 1967. These results were contrary to the findings of Bryant et al. (1966), and Pratt et al. (1964)

TABLE IX

CHEMICAL COMPOSITION OF CORN SILAGE ON AN "AS FED" BASIS
HARVESTED AT FOUR STAGES OF MATURITY

Stage of Maturity	Percent					
	Dry Matter	Crude Protein	Crude Fiber	NFE	Ash	Ether Extract
			1965			
Late Milk	23.8	2.5	6.2	13.1	1.4	.6
Early Dough	27.8	3.1	7.2	15.1	1.7	.8
Late Dough	29.8	3.0	6.9	17.4	1.7	.9
Mealy Endosperm	31.5	3.3	8.7	16.8	2.2	.7
			1966			
Late Milk	20.8	2.2	5.2	11.5	1.4	.6
Early Dough	23.6	2.4	5.0	13.7	1.5	.7
Late Dough	26.8	2.6	5.5	16.3	1.5	.9
Mealy Endosperm	31.9	3.3	6.8	19.0	1.8	1.0
			1967			
Late Milk	26.6	2.0	6.0	16.5	1.2	.9
Early Dough	28.3	2.0	6.2	17.9	1.2	1.0
Late Dough	29.6	2.2	6.5	18.8	1.2	.9
Mealy Endosperm	39.1	2.9	8.1	25.4	1.5	1.2
			Three Year Summary			
Late Milk	23.7	2.3	5.8	13.7	1.3	.7
Early Dough	26.5	2.5	6.1	15.5	1.5	.8
Late Dough	28.7	2.6	6.3	17.5	1.5	.9
Mealy Endosperm	34.2	3.1	7.9	20.4	1.8	1.0

in which they reported that the percent crude protein decreased with increasing maturity. However, the maturity stages used in this study did not represent the ranges used in either of the two previously mentioned studies.

On the "as fed" basis the percent of nitrogen free extract increased as the maturity increased except in the fourth stage in 1965. Similar results were obtained by Bryant et al. (1966) and Huber et al. (1965).

A three year average for each stage of maturity and each component of the chemical analysis is also given in Table IX. All of the individual constituents increased with increasing maturity. The only exceptions to this are the second and third stages of maturity for ash which for all practical purposes were the same.

Chemical Analysis on a Dry Matter Basis

In an attempt to clarify some of the apparent inconsistencies found in the chemical analysis on an "as fed" basis the analysis was converted to a dry matter basis. This data is presented in Table X.

There were indications of a greater yearly variation than there was a trend within years. This could be a reflection of the variation of moisture and/or temperature during the harvesting season on the physiological status of the plant. The animals were able to detect these yearly differences as indicated by the average daily gains in the following section.

However, neither the visual scoring as previously mentioned, nor the chemical analysis on either the "as fed" or the dry matter basis were

TABLE X

CHEMICAL COMPOSITION OF CORN SILAGE ON A DRY MATTER BASIS HARVESTED AT FOUR STAGES OF MATURITY

Stage of Maturity	Percent				
	Crude Protein	Crude Fiber	NFE	Ash	Ether Extract
			1965		
Late Milk	10.7	26.0	55.1	5.7	2.6
Early Dough	11.2	25.8	54.2	6.1	2.7
Late Dough	10.2	23.0	58.4	5.5	3.0
Mealy Endosperm	10.3	27.6	53.1	6.8	2.1
			1966		
Late Milk	10.6	25.0	55.2	6.6	2.7
Early Dough	10.2	21.7	58.9	6.4	2.9
Late Dough	9.7	20.7	60.8	5.6	3.3
Mealy Endosperm	10.3	21.3	59.5	5.7	3.3
			1967		
Late Milk	7.7	22.6	62.2	4.4	3.2
Early Dough	7.0	21.9	63.2	4.3	3.6
Late Dough	7.3	22.0	63.4	4.0	3.2
Mealy Endosperm	7.3	20.7	64.9	3.9	3.1
			Three Year Summary		
Late Milk	9.7	24.5	57.5	5.5	2.8
Early Dough	9.5	23.1	58.8	5.6	3.1
Late Dough	9.1	21.9	60.9	5.1	3.1
Mealy Endosperm	9.3	21.5	59.2	5.5	2.8

able to consistently detect these differences. These inconsistencies between animal performance and either visual appraisal or chemical analysis were not fully clarified in digestibility studies conducted by Prigge (1968) on the same silages fed these cattle for 1965 and 1966.

II. ANIMAL PERFORMANCE

Average Daily Feed Intake Per Head

The average daily feed intake per head for the four stages of maturity in 1965, 1966, and 1967 are given in Tables XI, XII, and XIII, respectively. A three year summary is given in Table XIV. In addition selected data by years is given in Table XV.

The consumption of corn silage is given on both an "as fed" basis and a dry matter basis by years in Tables XI, XII, and XIII. The consumption of hay and cottonseed meal is given on a dry matter basis only since all animals received the same amount on an "as fed" basis.

The average daily intake per head of corn silage on an "as fed" basis decreased in all three years as maturity increased, reflecting the dry matter level of the silage. In all three years as well as the three year summary (Table XIV) the consumption of the fourth stage of maturity was significantly ($P < .05$) lower than the other three stages.

Data presented in the three year summary (Table XIV), as well as the individual years of 1965 and 1966, show an increase in consumption of air dry matter with increasing maturity through the third stage. The first and fourth stages of maturity resulted in significantly lower ($P < .05$) average daily intake of air dry silage per head than the second and third stages. Total air dry matter consumption which includes the air

TABLE XI

ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR 1965

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
No. animals/year	10	9	10	10	10	9	10	10
No. reps/year	2	2	2	2	2	2	2	2
Average weight and gain/head								
Initial	467.00	469.00	467.00	467.00	619.00	633.00	623.00	587.00
Final	619.00	633.00	623.00	587.00	772.00	776.00	777.00	733.00
Total	152.00	164.00	156.00	120.00	153.00	143.00	154.00	146.00
Av. Daily Gain	1.55[a]	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	7.2[ac]	7.6[ab]	8.2[b]	6.6[c]	3.6	4.2	4.5	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

TABLE XI (continued)

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Lbs. feed/lb gain								
Corn silage - as fed	19.7[a]	16.3[b]	17.2[b]	16.9[b]	1.0	1.1	1.0	1.1
Corn silage - air dry	4.7[a]	4.6[a]	5.2[b]	5.4[b]				
Hay	1.3	1.2	1.3	1.6	1.1	1.2	1.1	1.2
Cottonseed meal	1.0	.9	.9	1.2	.9	.9	.8	.9
Corn					6.8	7.3	6.6	7.3
Total ADM	7.0	6.7	7.4	8.2	8.8[ab]	9.4[a]	8.5[b]	9.4[a]
Grades								
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

[a,b,c] Means on the same line with a different superscript letter are statistically different at the .05 level of probability.

TABLE XII

ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR 1966

	Silage Phase				Full Fed Phase			
	Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
No. animals/year	10	10	10	10	10	10	10	10
No. reps/year	2	2	2	2	2	2	2	2
Average weight and gain/head								
Initial	485.0	475.0	478.0	478.0	698.0	686.0	678.0	658.0
Final	698.0	686.0	678.0	658.0	827.0	828.0	787.0	786.0
Total	213.0	211.0	200.0	180.0	129.0	142.0	109.0	128.0
Av. 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
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

TABLE XII (continued)

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Lbs. feed/lb. gain								
Corn silage - as fed	18.8[a]	18.3[a]	17.3[b]	14.3[c]	1.3	1.2	1.5	1.3
Corn silage - air dry	4.2[a]	4.6[ab]	5.0[b]	5.0[b]				
Hay	.9	.9	1.0	1.1	1.3	1.2	1.5	1.3
Cottonseed meal	.7	.7	.7	.8	.9	.9	1.1	1.0
Corn					10.2	9.3	11.4	10.2
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

[a,b,c] Means on the same line with a different superscript letter are statistically different at the .05 level of probability.

TABLE XIII

ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR 1967

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Early Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
No. animals/year	10	10	10	10	10	10	10	10
No. reps/year	2	2	2	2	2	2	2	2
Average weight and gain/head								
Initial	477.0	477.0	478.0	479.0	673.0	681.0	672.0	664.0
Final	673.0	681.0	672.0	664.0	797.0	812.0	816.0	819.0
Total	196.0	204.0	194.0	185.0	124.0	131.0	144.0	155.0
Av. 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[b]	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

TABLE XIII (continued)

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Lbs. feed/lb gain								
Corn silage - as fed	19.8[a]	18.3[b]	17.5[b]	15.0[c]	1.1	1.2	1.3	1.1
Corn silage - air dry	5.6[a]	5.5[a]	5.5[a]	6.2[b]				
Hay	1.1	1.1	1.2	1.2	.9	.9	.8	.7
Cottonseed meal	.8	.8	.9	.9	1.3	1.2	1.1	1.0
Corn					9.2	8.6	7.8	7.2
Total ADM	7.5	7.4	7.6	8.3	11.4[a]	10.7[ab]	9.7[bc]	8.9[c]
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

[a,b,c] Means on the same line with a different superscript letter are statistically different at the .05 level of probability.

TABLE XIV

THREE YEAR SUMMARY OF ANIMAL PERFORMANCE
AND FEED CONSUMPTION

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
No. animals/year	10	10	10	10	10	10	10	10
No. reps/year	2	2	2	2	2	2	2	2
Average weight and gain/head								
Initial	476.0	474.0	473.0	474.0	663.0	667.0	658.0	636.0
Final	663.0	667.0	658.0	636.0	799.0	805.0	793.0	779.0
Total	187.0	193.0	185.0	162.0	136.0	138.0	135.0	143.0
Av. 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	8.6[a]	9.2[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

TABLE XIV (continued)

	Silage Phase				Full Fed Phase			
	Late Milk	Early Dough	Late Dough	Mealy Endosperm	Late Milk	Early Dough	Late Dough	Mealy Endosperm
Lbs. feed/lb. gain								
Corn silage - as fed	19.4[a]	17.6[b]	17.3[b]	15.4[c]	1.1	1.2	1.3	1.2
Corn silage - air dry	4.8[a]	4.9[ab]	5.2[bc]	5.5[c]				
Hay	1.1	1.1	1.2	1.3	1.1	1.1	1.1	1.1
Cottonseed meal	.8	.8	.8	1.0	1.0	1.0	1.0	1.0
Corn					8.7	8.3	8.6	8.2
Total ADM	6.7[a]	6.8[a]	7.2[b]	7.8[c]	10.8	10.4	10.7	10.3
Grades								
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] Means on the same line with a different superscript letter are statistically different at the .05 level of probability.

dry matter for hay and cottonseed meal in addition to that from silage showed the same results as the silage consumption on an air dry basis.

These results did not agree with the findings of Johnson et al. (1965), Bryant et al. (1966), Huber et al. (1965), Noller et al. (1963), and Bryant et al. (1965) in which they showed that dry matter consumption of silage increased with increasing maturity. In this study this was only true for the first three stages of maturity. The consumption of the fourth stage decreased. However, these results were similar to the work by Henderson (1968) and Huber et al. (1967) which showed that silage harvested in the late dent stage had lower daily dry matter intake than silages harvested earlier.

These results indicated that the time to harvest silage to obtain optimum daily dry matter consumption is in the early to late dough stage. This would be intermediate to the hard dough stage suggested by Huber et al. (1963) and Gay (1966), and the very early dent stage suggested by Noller et al. (1963).

Average Daily Gains

Average daily gains (ADG) of heifers for the silage phase in 1965, 1966, and 1967 are given in Table XV. The three year summary is given in Table XIV (page 49). In all three years the first three stages produced similar ADG while the fourth stage was always significantly lower ($P < .05$). There was also a significant difference ($P < .05$) in the ADG among years. This variation among years was probably due to the difference in the growing seasons and climatic conditions which produced silages of varying physiological maturity. The first year (1965) was considered a poor silage year, the second (1966) an above average silage year, and the third

TABLE XV

YEARLY AVERAGE DAILY GAINS, MOISTURE CONTENT OF SILAGES, 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	1965	1.55[a]	1.67[a]	1.59[a]	1.23[b]
	1966	2.17[a]	2.15[a]	2.04[a]	1.84[b]
	1967	1.75[a]	1.82[a]	1.73[a]	1.65[b]
Air Dry Matter in Wet Silage, percent	1965	23.8	27.8	29.8	31.5
	1966	20.8	23.6	26.8	31.9
	1967	26.6	28.3	29.6	39.1
Daily Air Dry Matter Intake, pounds per day	1965	7.2[ac]	7.6[ab]	8.2[b]	6.6[c]
	1966	8.9[a]	10.0[b]	10.3[b]	9.3[a]
	1967	9.8[ab]	10.1[ac]	9.6[b]	10.3[c]
Air Dry Matter Intake, pounds per pounds of gain	1965	4.7[a]	4.6[a]	5.2[b]	5.4[b]
	1966	4.2[a]	4.6[ab]	5.0[b]	5.0[b]
	1967	5.6[a]	5.5[a]	5.5[a]	6.2[b]

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

year (1967) an average silage year. The differences in ADG from year to year reflect the yearly differences as can be seen in Table XV.

These results were similar to the results reported by Geasler et al. (1967) where the ADG of cattle fed September harvested silage was significantly higher than November harvested silage.

The ADG for the full fed phase in 1965, 1966, 1967, and the three year summary are given in Table XI (page 43), Table XII (page 45), Table XIII (page 47), and Table XIV (page 49), respectively. Since these are not a direct result of the silage, they will not be discussed in this thesis other than the fact that a significant ($P < .05$) interaction between year and maturity was observed in both full fed average daily gain and total average daily gain.

The full fed phase had a tendency to cancel the effects on ADG that were carried over from the silage phase.

Pounds of Feed Per Pound of Gain

The pounds of feed per pound of gain for 1965, 1966, 1967, and the three year summary are given in Table XI (page 43), Table XII (page 45), Table XIII (page 47), and Table XIV (page 49), respectively. The results are given for silage on an "as fed" basis, silage on an air dry basis, hay, and cottonseed meal. However, the silage results were the primary concern since there were only slight differences in the amounts of hay and cottonseed meal.

The pounds of silage per pound of gain on an "as fed" basis decreased as the maturity increased for two of the three years (1966 and 1967). In all three years the highest amount of silage "as fed" required

for a pound of gain was for the first cutting. The fourth cutting was the lowest in all years except 1965.

The three year summary showed a decrease with increasing maturity also. The first cutting was significantly higher ($P < .05$) than the other three cuttings, while the fourth stage was significantly lower ($P < .05$) than the other three.

However, when the pounds of silage per pound of gain were expressed on an air dry basis, the results were somewhat different; the fourth cutting requiring more silage dry matter per pound of gain than any other stage of maturity in all three years.

The three year summary (Table XIV, page 49) showed an increased amount of air dry matter from the silage was required to produce a pound of gain as maturity increased. This is the reverse of what the "as fed" basis indicated. However, this was to be expected since the amount of moisture decreased with increasing maturity.

The total air dry matter (ADM) required per pound of gain was similar to the silage on an air dry basis even though it included the air dry matter from hay and cottonseed meal. The fourth stage required the most air dry matter per pound of gain in all three years. The three year summary showed that an increase in total air dry matter was required as maturity increased. The fourth stage required significantly more ($P < .05$) ADM per pound of gain than the other three stages.

These results agreed with those of Geasler et al. (1967) and Henderson (1968) in which they found that the feed required per unit of weight gain was less for the earlier harvested silages than for later harvested silages.

Carcass Data

The carcass data from this experiment was subjected to statistical analysis to determine if there were effects due to silage maturity. The results showed that there were no significant differences ($P < .05$) due to silage maturity in intermediate live condition grade taken at the end of the silage feeding phase. Final condition grade, back fat thickness, carcass weight, dressing percent, marbling score, carcass grade, percent kidney fat, and ribeye area showed no significant differences. However, all of these except intermediate condition grade and dressing percent had a significant ($P < .05$) yearly variation.

These results were in contrast to the findings of Geasler et al. (1967) in which they found that early harvested silage produced superior carcasses when compared on the basis of percent boneless, trimmed retail cuts; fat thickness; percent kidney, heart, and pelvic fat; cold carcass weight; and dressing percent.

Although there were no differences in cattle condition grade due to silage maturity, the condition grade did increase about one-third of a grade during the silage phase, and almost two-thirds of a grade during the full fed phase which was 23 days shorter than the silage phase. This can be accounted for by the differences in energy intake. The average USDA carcass grade was about one-third of a grade below the final live grade. This was due to the fact that the carcass grade was more representative of the marbling, whereas the live grade represented the external finish.

The full fed phase had the tendency to cancel any effects from the silage phase. If these heifers had been slaughtered at the end of

the silage phase, there might have been differences in the carcass characteristics due to treatment.

Pounds of Beef Produced Per Acre of Silage

The pounds of beef produced per acre of silage is given in Table XVI for 1966 and 1967. This data was not obtained for 1965. As can be seen in Table XVI there was considerable yearly difference. The highest year, 1966, represents an above average silage year while the lower year, 1967, represents an average silage year. In both years the pounds of beef produced per acre of silage had a tendency to increase with increasing maturity through the third stage of maturity. The highest production of pounds of beef per acre of silage was with the second and third stages of maturity. The third stage was the highest, and the first stage was the lowest with the second and fourth stages being intermediate. Based on these results, the best time to harvest silage for maximum pounds of beef produced per acre of silage is in the early dough to late dough stages.

TABLE XVI

BEEF PRODUCTION PER ACRE

	Stage of Maturity							
	Late Milk		Early Dough		Late Dough		Mealy Endosperm	
	1966	1967	1966	1967	1966	1967	1966	1967
Pounds of beef per acre of silage	2034	1806	2328	1927	2381	2252	2190	1829
Additional feed, pounds per acre								
Cottonseed meal	1972	1535	1629	1579	1762	1936	1798	1664
Hay	2624	2003	2186	2119	2360	2592	2387	2213

CHAPTER V

SUMMARY AND CONCLUSIONS

The three objectives in this investigation were to (1) determine the effects of the four stages of maturity on silage yields and losses; (2) to evaluate both a visual method of silage scoring and chemical analysis; and (3) to determine the effects of corn silage harvested at four stages of maturity (late milk, early dough, late dough, and mealy endosperm) on the performance of feeder heifers.

Theoretical green chop yield had a tendency to decrease as maturity increased. The tonnage of green chop ensiled was similar for the first three stages of maturity and higher than for the fourth stage. Expressed either as a percent of the theoretical yield or as dry matter per acre, the quantity of green chop ensiled increased through the third stage. Edible silage expressed as tons of dry matter per acre, increased through the third cutting. Losses between the theoretical values and the quantity ensiled were lower for the two middle stages of maturity as were the unaccountable losses between the time of ensiling and the actual quantity fed.

Total visual score was closely associated with animal performance with the second and third stages of maturity, but was not as good an indicator for the first and fourth stages of maturity. It was a good indicator of the daily air dry intake of silage by the animals.

Individual components of the chemical analysis, on an "as fed" basis, had a tendency to increase with increasing maturity in the three

year summary. Chemical analysis was not closely associated with animal performance.

Animal performance showed yearly differences in silages which were not indicated by (1) chemical analysis, (2) by consumption on either an "as fed" or dry matter basis, or (3) the silage scores. Neither could the differences be explained by the digestibility studies conducted on the same silages by Prigge (1968).

Average daily silage intake "as fed" decreased with increasing maturity, with the fourth stage of maturity being significantly less ($P < .05$) than the other three. However, in the three year summary expressed on an air dry basis, it was significantly higher ($P < .05$) for the middle stages of maturity than for the first and fourth stages.

Average daily gains of the heifers during the silage phase for the late milk, early dough, and late dough stages were similar, but significantly higher ($P < .05$) than the gains obtained with the mealy endosperm stage.

Pounds of feed required per pound of gain on an "as fed" basis had a tendency to decrease with increasing maturity. However, expressed on an air dry basis the trend reversed.

No significant ($P < .05$) differences were found in (1) the live condition grades taken at the end of the silage phase, (2) the final live condition grades, and (3) the carcass characteristics obtained at the end of the full fed phase.

Pounds of beef produced per acre of silage was highest for the late dough stage, and followed in decreasing order by the early dough, mealy endosperm, and late milk stages.

In the full fed phase no significant ($P < .05$) differences were found in average daily gain or air dry matter intake indicating no "carry over" effects from the silage phase to the full fed phase.

These results indicate that the proper time to harvest silage to obtain maximum air dry matter intake and the most beef produced per acre of silage is from the early dough to the late dough stages. The most total dry matter and edible dry matter per acre was obtained with the late dough stage of silage. However, the average daily gains indicated that there were no significant ($P < .05$) differences in any of the first three stages of maturity.

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