THE EFFECT OF LEVEL OF SUPPLEMENTAL WINTER FEEDING ON PERFORMANCE OF BEEF COWS GRAZING BERMUDAGRASS PASTURE

By

FRANK EDWIN BATES

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1950

Submitted to the faculty of the Graduate
College of the Oklahoma
State University in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1967

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WINTER FEEDING ON PERFORMANCE OF
BEEF COWS GRAZING
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Thesis Adviser

Dean of the Graduate College

ACKNOWLEDGMENTS

The author expresses his appreciation to Dr. J. E. McCroskey of the Animal Science Department for his guidance during the course of this study and in the preparation of this thesis.

Appreciation is extended to Dr. L. S. Pope, Animal Science Department Head, Dr. W. F. Taggart and Dr. Charles Nichols, Extension Livestock Specialists, for their counsel and guidance in the Masters study.

Sincere appreciation is also extended to Dr. Robert D. Morrison, Mathematics-Statistics Department, for his assistance in the analysis of the data.

The author appreciates the cooperation and assistance of Mr. Dwight Stephens, Darrel McNutt, Raymond Edwards, and others on the staff at Fort Reno Livestock Research Station in caring for the experimental animals and collection of data.

Gratefulness is also extended to my wife, Dorcie, whose patience and encouragement made possible the accomplishment of all course work required for the degree.

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INTRODUCTION

The acreage of bermudagrass pasture has increased in Oklahoma in recent years due to the conversion of much marginal farming land to improved pastures. Bermudagrass has been the predominant improved pasture grass in Oklahoma due to its high yield of forage per acre, its favorable response to added fertilizer, and its persistency after it has been established.

The rate of gain of cattle on bermudagrass (Cynodon dactylon) has been shown to be satisfactory in the spring and early summer but gains are normally very low in July, August, and September in spite of abundant growth and rather high protein content of the grass. Oklahoma research indicates that the increased beef gain per acre on fertilized pastures is due primarily to greater carrying capacity rather than greater gains per animal (Elder and Murphy, 1961).

Bermudagrass is being used more widely as a winter pasture for cattle in Oklahoma because of the increase in acreage of this pasture plant. Since the cow-calf system of beef production is the most predominant system in the sections of Oklahoma best suited to bermudagrass, there is a need for information on the type and amount of supplement needed by beef cows wintered on this type of pasture. Furthermore, considerable data are available on wintering beef cows on native grass pastures, but little information is available on optimum winter feeding on bermudagrass. Therefore, a study was undertaken at the Fort Reno Livestock Experiment Station in the fall of 1965 to determine the effect of level of winter supplementation on performance of beef cows grazing bermudagrass pasture.

REVIEW OF LITERATURE

Supplemental Feeding of Beef Cows and Calves. Numerous studies have been conducted on the influence that winter supplementation has on milk production, cow weight changes, and weight gains of calves from cows grazing native grass pastures. It is necessary to know the relationship between winter feeding levels and cow performance from an economical point of view since the cost of feeding the cow during the winter makes up a large part of the cash production costs.

The effect of milk production of beef cows on growth of calves was studied by Gifford (1949). Records of milk production and growth of calves were obtained on twenty-eight Hereford, seven Angus, five Shorthorn cows and their calves. The cows and calves were kept on pasture nine or ten months. During the remainder of the year, the cows received silage, prairie hay and 1.5 pounds of cottonseed meal pellets daily. Two to four pounds of grain supplement was fed when lactation occured during the winter months. Creep feeding was practiced only during the winter months and the calves were weaned at eight months. The average daily (24 hours) milk production was 8.6, 7.8, 6.0, 6.2, 4.7, 4.7, and 4.2 pounds for the first eight months respectively. The average daily gain of the calves was approximately 1.5 pounds. The correlation between milk production and calf weight was slightly higher in the Shorthorn and Angus cows than was found in the Herefords. Gifford indicated that the importance of high milk production in beef cows could be overestimated, and the maximum milk production normally attained during the first six weeks of lactation is affected by the capacity of the young calves to consume the milk.

Work by Howes et al. (1958) with Brahman and Hereford heifers indicated that protein level of the ration of the dam significantly affected calf growth and milk yield. The two breeds were divided into two treatment groups and fed 100 and 50 percent of the National Research Council requirements for protein, respectively. The daily gains of the calves over the first 112 days for the 100 and 50 percent NRC allowance, respectively, were 1.74 and 1.23 pounds for Brahmans; 1.32 and 0.97 pounds for Herefords. The calculated dry matter and protein supply from the milk became inadequate to maintain growth between the second and third months in all experimental groups, indicating that from the third month, the calves must have received much of their nutrients from grass.

Levels of nutrition for beef cows calving in December were studied by Neville et al. (1960) over a three year period. Cows were on three levels of nutrition from six weeks pre-calving until the calves were four months old, then all cows were fed at the same nutritional level until weaning. The low plane (LP) received grass silage plus one pound of cottonseed meal, the medium plane (MP) received corn silage plus one pound of cottonseed meal, and the high plane (HP) received the MP ration in addition to limited winter pasture. The four month average daily milk production and calf weights (corrected for sire and sex) were LP=8.5, 215 pounds; MP=10.2, 251 pounds; and HP=11.5, 273 pounds. Milk production and calf weights at eight months were LP=8.1, 400 pounds, MP=9.6, 448 pounds; and HP=10.5, 461 pounds.

Neither high level of wintering nor creep feeding was profitable in a study reported by Furr (1959). Sixty-eight Hereford heifers calving for the first time at approximately 30 months of age, grazed native grass pasture year-long. During the winter two groups received 1.5 pounds of pelleted cottonseed meal while two groups received a daily supplement of 2.5 pounds cottonseed meal and three pounds of grain. The calves from one group of cows, within each level of wintering, were creep-fed until mid-April. The four-year average winter weight loss of the high level cows was 36 pounds less than those fed the low level. Cows with creep-fed calves had an average winter weight loss of 30 pounds more than cows with non-creep-fed calves. The high level of winter feeding of the cows increased calf gains 30 pounds over the low level group. During the four trials, a total of 18 cows on the low level failed to calve versus nine for the high level. The average increase in gain due to creep feeding was 87 pounds for calves produced by the low level cows and 52 pounds for the high level. The first calves from dams on both levels had lighter weaning weights than subsequent calves. It was concluded that production of first calf heifers may be impaired when subjected to the same level of wintering as mature cows, because the amount of nutrients consumed by the young cows was not adequate for both cow growth and lactation.

A similar study was reported by Furr (1962) in which milk production estimates, cow weight changes, and calf gains were obtained. High level cows (fed 6.58 pounds of a cottonseed meal and milo mixture daily) lost 27 pounds less during the wintering period than low level cows (fed 2.5 pounds cottonseed meal daily) in Trial I. Average daily (24 hour) milk production was 5.92 and 6.40 pounds for the low and high level groups, respectively. Calves from high level cows in Trial II averaged 16 pounds heavier than calves from the low level cows at weaning.

Pinney (1962) found birth and weaning weights were affected very little by either winter feed level or age at first calving. Low level cows (1.0 pound cottonseed meal pellets) consistently calved later (7 to 12 days) than those on medium (2.5 pounds cottonseed meal pellets) or high levels (2.5 pounds cottonseed meal pellets and 3.0 pounds oats) but had higher conception rates and lost fewer calves from birth to weaning.

Beef cows on restricted winter feed decline materially in milk production during the period of restricted feeding, but will respond to lush grazing by an increase in milk flow. Harris et al. (1962) conducted a study in which one group of 30 Hereford females (optimum group) were full fed good quality grass hay plus two pounds cottonseed meal daily during the winter period and had access to an improved river bottom pasture. The second or restricted-fed group (25 Hereford females) received inferior quality grass ad libitum, but no protein supplement and these animals were confined to a small sod-lot during the winter test (November 1 through March 3). The three year average difference in adjusted calf weaning weight amounted to 43 pounds in favor of the optimum-fed group. Daily milk for the two groups was 9.18 and 6.02 pounds for the optimum and restricted-fed groups, respectively. After 56 days on lush spring forage milk production values were 8.9 and 9.0 for the optimum and restricted groups, respectively. The calves from the restricted cows were lighter at weaning than those from more liberally fed dams.

Performance of cows studied by Velasco (1962) over a three year period indicated that 2.5 pounds of cottonseed meal pellets provide adequate supplemental winter feed on native grass pasture. During the winter period, the cows on low level (range plus no supplement) lost considerably more weight than those on medium (2.6 pounds cottonseed meal) and high levels (6 pounds of a 40 percent cottonseed meal and 60 percent ground milo mixture) of winter supplementation. Difference in average birth weight and average calving date were small for the three levels. Weaning weights of calves from dams on the medium and high levels were nearly equal while calves from low level cows were considerably lighter. The average 24 hour estimates of milk production were 6.25 and 8.12 pounds for the low and high level lots, respectively, for the complete lactation period. There was a difference of 56 pounds in weaning weight of calves in favor of the high level of winter supplementation over the low levels.

Pinney (1963) found milk production was directly related to the amount of winter supplement received by cows with the exception that the very high supplementation drastically reduced milk flow compared to a high level. The gains of the calves were correlated with the quantity of milk produced by their dams to a greater extent during the early part of the lactation period.

Most winter supplementation work has been concerned with predetermined levels of feed and comparisons between kinds of supplements. However, Smithson et al. (1966) conducted a study with 120 heifer calves in which supplemental feed allowances were changed when necessary to effect desired weight changes during the winter. The experimental treatments were designed to bring about four winter weight change patterns. The heifers were allotted into four treatment groups and started on test at an average age of eight months. The low level supplementation was designed for the heifer calves to make no gain the first winter and lose 20 percent of their fall weight during subsequent winters including calving weight loss. The moderate level was designed for heifer calves to gain 0.5 pound daily the first winter and lose 10 percent of their fall weight during subsequent winters including calving weight loss. High level supplementation provided for 1.0 pound of gain daily the first winter as calves, and lose less than 10 percent during the subsequent winters also including calving weight loss. The fourth group of heifers were self-fed the first winter as calves and subsequent winters. The winter supplemental feed consisting of cottonseed cake or cottonseed cake and ground milo was adjusted periodically to produce the weight change patterns. The low level females were confined to dry lot during the early part of each winter and fed wheat straw to initiate the desired weight loss. They were then maintained on native grass pasture during the remainder of the winter with supplemental feeds as necessary to produce the desired weight change. The females in all other treatments were maintained on native grass pastures during the entire winter and fed the appropriate levels of supplemental feeds. All groups grazed native grass pasture during the summer months. These workers reported that the major influence of winter protein supplement levels on cow productivity occurs during the first three calf crops. Low level cows calved later and weaned lighter calves than moderate or high level cows the first three calf crops. The weight change pattern of moderate level cows appeared to be consistent with both productivity and economy of wintering. Increased supplement cost for the high level cows was not offset by increased productivity. Development and maintenance of beef females at the very high level reduced productivity below that observed for the moderate levels. Level of winter feed had little effect on calving date after the fourth calf crop. The performance of low level cows after the fourth calf crop was comparable to moderate and high levels. It appears from these data that beef females should gain 0.5 pound daily the first winter as calves and lose 10 percent of their fall weight during subsequent winters including calving weight loss.

Most milk production, calf gains, cow weight changes, and supplementation investigations have considered native grass, temporary winter pastures, cool season grasses and clovers as the primary roughage. Lynd et al. (1955) measured the productivity of beef cows on common bermudagrass plus legumes and on overgrazed native grassland. A stocking rate of one cow and calf to 10 acres of unimproved pasture, and one cow and calf for each six acres of improved pasture was used in this study. The larger number of calves produced on the improved pasture had higher weaning weights during the first three years of the study. There was less difference between the weaning weights of calves in both pastures as the experiment continued. The four-year average on the unimproved native pasture was 14 calves from 16 cows with an average weaning weight of 391 pounds, while the improved pasture produced an average of 21.8 calves from 26 cows with a weaning weight of 421.5 pounds during the same period.

The weight changes of high grade Hereford cows nursing calves were closely correlated with steer weight changes on bermudagrass during the summer months in work by Elder and Murphy (1961). Loss of cow weight during the summer months did not affect the calf weights unless cow weight losses extended over a period of 60 days or more. Calves from the Hereford cows gained 1.5 pounds daily on bermudagrass pasture. Calf gains were more uniform during the season than gains of steers.

Work with steers on Coastal bermudagrass has revealed that animal gain per acre has been generally high, but the daily gain per animal has been low. This raises a question as to the adequacy of Coastal bermudagrass pastures as the sole feed for a beef cow nursing a calf. Anthony et al. (1962) studied the effect of supplemental feeding of beef cows and calves versus non-supplemental feeding on Coastal Bermudagrass. Sixteen Hereford cows and their calves were divided into four groups and supplemented as follows: (1) grazing only; (2) supplemental feed to cows only; (3) supplemental feed to calves only; and (4) supplemental feed to both cows and calves. Supplemental feed to each cow group consisted of four pounds of a high grain mixture daily. The calves receiving supplement were full fed the same mixture in a creep. Two year average daily gain data for the calves were 1.71, 1.84, 1.89, and 2.11 for groups one through four, respectively. Further results of this study showed cow gains to be 88, 163, 191, and 193 pounds for the entire summer for lots 1, 2, 3, and 4, respectively. These workers stated that under most conditions a gain of 88 pounds for a cow nursing a calf would be adequate, therefore Coastal Bermudagrass alone furnished adequate feed for a cow nursing a calf.

Coastal Bermudagrass hay was equally as effective as alfalfa hay for wintering mature pregnant beef cows when the two hays were fed at the same level in a report by E. K. Crouch and J. K. Riggs (1966). No supplement was added except bonemeal and salt. The winter hay cost was $5.23 less per cow for those fed Coastal Bermudagrass than for those fed alfalfa. Sixty-eight beef cows, mostly Brahman-Hereford crosses were divided into two treatments and fed 109 days with an average daily intake of 14.7 and 14.2 pounds of bermudagrass and alfalfa hay, respectively. The average weight loss for the cows fed bermuda hay during the winter period was 81 pounds while the cows fed alfalfa averaged 92 pounds loss. The average weaning weight of the calves from cows fed alfalfa was 523 pounds at 226 days of age while the calves from cows fed bermudagrass hay was 528 pounds at 214 days of age.

Phosphorous Supplementation. The effects of phosphorous utilization as evidenced by growth, reproduction, and milk production of beef animals has been reported by Forbes *et al*. (1935). Studies by these workers revealed that neither diet nor blood changes had any influence on phosphorous content in the milk. Palmer and Eckles (1927), Green and DuToit (1927), reported that blood of cattle suffering from phosphorous deficiency is very low in inorganic phosphorous. Henderson and Weakley (1930) and Huffman *et al*. (1932) reported that a low concentration of inorganic phosphorous in the blood is an indication of a ration inadequate in this element. Stanley (1938) stated that blood phosphorous levels consistently below five mg. per 100 ml. of blood serum are usually a definite indication of lack of available phosphorous in the feed. According to Maynard and Loosli (1956), the phosphorous level usually lies between four and nine mg. per 100 ml. of blood depending upon the age and species.

Watkins and Knox (1948) expressed doubt that four mg. of inorganic phosphorous per 100 ml. blood plasma represents the minimum level consistent with good health and production in mature range cows. These workers conducted a study with 10 five-year-old Hereford cows and calves, 2 dry cows, and 2 yearling steers over a period of three years. One group known as the "mineral lot" had access to a mixture of 40 percent di-calcium phosphate and 60 percent salt, and the "non-mineral lot" had only salt. The feeding of di-calcium phosphate provided an average of 2.5 grams of phosphorous per day for each cow in the mineral-fed lot.

Principal grasses grazed by both lots were Black Grama and Sand Dropseed. The forage phosphorous was found to be fairly close in agreement with the inorganic blood plasma phosphorous taken on the same date from the non-mineral-fed group. These workers observed that levels below four mg. per 100 ml. were found much of the time in the mineral-fed lot and on occasions the low level of two mg. was reached. The calculated phosphorous intake varied from about 7 to 16 grams a day, with an average daily intake of less than 12 grams for the mineral-fed lot. These workers reported an excellent appearance of the mineral-fed cows and having a high level of production. The average weight of calves weaned at seven months of age from the mineral-fed cows for the three years was 470 pounds, while the non-mineral-fed cows weaned calves that averaged 434 pounds.

It has been accepted that vitamin A is essential to the very young calf since his body reserves for this vitamin are very low at birth. The cow on her natural ration receives vitamin A only in the form of carotene. A portion of the carotene is secreted in milk as such and a portion is transformed into vitamin A and so secreted (Maynard and Loosli, 1956). Thomas et al. (1953) reported that milk from phosphorous deficient cows contained more carotene but less vitamin A than milk from cows fed an adequate phosphorous ration. Nine bred Hereford cows, after a preliminary period of low phosphorous intake, were used in the study. Four cows were subjected to low phosphorous intake eight weeks before and eight weeks after calving; the other five were given a phosphorous suplement during this period. All cows received equal but limited amounts of carotene supplied by prairie hay. Determinations were made of the phosphorous content of the blood plasma. The carotene and vitamin A content were obtained from plasma, liver, and milk. Average plasma-carotene levels were generally higher in phosphorous deficient cows than in those fed adequate phosphorous. Plasma-vitamin A levels appeared to be unaffected by phosphorous deficiency. At eight weeks after calving, both groups of cows had lost similar amounts of carotene and vitamin A from the liver.

Using 10 grams of phosphorous as the maintenance requirement for a 1000 pound dairy cow, Huffman et al. (1933) concluded that there should be an additional allowance of 0.75 grams per pound of milk.

The annual milk production of dairy cows fed adequate amounts of phosphorous prior to and during lactation was shown to be much greater than when the same animals go through a lactation period with low phosphorous reserves and inadequate phosphorous supply. Eckles et al. (1932) found that dairy cows fed ample amounts of nutrients, except phosphorous, have a relatively short lactation period and consequently a low total production. The same cows fed sufficient phosphorous produce much more milk in a more extended lactation period with a greatly reduced cost per unit of milk. The increases in milk production with adequate phosphorous supplementation in the report ranged from 50 to 146 percent. The differences in milk production were due solely to the amount of phosphorous ingested.

Relationship Between Calf Gains and Milk Production. Beef cattle producers in recent years are recognizing the importance of milk production in both purebred and commercial herds. The few reports on milk production of beef cows indicate that a majority of the English breeds are rather poor milk producers. It is necessary since milk supplies most of the nutrients in the early life of the calf, that an adequate amount of milk be produced. Therefore, the adequacy of a milk supply can be expected to have a marked effect on the growth and economy of gain in the calf. Beef cows are not often checked for milk production due to the difficulty of obtaining records because of the type of management and facilities available.

A partial correlation study conducted by Knapp et al. (1941) indicated that milk consumption had the greatest influence on rate of gain in calves. The average daily gain before weaning and estimate of daily milk production of dams were significantly correlated (r=0.517). These workers observed that when selection of replacement breeding animals was made during the suckling period, the calves selected were those that made the greatest gain. These calves were from cows that gave the most milk, but scored the poorest on beef characteristics.

Gifford (1949) reported correlations of 0.60, 0.71, 0.52, and 0.35 between the quantity of milk produced daily by the dams and the daily gains in weight of their calves during the first through the fourth months. Data obtained on twenty-eight Hereford, seven Aberdeen Angus, and five Shorthorn cows revealed that the quantity of milk produced, increased up to six years of age. Cows between two and three years of age produced less milk than cows of any other age studied. Gifford (1953) concluded that factors other than the daily amount of milk produced by the cows influenced growth in calves between the ages of three months and weaning time. The calves from lower producing dams were able to secure sufficient food nutrients from pasture to make gains similar to those calves that had a better milk supply. Gifford stated that there was evidence that calves from low producing dams did not receive ample milk which resulted in lower weaning weights than those that had a larger milk supply during the first three or four months.

Milk Production Sampling Methods. Most milk production studies in beef cows have been based on periodic samplings rather than total production. A number of sampling procedures have been used. These include total production, periodic milking by hand or machine, and calf weight differences.

Lifetime milk production records were reported on seven Angus cows by Cole and Johansson (1933). The cows were stall fed and milked twice daily. The average milk production was 3,000 pounds per lactation with a range of

1,027 to 6,746 pounds in the first lactation.

Some workers (Dawson et al., 1960) believe that the nursing method has an advantage over milking by hand or machine in that it takes advantage of any ability of the calf to encourage the cow to give more milk. These workers indicate that letting the calves nurse three times a day might get more milk from relatively low producing cows than one would get from hand milking twice a day. Milk production was estimated by weighing the calves weekly before and after nursing. The calves were separated from their dams the evening before the test, then allowed to nurse at 4:00 a.m. and 8:00 p.m. on weigh day.

A procedure of milk production estimation was proposed by Anthony et al. (1959) in which the cow was separated from her calf and injected with two c.c. of oxytocin (40 U.S.P. units). The udder was washed with warm water and teat cups of a portable milking machine attached. The first milking was a pre-test milk-out with no weighing or sampling. The cow remained separated from her calf overnight, but was supplied with feed and water. Twelve hours later on test day, the milk-out procedure was the same as the pre-test, but the total production was weighed and sampled for butter fat. Production was reported on a 12 hour "fat corrected milk" basis.

The most universally used method of estimating milk production in beef cows has been by weight differences of the calves before and after nursing (Velasco, 1962). The general procedure has been to lot the calves separately from their dams the day before test day, allow them to nurse in the evening, and remain separated overnight. Neville et al. (1960) using this method with 135 Hereford cows, obtained milk weight twice each day, four times during lactation (about every two months) between birth and weaning at eight months. Calf weight difference was also used by Pinney (1963) to estimate milk production; however, when the calves were under one month of age, three eight-hour periods were used since the calves had difficulty in nursing the dam completely dry. The succeeding milking periods were 12 hour intervals throughout the lactation period.

Samples of milk production were obtained by Gifford (1953) during a two day period each month by hand milking one side of the udder one day and the other half the following day. The total collected by hand milking was estimated milk yield for a 24 hour period.

Summary. The amount of winter protein supplementation to beef cows nursing calves has an effect on calf gains. Experiments with cows fed very low or excessive amounts of winter supplement have resulted in lower milk production and calf gains. Since the amount of winter protein supplementation has more influence during growth and development, consideration should be given to feeding a higher level of winter supplement to beef females through their first three calf crops with lower levels fed thereafter.

Phosphorous is essential for growth, reproduction, and milk production. Phosphorous blood levels consistently below five mg. per 100 ml. blood plasma indicate a phosphorous deficient ration. Approximately 10 to 12 grams of phosphorous are required for maintenance of a 1000 pound cow and 0.75 grams should be added for each pound of milk produced.

Bermudagrass has been shown to be comparable to other warm season species if it is managed properly. Cows grazing bermudagrass usually make adequate weight gains over the entire season. Calf gains are not greatly affected during this period. Bermudagrass, under most conditions, will furnish adequate feed for a cow nursing a calf during the growing season.

The rate and efficiency of gain of calves during the suckling period depends to a large extent on the performance of the dam in milk production. Calves from higher producing dams tend to gain faster than calves from low producing dams, especially during the first three or four months of lactation. Calves from higher producing dams also tend to be considerably heavier at weaning due to the influence that an adequate milk supply has during the early life of the calf. Correlations between milk production and average daily gain of calves are significant up to the third or fourth month of age.

The method of estimating daily milk production used most frequently in beef cattle has been calf weight difference before and after nursing. This method seems to provide the most natural environment for estimating milk yield. Several variations of this method have been used by various workers.

MATERIALS AND METHODS

Forty-eight grade Hereford cows were used in a study to determine the effect of level of protein supplement and supplemental phosphorous during the winter on cow and calf performance on Midland Bermudagrass pasture. The cows were bred to calve in February, March, and April and were allotted into six equal groups on the basis of age, weight, and condition. Ages ranged from four to six years with average weight of all cows being approximately 1000 pounds.

All cows grazed together in a 140 acre pasture of Midland Bermudagrass and were fed their supplement once daily in individual stalls. The winter feeding period was from December 3, 1965, to April 15, 1966 (136 days). Treatments consisted of three levels of protein supplement and two levels of phosphorous supplement. The protein supplement was cottonseed meal (41% crude protein). Phosphorous was supplemented in the form of monosodium phosphate (20.6% available phosphorous). Lots 1, 3, and 5 received one, two and three pounds of cottonseed meal per head daily, respectively, with no additional supplemental phosphorous. Lots 2, 4, and 6, respectively, received one, two, and three pounds of cottonseed meal per head daily, plus 36.0 grams of monosodium phosphate. Salt was provided free choice to all groups. Each cow was injected with one million I. U. of Vitamin A in January, 1966.

The pasture was cross-fenced into four pastures to allow rotational grazing during the growing season. Six-hundred pounds of ammonium nitrate was applied per acre in three equal applications on May 1, June 30, and August 1, 1966. Bermudagrass hay, cut from the same field, was fed during periods when ice and snow covered the pasture.

Cows were weighed every two weeks beginning December 3, 1965 (initial weight) with the final weight taken November 29, 1966. Pre-calving and post-calving weights were determined within the two week period prior to and following calving. Calves were weighed on the date of birth and weighed every two weeks beginning May 23, 1966, until weaning October 5, 1966.

Twenty-four-hour milk production data were obtained six times during the summer beginning June 1, and ending September 27, 1966. The technique used for estimating milk production was weight difference of calves before and after nursing. Calves were separated from their dams the afternoon prior to test day, allowed to nurse in the late evening and separated again from their dams during the night. On test day, the calves were weighed at 6:00 a.m. (empty weight), allowed to nurse their dams, then reweighed. The difference between the two weights was used to estimate the previous twelve-hour milk production. The same procedure was followed at 6:00 p.m. of the same day. The two twelve-hour milk weights were totaled to estimate twenty-four-hour milk production.

Blood samples were taken from one-half of the cows in each treatment at the beginning and end of the wintering period and analyzed for blood serum phosphorous.

A chemical analysis of the grass in January, 1966, showed the grass to contain 5.03 percent crude protein and 0.066 percent phosphorous.

A statistical analysis of covariance was used to determine the effects of cottonseed meal and phosphorous supplementation on cow weight changes. Due to unequal numbers of cows in each treatment, means for treatments were used to obtain the sum of squares for each independent and dependent variable. The independent variables were initial weight, cottonseed meal linear x phosphorous, and cottonseed meal quadratic x phosphorous. The dependent variables in this analysis were weights taken at pre-calving, post-calving, July 6, October 5, and November 29. It was necessary to adjust to treatment means for variation in initial weight in the covariance analysis. A preliminary examination of the data indicated a linear relationship of initial weight and response, therefore, covariance was considered to be valid. Periods of study used in determining the effect of winter supplementation on cow weight were (1) initial to pre-calving, (2) initial to post-calving, (3) initial to July 6, (4) initial to October 5, and (5) initial to November 29. The July 6, date was chosen to conclude one period because the quality of bermudagrass usually begins to decline around July 1; therefore, a decline in cow performance might be expected. October 5 was chosen to conclude another period since the calves were weaned on this date.

A statistical analysis of variance was made on blood serum phosphorous to determine the influence of level of protein supplement and phosphorous on blood serum phosphorous level. Blood samples were obtained on December 15 and April 15 from cows randomly selected in each treatment.

An analysis of variance was also used to statistically test the effect of level of winter supplement of dams on the following calf performance characteristics: (1) 205 day adjusted weight, (2) average daily gain to weaning, (3) average daily gain to July 6, and (4) average daily gain from July 6 to weaning. This method of statistical analysis was used because of the small difference in the average calving dates and birth weights. All calves were weaned on October 5, 1966 and their weaning weights were adjusted for age and corrected for sex. The adjustment to a standard 205 day weight was made as follows:

$$\frac{\text{Final weight} - \text{Birth weight}}{\text{Age in Days}} \times 205 + \text{Birth weight} = \text{Adjusted 205 Day weight}$$

Correction to a steer equivalent was made by addition of 5 percent of the adjusted 205 day weight to heifer weaning weights.

An analysis of variance was used to test the effect of the six protein and phosphorous supplementation treatments on milk production at six different dates. Dates of milk production estimates were June 1, June 15, July 1, August 2, August 30, and September 27.

RESULTS AND DISCUSSION

Cow Weight Changes. Cottonseed meal (CSM) levels had a significant effect (P<.05) on pre-calving and post-calving weight of cows, but did not have any significant effect on cow weight changes at any subsequent period (Tables III through VII). As the level of cottonseed meal increased, the average cow weights increased to pre-calving (Table I). Lots 1 and 2 (fed one pound CSM) lost an average of 6 pounds of weight from initial to pre-calving (Table II). Lots 3 and 4 (fed two pounds of CSM) gained an average of 7 pounds while the most gain was observed in lots 5 and 6 (fed three pounds CMS) with an average of 22 pounds gain from initial to pre-calving. A significant difference (P<.05) in cow weight changes to pre-calving was observed in favor of lots fed three pounds of cottonseed meal over lots fed one pound. No significant difference in cow weight changes to pre-calving was observed between lots fed one and two pounds of cottonseed meal. Lots 1 and 2 obtained 0.33 pound of digestible protein from cottonseed meal which was considerably lower than the recommendations of the National Research Council (.8 pound digestible protein) for wintering mature beef females. The failure of the cows to gain on the one pound level may have been due to insufficient protein consumption. Lots fed two and three pounds of cottonseed meal had more satisfactory weight changes during the wintering period to pre-calving.

The effect of levels of protein supplementation on cow weight changes were also significant ($P<.05$) at post-calving. Cows fed one pound of cottonseed meal (lots 1 and 2) lost an average of 130 pounds during the winter including calving loss. Those fed two pounds (lots 3 and 4) lost an average of 118 pounds, while those fed three pounds (lots 5 and 6) lost an average of 100 pounds including calving weight loss. The significant difference ($P<.05$) in cow weight changes to post-calving again favored the cows fed three pounds of cottonseed meal over lots fed one pound. No significant difference in cow weight changes to post-calving was observed between lots fed one and two pounds of cottonseed meal or lots fed two and three pounds of cottonseed meal. The average weight losses of cows during the winter, including calving weight loss, were 11.9, 10.9, and 9.1 percent of their initial fall weight, respectively, for the one, two, and three pound levels. The percent of winter weight loss of all lots was similar to weight losses of mature spring-calving cows in a study by Smithson et al. (1966). Cows fed one pound of cottonseed meal made less gain during the winter to pre-calving and lost more weight at calving, thereby resulting in a larger percent post-calving weight loss (Table II). Cows fed two pounds of cottonseed meal made satisfactory gains during the winter to pre-calving and lost an average of 12 pounds less at calving than those fed one pound of cottonseed meal. Cows fed the three pound level had the smallest calving loss of all groups.

Periods in this study from initial to July 6, and subsequent periods showed no significant difference in cow weight changes due to winter levels of supplemental feeding (Tables V, VI, and VII). Gains made after calving were apparently due primarily to effects of the bermudagrass pasture. Cows in each lot were considerably heavier at the end of the year than they were at the beginning of the trial. The yearly gains in weight from December 1965 to November 1966 were 68, 108, 81, 89, 110, and 93 pounds, respectively, for lots 1, 2, 3, 4, 5, and 6 (Tables I and II). A total of 136, 272, and 408 pounds of cottonseed meal was fed to each cow, respectively, for the one, two, and three pound levels.

The addition of 36.0 grams of monosodium phosphate did not have a significant effect on cow weight changes during any period (Tables III through VII). One pounds of cottonseed meal provided 3.6 grams of phosphorous and 36.0 grams of monosodium phosphate provided 7 grams of phosphorous. The total daily phosphorour consumed in the supplemental feed was 3.6, 10.6, 7.2, 14.2,10.8, and 17.8 grams, respectively, for lots 1, 2, 3, 4, 5, and 6. Lot 6 exceeded NRC recommendations for phosphorous supplementation (15 grams) during the gestation period; however, it is likely that lots 2, 4, and 5 also received the recommended amount of phosphorous assuming the cows ate 18 pounds of grass. Cow weight changes (Table I) were not significantly influenced by the amount of phosphorous received.

Milk Production. Level of winter supplementation had a significant effect ($P<.005$) on milk production (Table XI). The average twenty-four-hour milk production estimates for treatments were 12.0 12.97, 12.27, 13.76, 15.09, and 13.44 pounds for lots 1, 2, 3, 4, 5, and 6, respectively, (Table X) during the entire summer. As the level of cottonseed meal (CSM_L) was increased there was a significant ($P<.005$) increase in milk production. The average twenty-four-hour milk production estimates for the one, two, and three pound levels were 12.5, 13.0, and 14.3, respectively. It was found that CSM_L X P, and CSM_Q X P were significant ($P<.005$). The interaction of cottonseed meal linear and phosphorous (CSM_L X P) may be explained by the increase in milk production of the cows in lots 2 and 4 over the cows in lots 1 and 3. The addition of phosphorous appeared to improve milk production of cows fed one and two pounds of cottonseed meal. When the level of three pounds of cottonseed meal was fed, the addition of phosphorous did not cause an increase in milk production which would explain the quadratic effect of cottonseed meal and phosphorous (CSM_Q X P). Using Duncan's multiple range test on means, it was found that cows fed three pounds of cottonseed meal with no additional phosphorous were significantly higher ($P<.01$) in average twenty-four-hour milk production than treatments 1 and 3. Some of this difference may be due to chance because of the limited number in each lot.

A significant difference ($P<.005$) in milk production was observed by dates. This was expected since a cow normally declines in milk production after having reached her peak. A peak in milk production was not established in this trial as the first estimation was taken when the calves averaged approximately 10 weeks in age. However, a measure of the performance of each lot is plotted in Figures 1 and 2 with milk production means for dates in Table XII. A decline in milk production was observed for all lots to August 2, then an increase was observed before another decline. The increase in milk production in late summer was due to lush growth of bermudagrass after late summer rains.

Calf Weights. Levels of winter supplementation did not significantly affect the 205-day adjusted calf weaning weights (Table XIII), average daily gains from birth to weaning (Table XIV), or average daily calf gains from July 6 to weaning. However, calves from cows fed one pound of cottonseed meal during the winter gained significantly slower ($P<.10$) from birth to July 6 than calves from cows fed the two and three pound levels of cottonseed meal (Table XV). There was no significant difference between the gain of calves from cows fed the two and three pound levels of cottonseed meal. Average weights of calves on July 6 from cows fed one, two, and three pounds of cottonseed meal were 276.9, 295.7, and 294.8 pounds, respectively, (Table I).

The average daily gains of calves between treatment groups were not significantly different from the fourth month to weaning. The calves were apparently obtaining sufficient nutrients from milk and bermudagrass to make satisfactory gains during this period.

Blood Phosphorous. Phosphorous supplementation of cows during the winter had no statistically significant effect on blood serum phosphorous levels (Table VIII). The average changes from initial (12-15-65) to final (4-15-66) sampling were -1.82, 1.05, 0.75, 0.32, -1.27, and -1.51 milligrams of phosphorous per 100 milliliters of blood for lots 1, 2, 3, 4, 5, and 6, respectively, (Table IX). Lots 3 and 6 had the lowest and highest average blood serum phosphorous at the beginning of the trial with 4.66 and 6.01 milligrams per 100 milliliters of blood, respectively. The highest and lowest average blood serum phosphorous levels on final sampling date were observed in lots 2 and 5, respectively, with 6.5 and 4.0 milligrams per 100 milliliters of blood. Only seven cows in the study were below the plasma phosphorous level recommended by Maynard and Loosli (1956). Apparently there were no effects of low blood phosphorous level on cow weight, calf weights, or milk production.

SUMMARY

A study was conducted to determine the effect of level of supplemental winter feeding on the performance of 48 grade Hereford cows grazing bermudagrass pasture. All cows were grazed together in a Midland Bermudagrass pasture year long and were supplemented in individual stalls during the winter period. The cows were allotted into six equal groups and two groups were fed each of three levels of protein supplement (1.0, 2.0, and 3.0 pounds of 41% cottonseed meal). Three of the six groups received a phosphorous supplement (36 grams monosodium phosphate) in addition to the protein supplement. Response criteria studied were cow weight changes, calf weights, milk production, and blood serum phosphorous of cows.

Cottonseed meal levels had a significant effect ($P<.05$) on pre-calving and post-calving weight of cows, but did not have any significant effect on cow weights at any subsequent period. Cows fed 3.0 pounds of protein supplement were significantly heavier ($P<.05$) at pre-calving and post-calving than cows fed 1.0 or 2.0 pounds of protein supplement; however, all lots made acceptable gains during these two periods. The addition of a phosphorous supplement did not have any significant effect on cow weight changes.

The level of winter supplemental feed did, however, have

a highly significant ($P<.005$) effect on milk production. An increase in milk production was observed as the level of cottonseed meal was increased. The average twenty-four-hour milk production estimates were 12.49, 13.02, and 14.27 for lots 1, 2, and 3, respectively. The addition of phosphorous appeared to increase milk production for cows fed 1.0 and 2.0 pounds of cottonseed meal, but did not cause an increase in milk production for cows fed 3.0 pounds of cottonseed meal.

A significant effect ($P<.1$) of level of winter protein supplement to cows was observed in calf gains from birth to July 6. Calves from cows fed 2.0 and 3.0 pounds of cottonseed meal were significantly heavier ($P<.1$) on July 6, than calves from cows fed 1.0 pound of cottonseed meal. No significant difference was observed in calf gains from birth to July 6 in calves from cows fed 2.0 and 3.0 pounds cottonseed meal. Level of winter supplementation did not significantly affect 205-day adjusted calf weaning weight, average daily calf gain from birth to weaning or calf gain from July 6 to weaning. No significant effect on blood serum phosphorous due to level of winter supplementation of phosphorous was found.

Results of this one year study indicate that one pound of 41% cottonseed meal is adequate protein supplement from the standpoint of performance and economy of cows grazing good Midland Bermudagrass pasture. This grass was handled under optimum conditions while under normal conditions the quality and quantity might be less than optimum. Therefore, more protein supplement might be needed to get desired results. The addition of a phosphorous supplement may improve milk production of beef cows fed two pounds or less of cottonseed meal.

TABLE I

EFFECT OF LEVEL OF WINTER SUPPLEMENT ON COW AND CALF PERFORMANCE

Lot Number	1	2	3	4	5	6
Level of cottonseed meal (lb.)	1.0	1.0	2.0	2.0	3.0	3.0
Level of monosodium phosphate (gm.)	0.0	36.0	0.0	36.0	0.0	36.0
Number of cows raising calves[1]	7	6	7	8	8	8
Average cow weight (lb.)[2]						
Initial (12-3-65)	1102	1073	1084	1096	1093	1117
Pre-calving	1084	1079	1092	1102	1130	1124
Post-calving	965	950	955	989	994	1016
July 6	1014	1041	1015	1042	1093	1063
October 5 (weaning)	1096	1116	1119	1123	1137	1203
Final (11-29-66)	1166	1181	1165	1185	1203	1210
Yearly gain	64	108	81	89	110	93
Average calf weight (lb.)						
Birth	75.6	73.0	80.1	89.1	83.1	75.4
July 6	281.2	272.5	292.4	299.0	287.1	302.5
Weaning (10-5-66)[3]	471.3	481.1	483.0	489.7	500.0	477.8
Average birth date of calves	Mar 5	Mar 7	Mar 7	Mar 12	Mar 14	Mar 10

[1] There were eight cows in each lot at beginning of test.
[2] The average weight of only cows raising calves.
[3] Adjusted for age and corrected for sex.

TABLE II

AVERAGE WEIGHT CHANGE OF COWS

Lot number	1	2	3	4	5	6
Level of cottonseed meal (lb.)	1.0	1.0	2.0	2.0	3.0	3.0
Level of monosodium phosphate (gm.)	0.0	36.0	0.0	36.0	0.0	36.0
Initial to pre-calving (lb.)	- 18	6	8	6	37	7
Initial to post-calving (lb.)	-137	-123	-129	-107	-99	-101
Initial to post-calving (%)[1]	- 12.4	- 11.5	- 11.9	- 9.8	- 9.1	- 9.0
Initial to July 6 (lb.)	- 88	- 31	- 69	- 54	0	- 44
Initial to October 5 (lb.)	- 6	43	35	25	89	86
Initial to November 29 (lb.)	64	108	73	89	110	93

[1] Expressed as a percent of the initial weight.

TABLE III

ANALYSIS OF COVARIANCE FOR COW WEIGHT FROM INITIAL TO PRE-CALVING

Sources of variation	df	MS	F
Total	44		
Mean	1	53526384.00	
Initial weight[1]	1	273734.59	94.845[a]
CSM_L[2]	1	16343.951	5.6629[b]
CSM_Q[3]	1	.0067586108	.000002
Phos.	1	367.09406	.127
CSM_L X P[4]	1	4807.2321	1.666
CSM_Q X P[5]	1	377.8458	.131
Error	37	2886.1216	

a (P<.005)
b (P<.05)

1 Initial weight as a covariable.

2 CSM_L: Linear effect of cottonseed meal levels.

3 CSM_Q: Quadratic effect of cottonseed meal levels.

4 CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

5 CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE IV

ANALYSIS OF COVARIANCE FOR COW WEIGHT FROM INITIAL TO POST-CALVING

Sources of variation	df	MS	F
Total	44		
Mean	1	41483610.00	
Initial weight[1]	1	177077.56	50.47[a]
CSM_L[2]	1	19893.944	5.67[b]
CSM_Q[3]	1	176.59473	.05
P	1	1122.3483	.3199
CSM_L X P[4]	1	2360.6471	.673
CSM_Q X P[5]	1	1189.1368	.3389
Error	37	3508.2361	

[a] ($P<.005$)
[b] ($P<.05$)

[1] Initial weight as a covariable.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE V

ANALYSIS OF COVARIANCE FOR COW WEIGHT FROM INITIAL TO JULY 6

Sources of variation	df	MS	F
Total	44		
Mean	1	47580001.00	
Initial weight[1]	1	203414.32	77.52[a]
CSM_L[2]	1	3731.8374	1.42
CSM_Q[3]	1	913.31119	.348
Phos.	1	2426.5428	.925
CSM_L X P[4]	1	7102.0194	2.7066
CSM_Q X P[5]	1	4.1341364	.00157
Error	37	2623.8784	

[a] (P<.005)

[1] Initial weight as a covariable.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE VI

ANALYSIS OF COVARIANCE FOR COW WEIGHT FROM INITIAL TO OCTOBER 5 (WEANING DATE)

Sources of variation	df	MS	F
Total	44		
Mean	1	55631264.00	
Initial weight[1]	1	254849.64	98.901[a]
CSM_L[2]	1	6791.6057	2.356
CSM_Q[3]	1	240.65494	.093
Phos.	1	2177.1213	.845
CSM_L X P[4]	1	3073.7675	1.193
CSM_Q X P[5]	1	857.17887	.333
Error	37	2576.8108	

[a] ($P<.005$)

[1] Initial weight as a covariable.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE VII

ANALYSIS OF COVARIANCE FOR COW WEIGHT FROM INITIAL TO FINAL WEIGHT (11-29-66)

Sources of variation	df	MS	F
Total	44		
Mean	1	59321600.00	
Initial weight[1]	1	176822.28	69.516[a]
CSM_L[2]	1	5364.8116	2.109
CSM_Q[3]	1	2739.8953	1.077
Phos.	1	1551.1084	.6098
CSM_L X P[4]	1	2206.6203	.868
CSM_Q X P[5]	1	364.97844	.143
Error	37	2543.6143	

[a] (P<.005)

[1] Initial weight as a covariable.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_L X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE VIII

ANALYSIS OF COVARIANCE FOR BLOOD SERUM PHOSPHOROUS OF COWS FROM DECEMBER 15, 1965 TO APRIL 12, 1966

Sources of variation	df	MS	F
Total	18		
Mean	1	5161684.500	
Initial Blood Phos.[1]	1	37765.510	.702
CSM_L[2]	1	44472.132	.827
CSM_Q[3]	1	9679.095	.1799
Phos.	1	56601.570	1.052
CSM_L X P[4]	1	556.55929	.0103
CSM_L X P[5]	1	7730.6449	.144
Error	11	53788.102	

[1] Initial blood serum phosphorous as a covariable.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_L X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE IX

AVERAGE BLOOD SERUM PHOSPHOROUS
OF COWS

Lot Number	1	2	3	4	5	6
Level of cottonseed meal (lb.)	1.0	1.0	2.0	2.0	3.0	3.0
Level of monosodium phosphate (gm.)	0.0	36.0	0.0	36.0	0.0	36.0
Number of cows	3	3	3	4	3	4
			mg./100 ml. blood			
12-3-65	5.87	5.45	4.66	5.58	5.27	6.01
4-15-66	4.05	6.50	5.31	5.90	4.0	4.5
Average change	-1.82	1.05	.75	.32	-1.27	-1.51

TABLE X

AVERAGE 24-HOUR ESTIMATE OF MILK PRODUCTION (LB.)[1]

Lot and Treatment	Mean	S.D.
Lot 1 (1.0 lb. CSM)	12.01	±2.91
Lot 2 (1.0 lb. CSM + 36.0 gm. Phos.)	12.97	±2.41
Lot 3 (2.0 lb. CSM)	12.27	±1.62
Lot 4 (2.0 lb. CSM + 36.0 gm. Phos.)	13.76	±1.22
Lot 5 (3.0 lb. CSM)	15.09	±1.17
Lot 6 (3.0 lb. CSM + 36.0 gm. Phos.)	13.44	±2.39

[1] Average of 6 sampling periods.

TABLE XI

ANALYSIS OF VARIANCE FOR 24-HOUR MILK PRODUCTION

Sources of variation	df	MS	F
Total	35		
Dates[1]	5	32.74749	82.6977[a]
Treatments[2]	5	7.51402	18.9752[a]
Dates X Treatment[3]	25	.39599	

[a] $(P<.005)$

[1] Milkings taken on 6 dates.

[2] Means of treatment were used.

[3] Experimental error.

TABLE XII

AVERAGE MILK PRODUCTION OF COWS ON DIFFERENT LEVELS OF WINTER SUPPLEMENTAL FEED (1965-66)

Lot number	1	3	5	2	4	6
Level of cottonseed meal (lb.)	1.0	2.0	3.0	1.0	2.0	3.0
Level of monosodium phosphate (gm.)	0.0	0.0	0.0	36.0	36.0	36.0
			pounds of milk			
June 1	15.9	16.0	18.9	16.9	18.3	16.4
June 15	13.8	13.9	16.5	14.1	14.2	15.8
July 1	11.1	11.5	14.6	13.4	14.8	14.1
August 2	10.2	10.9	12.6	10.8	11.5	11.8
August 30	11.4	11.0	14.8	12.4	13.1	11.9
September 27	9.8	10.4	13.2	10.2	10.6	10.7

TABLE XIII

ANALYSIS OF VARIANCE FOR CALF WEANING WEIGHT[1]

Sources of variation	df	MS	F
Total	44		
Mean	1	10549705.00	
CSM_L[2]	1	3490.2526	2.286
CSM_Q[3]	1	30.642755	.02
Phos.	1	.00061404	.0000004
CSM_L X P[4]	1	581.8598	.381
CSM_Q X P[5]	1	501.77346	.329
Error	38	1526.5691	

[1] 205 day weight adjusted for age and corrected for sex.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE XIV

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN OF CALVES FROM BIRTH TO WEANING[1]

Sources of variation	df	MS	F
Total	44		
Mean	1	185.68982	
CSM_L[2]	1	.12896148	.716
CSM_Q[3]	1	.006160222	.034
Phos.	1	.00039145283	.00217
CSM_L X P[4]	1	.28755118	1.597
CSM_Q X P[5]	1	.1847926	1.026
Error	38	.18003178	

[1] 205 day weight adjusted for age and corrected for sex.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE XV

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN OF CALVES FROM BIRTH TO JULY 6

Sources of variation	df	MS	F
Total	44		
Mean	1	154.6875	
CSM_L[1]	1	.30529906	3.5058[c]
CSM_Q[2]	1	.018744631	.215
Phos.	1	.0012893537	.0148
CSM_L X P[3]	1	.1414154	1.624
CSM_Q X P[4]	1	.13671465	1.57
Error	38	.087084869	

[c] (P<.1)

[1] CSM_L: Linear effect of cottonseed meal levels.

[2] CSM_Q: Quadratic effect of cottonseed meal levels.

[3] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[4] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

TABLE XVI

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN OF CALVES FROM JULY 6 TO WEANING[1]

Sources of variation	df	MS	F
Total	44		
Mean	1	190.19524	
CSM_L[2]	1	.011572792	.2425
CSM_Q[3]	1	.024688281	.517
Phos.	1	.033483060	.702
CSM_L X P[4]	1	.036489487	.765
CSM_Q X P[5]	1	.0050853767	.107
Error	38	.047727083	

[1] 205 day weight adjusted for age and corrected for sex.

[2] CSM_L: Linear effect of cottonseed meal levels.

[3] CSM_Q: Quadratic effect of cottonseed meal levels.

[4] CSM_L X P: Interaction of cottonseed meal linear and phosphorous.

[5] CSM_Q X P: Interaction of cottonseed meal quadratic and phosphorous.

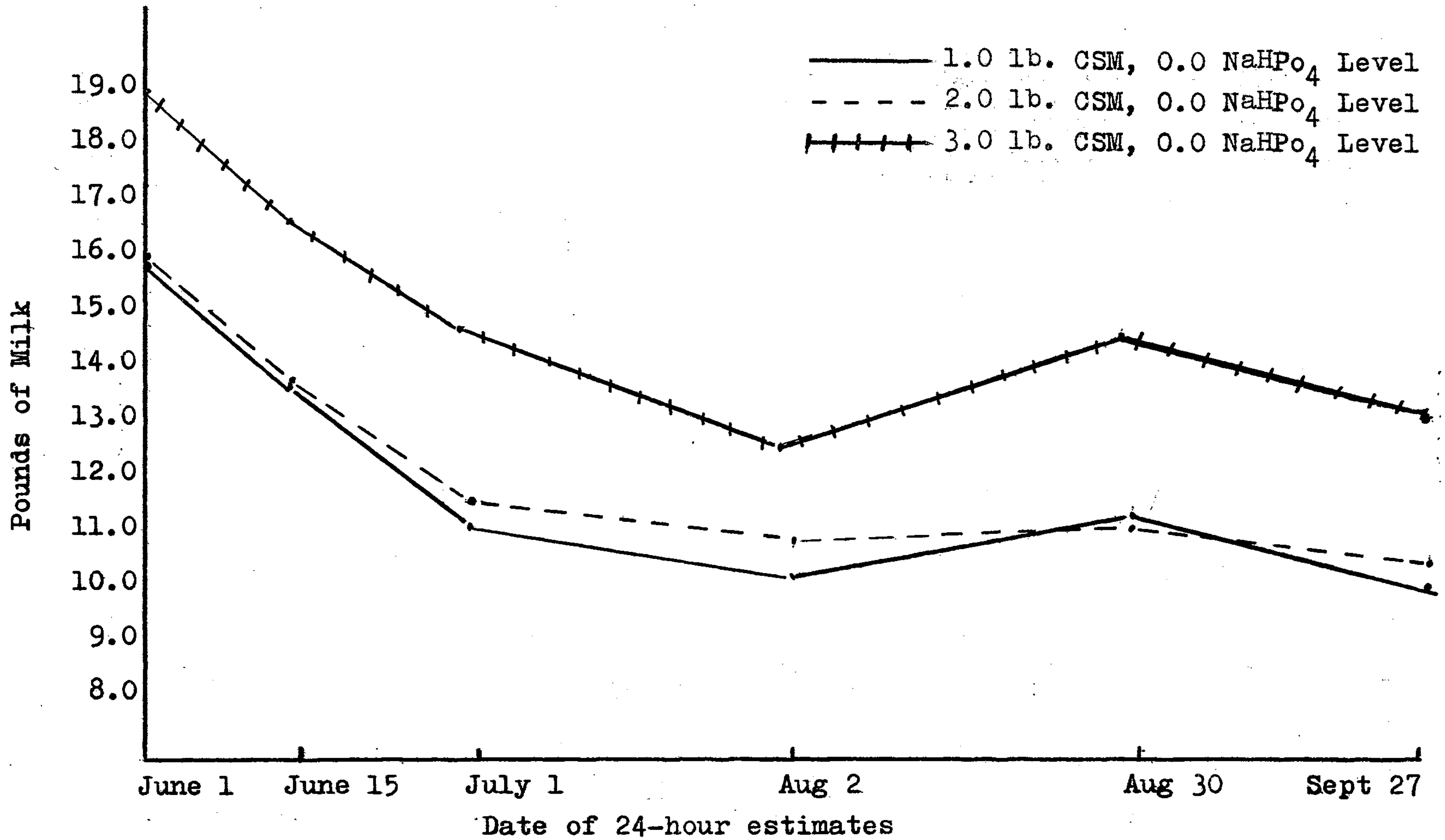

Figure 1. Summer Lactation Curves for Cows Wintered on 1.0, 2.0, and 3.0 Pounds Cottonseed Meal.

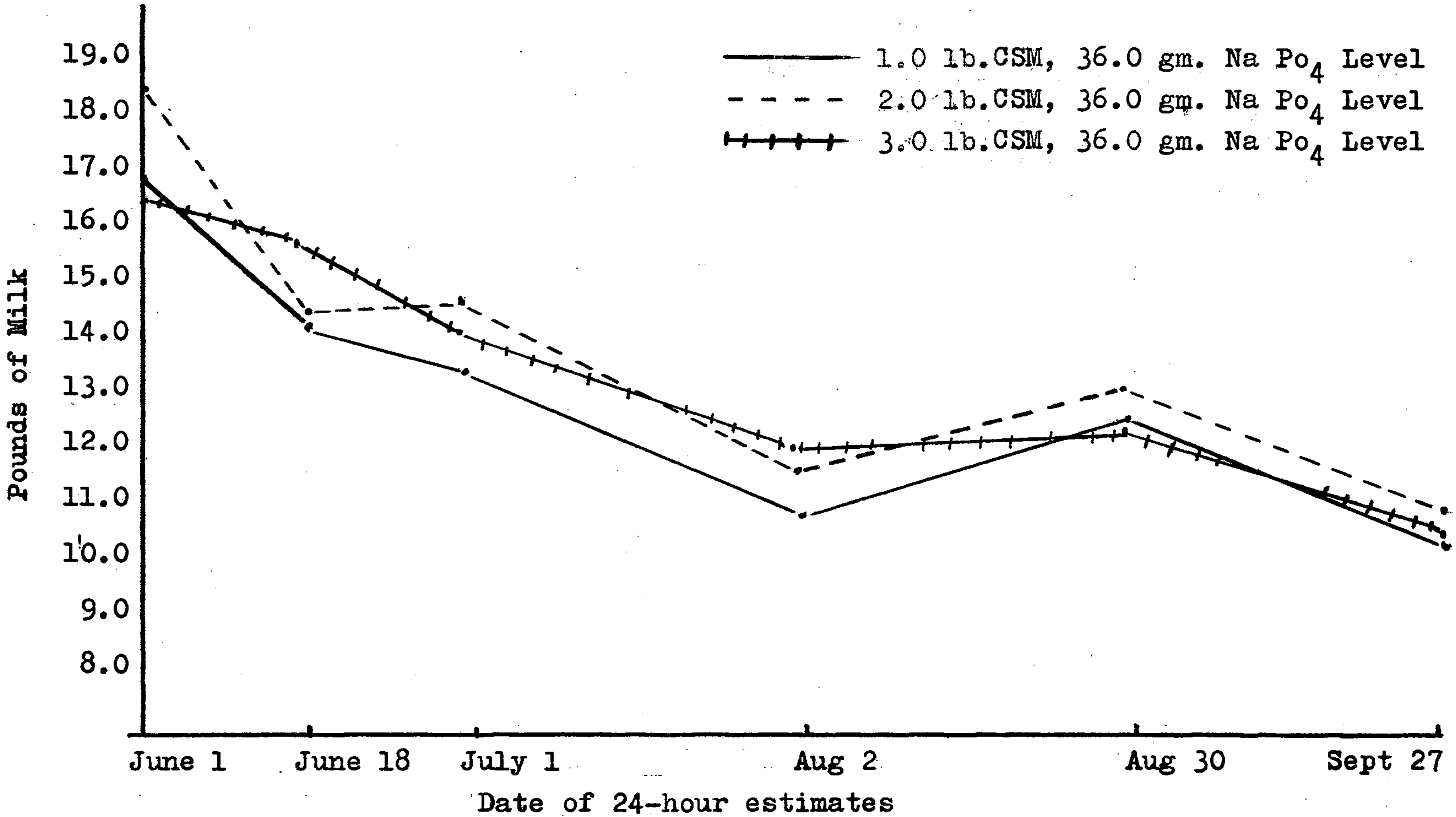

Figure 2. Summer Lactation Curves for Cows Wintered on 1.0, 2.0, and 3.0 Pounds Cottonseed Meal + 36.0 gm. Monosodium Phosphate.

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VITA

Frank Edwin Bates

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF LEVEL OF SUPPLEMENTAL WINTER FEEDING ON PERFORMANCE OF BEEF COWS GRAZING BERMUDAGRASS PASTURE

Major Field: Animal Science (Nutrition)

Biographical:

Personal Data: Born near Norman, Oklahoma, November 1, 1928, the son of Joseph A. and Chrissie L. Bates.

Education: Attended grade school at Blackburn, Rocky Point, and Noble, in Cleveland County, Oklahoma; graduated from Noble High School in 1946; received the Bachelor of Science degree from the Oklahoma State University, with a major in Animal Science in May, 1950; completed the requirements for a Master of Science degree from Oklahoma State University in May, 1967.

Professional Experience: Herdsman and later manager of a registered Aberdeen Angus ranch from June, 1950 to September, 1955; served from October, 1955 to September, 1957 as Assistant Loan Supervisor with the Farmers Home Administration, Anadarko, Oklahoma; entered the Oklahoma State University Extension Service October, 1957, serving as Assistant County Agent in Jefferson County two years and Associate County Agent in Carter County until January, 1966.