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# The effects of additions of urea and sulfate sulfur to corn silage at varying stages of maturity used for the production of market beef heifers in Tennessee

Dalie T. Thomas

To the Graduate Council:

I am submitting herewith a thesis written by Dalie T. Thomas entitled "The effects of additions of urea and sulfate sulfur to corn silage at varying stages of maturity used for the production of market beef heifers in Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. C. Chamberlain, Major Professor

We have read this thesis and recommend its acceptance:

J. A. Corrick, Haley M. Jamison, J. G. Snell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 1, 1971

To the Graduate Council:

I am submitting herewith a thesis written by Dalie T. Thomas entitled "The Effects of Additions of Urea and Sulfate Sulfur to Corn Silage at Varying Stages of Maturity Used for the Production of Market Beef Heifers in Tennessee." 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.

C. C. Chamberlain
Major Professor

We have read this thesis and recommend its acceptance:

James A. Corrick, Jr.

Haley M. Jamison

James S. Snell

Accepted for the Council:

Shelton A. Smith
Vice Chancellor for
Graduate Studies and Research

# THE EFFECTS OF ADDITIONS OF UREA AND SULFATE SULFUR TO CORN SILAGE AT VARYING STAGES OF MATURITY USED FOR THE PRODUCTION OF MARKET BEEF HEIFERS IN TENNESSEE

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A Thesis

Presented to

the Graduate Council of

The University of Tennessee

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Dalie T. Thomas

December 1971

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ABSTRACT

One hundred and twenty medium grade heifers were involved in a three-year study of the production of market beef heifers fed urea, limestone and/or sulfur treated corn silage cut at various stages of maturity. The heifers were full fed silage for approximately 116 days and then full fed grain for approximately 74 days or until they reached a condition grade of low good to average good.

Each year 40 heifers were uniformly lotted into eight lots on the basis of weight and type and condition grades. The heifers were fed four treatments with two lots per treatment and 28 day weights were recorded throughout the trial. The heifers were graded and subjectively evaluated at the beginning and end of both the silage and concentrate phases. At the completion of the concentrate phase the heifers were sold to a packing plant and carcass data were obtained.

In 1968 and 1969 there was no significant difference ($P<.05$) in ADG of the heifers when fed urea-limestone treated corn silage harvested at three stages of maturity. The results also showed no significant difference ($P<.05$) in ADG, feed consumption and total ADM per pound of gain when sodium sulfate was added to the urea-limestone treated corn silage to maintain a 12:1 nitrogen to sulfur ratio.

During the three-year study (1968-70) there were no significant carryover effects ($P<.05$) from the silage phase to the concentrate phase due to the addition of urea, limestone and sulfur to green chop at ensiling time.

In 1970 one of the four treatments of silage contained 20 pounds

of urea, 10 pounds of limestone and 3 pounds of sodium sulfate per ton of green chop. The additional 3 pounds of sulfur was added to maintain a nitrogen to sulfur ratio of approximately 12:1. None of the results showed any significant difference ($P<.05$) due to the additional urea and/or sulfur.

There were no significant differences in carcass data results due to the treatment effects of the silage.

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## CHAPTER I

## INTRODUCTION

According to the Tennessee Department of Agriculture (1970) between 1960 and 1969 the total number of beef cows in Tennessee had increased from 492,000 to 922,000. This increase in beef cow numbers was paralleled by an increase in corn silage production from 483,000 tons in 1960 to 1,275,000 tons in 1969 (Tennessee Department of Agriculture, 1970). On good farm land more pounds of beef per acre can be produced from good corn silage than from any other crop.

Previous work of Vickers (1970) had shown no differences in animal performance due to the stage of maturity of corn at ensiling time; late milk, early dough or late dough. The silage fed these cattle had been supplemented with cottonseed meal (CSM). The addition of urea was being recommended to increase the crude protein equivalent of corn silage. The question raised then was whether the same results would be obtained with urea added to the corn at ensiling at the three stages of maturity as when CSM was fed when the silage was removed from the silo. In addition, urea markedly altered the nitrogen sulfur (N:S) ratio. Sulfur is a required nutrient, and is used with nitrogen in the formation of amino acids. Would additional sulfur need to be added to maintain the normal N:S ratio when urea was added to corn at ensiling time was a question that had not been answered for beef cattle. The third question left unanswered by Vickers' (1971) work was whether the addition of corn (energy) during the silage feeding phase would improve animal performance for those fed urea treated silages.

This study presents the results of the three years of work (1968-70) concerning the effect of additions of urea and sulfur to corn silage at varying stages of maturity used for the production of market beef heifers in Tennessee.

CHAPTER II

# LITERATURE REVIEW

## Role of Sulfur

Sulfur in animal nutrition is involved in many of the reactions that take place in the animal body. It is primarily involved with the sulfur-containing compounds such as methionine, cystine, glulathione, biotin, lipoic acid, coenzyme A and serves as a cofactor for many enzymatic reactions (Maynard and Loosli, 1969). There has long been the general assumption that all practical rations would meet the sulfur requirement.

The early workers asserted that a practical ration would meet the requirements for sulfur due to the large number of sulfur-containing compounds found in animal feeds. Although these were predominantly organically bound sulfur, some inorganic compounds such as sulfates and sulfites were included. Much of the earlier work indicated that the animal can make little or no use of the inorganic forms of sulfur, but later work has shown that all forms can be utilized to supply the sulfur although some forms may be more readily available than others (Garrigus et al., 1950; Hale and Garrigus, 1953).

Hunt et al. (1954) found that sulfur supplementation stimulated cellulose digestion. Lower cellulose digestion leads to lower dry matter intake. This has been a typical problem of rations either purified or purposely low in sulfur and sulfur-containing amino acids, and is not restricted to ruminants alone but has been shown in other animal species (Sanahuja, Rio and Lede, 1965).

According to Wiley and Garrison (1966), methionine, a sulfur containing amino acid, can be considered as an essential amino acid present in plants and animals. The sulfur to nitrogen ratio in quality protein is normally about 1:15.

Sulfur Work--Sheep

A review of the literature shows that much work has been done concerning the sulfur requirements of sheep (Block and Stekol, 1950; Davis et al., 1954; Thomas et al., 1951) but only a limited amount has been done with either beef or dairy cattle.

The value of experimental sulfur in a methionine deficient ration was studied by Garrigus et al. (1950). In their study lambs were grouped into trios and the number one lamb of each trio was fed a basal ration low in sulfur bearing amino acids, number two lamb was fed the basal ration supplemented with 0.5% elemental sulfur and number three lamb was fed the basal ration supplemented with 0.5% of methionine. The difference in weight gain between controls and those receiving 0.5% sulfur, while in favor of the group receiving sulfur, was not significantly different ($P<.05$). The difference in gains between controls and those receiving 0.5% methionine was highly significant ($P<.01$). The increased weight of wool produced by the lambs receiving both sulfur and methionine was highly significant ($P<.01$) when compared to the wool weight of the controls. This work indicated that sulfate sulfur can be utilized to some extent in supplying the sulfur for the synthesis of sulfur containing amino acids. In similar feeding trials by Loosli et al. (1949) it was demonstrated that the 10 amino acids (including methionine) classified as being essential for rat growth, are synthesized in the rumen from a ration containing high levels of urea. The only source of sulfur in these diets was sodium sulfate. Therefore, it appears that the microorganisms of the rumen are able to utilize inorganic sulfur and urea nitrogen in the synthesis of methionine.

Thomas et al. (1951), using purified rations, showed that lambs have a definite dietary requirement for sulfur, and that this requirement can be met by feeding inorganic sulfur. One of the two purified diets deficient in total sulfur contained sufficient urea to meet the requirements for crude protein equivalent but had no sulfur added while the other diet contained sulfate sulfur. On the sulfur deficient diet one of the lambs died after 80 days. The three remaining animals then had the sulfate sulfur added to their diet and began to gain within a few days. The sulfur deficiency was manifest by deprived appetites, chewing the wood pens and pulling and consuming wool from their own backs. A post-mortem examination of the dead animal failed to disclose specific pathological lesions. This study demonstrated that in the absence of dietary sulfur, urea nitrogen was apparently not efficiently utilized since the sulfur deficient lambs not only showed negative sulfur balances, but also negative nitrogen balances.

Sulfur is also required for the growth of wool in sheep. Thomas et al. (1951) found that wool would continue to grow, but at a retarded rate, for as long as five months on a sulfur deficient diet, even though the lambs were continuously losing body weight. This suggested that the growth of wool would appear to have the greater priority on nutrients from the metabolic pool than the body tissue or maintenance.

Starks et al. (1952) demonstrated that elemental sulfur can be used by sheep to partially supply the dietary needs for sulfur when added to a low sulfur ration where urea was the major source of nitrogen. Lambs receiving elemental sulfur retained significantly ($P<.05$) more nitrogen and sulfur, had more wool growth and they lost less weight than lambs on the basal ration.

Hale et al. (1953) demonstrated synthesis of cystine, another sulfur containing amino acid, in the sheep from elemental and sulfate sulfur using $^{35}S$. The work suggested that sulfate sulfur may be better utilized for the synthesis of cystine than elemental sulfur. This could be due in part to the difference in the solubility of the two compounds.

It was suggested by Willman et al. (1946) that urea is inefficiently converted to protein by sheep or that the protein that is synthesized by the microorganisms of the rumen is of poor quality. They demonstrated that for fattening lambs urea did not have as much value as linseed meal as a protein supplement. When urea was used as the major source of nitrogen the average daily gain was about 0.26 pounds per day, whereas, linseed meal used to supplement the same basal ration gave average daily gains of 0.32 pounds per day. In an attempt to improve the utilization of the urea nitrogen, sodium sulfate was added to some of the urea containing rations. The addition of sodium sulfate was unsuccessful in these experiments in increasing the utilization of urea nitrogen by lambs.

Loosli et al. (1945) studied the value of methionine as a supplement for rations containing urea. Their basal diet contained the following by weight: alfalfa meal, 5.0; ground timothy hay, 29.0; cane molasses, 5.0; yellow corn, 12.0; ground oats, 8.0; brewer's yeast, 0.9; irradiated yeast, 0.1; corn oil, 1.3; and minerals, 0.88. In addition, the experimental rations were made by adding the following amounts of nitrogen supplements by weight to the basal diet: linseed, 9.54; urea, 1.25; urea plus sodium sulfate, 1.06; and urea, 102 plus methionine, 1.11. In the urea plus sodium sulfate ration sodium sulfate was added to supply the same amount of sulfur as was supplied by the methionine in the urea methionine ration. The protein equivalent content of the basal diet was 6.55% and that of the other diets ranged from 9.97% to 10.58%. The average daily gains in body were: basal, 0.07; basal plus urea, 0.17; basal plus urea plus sulfate, 0.18; basal plus urea plus methionine, 0.28; and basal plus linseed meal, 0.31. Thus the sheep fed linseed meal or methionine had higher average daily gains than sheep fed urea or urea plus sulfate. This work also indicated that the addition of sulfur to the urea containing diet improved the nitrogen balance and proportion of the dietary nitrogen retained, though the rate of gain was not affected.

Sulfur Work--Dairy Cattle

Davis et al. (1954) observed that there was no significant difference in milk production from three groups of cows with each group receiving one of the following rations: basal ration plus soybean oil meal, basal ration plus urea and basal ration plus sodium sulfate.

The results of their chemical analyses indicated that published data on the sulfur content of plants are incorrect. Newer chemical methods for determining sulfur in feeds indicated that the older published values were low.

Jones, Haag and Weswig (1952) and Davis et al. (1954) did not improve gain of dairy heifers by adding sulfur. However, it appeared that little attempt was made to produce a sulfur deficiency. There may be little or no response to sulfur after the minimum requirements are met.

Brown et al. (1960) fed a basal ration, a basal ration plus urea and sodium sulfate and a basal ration plus soybean oil to dairy heifers. Their results indicated that the addition of urea and sulfate sulfur significantly increased average daily gains. However, the group receiving the conventional protein supplement made even larger gains than those receiving urea and sulfate sulfur.

Reports by Martin et al. (1964) and Whanger (1965) have shown that an apparent lack of sulfur can cause a drastic reduction in cellulose digestion and produce changes in the proportions of volatile fatty acids produced.

Jones and Haag (1946) reported that sodium sulfate may improve the utilization of urea fed in a ration containing 3.0% urea with an overall sulfur content of 0.13%. This work indicated that heifers receiving additional sulfate sulfur in 8 of the 11 pairs studied averaged 0.2 and 0.3 pounds more gain per day than the non-supplemented heifers.

According to Lassiter et al. (1958a) blood concentration of urea nitrogen showed a tendency to increase as the intake of urea nitrogen increased, but the concentration of serum protein decreased significantly ($P<.05$) in dairy heifers. They concluded that this phenomenon apparently indicated a disturbance of protein metabolism when high levels of urea were fed without additional sulfur.

In a later study, Lassiter et al. (1958b) studied the value of adding sulfur to rations containing high amounts of urea. Three rations were fed which contained 30%, 50% and 70%, respectively, of the total nitrogen as urea nitrogen. Ration one contained 0.171% sulfur. Sodium sulfate was added to rations two and three to increase the sulfur content of these rations up to about 0.174% and 0.178%, respectively. The growth rate of all groups of heifers in the second study was somewhat improved when compared to the initial study (Lassiter et al., 1958a) where sulfur was not added to rations two and three. Lassiter et al. (1958b) concluded that sulfur improved the utilization of rations fed to dairy heifers that contained high amounts of urea, but that other factors seem to be needed for proper utilization of high grain rations in which urea supplies up to 70% of the total nitrogen.

Research on the utilization of urea nitrogen as a nitrogen source for the ruminant has demonstrated that sulfur may be one of the factors which limits the efficiency of the urea utilization (Lassiter et al., 1958a,b; Thomas et al., 1951; and Loosli and Harris, 1945).

Loosli et al. (1949) found that synthesis of sulfur containing amino acids from non-protein nitrogen and inorganic sulfur depends upon bacterial activity in the rumen. On the basis of those findings they suggested that an inorganic sulfur source should be added to the rations of dairy cattle and other ruminants when urea or ammonia furnished part of the nitrogen for microbial synthesis. A nitrogen to sulfur ratio of about 15:1 has been found in the average mixed proteins of the body tissue. Thus, they suggested that added forms of non-protein nitrogen and sulfur should be furnished so that this ratio of 15 parts of nitrogen to 1 part of sulfur is maintained.

Jacobson et al. (1967) obtained lower dry matter intake, and lower levels of free amino acids in the plasma and rumen and lower milk production on a sulfur deficient diet. The sulfur containing amino acids were found by other workers to be in the lowest concentration in both the rumen microorganisms and in bovine blood plasma of all the amino acids studied (Abdo et al., 1964; and Purser and Buechler, 1966). This may indicate that the sulfur containing amino acids could be the first limiting amino acids in meeting the physiological requirements of the animal.

Jacobson et al. (1967) observed significant increases in milk yield on a ration in which sulfates increased total sulfur from 0.10% in the basal ration to 0.18% in the supplemented ration. The corn silage fed as the only forage was selected to be low in sulfur content and contained only about one-third as much sulfur as normal corn silage. The content was calculated to be 0.09% sulfur on a dry basis (0.2% on a 22% dry matter) and nitrogen to sulfur ratio was approximately 15:1. However, they found that even with the added sulfur, the decline in milk yield was more rapid than normal, indicating that the level of supplementation used was not high enough or inefficiently used.

These studies have shown that sulfur is an essential trace mineral for ruminants and yet the NRC sets no minimum standard for meeting the sulfur requirement in the ration of beef cattle. There are essentially no reports concerning sulfur requirements or sulfur addition for beef cattle rations. These studies also suggest that it may be desirable to supply additional inorganic sulfur when non-protein nitrogen is fed, especially in feeds low in sulfur. However, excess sulfur may enhance molybdenum toxicity and modify copper utilization (National Research Council, 1966). One reason that few people have experienced a sulfur deficiency is because most soils, especially those fertilized with mixtures containing sulfur, provide enough sulfur to the plant so that the feed source contains enough sulfur to maintain normal body function.

# CHAPTER III

## EXPERIMENTAL PROCEDURE

The experiments were conducted over a three-year period from 1968-70 at the Tobacco Experiment Station near Greenville, Tennessee. The first two years of work were a continuation of a previous three-year study (Vickers, 1971) to determine the effects of the maturity of corn silage at harvesting on the performance of beef heifers. Urea and limestone were added at the rate of 10 pounds of each per ton of green chop corn when harvested at three stages of maturity: late milk, early dough and late dough. In addition, an attempt was made to determine if it was essential to add sulfur to urea-limestone treated corn silage to maintain the proper nitrogen to sulfur ratio. The procedures of the experiments will be discussed in the remainder of this chapter.

### Production of Silage

The green chop was grown on Class I land comprised of 80% Huntington silt loam and 20% Lindside silt loam. Dixie 29, a recommended early maturing hybrid corn, was planted at a rate that produced 16,000 to 18,000 plants per acre. Each fall small grains were sown for a cover crop to be used as winter pasture after the green chop had been harvested. Each spring the field was top dressed with 50 pounds per acre of nitrogen and 24 tons per acre of cattle manure. After plowing under this fertilizer and small grain residue, 160 pounds of nitrogen per acre, 27 pounds of phosphorus per acre and 50 pounds of potassium per acre were broadcast on the field before the corn was planted. Recommended rates of either Simazine or Atrazine were used for weed control.

## Stages of Maturity

For the years 1968 and 1969 the corn was harvested at three stages of maturity: late milk, early dough and late dough. The first stage of maturity (late milk) contained some juice in the kernel, had about 10% of the kernels dented, there was no loss of color in the shuck, and did not have more than 5.0% firing on the bottom leaves. The second stage of maturity (early dough) contained no juice but the kernels were still soft. Practically all the kernels were dented, the shuck and ear were beginning to lose the green color and there was from 5% and 10% firing on the bottom leaves. In the third stage of maturity (late dough) the endosperm was rather firm and the kernels contained approximately 50% moisture. About 15% to 20% of the total plant was fired and approximately half of the green color had disappeared from the ear shuck. In 1970 all the corn was harvested at the early dough stage of maturity.

## Harvesting and Storage of Silage

Two upright silos measuring 10 feet by 30 feet with a capacity of approximately 10 tons were filled for each treatment each year. The green chop was harvested each year with a field chopper set for 0.5 inch cut. Before the green chop was put in the silo, urea, limestone and sodium sulfate were broadcast over each wagon load of green chop at the desired rate for each designated treatment. The green chop normally had a minimum of one month of fermentation before the silos were open and feeding began.

## Chemical Analysis of the Silage

A chemical analysis of samples from each silo was made according to A.O.A.C. (1965) recommendations. Samples were taken from each treatment each year. The samples were processed, ground through a Wiley Mill and then a proximate analysis to determine the chemical composition of each sample was made.

## Description of Animals

Forty beef heifer calves were purchased at graded Tennessee feeder-calf sales for each year of the experiment. These heifers graded either medium or good and weighed between 450 and 500 pounds at the livestock market. After a two to three week adjustment period, the heifers were then reweighed and regraded for type and condition. On the basis of weight, grade (both type and condition) and weight changes during the adjustment period, the heifers were allotted in uniform lots. Two lots containing five heifers were randomly assigned to each treatment with two lots per treatment. Although the animal feeding phase of the experiment each year extended into the winter succeeding the silage harvest, the year of harvest will be used to describe each of the three years.

## Feeding Phase

During the silage feeding phase the heifers were fed corn silage ad libitum once a day with increases or decreases in daily feed levels based on the amount of feed left in the trough from the previous day. In addition, each heifer received approximately two pounds of good quality alfalfa-orchardgrass hay per head per day. In 1968 and 1969 the silages in the first treatment (late milk), second treatment (early dough) and third treatment (late dough) were treated with 10 pounds of urea and 10 pounds of limestone per ton of green chop. The fourth treatment (early dough) was treated with 10 pounds of urea, 10 pounds of limestone and 1.5 pounds of sodium sulfate per ton of green chop to maintain a nitrogen to sulfur ratio of about 12:1.

All treatments of silage in 1970 were harvested at the early dough stage of maturity. The first treatment had no urea or limestone added to the green chop. The cattle received one pound of cottonseed oil meal (42%) per head per day as a protein supplement spread over the silage at each feeding period to give approximately the same nitrogen intake level as in treatments two and three. Silage in treatment two contained 10 pounds of urea and 10 pounds of limestone per ton of green chop and was comparable to treatment two in 1968 and 1969. Silage in treatment three was supplemented with 10 pounds of urea, 10 pounds of limestone and 1.5 pounds of sodium sulfate per ton of green chop. This treatment was comparable to the fourth treatment in 1968 and 1969. Treatment four had 20 pounds of urea, 10 pounds of limestone and 3 pounds of sodium sulfate added per ton of green chop. This doubled the quantity of urea nitrogen but maintained the nitrogen and sulfur ratio of 12:1 used in treatment three.

After being on the silage phase for 106 days (1968), 126 days (1969), 125 days (1970), the heifers were full fed grain for 96 days (1968), 90 days (1969) and 35 days (1970). The difference in the days on full feed was due to the fact that in 1968 and 1969 the heifers received no grain during the silage phase, while the heifers in 1970 received five pounds of grain per day during the silage phase. At the end of the silage phase and again at the end of the experiment the heifers were subjectively evaluated for condition. All of these heifers were weighed and graded on two consecutive days at the beginning and end of each phase and at 28 days intervals throughout the experiment. The feeding phase of the experiment was completed when the average of the heifers graded "Good."

## Carcass Data

At the conclusion of each experiment, the cattle were weighed, evaluated and trucked immediately (a distance of approximately 70 miles) to a packing plant where they were again weighed and were slaughtered and hot carcass weights were obtained. From the hot carcass weight and the live weight at the feed lot, dressing percentage was determined. After chilling 48 hours, carcass grades, including conformation, maturity and marbling scores were made by a U.S.D.A. grader. Percent kidney fat, backfat measurements and loin-eye area were estimated according to procedures set forth by the American Meat Science Association (Schoonover *et al*., 1967).

## Statistical Analysis of Data

Significance of treatment effects were determined by an analysis of variance and the multiple range test of Duncan (1955).

## CHAPTER IV

## RESULTS AND DISCUSSION

### Corn Silage Maturity Effects

The results in Tables I, II and III describe the effects of three different stages of maturity of corn silage treated with 10 pounds of urea and 10 pounds of limestone per ton of green chop on feedlot performance. The following model was found to be appropriate to describe the expected variation of feedlot performance due to harvesting corn silage at three different stages of maturity in 1968 and 1969.

$Y = \mu + Y + C\ (Y + C) + P + e,$

where, Y is the expected or predicted performance

and $\mu$ is Mu, the overall mean,

and Y is the effect due to year,

and C is the effect due to stage of maturity,

and P is the effect due to variation between pens within stage of maturity-year,

and e is the normal variation expected between heifers treated alike within a subclass having the same genetic and biological potential.

Table III shows there were no significant differences ($P<.05$) between the 18 variables studied comparing the three different stages of maturity to feedlot performance in both the silage phase and concentrate phase of 1968 and 1969.

### Silage Phase

The difference in average daily gain (ADG) of the cattle during

TABLE I. 1968 SUMMARY OF ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR SILAGE AND CONCENTRATE FEEDING PHASES

| | Silage Phase (106 days) Maturity Stage of Silage | | | Concentrate Phase (96 days) Maturity Stage of Silage During Silage Feeding Phase | | |
|---|---|---|---|---|---|---|
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| No. animals/yr. | 10 | 10 | 10[a] | 10 | 10 | 10 |
| No. rep./yr. | 2 | 2 | 2 | 2 | 2 | 2 |
| Avg. wt. gain/head, lbs. | | | | | | |
| Initial | 505 | 501 | 500 | 602 | 632 | 604 |
| Final | 602 | 632 | 604 | 796 | 821 | 805 |
| ADG | 0.91 | 1.24 | 0.98 | 2.02 | 1.96 | 2.10 |
| Total ADG (202 days) | --- | --- | --- | 1.44 | 1.58 | 1.51 |
| Daily feed intake/head, lbs. | | | | | | |
| Corn silage (as fed) | 30.0 | 31.3 | 24.7 | 18.2[b] | 18.8[b] | 14.6[b] |
| Corn silage (ADM) | 7.3 | 8.7 | 9.6 | --- | --- | --- |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Urea, 45% protein sup. | --- | --- | --- | 1.5 | 1.5 | 1.5 |
| Corn cob meal | --- | --- | --- | 20.2 | 20.0 | 20.1 |
| Lbs. fed/lb. gain | | | | | | |
| Corn silage (as fed) | 32.9 | 25.2 | 25.2 | --- | --- | --- |
| Corn silage (ADM) | 8.0 | 7.0 | 9.8 | --- | --- | --- |
| Hay | 2.2 | 1.6 | 2.0 | 1.0 | 1.0 | 1.0 |
| Urea, 45% protein sup. | --- | --- | --- | 0.7 | 0.8 | 0.7 |
| Corn cob meal | --- | --- | --- | 10.0 | 10.2 | 9.6 |
| Total ADM | 10.2 | 8.6 | 11.8 | 11.7 | 12.0 | 11.3 |

TABLE I (continued)

| | Silage Phase (106 days) | | | Concentrate Phase (96 days) | | |
|---|---|---|---|---|---|---|
| | Maturity Stage of Silage | | | Maturity Stage of Silage During Silage Feeding Phase | | |
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| Grades | | | | | | |
| Initial type | 9.3[c] | 9.5 | 9.1 | --- | --- | --- |
| Initial cond. grade | 8.2 | 8.4 | 8.2 | 8.4 | 8.8 | 8.5 |
| Final cond. grade | 8.4 | 8.8 | 8.5 | 9.7 | 10.1 | 9.5 |

[a]One heifer was culled from the late dough stage treatment and a lot mean average was substituted for her.

[b]8 = High Standard, 9 = Low Good, 10 = Avg. Good, 11 = High Good.

[c]Fed for only 17 days during transition from silage to concentrate so not figured in dry matter intake for concentrate phase.

TABLE II. 1969 SUMMARY OF ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR SILAGE AND CONCENTRATE FEEDING PHASES

| | Silage Phase (126 days) Maturity Stage of Silage | | | Concentrate Phase (90 days) Maturity Stage of Silage During Silage Feeding Phase | | |
|---|---|---|---|---|---|---|
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| No. animals/yr. | 10 | 10 | 10 | 10 | 10 | 10 |
| No. rep./yr. | 2 | 2 | 2 | 2 | 2 | 2 |
| Avg. wt. gain/head, lbs. | | | | | | |
| Initial | 502 | 505 | 507 | 614 | 615 | 644 |
| Final | 614 | 615 | 644 | 766 | 762 | 783 |
| ADG | 0.89 | 0.87 | 1.08 | 1.69 | 1.63 | 1.54 |
| Total ADG (216 days) | --- | --- | --- | 1.22 | 1.19 | 1.26 |
| Daily feed intake/head, lbs. | | | | | | |
| Corn silage (as fed) | 28.8 | 28.6 | 28.2 | 17.3[a] | 17.3[a] | 17.3[a] |
| Corn silage (ADM) | 7.7 | 8.0 | 9.5 | --- | --- | --- |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Urea, 45% protein sup. | --- | --- | --- | 14.7 | 14.5 | 14.7 |
| Lbs. feed/lb. gain | | | | | | |
| Corn silage (as fed) | 32.4 | 32.9 | 26.1 | --- | --- | --- |
| Corn silage (ADM) | 8.7 | 9.7 | 8.8 | --- | --- | --- |
| Hay | 2.2 | 2.3 | 1.9 | 1.2 | 1.2 | 1.3 |
| CSM | --- | --- | --- | 0.9 | 0.9 | 1.0 |
| Corn cob meal | --- | --- | --- | 8.7 | 8.9 | 9.5 |
| Total ADM | 10.9 | 12.0 | 10.7 | 10.8 | 11.0 | 11.8 |

TABLE II (continued)

| | Silage Phase (126 days) Maturity Stage of Silage | | | Concentrate Phase (90 days) Maturity Stage of Silage During Silage Feeding Phase | | |
|---|---|---|---|---|---|---|
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| Grades | | | | | | |
| Initial type | 9.6[b] | 9.7 | 9.9 | --- | --- | --- |
| Initial condition | 7.7 | 7.7 | 7.7 | 8.0 | 8.0 | 7.9 |
| Final condition | 8.0 | 8.0 | 7.9 | 10.7 | 10.7 | 10.5 |

[a]Fed for only 14 days during transition from silage to concentrate so not figured in dry matter intake for concentrate phase.

[b]7 = Avg. Standard, 8 = High Standard, 9 = Low Good, 10 = Avg. Good, 11 = High Good.

TABLE III. TWO-YEAR (1968-69) SUMMARY OF ANIMAL PERFORMANCE AND FEED CONSUMPTION FOR SILAGE AND CONCENTRATE FEEDING PHASES

| | Silage Phase (2 yr. avg.) Maturity Stage of Silage | | | Concentrate Phase (2 yr.) Maturity Stage of Silage During Silage Feeding Phase | | |
|---|---|---|---|---|---|---|
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| No. animals/yr. | 20 | 20 | 20 | 20 | 20 | 20 |
| No. rep./yr. | 4 | 4 | 4 | 4 | 4 | 4 |
| Avg. wt. gain/head, lbs. | | | | | | |
| Initial | 504 | 503 | 504 | 608 | 624 | 624 |
| Final | 608 | 624 | 624 | 781 | 792 | 794 |
| ADG | 0.90 | 1.06 | 1.03 | 1.86 | 1.80 | 1.82 |
| Total ADG (116 days) | --- | --- | --- | 1.33 | 1.39 | 1.38 |
| Daily feed intake/head, lbs. | | | | | | |
| Corn silage (as fed) | 29.4 | 29.9 | 26.5 | 17.8[a] | 18.1[a] | 16.0[a] |
| Corn silage (ADM) | 7.5 | 8.4 | 9.6 | --- | --- | --- |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Urea, 45% protein sup. | --- | --- | --- | 1.5 | 1.5 | 1.5 |
| Corn cob meal | --- | --- | --- | 17.5 | 17.3 | 17.3 |
| Lbs. fed/lb. gain | | | | | | |
| Corn silage (as fed) | 32.7 | 28.2 | 25.7 | --- | --- | --- |
| Corn silage (ADM) | 8.4 | 8.4 | 9.3 | --- | --- | --- |
| Hay | 2.1 | 2.0 | 2.0 | 1.1 | 1.1 | 1.2 |
| CSM | --- | --- | --- | 0.8 | 0.9 | 0.9 |
| Corn cob meal | --- | --- | --- | 9.5 | 9.6 | 9.6 |
| Total ADM | 10.5 | 10.4 | 11.3 | 11.4 | 11.6 | 11.7 |

TABLE III (continued)

| | Silage Phase (2 yr. avg.) Maturity Stage of Silage | | | Concentrate Phase (2 yr.) Maturity Stage of Silage During Silage Feeding Phase | | |
|---|---|---|---|---|---|---|
| | Late Milk | Early Dough | Late Dough | Late Milk | Early Dough | Late Dough |
| Grades | | | | | | |
| Initial type | 9.5[b] | 9.6 | 9.5 | --- | --- | --- |
| Initial condition | 8.0 | 8.1 | 8.0 | 8.2 | 8.4 | 7.9 |
| Final condition | 8.2 | 8.4 | 8.2 | 10.3 | 10.4 | 10.0 |

[a]Fed for only 16 days during transition from silage to concentrate so not figured in dry matter intake for concentrate phase.

[b]8 = High Standard, 9 = Low Good, 10 = Avg. Good, 11 = High Good.

the silage phase fed silage harvested at the early dough stage of maturity approached significance (P<.05) in 1968 as shown in Table I. This difference was similar to work done by Vickers (1971) but the variation was not as great.

The ranking of ADG during both the silage phase and concentrate phase due to stage of harvest changes year by year are shown in Tables I and II. In 1968 the cattle fed the early dough stage silage had the highest ADG (1.24 pounds per day) and the cattle fed the late milk stage had the lowest ADG (0.91 pounds per day) while the ADG of 0.98 pounds per day for the late dough stage was intermediate. In 1968 one heifer fed silage harvested in the late dough stage and treated with urea and limestone was dropped from the study after the silage phase because she had gained only 5 pounds during that phase. A mean average of that lot was substituted for that heifer for the entire study. A carcass analysis of the cull heifer showed she had been carrying hardware in her stomach. However, in 1969 the highest ADG (1.08 pounds per day) was from cattle fed silage harvested at the late dough stage, the lowest ADG (0.87 pounds per day) was from cattle fed early dough stage silage while the late milk stage fed cattle were intermediate with a gain of 0.89 pounds per day. Because of the yearly variation there were no significant differences (P<.05) in the two year summary (Table III). Average daily gains during the concentrate phase ranked in the same order as in the silage phase in both 1968 and 1969 (Table I and II).

The lower consumption on an as-fed basis of corn silage harvested at the late dough stage in 1968 can be accounted for in a large measure by the percent of air-dry matter in the silage. The variation in percent air-dry matter ranged from 24.33% (late milk stage) to 39.0% (late dough stage) in 1968 as shown in Table IV. When silage on an as-fed basis is converted to air-day matter intake (corn silage as fed in Tables I, II and III, pages 18-23, x air-dry matter in Table IV) there is an increase in daily air-dry matter consumption with an increase in stage of maturity from late milk to late dough in both years.

Average daily gain in the forage phase was largely growth. This is indicated by the similarity in the initial and final condition grades for the silage phase in both 1968 and 1969 as described in Tables I, II and III.

Air dry matter (ADM) intake per day increased with increased maturity of the corn silage in both years (Tables I and II). This was similar to the work of Vickers (1971) for the same maturity stages. When converted to ADM per pound of gain there was yearly variation with the middle or early dough stage having the lowest ADM per pound of gain in 1968 (8.6 pounds) and the highest in 1969 (12.0 pounds). As a result of the yearly variation there was no significant difference (P<.05) in ADM per pound of gain in the two year summary (Table III.

These data show, therefore, that there are no significant differences (P<.05) in either feedlot performance or in condition scores, due to the stage of maturity at which the silage was harvested when 10 pounds of urea and 10 pounds of limestone were added per ton of green chop. This is similar to the work of Vickers (1971) with the same stages of maturity, but without the addition of urea or limestone.

TABLE IV. AIR DRY MATTER IN SILAGES, 1968-70

| Harvest Stage | Treatment | Percent ADM in Silages |
|---|---|---|
| 1968 | | |
| Late milk | (10+10+0)[a] | 24.33 |
| Early dough | (10+10+0) | 27.77 |
| Early dough | (10+10+0) | 34.07 |
| Late dough | (10+10+0) | 39.00 |
| 1969 | | |
| Late milk | (10+10+0) | 26.78 |
| Early dough | (10+10+0) | 28.10 |
| Early dough | (10+10+0) | 30.59 |
| Late dough | (10+10+0 | 33.78 |
| 1970 | | |
| Early dough | (0+0+0) | 25.52 |
| Early dough | (10+10+0) | 27.18 |
| Early dough | (10+10+1.5) | 27.43 |
| Early dough | (20+10+3) | 26.17 |

[a] Values for urea, limestone and sodium sulfate respectively per ton of green chop.

Concentrate Phase

There was a yearly variation in ADG in the concentrate phase, however, there was also a variation in the concentrate consumed per day. As indicated in Table I, page 18, during the concentrate phase the ADG (2.10 pounds per day) in 1968 for the cattle previously fed the late dough stage silage was highest. The cattle fed the late milk stage silage were intermediate with 2.02 pounds of gain per day and the cattle with the lowest ADG (1.96 pounds per day) were fed silage harvested at the early stage. The differences, however, were not significant ($P<.05$). Table II, page 20, shows that in 1969 the rankings were not the same. The cattle previously fed the late milk stage had the highest ADG (1.69 pounds per day) and the late dough stage had the lowest ADG (1.54 pounds per day). Cattle previously fed the early dough stage silage were intermediate with 1.62 pounds of gain per day. The average consumption of grain in 1968 was about 20.0 pounds of corn and cob meal per animal per day while the consumption of grain decreased to an average of 14.6 pounds of corn and cob meal per animal per day in 1969. This difference in grain consumption is reflected in ADG. In 1968 the cattle gained about 2.0 pounds per day, while in 1969 they gained about 16 pounds per day. However, when converted to ADM per pound of gain the results of the two years are similar.

The marked increase in ADG in the concentrate phase in 1968 and 1969 compared to the silage phase was probably due to adipose depositions. This is reflected in an increase of nearly two-thirds of an average final condition grade at the end of concentrate phase (10.2) compared to the condition grade at the end of the silage phase (8.3) as shown in Table III, page 22.

ADM--Maturity Relationship

Table IV shows an increase in the percent ADM in 1968 and 1969 with an increase in the stage of maturity of the silage. Increases from late milk stage (24.33% in 1968 and 26.78% in 1969), early dough stage (27.77% in 1968 and 18.10% in 1969), early dough stage and sulfur (34.07% in 1968 and 28.10% in 1969) to late dough stage (39.00% in 1968 and 33.78% in 1969) were similar to those obtained by Vickers (1971).

ADG for Periods and Years

Table V shows there was a noticeable difference in ADG ($P<.10$) although not significant ($P<.05$) between the initial 28 day periods and the post 28 days periods (remaining days of silage phase after the initial 28 days) with the three stages of maturity of corn silage in 1968 and 1969. The heifers gained approximately 0.50 of a pound more per day in the initial 28 day period than they did in the post 28 days period in 1968 and 1969. This higher ADG in the initial 28 day period may have been due to the fact that the heifers were on fall pasture supplemented with dry hay in some cases before they were placed on the feedlot. Therefore, the high initial 28 day weight could have represented fill with silage during the initial 28 day period.

As indicated in Table V there were no significant differences ($P<.05$) in the concentrate phase due to prior treatment of silages with 10 pounds of urea and 10 pounds of limestone per ton of green chop. If there were any carry over effects due to stage of maturity or treatment with urea and limestone, they were eliminated by

TABLE V. ADG OF HEIFERS FED SILAGES HARVESTED AT THREE STAGES OF MATURITY FOR SELECTED PERIODS FOR THE YEARS 1968-69

| Period | Late Milk | Early Dough | Late Dough |
|---|---|---|---|
| 1968 | | | |
| ADG[a]--Silage phase (106 days) | | | |
| Initial 28 days | 1.36 | 1.85 | 1.50 |
| Post 28 days | 0.74 | 1.02 | 0.80 |
| Total silage | 0.91 | 1.24 | 0.98 |
| ADG--Concentrate phase | 2.02 | 1.96 | 2.10 |
| ADG--Total (silage and concentrate) | 1.44 | 1.58 | 1.51 |
| 1969 | | | |
| ADG--Silage phase | | | |
| Initial 28 days | 1.27 | 1.10 | 1.40 |
| Post 28 days | 0.78 | 0.81 | 0.99 |
| Total silage | 0.89 | 0.87 | 1.08 |
| ADG--Concentrate phase | 1.69 | 1.63 | 1.54 |
| ADG--Total | 1.22 | 1.19 | 1.26 |
| 1968-69 Summary | | | |
| ADG--Silage phase (110 days) | | | |
| Initial 28 days | 1.32 | 1.48 | 1.45 |
| Post 28 days | 0.76 | 0.92 | 0.90 |
| Total silage | 0.90 | 1.06 | 1.03 |
| ADG--Concentrate phase | 1.86 | 1.80 | 1.82 |
| ADG--Total | 1.33 | 1.39 | 1.38 |

[a]ADG: average daily gain expressed in pounds.

full-feeding with grain in the concentrate phase. These results are similar to work done by Vickers (1971).

<u>Three-Year Study of Constant Levels of Urea, Limestone and Sodium Sulfate Added to Corn Silage</u>

The results shown in Tables VI and VII are from cattle fed two silages, both cut in an early dough stage of maturity and treated with 10 pounds each of urea and limestone or with 10 pounds each of urea and limestone plus 1.5 pounds of sodium sulfate per ton of green chop at ensiling, respectively.

The model found appropriate to describe the expected variation is given as follows:

$$Y = \mu + Y + S + (Y \times S) + P + e$$

where, Y is the expected or predicted performance,

and $\mu$ is Mu, the overall mean,

and Y is the effect due to year,

and S is the effect due to addition or deletion of sulfur,

and P is the effect due to variation between pens within a stage of maturity-year,

and e is the normal variation expected between heifers treated alike within a subclass having the same genetic and biological potential.

<u>Silage Phase</u>

Table VI shows that the addition of sulfur (1.5 pounds per ton of green chop) did not improve the utilization of silage treated with 10 pounds of urea and 10 pounds of limestone per ton of green chop. In 1968 and 1970 the ADG of 1.24 and 1.75 pounds per day, respectively,

TABLE VI. THREE-YEAR SUMMARY; SILAGE PHASE; COMPARISON OF UREA-LIMESTONE AND UREA-LIMESTONE-SULFUR TREATED CORN SILAGES; ANIMAL PERFORMANCE AND FEED CONSUMPTION

| | 1968 | | 1969 | | 1970 | | 3 Yr. Summary | |
|---|---|---|---|---|---|---|---|---|
| | U+L | U+L+S[a] | U+L | U+L+S | U+L | U+L+S | U+L | U+L+S |
| No. animals/yr. | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| No. rep./yr. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Avg. wt. gain/head lbs. | | | | | | | | |
| Initial | 501 | 500 | 505 | 520 | 552 | 556 | 509 | 525 |
| Final | 632 | 632 | 615 | 638 | 770 | 775 | 672 | 682 |
| ADG | 1.24 | 1.24 | 0.87 | 0.93 | 1.75[b] | 1.75[b] | 1.28 | 1.31 |
| Total days on feed | 106 | 106 | 126 | 126 | 125 | 125 | 115 | 115 |
| Daily feed intake/head, lbs. | | | | | | | | |
| Corn silage (as fed) | 31.3 | 30.4 | 28.6 | 28.9 | 30.1 | 29.2 | 30.0 | 29.5 |
| Corn silage (ADM) | 8.4 | 10.4 | 7.3 | 7.9 | 8.2 | 8.0 | --- | --- |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Corn | --- | --- | --- | --- | 5.0 | 5.0 | --- | --- |
| Lbs. feed/lb. gain | | | | | | | | |
| Corn silage (as fed) | 25.2 | 24.5 | 32.9 | 31.1 | 17.2 | 16.7 | 23.4 | 22.5 |
| Corn silage (ADM) | 7.0 | 8.4 | 8.4 | 8.6 | 4.7 | 4.6 | --- | --- |
| Hay | 1.6 | 1.6 | 2.3 | 2.1 | 1.1 | 1.1 | 1.6 | 1.5 |
| Corn | --- | --- | --- | --- | 2.9 | 2.9 | --- | --- |
| Total ADM | 8.6 | 10.0 | 10.7 | 10.7 | 8.7 | 8.6 | --- | --- |

TABLE VI (continued)

| | 1968 | | 1969 | | 1970 | | 3 Yr. Summary | |
|---|---|---|---|---|---|---|---|---|
| | U+L | U+L+S[a] | U+L | U+L+S | U+L | U+L+S | U+L | U+L+S |
| Grades | | | | | | | | |
| Initial type | 9.3[c] | 9.3 | 9.7 | 9.5 | 9.9 | 9.9 | 9.7 | 9.6 |
| Initial condition | 8.4 | 8.2 | 7.7 | 7.7 | 8.1 | 8.0 | 8.1 | 8.0 |
| Final condition | 8.8 | 8.5 | 8.0 | 7.5 | 9.4 | 9.6 | 8.7 | 8.5 |

[a]U - Urea (10#/ton); L - Limestone (10#/ton; S - Sodium Sulfate (1.5 #/ton).

[b]Cattle received 5# of grain per head per day in addition to silage in 1970 only.

[c]7 = Avg Standard, 8 = High Standard, 9 = Low Good, 10 = Avg. Good.

TABLE VII. THREE-YEAR SUMMARY; CONCENTRATE PHASE; COMPARISON OF UREA-LIMESTONE AND UREA-LIMESTONE-SULFUR TREATED CORN SILAGES; ANIMAL PERFORMANCE AND FEED CONSUMPTION

| | 1968 | | 1969 | | 1970 | | 3 Yr. Summary | |
|---|---|---|---|---|---|---|---|---|
| | Silage Treatment During Silage Feeding Phase | | | | | | | |
| | U+L | U+L+S[a] | U+L | U+L+S | U+L | U+L+S | U+L | U+L+S |
| No. animals/yr. | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| No. rep./yr. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Avg. wt. gain/head, lbs. | | | | | | | | |
| Initial | 632 | 632 | 615 | 638 | 770 | 775 | 672 | 682 |
| Final | 821 | 807 | 762 | 785 | 821 | 832 | 801 | 808 |
| ADG | 1.96 | 1.98 | 1.63 | 1.64 | 1.45[b] | 1.62[b] | 1.68 | 1.75 |
| Total days on concentrate | 96 | 96 | 90 | 90 | 35 | 35 | --- | --- |
| Total ADG | 1.58 | 1.52 | 1.19 | 1.23 | 1.68 | 1.72 | 1.52 | 1.52 |
| Total days on feed (silage + concentrate) | 202 | 202 | 216 | 216 | 160 | 160 | --- | --- |
| Daily feed intake/head, lbs.[c] | | | | | | | | |
| Corn silage (as fed) | 18.8 | 18.4 | 17.3 | 17.3 | 13.0 | 13.0 | 16.4 | 16.2 |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Urea, 45% protein sup. | 1.5 | 1.5 | 1.5 | 1.5 | 1.0 | 1.5 | 1.3 | 1.5 |
| Corn cob meal | 20.0 | 15.0 | 14.5 | 14.6 | 13.1 | 14.9 | 15.9 | 14.8 |
| Total ADM | 22.5 | 18.5 | 18.0 | 18.1 | 16.1 | 18.4 | 19.2 | 18.3 |
| Lbs. feed/lb. gain | | | | | | | | |
| Hay | 1.0 | 1.0 | 1.2 | 1.2 | 1.4 | 1.2 | 1.2 | 1.1 |
| Urea, 45% protein sup. | 0.8 | 0.8 | 0.9 | 0.9 | 0.7 | 0.9 | 0.8 | 0.8 |
| Corn cob meal | 12.6 | 9.9 | 12.2 | 11.9 | 7.8 | 8.7 | 10.5 | 9.7 |
| Total ADM | 14.4 | 11.7 | 14.3 | 14.0 | 9.9 | 10.8 | 12.5 | 11.6 |

TABLE VII (continued)

| | 1968 | | 1969 | | 1970 | | 3 Yr. Summary | |
|---|---|---|---|---|---|---|---|---|
| | Silage Treatment During Silage Feeding Phase | | | | | | | |
| | U+L | U+L+S[a] | U+L | U+L+S | U+L | U+L+S | U+L | U+L+S |
| Grades | | | | | | | | |
| Initial condition | 8.8[d] | 8.5 | 8.0 | 7.5 | 9.4 | 9.6 | 8.7 | 8.5 |
| Final condition | 10.1 | 9.3 | 10.7 | 10.6 | 11.1 | 11.0 | 10.6 | 10.3 |

[a]U - Urea (10#/ton); L - Limestone (10#/ton); S - Sodium Sulfate (1.5#/ton).

[b]Cattle received 5# of grain per head per day in addition to silage in 1970 only.

[c]Fed during the transition from silage to concentrate for periods of 17, 14, 9 days respectively for 1968, 1969 and 1970 (average of 13 days for the 3 years) so not figured in dry matter intake for the concentrate phase.

[d]7 = Avg. Standard, 8 = High Standard, 9 = Low Good, 10 = Avg. Good, 11 = High Good.

was the same for the urea-limestone treatments and the urea-limestone-sulfur treatments during the silage phase. The difference in ADG of 0.87 pounds (urea-limestone) to 0.93 pounds (urea-limestone-sulfur) in 1969 was non-significant (P<.05) as shown in Table VI.

In 1970 the heifers received 5.0 pounds of ground shelled corn per day during the silage phase and this addition of grain accounts for the higher ADG in 1970 (1.75 and 1.75 pounds) compared to the lower ADG in the silage phases of 1968 (1.24 and 1.24 pounds) and 1969 (0.87 and 0.93 pounds). The value of the addition of ground shelled corn to urea-limestone treated corn silage was demonstrated by Corrick and Hobbs (1968) when they added 6.0 pounds of ground shelled corn per day to urea-limestone treated corn silage and found it did not affect the utilization of urea or the consumption of silage during the silage phase.

There was no significant difference (P<.05) over the three-year period in corn silage consumed on an as-fed basis or an air dry basis as shown in Table VI. Since there were similar ADG's and similar consumption of an air dry matter basis, the difference in ADM per pound of gain over the three-year period was non-significant (P<.05). There was no significant difference (P<.05) in final condition grades at the end of the silage phase as shown in the three-year summary of Table VI.

Concentrate Phase

Table VII shows there was no significant difference (P<.05) in ADG during the concentrate phase between the two treatments (1.68 pounds for urea + limestone and 1.75 pounds for urea + limestone + sulfur), nor was there a significant difference (P<.05) in ADG for the combined silage and concentrate phases in which both treatments have an ADG of 1.52 pounds.

There was not an explanation for the higher daily consumption of corn and cob meal in 1968 by the cattle previously fed the urea and limestone treated silage (20.0 pounds of grain per day) compared to those previously fed the silage treated with urea, limestone, and sulfur treatment (15.0 pounds of grain per day). However, the increased consumption of 5.0 pounds per day was reflected in the total ADM per pound of gain (14.4 pounds compared to 11.7 pounds). Increased consumption of grain was reflected in the final condition grade which was approximately one-third of a grade higher (average good compared to low good) for the heifers consuming 20 pounds of corn and cob meal silage than for the heifers consuming 15 pounds. No significant difference ($P<.05$) in consumption was apparent between the two treatments in 1969 or in 1970. Thus, there was no significant difference ($P<.05$) in consumption or final condition grades in the three-year summary shown in Table VII, page 33. The urea-limestone treatment and the urea, limestone and sulfur treatment had no significant carryover effect ($P<.05$) from the silage phase to the concentrate phase, although there was a significant ($P<.05$) yearly variation.

An economically important fact between the 1968 and 1969 data and the 1970 data was observed. In 125 days of silage feeding in 1970 with an additional 5.0 pounds of ground shelled corn per day, each heifer consumed approximately 625 pounds of grain during the silage phase. In 35 days of full feeding 15 pounds of grain per day they consumed an additional 525 pounds of corn for a total of approximately 1,150 pounds of grain. In 1968 and 1969 the cattle received no corn during the silage phase but required 93 days of full feeding at a rate of 15 pounds of grain per day for a total intake of approximately 1,395 pounds of corn. Thus, the feeding of 5.0 pounds of corn during the silage phase of 1970 shortened the finishing period by approximately 58 days and saved about 245 pounds of corn per heifer.

One-Year Study of Varying Levels of Urea and Sodium Sulfate Added to Limestone Treated Corn Silage

Tables VIII and IX present the results of a one-year comparison (1970) of four different corn silages of corn harvested at the early dough stage of maturity in relation to animal performance and feed consumption. The first treatment contained no additives. The second treatment contained 10 pounds of urea and 10 pounds of limestone per ton of green chop added at ensiling. The third treatment contained 10 pounds of urea, 10 pounds of limestone and 1.5 pounds of sodium sulfate per ton of green chop added at ensiling. The fourth treatment contained 20 pounds of urea, 10 pounds of limestone and 3.0 pounds of sodium sulfate per ton of green chop added at ensiling.

The model found appropriate to describe the expected variation is as follows:

$Y = \mu + T + P + e$

where, Y is the expected or predicted performance,

and $\mu$ is the Mu, the overall mean,

and T is the effect due to treatment,

and P is the effect due to variation between pens within a treatment,

TABLE VIII. 1970 COMPARISON OF NON TREATED SILAGE TO SILAGES TREATED WITH UREA, LIMESTONE OR SULFUR-ON-ANIMAL PERFORMANCE AND FEED CONSUMPTION

| | Silage Phase | | | | Concentrate Phase | | | |
|---|---|---|---|---|---|---|---|---|
| | No Additives | (10+ 10+0) [a] | (10+ 10+1.5) | (20+ 10+3) | No Additives | (10+ 10+0) | (10+ 10+1.5) | (20+ 10+3) |
| No. animals/yr. | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| No. rep./yr. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Avg. wt. gain/head, lbs. | | | | | | | | |
| Initial | 548 | 552 | 556 | 557 | 792 | 770 | 775 | 781 |
| Final | 792 | 770 | 775 | 781 | 846 | 821 | 832 | 830 |
| ADG | 1.96 | 1.75 | 1.75 | 1.79 | 1.52 | 1.45 | 1.62 | 1.40 |
| Total ADG (125 days) | --- | --- | --- | --- | 1.86 | 1.68 | 1.72 | 1.71 |
| Daily feed intake/head, lbs. | | | | | | | | |
| Corn silage (as fed) | 30.6 | 30.1 | 29.2 | 29.4 | 13.0[b] | 13.0[b] | 13.0[b] | 13.0[b] |
| Corn silage (ADM) | 7.8 | 8.2 | 8.0 | 7.7 | --- | --- | --- | --- |
| Hay | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Urea, 42% cottonseed meal | 1.0 | --- | --- | --- | 1.3 | 1.0 | 1.5 | 1.5 |
| Corn cob meal | 5.0 | 5.0 | 5.0 | 5.0 | 13.1 | 13.1 | 14.9 | 13.5 |
| Total ADM | | | | | | | | |
| Lbs/feed/lb. gain | | | | | | | | |
| Corn silage (as fed) | 15.6 | 17.2 | 16.7 | 16.4 | --- | --- | --- | --- |
| Corn silage (ADM) | 4.0 | 4.7 | 4.6 | 4.3 | --- | --- | --- | --- |
| Hay | 1.0 | 1.1 | 1.1 | 1.1 | 1.3 | 1.4 | 1.2 | 1.4 |
| CSM | 0.5 | --- | --- | --- | 0.9 | 0.7 | 0.9 | 1.1 |
| Corn cob meal | 2.6 | 2.6 | 2.6 | 2.8 | 8.6 | 9.0 | 9.2 | 9.6 |
| Total ADM | 8.1 | 8.4 | 8.3 | 8.2 | 10.8 | 11.1 | 11.3 | 12.1 |

TABLE VIII (continued)

| | Silage Phase | | | | Concentrate Phase | | | |
|---|---|---|---|---|---|---|---|---|
| | No Additives | (10+ 10+0) | (10+ 10+1.5) | (20+ 10+3) | No Additives | (10+ 10+0) | (10+ 10+1.5) | (20+ 10+3) |
| Grades | | | | | | | | |
| Initial type | 9.8[c] | 9.9 | 9.9 | 10.2 | --- | --- | --- | --- |
| Initial condition | 8.2 | 8.1 | 8.0 | 8.2 | 9.8 | 9.4 | 9.6 | 9.4 |
| Final condition | 9.8 | 9.4 | 9.6 | 9.4 | 10.5 | 11.1 | 11.0 | 11.0 |

[a]Values for urea, limestone and sodium sulfate respectively per ton of green chop.

[b]Fed for an average of 9 days during transition from silage to concentrate so not figured in dry matter intake for concentrate phase.

[c]8 = High Standard, 9 = Low Good; 10 = Avg. Good, 11 = High Good.

TABLE IX. AVERAGE DAILY GAINS OF HEIFERS BY SELECTED PERIODS FOR 1970

| | No Additives | (10+10+0)[a] | (10+10+0) | (20+10+3) |
|---|---|---|---|---|
| Initial 28 day ADG silage | 1.93 | 1.59 | 1.57 | 1.57 |
| Post 28 ADG silage | 1.97 | 1.79 | 1.80 | 1.82 |
| Total ADG silage | 1.96 | 1.75 | 1.75 | 1.79 |
| Concentrate ADG | 1.52 | 1.45 | 1.62 | 1.40 |
| Total ADG | 1.86 | 1.68 | 1.72 | 1.71 |

[a]Values for urea, limestone and sodium sulfate respectively per ton of green chop.

and e is the normal variation expected between heifers treated alike within a subclass having the same genetic and biological potential.

Silage Phase

Cattle fed the silage without additives received 1.0 pounds of cottonseed meal per head per day containing 42% crude protein to provide the approximate crude protein equivalent supplied by the addition of 10 pounds of urea to the silage. Cattle fed the urea treated silages received no additional protein supplements.

As shown in Table VIII, the three treatments with urea and limestone added, regardless of whether urea was added at 10 to 20 pounds per ton and regardless of the level at which sodium sulfate was added performed similarly (1.75, 1.75 and 1.79 pounds per day). However, they all had significantly ($P<.05$) lower ADG's during the silage phase than did the heifers fed the untreated silage (1.96 pounds per day) which was supplemented with 1.5 pounds cottonseed meal per head per day.

The differences between the silage treatments on an as-fed basis and the difference between the silage treatments on an air dry matter basis was non-significant ($P<.05$). There was no significant difference ($P<.05$) between treatments in total air dry matter per pound of gain as shown in Table VIII.

Concentrate Phase

In the concentrate phase ADG's between treatments were similar indicating no carryover effects of urea, limestone or sodium sulfate from the silage phase. Additionally, there was no significant difference (P<.05) in the final condition as indicated in Table VIII.

As shown in Table IX, page 40, there was no significant difference (P<.05) in the ADG of the heifers fed untreated corn silage supplemented with cottonseed meal in the initial 28 day period (1.93 pounds per day) compared to the post 28 day period (1.97 pounds per day). However, the heifers receiving silage treated with urea and limestone either with or without sulfur had a lower ADG in the initial 28 day period (1.59, 1.57 and 1.57 pounds per day) than in the post 28 day period (1.79, 1.80 and 1.82 pounds per day, respectively). This could be interpreted as a period of adjustment by the rumen microbes to the utilization of urea as a nitrogen source. This idea of an adjustment period by the microbes of the rumen to high urea rations has also been proposed by Karr et al. (1965) in measuring ADG of lambs. In this study there was a 21 day adjustment period for urea compared with soybean meal. This adjustment effect did not carry over into the concentrate phase. There was no significant difference (P<.05) apparent in figuring the total ADG of both the silage and concentrate phases.

As shown in Table IX, 20 pounds of urea, 10 pounds of limestone and 3.0 pounds of sulfate sulfur added to green chop at the time of ensiling to maintain a nitrogen to sulfur ratio of 12:1 did not improve animal performance. This work agrees with the results found by Corrick and Hobbs (1968) who also found no improvement in animal performance due to the addition of 20 pounds of urea per ton of green chop at the time of ensiling.

## Effects on Carcass Characteristics

Average carcass data by treatments presented in Table VIII shows no significant difference ($P<.05$) in the characteristics measured indicating that the treatment of silage with urea, limestone or sodium sulfate does not affect these characteristics or they are eliminated by the concentrate phase. This lack of carcass difference was similar to the results obtained by Vickers (1971) with silages cut at four stages of maturity, but without additions of urea, limestone or sulfur (Table X).

TABLE X. THREE-YEAR SUMMARY OF CARCASS DATA

| | Final Greenville Weight | Drift[a] % | Hot Carcass Weight | Dress[b] % | Ribeye Inches Sq. | B.F. Inches |
|---|---|---|---|---|---|---|
| 1968 | | | | | | |
| Late milk (10+10+0)[c] | 796 | 2.1 | 450 | 56.5 | 9.2 | 0.26 |
| Early dough (10+10+0) | 808 | 2.6 | 477 | 58.1 | 10.1 | 0.32 |
| Late dough (10+10+0) | 786 | 2.2 | 461 | 57.3 | 9.9 | 0.27 |
| Early dough (10+10+1.5) | 821 | 2.9 | 459 | 56.9 | 9.8 | 0.34 |
| 1969 | | | | | | |
| Late milk (10+10+0) | 766 | 1.6 | 442 | 57.8 | 9.9 | 0.31 |
| Early dough (10+10+0) | 762 | 1.5 | 429 | 56.2 | 10.0 | 0.35 |
| Late dough (10+10+0) | 783 | 1.2 | 451 | 57.5 | 10.3 | 0.37 |
| Early dough (10+10+1.5) | 784 | 2.0 | 450 | 57.3 | 9.8 | 0.42 |
| 1970 | | | | | | |
| CSM | 792 | 2.8 | 486 | 57.4 | 10.0 | 0.33 |
| Early dough (10+10+0) | 770 | 2.8 | 472 | 57.4 | 10.7 | 0.34 |
| Early dough (10+10+1.5) | 775 | 2.8 | 473 | 56.8 | 10.9 | 0.33 |
| Early dough (20+10+3) | 781 | 2.5 | 474 | 57.1 | 10.5 | 0.31 |

[a] $\frac{\text{Loss in wt. from Greenville to Knoxville}}{\text{Greenville weight}} \times 100$

[b] $\frac{\text{Hot carcass wt.}}{\text{Greenville wt.}} \times 100$

[c] Values for urea, limestone and sodium sulfate respectively per ton of green chop.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

There were three objectives in this three-year study of the production of market beef heifers in Tennessee. The first objective was to determine the variation of ADG of heifers fed urea-limestone treated corn harvested as silage at three different stages of maturity. The second objective was to determine if the addition of sulfate sulfur to urea-limestone treated corn silage improved the utilization of the non-protein nitrogen supplied by the urea as measured by ADG, feed efficiencies and carcass data. The third objective was to determine if additional sulfur was needed to maintain a nitrogen to sulfur ratio of approximately 12:1 when the amount of urea added to the green chop at ensiling time was increased from 10 pounds to 20 pounds per ton.

Each year 40 heifer calves (450-500 pounds) grading medium or good were purchased at Tennessee feeder calf sales for the study. After an adjustment period of approximately two weeks, the heifers were lotted into eight uniform groups of five each and lots randomly assigned to treatments with two lots per treatment. The feeding period was divided into a silage phase and a concentrate phase. The heifers were weighed every 28 days and graded at the beginning and end of each feeding period. At the completion of the concentrate phase, the heifers were marketed for slaughter and carcass data were obtained.

In 1968 and 1969 there was no significant difference ($P<.05$) in ADG of heifers fed urea-limestone treated corn harvested at three stages of maturity. There was also no significant difference ($P<.05$)

in the concentrate phase in feed consumption, ADM consumption or total ADM per pound of gain due to these previously mentioned treatments. There was no interaction due to the addition of urea and limestone when added to corn harvested at three stages of maturity to produce corn silage. Thus urea and limestone is equally effective when used at all three stages of maturity.

The addition of 1.5 pounds of sodium sulfate to silage treated with 10 pounds of urea and 10 pounds of limestone per ton of green chop at ensiling time resulted in no significant difference ($P<.05$) in either the consumption of silage "as-fed" or consumption of ADM per pound of gain. However, there was a yearly variation between treatments.

During the three-year study there was no significant carryover effect ($P<.05$) from the silage phase to the concentrate phase due to the additions of urea, limestone and sulfur to green chop at ensiling time.

In 1970 one of the four treatments of silage was treated with 20 pounds of urea, 10 pounds of limestone and 3 pounds of sodium sulfate per ton of green chop at ensiling time to determine if additional urea and sulfur would improve animal performance. The additional sulfur was added to maintain a nitrogen to sulfur ratio of 12:1. The results show that the additional urea and sulfur did not improve non-protein nitrogen utilization or ADG. Cattle fed silages treated with urea, limestone and/or sulfur did not achieve ADG's comparable to those obtained with untreated corn silage supplemented with 1.5 pounds of cottonseed meal per day.

Average carcass data by treatments showed no significant difference (P<.05) in the characteristics measured indicating that the treatment of silage with urea, limestone or sodium sulfate does not affect these characteristics or they were obscured by the concentrate feeding phase.

# LITERATURE CITED

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A.O.A.C. 1965. Official Methods of Analysis (10th ed.). Association of Official Agricultural Chemists. Washington, D.C.

Abdo, K. M., K. W. King and R. W. Engel. 1964. Protein quality of rumen microorganisms. J. Anim. Sci. 23:734.

Block, R. J. and J. A. Stekol. 1950. Synthesis of sulfur-containing amino acids from inorganic sulfate by ruminants. Proc. Soc. Exp. Biol. Med. 73:391.

Brown, L. D., R. S. Emery, E. J. Beene and C. A. Lassiter. 1960. Effect of level and source of sulfur on the utilization of urea by dairy heifers. J. Dairy Sci. 43:890.

Corrick, J. W. and C. S. Hobbs. 1968. Performance of feeder heifers fed corn silages treated with 10, 15 and 20 pounds of urea per ton. Tennessee Farm and Home Science Progress Report No. 68, October, November, December:15.

Davis, R. F., C. Williams and J. K. Loosli. 1954. Studies on sulfur to nitrogen ratios in feeds for dairy cows. J. Dairy Sci. 37:813.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Garrigus, U. S., H. H. Mitchell, W. H. Hale and J. S. Albin. 1950. The value of elemental sulfur in a methionine deficient sheep ration. J. Anim. Sci. 9:656.

Hale, W. H. and U. S. Garrigus. 1953. Synthesis of cystine in wool from elemental sulfur and sulfate sulfur. J. Anim. Sci. 12:492.

Hunt, C. H., T. V. Hershberger, J. H. Cline and O. G. Bently. 1954. The effect of carbohydrates and sulfur on B vitamin synthesis, cellulose digestion and urea utilization by rumen microorganisms in vitro. J. Anim. Sci. 13:510.

Jacobson, D. R., J. W. Barnett, S. B. Carr and R. H. Hatton. 1967. Voluntary feed intake, milk production, rumen content, and plasma-free amino acid levels of lactating cows on low sulfur and sulfur-supplemented diets. J. Dairy Sci. 50:1248.

Jones, I. R. and J. R. Haag. 1946. Utilization of non-protein nitrogen by dairy heifers. J. Dairy Sci. 29:535.

Jones, I. R., J. R. Haag and P. H. Weswig. 1952. The relation of sulfur compounds to lactation in ruminants. J. Dairy Sci. 35:503.

Karr, M. R., U. S. Garrigus, E. E. Hatfield and H. W. Norton. 1965. Factors affecting the utilization of nitrogen from different sources by lambs. J. Anim. Sci. 24:459.

Lassiter, C. A., R. M. Grimes, C. W. Duncan and C. F. Huffman. 1958a. High-level urea feeding to dairy cattle. I. Effect of high-level urea feeding on the growth and metabolism of growing dairy heifers without sulfur supplementation. J. Dairy Sci. 41:281.

Lassiter, C. A., C. F. Huffman, R. M. Grimes and C. W. Duncan. 1958b. High-level urea feeding to dairy cattle. II. The effect of sulfur supplementation on the growth of dairy heifers. Michigan State University Quarterly Bul. 40:724.

Loosli, J. K. and L. E. Harris. 1945. Methionine increases the value of urea for lambs. J. Anim. Sci. 4:435.

Loosli, J. K., H. H. Williams, W. E. Thomas, F. H. Ferris and L. A. Maynard. 1949. Synthesis of amino acids in the rumen. Science 110:144.

Martin, J. E., L. R. Arrington, J. E. Moore, C. B. Ammerman, G. K. Davis and R. L. Shirley. 1964. Effect of magnesium and sulfur upon cellulose digestion of purified rations by cattle and sheep. J. Nutr. 83:60.

N.R.C. 1966. Nutrient requirements of dairy cattle. National Research Council, Washington, D.C.

Purser, D. B. and S. M. Buechler. 1966. Amino acid composition of rumen organisms. J. Dairy Sci. 49:81.

Sanahuja, J. C., M. E. Rio and M. N. Lede. 1965. Decrease in appetite and biochemical change in amino acid imbalance in the rat. J. Nutr. 86:424.

Starks, P. B., W. H. Hale, U. S. Garrigus and R. M. Forbes. 1952. The utilization of elemental sulfur and urea nitrogen by growing lambs on a purified ration. J. Anim. Sci. 11:776.

Tennessee Crop Reporting Service. 1970. Bulletin T-7.

Thomas, W. E., J. K. Loosli, H. H. Williams and L. A. Maynard. 1951. The utilization of inorganic sulfates and urea nitrogen by lambs. J. Nutr. 43:515.

Vickers, R. T. 1971. Effects of corn plant maturity at ensiling on the performance of feeder heifers. Thesis, Univ. of Tenn.

Whanger, P. D. 1965. The effect of sulfur depletion on organic acid production and some related effects in the rumen of sheep. Dissertation Abstrs. 26:679.

Wiley, W. H., O. B. Garrison. 1966. Sulfur-essential for protein. S.C. Agr. Exp. Sta. Bul. 55.

Willman, J. P., F. B. Morrison and E. W. Klosterman. 1946. Lamb feeding experiments. Cornell Agr. Exp. Sta. Bul. 834.

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