EFFECT OF HEAVY APPLICATIONS
OF FERTILIZER TO ALFALFA-BROME PASTURES ON
THE HEALTH AND REPRODUCTIVE PERFORMANCE OF BEEF COWS

By

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D. S.

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INTRODUCTION

In recent years there has been increased concern over the loss of livestock, particularly beef cattle, from causes which are unknown but which appear to be associated with faulty nutrition. Examples of disorders, frequently reported by livestock producers in their requests for information about the underlying cause, are digestive distrubances, reproductive troubles, unthriftiness and lowered milk production. In several instances, these disorders have been associated with cattle grazing pastures that were heavily fertilized.

The prevailing tendency is to measure plant response to soil treatment in terms of yield per acre, rather than in terms of animal health; and few investigators have thoroughly studied the possible modifications which may occur in the composition of the plant following heavy fertilization.

The fact that the composition of the plant may be modified by the use of fertilizer was apparent from the earliest soil fertility studies. Most workers have studied the effect of fertilizers on protein, dry matter and the major elements in the plant. However, recent research indicates that heavy fertilization may lower some of the minor elements in the plant to a deficiency level, or may raise others to a toxic level.

The improvement of the soil has been, and will continue to be, of great importance in animal nutrition and health by providing higher yields of feed required for a more intensive type of livestock production and a growing livestock population. However, the quality of the product produced by fertilization should also be considered. The quality as well as the quantity of forage should be improved when fertilizers are applied to the soil. This possible change in quality of forage represents an area deserving of further research of a sound, long-time nature.

REVIEW OF LITERATURE

Effects of Fertilization on Composition of the Plant

As pointed out by Beeson (1946), the mineral composition of plants is a function of many factors, such as climate, rainfall and use of fertilizers. Plant composition is the end result of a number of processes, many of which are controlled by environmental factors.

Beeson (1945) stated that plant and animal diseases caused by mineral deficiencies are more frequently associated with liming practices than with any other factor.

Matrone et al. (1949) have reported that rations of raw soybeans and soybean hay produced on unfertilized land and on land fertilized with phosphate were equally digestible and produced similar gains in lambs. However, when cerelose replaced the soybeans in the ration, lambs fed the fertilized hay made significantly greater gains than those fed the unfertilized hay. Matrone and associates (1954) fed a diet containing 76 percent fertilized or unfertilized soybean forage to rabbits. The rabbits fed the undertilized forage made smaller weight gains, had a lower level of inorganic phosphorus in the blood serum, and their bones showed greater fragility than did rabbits of the fertilized group. However, when monocalicum phosphate was added to both rations, the unfertilized group made the greater gains.

Vandecaveye (1940) pointed out that certain soils produced forages of better feeding quality than others, and that livestock producers made use of this knowledge long before much had been learned about the chemical composition of crops, or the nutritive elements responsible for superior feeding quality. Vardecaveye and Baker (1944) stated that certain forage crops were more responsive to fertilizers than others, and that pasture herbage proved to be the most responsive.

Blaser and Stokes (1942) and Blaser et al. (1942) in Florida showed that the addition of calcium, phosphorus and potassium to soils deficient in these elements resulted in significant increases in calcium, phosphorus, potassium and protein in the plant, and also in yield of the plant. Brown and Hollowell (1940) stated that superphosphate applied as a fertilizer usually increased the calcium content of grasses or legumes.

Phosphate fertilizers become tied-up in calcareous soil as insoluble tricalcium phosphate; however, it requires about 3 years for this to take place. Hinkle (1942) reported that fertilization of alfalfa and sweet colver with phosphates significantly increased the phosphorus content of the hay, the fertilized hay containing, on an average, about one-third more phosphorus than the unfertilized hay.

Fraps and co-workers (1943) reported that superphosphate greatly increased the yeild, and the protein, phosphorus and calcium content of mixed forage consisting of Dallis grass, lespedeza, white clover and black medic, and of carpet grass. Lime alone increased yields 45 to 53 percent and also increased the protein, phosphorus and calcium content of the mixed forage and carpet grass.

Working with Austrian winter peas and common vetch, Davis and Brewer (1940) have shown that liming low-calcium soils enables plants to utilize larger quantities of phosphorus supplied by application of superphosphate.

Lime alone produced an increase in the calcium content of the forage only, while lime applied with superphosphate produced an increase in calcium, phosphorus and protein of the forage.

When dairy cows were fed rations grown entirely on depleted or heavily fertilized soils, Dexter et al. (1950) and Duncan et al. (1952) could find no difference in amino acid content of colostrum or terminal milk of the cows.

Many factors such as soil type, pH and climatic conditions modify the effect that fertilizers may have on the plant. In general, liming the soil will result in a higher concentration of calcium in the plant and will aid in the utilization of phosphorus. The application of phosphorus may or may not increase the phosphorus content of the forage, but when lime and phosphorus are applied together, the result is usually an increase in the calcium, phosphorus and protein content of the forage.

Effect of Fertilization on Minor Mineral Elements in Plants and on the Health of Livestock Consuming the Plants

Most of the experiments dealing with fertilization have been concerned with increasing the yield of forage per acre. Although yield per acre is of the utmost importance, serious complications may develop if an intensive fertilization program is instituted without giving sufficient attention to its effect on the composition of the plant. To be of the most benefit, fertilizers should increase both the yield and the nutritional quality of the forage.

According to Beeson (1941, 1946) liming practices and intensive fertilization in most cases exert a depressing effect on the availability of micronutrients such as boron, manganese, iron and cobalt. Beeson and co-workers (1944) state that greatly increasing yields through heavy fertilization may rapidly deplete the soil of micronutrients when they are present in subnormal quantities. Improvement of the over-all nutritional quality of forage through fertilization may be limited under some conditions unless attention is given to micronutrients as well as to calcium, phosphorus and protein.

Plumlee and associates (1953) in studies with identical twin calves have shown that the addition of a trace mineral supplement consisting of magnesium, manganese, cobalt, copper, iron and zinc to a ration of corn cobs and Purdue Cattle Supplement A resulted in lower daily gains and feed consumption. When magnesium alone, magnesium and iron, or a combination of magnesium, iron and manganese were excluded from the supplement the same results were obtained as when the complete trace mineral mix was fed.

Keener et al. (1954) and Lyford (1945), working in New Hampshire with dairy cattle, reported that the cobalt content of forage may be reduced to a deficiency level in heavy yields of forage resulting from the use of chemical fertilizers, as well as poultry manure.

Keener and associates (1953) reported that dairy heifers fed timothy and ladino-brome hays grown under intensive fertilization, and supplemented with a low-mineral grain mixture, developed marked cobalt deficiency symptoms in about 6 months. After this condition was corrected by cobalt supplementation, symptoms of iron, copper and iodine deficiency appeared. Keener (1953) stated that excessive liming may reduce the amount of certain trace elements in forage crops. He also reported that pulverized limestone (100 gm. per head per day) fed to dairy heifers as a supplement to grass silage depressed the digestibility of both protein and energy.

Blucker (1953) and Swader (1955) could not show consistent decreases in weight gains or weaning weight of calves from adding as much as 500 ppm. manganese to the daily ration of beef cows.

Working in Australia with sheep, Dick and Bull (1945) reported that the addition of 10 or 100 mg. of molybdenum per day to a ration containing equal parts of oat and alfalfa hay decreased the copper concentration in the liver of ewes. Feeding a copper supplement failed to correct the condition.

Dick (1952) fed rations containing varying amounts of alfalfa and oat hay to several groups of sheep. The copper intake was adjusted to 15 mg. per day and the molybdenum intake was adjusted to 10.7 mg. per day for all groups. There was only a slight rise in the copper content of the livers in the group which consumed only alfalfa, but from group to group, there was a constantly greater amount of copper stored in the liver as the proportion of oat hay in the ration was increased. The author postulated that there was a factor(s) present in alfalfa that decreased the storage of copper in the liver, and that molybdenum was not entirely responsible for the low liver stores.

Bull (1953) worked with sheep fed rations of alfalfa and oat hay. A control lot received oat hay without the addition of copper or molybdenum. The copper intake of these animals was 2.9 mg. per day, an amount considered to be inadequate. However, there was a rise from 370 ppm. to 417 ppm. in the mean copper concentration in the liver of the control lot during the experiment. The copper and molybdenum intake of the other lots of sheep was adjusted to 10 mg. of each daily. In the lot receiving only alfalfa, the mean copper concentration in the liver fell from 374 ppm. to 260 ppm; whereas, in the lot receiving oat hay, there was a rise from 358 ppm. to 796 ppm.

Russell (1944) in England pointed out that in "teart" pastures in that country, the forage contains an excess of molybdenum. The administration of copper sulfate is a cure for the condition which develops in cattle on "teart" pastures even though the copper content of the forage is well above the deficiency level. Applications of sulfate of ammonia increased the yield and reduced the molybdenum content of the forage in proportion to the increased yield. The total amount of molybdenum absorbed from the soil was not decreased.

McLean and co-workers (1943), using Chinchilla rabbits as experimental animals, found that alfalfa grown on soil with an excess of calcium or phosphorus, and soybeans grown on soil made deficient in potassium through excessive liming, have a lower nutritive value than those grown on untreated soil.

Price et al. (1951) at the Virginia station found that, in general, liming depressed the cobalt, copper, manganese and zinc content of forage. A complete fertilizer increased the amount of cobalt and manganese in forage.

Barshad (1948) stated that molybdenum is highly soluble in alkaline soils and that legumes tend to absorb more molybdenum than nonlegumes. Legumes grown on soils that contained from 1.5 to 5 ppm. molybdenum may contain 10 ppm. or more of this element. The author believed that rations containing 10 ppm. molybdenum were toxic to cattle.

Robinson and associates (1951) reported that the molybdenum content of alfalfa, crimson clover and Austrian winter peas grown on acid soils high in molybdenum may be increased by heavy liming, and on some soils to the point where crops are toxic to cattle.

Bear et al. (1951) stated that liming an acid soil increased the supply of calcium and magnesium and increased the availability of soil phosphorus and molybdenum.

As stated before, many factors act to modify the effect that fertilizers may have on the plant. However, in general, heavily limed soils usually result in depressed cobalt, boron, iron, manganese and zinc content of the plant. Heavily liming the soil will usually increase the calcium, magnesium and molybdenum content of the plant. Complete fertilizers, as a rule, do not have as great an altering effect as lime on the micronutrient composition of plants.

Studies with livestock have shown that the cobalt content of forage may be reduced to a deficiency level where high yields of forage result from the use of chemical fertilizers or poultry manure on certain soils. Studies in Australia with sheep, indicate that molybdenum plus an unknown factor(s) in alfalfa impairs the storage of copper in the liver. There is also evidence to indicate that heavily liming acid soils of a high molybdenum content may lead to molybdenum toxicity in livestock.

EXPERIMENTAL OBJECTIVES

The purposes of this study were as follows:

I To study the effect of heavy applications of chemical fertilizer on the health and reproduction performance of beef cows.

II To study the effect of heavy applications of chemical fertilizer on the chemical composition of the forage produced.

III To study the effect of forage, produced on heavily fertilized land, on the growth response of rabbits.

PROCEDURE

An experiment was initiated at the Fort Reno Experiment station to test the effect of increased amounts of fertilizer on pastures as they effect the health and reproductive performance of beef cows subsisting on forage grown on the area.

Two, comparable, 57-acre plots of land were selected in the fall of 1950 for this experiment. During the summer of 1950, a crop of corn was produced on this land. It was plowed in September, 1950, and a seed bed prepared. Six soil samples were taken for analysis from each plot. In brief, the analysis showed that the soil was basic, had a high phosphorus content and contained a medium amount of potassium. Fertilizer was applied to one plot at a rate commensurate with the recommendations of the soils department of Oklahoma Agricultural and Mechanical College. This plot received 100 lb. of superphosphate (analysis 0-33-0) per acre and was designated the "control" plot. Limestone and superphosphate were applied to the other plot, designated the "fertilized" plot, at a rate five times that recommended by the soils department. This plot received 5 tons of agricultural limestone and 500 lb. of superphosphate per acre. In February, 1953, another 1000 lb. of superphosphate was applied to the fertilized plot, making a total of 1500 lb. per acre during the experiment.

A seeding of alfalfa and brome grass was made in late September, 1950. The fall and winter season of 1950-51 proved to be very unfavorable for fall seeding, and a stand was not obtained. Both areas were summer-fallowed in 1951, and a seeding was made in early September on approximately 35 acres of the fertilized plot with seed that remained from the previous seeding. The remaining 22 acres of this plot and the 57 acres of the control plot were not seeded until late in September because of lack of seed.

The early seeding on the fertilized plot was highly successful. However, the late seeding was not well established before an early freeze and cold weather in November and, as a result, was not as successful as the early seeding. Further seedings were made, but a stand sufficient to permit grazing was not established on the control plot until the summer of 1954. In both plots, the forage was predominantly alfalfa.

On October 31, 1951, 20 two-year-old Hereford heifers were delivered to Fort Reno from the Wilburton station in southeastern Oklahoma. They had previously been used in nutritional tests at Wilburton. All of the heifers had been fed the same basal winter ration and half of them received a trace mineral mix consisting of iron, copper and cobalt. The other half had been fed only salt and bone meal as their mineral supplement.

Upon arrival at Fort Reno, all heifers were wintered on wheat pasture and native grass. On April 7, 1952, they were divided into two equal lots on the basis of body weight and calving record and were assigned to their respective treatments at random. Four heifers that received trace minerals at Wilburton were assigned to Lot 1, and the other six were assigned to Lot 2.

According to the original plan, one lot of heifers was to graze the control pasture and the other lot the fertilized pasture during the grazing season. Sufficient hay was to be cut and baled during the summer from both pastures to provide winter feed for the heifers. The heifers were to be wintered in traps and fed the hay cut from their respective pastures, free choice. Salt was to be fed free choice with no other mineral supplement.

Because of unfavorable weather conditions, sufficient forage was not available on the control pasture during the summers of 1952 and 1953 to permit grazing; hence, the control lot (Lot 1) was summered on native grass. However, the control pasture did produce enough hay each year for the winter period. The fertilized lot (Lot 2) grazed their assigned pasture each summer from 1952 through 1954.

In the fall of 1952, six additional three-year-old heifers from the Lake Carl Blackwell experimental range were added to Lot 2 to provide a larger number of animals for observation. They were handled in the same manner as the cows in Lot 2. In July, 1952, one cow in Lot 2 died of bloat. In September, 1953, another cow in Lot 2 died of bloat, and in the fall of 1954 a third cow was removed from this lot because of a pleural abscess, leaving a total of 13 cows in the fertilized lot.

In December, 1953, four cows with known production records in Lot 1 were exchanged with a like number from Lot 2. Each cow (with one exception) had previously produced two calves, and the switch was made to compare their past performance with their performance on the opposite treatment. From May 1 to September 1, of each year the cows of each lot were exposed to purebred Hereford bulls.

All calves were weighed and tattooed at birth. They were castrated and dehorned at about 6 weeks of age. The cattle were provided with rubbing posts and sprayed from two to four times a year to control horn flies, and were sprayed once a year for lice and two to four times during the winter for grubs.

Samples of forage from both pastures were collected for chemical analysis in April, 1953; April, 1954, and July, 1954. Chemical determinations of major constituents were made in the Department of Agricultural Chemistry Research. Minor elements were determined by spectrographic methods at the University of Florida.

Growth studies with New Zealand white rabbits fed forage cut from both pastures at Fort Reno have been conducted at Stillwater. The second of two tests is in progress.

RESULTS AND DISCUSSION

Reproductive Performance of the Cows

The results obtained on cow and calf performance, by years, are given in appendix Tables XI (1952), XII (1953) and XIII (1954). A summary covering the essential data from each of these tables, is presented in this discussion.

Because of unfavorable weather conditions at time of seeding, the control pasture produced no grazing and only enough forage for hay during the winter period for the first two years of the test. Therefore, the cows of Lot 1 were grazed on native grass pastures during the summers 1952 and 1953. Sufficient forage was produced on the fertilized pasture to permit grazing during each summer, and furnished enough hay for the winter period each year. Both lots of cows were wintered each year in small traps and fed hay, free-choice, cut from their respective pastures. Salt was available at all times, but no other supplement or minerals were fed. A summary of the performance of the cows in the summer of 1952 is given in Table I.

It must be remembered when making comparisons of lots in Table I, that the cows in Lot 1 were summered on native grass. The cows in Lot 1 gained more during the year but failed to wean as heavy calves as those in Lot 2. The average birth weight of the calves in both lots were the same, but the Lot 2 cows weaned calves that were, on an average, 15 lb. heavier than the calves weaned by the cows in Lot 1. In 1952 the cows in Lot 1 weaned five calves. Two cows aborted, one cow

Table I Summary of Performance of Cows and Calves in 1952

Items Compared	Lot 1 Control	Lot 2 Fertilized
No. of Cows Per Lot	10	10 1/
Av. Wt. of Cows (lb.)		
Initial 4-7-52	940	927
At Weaning 10-17-52	1192	1123
Av. Gain	252	196
No. of Calves Born	6 2/	6
No. of Calves Weaned	5 3/	6
Av. Corr. Birth Wt. of Calves (lb.). 4/	78	78
Av. Corr. Weaning Wt. of Calves (lb.). 5/	476	491

1/ One cow died of bloat in July, 1952.

2/ For detailed results of performance of cows and calves, see appendix tables.

3/ Weaning weight of calf could not be found.

4/ Corrected for sex by adding 5 lb. to the actual birth weight of each heifer.

5/ Corrected for age by adjusting all calves to a standard age of 210 days and for sex by adding 25 lb. to the age-corrected weight of each heifer.

did not breed, one cow calved late and one calf-weight could not be found. The cows in Lot 2 weaned six calves. One cow in this lot died of bloat, one cow was open and two cows calved late. Calves from cows calving late were not included in the summary tables.

Six, bred, three-year-old heifers were added to Lot 2 in November, 1952, to increase the number of animals on which observations could be made. These heifers were subjected to the same management system as the other cows in Lot 2. A sufficient stand of forage had not been established on the control pasture by the summer of 1953 to permit grazing, hence the cows in Lot 1 were again summered on native grass. The wintering procedure for 1953-54 was the same as previously practiced.

The nine cows from the previous year and the six cows from the Lake Carl Blackwell experimental herd made a total of 15 cows in Lot 2 during the spring and summer of 1953. All of the original cows in Lot 1 were retained in Lot 1. A summary of the performance of the two lots of cows in 1952-53 is given in Table II.

Table II Summary of Performance of Cows and Calves in 1953

Items Compared	Lot 1	Lot 2	
		Fertilized	
	Control	Original	Blackwell[1/]
No. of Cows Per Lot	10	9	6[2/]
Av. Wt. of Cows (lb.)			
Initial 10-17-52	1192	1123	998
At Weaning 10-2-53	1262	1324	1213
Av. Gain	70	201	215
No. of Calves Born	7[3/]	7[4/]	5
No. of Calves Weaned	6	5	5
Av. Corr. Birth Wt. of Calves (lb.)	68	75	71
Av. Corr. Weaning Wt. of Calves (lb.)	493	500	467

[1/] Heifers added from Lake Carl Blackwell herd in fall of 1952.

[2/] One cow died of bloat in September, 1953.

[3/] One calf died of a broken neck while a blood sample was being taken; weights not included in table.

[4/] Includes two fall calves whose weights are not included in the averages.

Cows of Lot 1 (again on native grass during the summer) as compared to those of Lot 2 made smaller yearly gains and their calves were lighter at birth, although they weaned calves of about the same weight as did the original cows in Lot 2. At weaning, their calves were 26 lb. heavier, on an average, than the calves from the Blackwell cows grazing the fertilized plot.

A sufficient stand of forage had been established on the control pasture to permit grazing of this area during the summer of 1954. Both lots of cows were wintered in the manner previously described (1952-53) and grazed their assigned pastures during the summer of 1954. However, there was a severe drought during the summer of 1954 and neither pasture produced sufficient forage for grazing after July. Baled hay, cut the preceding year from their respective pastures, was fed both lots of cows during this dry period. A summary of the performance of the cows in 1953-54 is given in Table III.

The calves weaned by both groups of cows in 1954 were, on an average, the lightest ones weaned in this experiment. The drought and hot weather was probably responsible, in part, for the low weaning weights.

The original cows in Lot 2 weaned the heaviest calves, but they lost more of their calves. Autopsy of two calves from Lot 2 showed that one calf died of uremic poisoning and another died of an acute bacterial infection. The Blackwell cows had the heaviest calves at birth, but they were the lightest at weaning. During the winter several sick calves in both lots were treated with injections of antibiotics. In most cases there was a response to this treatment, indicating the presence of bacterial infection.

Table III Summary of Performance of Cows and Calves in 1954

Items Compared	Lot 1 Control	Lot 2 Fertilized Original	Lot 2 Fertilized Blackwell
No. of Cows Per Lot	10	9[1/]	5
Av. Wt. of Cows (lb.)			
Initial 10-2-53	1310	1278	1178
At Weaning 10-1-54	1282	1253	1238
Av. Gain	-28	-25	60
No. of Calves Born	10	9	5
No. of Calves Weaned	9	5	4
Av. Corr. Birth Wt. of Calves (lb.)	71	72	79
Av. Corr. Weaning Wt. of Calves (lb.)	447	464	445

1/ One cow removed from experiment in October, 1954 because of pleural abscess and telang liver.

In December, 1953, four cows with known production records in Lot 1 were exchanged with a like number from Lot 2. Each cow (with one exception) had previously produced two calves, and the switch was made to compare their past performance with their performance on the opposite treatment. A summary of the performance of these cows is given in Table IV.

The production of Group 1 (switched from fertilized to control) in 1954 dropped considerably as compared to previous performance. Their calves averaged 9 lb. lighter than their previous calves at birth and averaged 61 lb. lighter at weaning. The production of

Table IV Comparison of Performance of 4 Cows Taken from Each Lot and Reversed on Treatment in the Summer of 1954 (Wt. in lb.)

Cow No.	Cow Wt. Initial 10-2-53	Cow Wt. Final 10-1-54	Av. of 1952 and 1953 Production on Initial Pasture: Corr. Birth Wt. of Calves	Av. of 1952 and 1953 Production on Initial Pasture: Corr. Weaning Wt. of Calves	Av. of 1954 Production on Opposite Pasture: Corr. Birth Wt. of Calves	Av. of 1954 Production on Opposite Pasture: Corr. Weaning Wt. of Calves
Group 1 Switched from Fertilized to Control Pasture						
6	1650	1575	85	533	63	450
14	1125	1125	71	490	67	420
21	1275	1280	89	548	83	430
22	1175	1260	71	485	68	died 1/
Av. Wt.	1306	1310	79	494	70	433
Group 2 Switched from Control to Fertilized Pasture						
7	1240	1195	72	515	70	505
10	1130	1165	79	465	76	455
15	1125	970	67	450	72	455
19	1250	1245	73	495 2/	73	475
Av. Wt.	1186	1144	73	481	73	473

1/ Cause of death was undetermined.

2/ Based on only one calf.

Group 2 (switched from control to fertilized lot) also dropped, but not as much as Group 1. The unfavorable weather in the summer of 1954 is believed to be at least partially responsible for the drop in productivity of the cows. Although the production of the cows in Group 1 declined the most, there was no indication that this decline was due to experimental treatment.

Because of abortions and cows failing to breed, both lots of cows were tested for contagious abortion in January, 1952. All cows gave a negative test. There were several unexplained abortions in both lots again in 1953 and due to these losses, the cows were again tested for contagious abortion and for leptospirosis in April, 1954. Nine cows gave suspicious tests for contagious abortion and three gave positive tests for leptospirosis. However, the tests could not be correlated with calf losses. It is believed that most calf losses resulted from intestinal and respiratory infections, possibly associated with low milk production of the cows.

The cows in this experiment do not appear to be heavy milkers. They have consistantly weaned lighter calves than cows of comparable ages at Fort Reno. Their udders are small and flabby even during the peak of milk flow, and their calves attempt to nurse more often than normal.

According to Swanson and Spann (1954), dairy heifers that were fed fattening rations failed to give as much milk, or to milk as long during the first and second lactations, as heifers fed normal rations. Pratt (1954) pointed out that the performance of dairy cows in their first lactation period was about the same whether they were fed a liberal grain ration or a limited grain ration. However, the second year, the limited-fed cows out produced the liberal-fed cows, and this same trend held true through the third year. Cows in the experiment reported herein appeared to decline in productivity as measured by weaning weights of their calves. This might be explained, at least in part, by Pratt's observations.

In the spring of 1954, a sample of milk was taken from a cow in Lot 2 that had just lost her calf. The milk was brought to Stillwater and fed to two weanling white rats for 2 weeks. The rats made gains considered normal on milk alone, and showed no ill effects. Blood samples taken from two calves of each lot in the spring of 1954 contained normal amounts of both carotene and vitamin A.

Six heifers produced by cows in Lot 2 in 1953 were added to Lot 2 in April, 1954. These heifers will make it possible to study the reproductive performance of second generation animals continuously fed the fertilized forage. The growth of these heifers is presented in Table V. They were exposed to a purebred Hereford bull in the summer of 1954, and will calve as two-year-olds in the spring of 1955.

Table V Growth Record of Second Generation Heifers Added to Lot 2 in 1954 (Wt. in lb.)

Heifer No.	Corr. Birth Wt.	Corr. Weaning Wt.	Weight at -		
			4-14-54	10-1-54	11-19-54
013[1/]	63	460	645	825	890
033	70	460	595	730	825
103	75	490	605	830	810
123	72	490	600	755	870
163	69	465	525	675	735
172	63	370[2/]	630	820	885
Av. Wt.	69	456	600	773	836

1/ Last digit indicates the year the calf was born.
2/ Born in November, 1952.

The heifers have made above-average weight gains on the fertilized forage and appear to be in good health at this time.

Chemical Composition of the Forage

Several forage samples were collected for chemical analysis. Samples of 1952 forage were not abailable. The major constituents of the forages are shown in Table VI, and the mineral composition is given in detail in Table VII.

Table VI Chemical Composition of the Forage

Forage Treatment	Percent Dry Matter	Percentage Composition of Dry Matter				
		Ash	Protein (Nx6.25)	Ether Extract	Crude Fiber	N.F.E.
Alfalfa hay[1/]	90.50	9.06	16.35	2.21	31.93	40.44
Control[2/]	94.02	10.69	18.46	2.77	29.95	44.49
Fertilized[2/]	94.60	13.24	20.04	2.27	29.00	41.16
Control[3/]	94.96	6.68	11.54	2.25	43.17	41.67
Fertilized[3/]	95.23	7.61	13.65	2.00	39.24	42.51
Control[4/]	91.14	9.44	17.16	2.46	38.48	42.13
Fertilized[4/]	91.12	11.34	20.22	2.45	35.17	40.57

[1/] Composition of alfalfa (all analyses) as reported by Morrison (1951).

[2/] Sample collected in April, 1953.

[3/] Sample collected in April, 1954.

[4/] Sample collected in July, 1954.

The analytical results in Table VI show that the fertilized forage contained a larger percentage of ash and protein than the unfertilized forage. Similar results have been reported by Blazer and Stokes (1942). The control forage contained the larger percentage of ether extract and crude fiber, while crude protein favored the fertilized forage. In general, however, differences between the forages in these values cannot be considered very significant in view of the range of values reported by Morrison (1951) and Glendening et al. (1952) for alfalfa hay.

As shown by the analysis in Table VII, the fertilized forage was consistantly higher in calcium, phosphorus, potassium, copper, manganese, zinc and iron than the control forage. According to Blazer and Stokes (1942), Blazer et al. (1942) and Davis and Brewer (1940), a rise in the calcium, phosphorus and protein of the plant is to be expected when lime and superphosphate are applied to the soil. However, Beeson (1941, 1946), Keener (1953) and Price et al. (1951) have reported that liming soils may reduce the content of the minor mineral elements in the forage. However, in the present comparisons, the minor elements were consistently higher in the fertilized forage, except in the case of molybdenum. The soil on which this forage was produced had not been badly cropped or eroded. It was bottom land and possibly it was higher in trace mineral content than the soils fertilized by Keener (1953). Keener was able to produce trace mineral deficiencies in dairy cattle subsisting on forages produced from heavily fertilized soils in New Hampshire.

In terms of the recommended daily allowances of minerals for livestock, as given by Morrison (1951) and Maynard (1947), the mineral elements in both the control and fertilized forages appear to be present in adequate amounts for normal growth and reproduction, so far as requirements are known. None of the minerals appear to be present in such large amounts as to cause toxicity.

Table VII Mineral Composition of the Forage

Forage Treatment	Percent			Parts Per Million						
	Ca	P	Mg	Na	K	Cu*	Mo*	Mn*	Zn*	Fe*
Alfalfa hay[1]	1.45	0.47	0.49	9.22	248	28.00	.90	48.00	-	23.07
Control[2]	1.06	0.21	0.46	10.42	202	11.83	2.09	31.42	3.75	15.19
Fertilized[2]	1.23	0.30	0.25	4.86	314	14.63	2.05	37.34	6.09	15.95
Control[3]	0.85	0.22	0.19	9.90	191	11.72	2.66	4.43	4.42	7.31
Fertilized[3]	0.88	0.25	0.19	5.25	261	12.24	2.62	17.25	5.79	12.35
Control[4]	1.38	0.28	0.14	9.44	196	10.40	2.49	22.39	6.64	11.27
Fertilized[4]	1.66	0.35	0.15	5.93	238	12.19	2.77	23.14	12.28	12.62

* Analysis by spectrographic methods conducted at the University of Florida by Dr. George K. Davis.

1/ Average mineral composition of alfalfa hay as reported by Glendening _et al._ (1953).

2/ Sample collected in April, 1953, and probably ground in a hammer mill before analysis.

3/ Sample collected in April, 1954.

4/ Sample collected in July, 1954.

A comparison of the average mineral composition of the alfalfa reported by Glendening et al. (1952) with that of forages in this experiment shows that the experimental forages produced at Fort Reno are higher in molybdenum, but lower in all other minerals with the exception of potassium. According to the results obtained by Swader (1955) and Blucker (1953) with forced feeding of manganese to beef cows, the manganese content of the experimental forages is not high enough to be toxic.

Growth Studies with Rabbits

Two growth studies with New Zealand white rabbits have been conducted at Stillwater in conjunction with the experiment at Fort Reno. During the first trial, the rabbits were fed ground hay, produced either on the control or fertilized plots, with the addition of a small amount of yellow corn later in the trial. During the second trial, the rabbits were fed a pellet containing ground hay from the two areas, and ground yellow corn. Salt was available, free-choice, but no additional minerals were fed.

Twenty New Zealand white rabbits were obtained near Stillwater for the first trial. They were divided into two lots on the basis of body weight and were assigned to treatment at random. They were housed, two to a pen, in upright chicken brooders and weighed at 2-week intervals throughout the trial. Eleven New Zealand white rabbits were obtained from a commercial breeder near Ponca City for the second trial. They were handled in the same manner as the rabbits in Trial 1, except that they were housed in individual pens of rabbit hutches.

The first trial was started in December, 1953. A total of 10 rabbits per treatment were fed only ground hay until about the middle of January. At this time, three rabbits had died of undetermined causes. The slow weight gains of the rabbits seemed to indicate a lack of energy in the ration. From this point on, 70 gm. of corn was added daily to the ration of each rabbit. A summary of the weight gains during the first trial is given in Table VIII.

Table VIII Summary of Weight Gains of Rabbits in Trial I

Rabbit No.	Weights of Rabbits by Periods (grams) Initial 12-19-53	1-16-54[1/]	2-21-54	3-21-54	Final 4-4-54
		Control			
356	1367	1312	1805	2196	2373
364	1693	1926	2345	2486	2666
366	1507	1709	2205	2177	2173
370	1607	1896	2680	3000	3125
360	1422	died 1-15-54[2/]			
252	1436	1668	2355	2700	2849
363	1592	1742	2225	2547	2705
367	1655	2013	2405	2642	2695
352	1319	1591	2205	2428	2694
358	1354	1397	1560	1988	1820
Av. Wt. (gm.)	1495	1695	2198	2463	2567
Av. Gain		200	703	968	1072
		Fertilized			
353	1686	died 12-29-53[2/]			
351	1628	1744	2380	2671	2897
361	1310	1208	died 1-18-54[2/]		
369	1360	1201	1390	1520	1657
359	1779	2011	2355	2682	2838
368	1896	2048	2530	2772	2882
354	1684	2053	2565	3005	3115
355	1579	1727	2445	2762	2893
357	1474	1797	died 2-19-54[2/]		
365	1415	1192	1855	2364	2604
Av. Wt. (gm.)	1581	1665	2231	2540	2698
Av. Gain		84	650	959	1117

[1/] Corn was added to the ration of each rabbit for the remainder of the trial.

[2/] Undetermined cause of death.

On an average, rabbits fed the control forage made greater weight gains than those fed the fertilized forage, until the final weigh period. The control lot developed a severe infection of ear canker late in the trial. The fertilized lot was also infected, but the infection was not so severe as in the control lot and it may have had less effect on gains during the last weigh period.

A second trial was started in November, 1954, with 11 New Zealand white rabbits. These rabbits were fed a pellet containing 75 percent ground hay and 25 percent ground yellow corn. Chemical analysis of the pellets is presented in Table X. Corn was added to fortify the energy content of the ration. The forage used in formulating the pellets was cut in the pre-bloom stage and was of high quality. It was necessary to prepare a second batch of pellets from ground baled hay, cut the previous summer, and ground corn. Thirty percent corn was used to supply additional energy in formulating the second batch of pellets since the hay was coarse and stemmy. A summary of the weight gains of the rabbits during the second trial is given in Table IX.

Feed consumption data were recorded in the second trial. However, the tendency of the second batch of pellets to crumble prevented an accurate measure of feed intake. Feed consumption records for the first batch of pellets showed that up to the middle of January, the control lot consumed an average of 227 gm. less feed but made greater weight gains than the fertilized lot. As indicated in Table X, the control pellets were considerably higher in protein than the fertilized pellets. This difference was probably responsible for most of the difference in weight gains when the first batch of pellets was being fed.

Table IX Summary of Weight Gains of Rabbits in Trial II

Rabbit No.	Weight of Rabbits by Periods (grams) Initial 11-14-54	12-14-54	1-9-55[1]	Final 2-6-55
		Control		
501	2528	3333	3466	3642
504	2828	3557	3960	4225
505	2663	3710	3930	4062
510	2448	3772	4120	4170
512	2995	3798	3870	3752
Av. Wt. (gm.)	2692	3634	3869	3970
Av. Gain		942	1177	1278
		Fertilized		
502	2866	3665	3845	4310
503	2909	3573	3490	3665
506	2065	2913	2890	3195
508	2774	3609	3946	4017
509	2987	3708	4168	4155
511	2704	3260	3368	died 1-24-55[2]
Av. Wt. (gm.)	2718	3455	3618	3868
Av. Gain		737	900	1150

[1] Second batch of pellets was fed for the remainder of the trial.
[2] Cause of death was undetermined.

These growth studies with rabbits failed to indicate any marked difference in forages produced from the control or the fertilized plots.

Table X Chemical Composition of Pellets Fed in Trial II

Forage Treatment	Percent Dry Matter	Percentage Composition of Dry Matter: Ash	Protein (Nx6.25)	Ether Extract	Crude Fiber	N.F.E.	Ca	P	Mg
Control I	94.14	5.40	19.32	5.40	22.25	53.99	1.08	.15	.23
Fertilized I	94.15	6.33	15.67	3.10	27.88	52.84	1.13	.12	.15
Control II[1]	94.45	5.94	18.40	5.20	22.94	53.04	1.56	.14	.20
Fertilized II[1]	93.88	7.37	20.36	3.04	23.37	51.91	1.26	.17	.19

[1] Second batch of pellets fed from the middle of January to the end of the trial.

SUMMARY

An experiment was initiated at the Fort Reno station in the spring of 1952 to study the effects of increased amounts of fertilizer on the health and reproductive performance of beef cows.

Two, comparable, 57-acre plots of land were selected for this study and seeded to an alfalfa and brome-grass mixture in the fall of 1951. One plot was fertilized as recommended by the soils department of Oklahoma Agricultural and Mechanical College, and received 100 lb. of superphosphate (analysis 0-33-0) per acre. The other plot was fertilized at five times the recommended rate, and received 5 tons of lime and 500 lb. of superphosphate per acre. This plot also received a further application of superphosphate (1000 lb. per acre) in the winter of 1953. Due to unfavorable weather conditions, a seeding was not established on the control plot sufficient to permit grazing until the summer of 1954, although hay was cut from this area in 1952 and 1953.

Twenty, three-year- old grade Hereford heifers were divided into two equal lots and started on test in April, 1952. Six additional heifers were added to the fertilized lot in the fall of 1952. During the summer, the cows grazed their assigned pastures except for the control lot in the summers of 1952 and 1953. Each winter, the cows were fed hay, free choice, cut from their respective pastures. Salt was available, free choice, but no other mineral or supplement was fed.

Low reproductive performance and a decline in weaning weights were observed in this study. There were only slight differences in the performance of the cows between the control and fertilized lots. Calf losses and poor production could not be associated with either a mineral

deficiency, or excess, as indicated by the chemical composition of forage samples. It is possible that poor milk flow of the cows resulted from an abnormally fat condition, and exposure of the calves to disease while in winter quarters, were at least partially responsible for the poor performance observed. Six heifers, produced by cows in the fertilized lot, were added to this lot in 1953 and made normal growth to 18 months of age. In December, 1953, four cows with known production in the control lot were exchanged with a like number from the fertilized lot, and there was no indication of an inability to perform as well as could be expected on the opposite forage.

Forage samples were collected three times during the study and detailed chemical analyses were made. No marked differences in composition were observed although the fertilized forage was higher in ash protein, calcium, phosphorus, copper, iron, potassium, manganese and zinc.

Two growth studies with New Zealand white rabbits were conducted at Stillwater. The rabbits were fed forage from the control and fertilized pastures with small additions of yellow corn. No detrimental effects on weight gains could be shown from feeding either forage.

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A P P E N D I X

Table XI Performance of Cows and Calves in 1952

Cow No.	Cow Weights Initial 4-7-52	Final 10-17-52	Calf Production Data Birth Date	Sex	Corr. Birth Wt.	Corr. Weaning Wt.
			Control			
7	1065	1185	4-30	M	70	490
10	825	1135	2-26	F	90	440
11	810	1200	Calved late			
13	970	1320	Aborted 1-7-52			
15	825	1015	2-11	F	73	455
18	815	1220	Open			
19	940	1225	2-24	F	73[1/]	
20	1010	1265	Aborted			
24	1225	1310	5-16	M	95	525
25	910	1040	6-12	F	69	470
Av. Wt. (lb.)	940	1192			78	476
			Fertilized			
6	1120	1430	5-15	F	90	555
8	940	1170	Open			
12	1080	1245	4-3	M	80	420
14	800	1085	2-10	F	73	515
21	900	1215	2-24	M	92	520
22	820	1125	3-1	F	71	510
23	885	Cow died of bloat in July				
26	945	1355	Calved late			
28	950	1075	4-5	M	60	425
32	830	1305	Calved late			
Av. Wt. (lb.)	927	1123			78	491

1/ No record of calf at weaning.

Table XII Performance of Cows and Calves in 1953

Cow No.	Cow Weights Initial 10-17-52	Final 10-2-53	Calf Production Data Birth Date	Sex	Corr. Birth Wt.	Corr Weaning Wt.
			Control			
7	1185	1240	4-6	M	73	540
10	1135	1130	2-21	F	68	490
11	1200	1150	Calf died of broken neck			
13	1320	1300	3-20	F	57	445
15	1015	1125	2-28	F	60	445
18	1220	1245	2-27	F	79	545
19	1225	1250	2-17	F	73	495
20	1265	1455	Aborted			
24	1310	1500	Calf born dead			
25	1040	1220	Aborted			
Av. Wt. (lb.)	1192	1262			68	493
			Fertilized			
Original Cows						
6	1430	1605	4-4	M	80	510
8	1170	1455	Open			
12	1245	1285	3-12	F	72	490
14	1085	1125	4-5	F	69	465
21	1215	1275	2-24	M	85	575
22	1125	1175	2-20	F	70	460
26	1355	1380	10-2-52	M	51	350[1]
28	1075	1285	Aborted			
32	1305	1330	11-11-52	F	63	370[1]
Av. Wt. (lb.)	1123	1324			75	500
Blackwell Cows[2]	11-21-52					
6 [3]	1050	1385	Calf born dead			
10	970	1335	3-1	F	75	490
13	955	1095	4-3	M	63	485
30	1025	1100	3-8	M	78	490
32	1025	1180	2-10	F	63	460
59	940	1180	2-20	M	74	410
Av. Wt. (lb.)	998	1213			71	467

[1] Fall calves, weights not included in the averages.

[2] Bred heifers from Lake Carl Blackwell experimental herd.

[3] Cow died of bloat in September, 1953.

Table XIII Performance of Cows and Calves in 1954

Cow No.	Cow Weights Initial 10-2-53	Final 10-1-54	Calf Production Data Birth Date	Sex	Corr. Birth Wt.	Corr. Weaning Wt.
			Control			
6 1/	1650	1575	3-16	F	63	450
11	1150	1180	3-3	M	60	450
13	1300	1265	2-15	M	88	405
14 1/	1125	1125	4-2	F	67	420
18	1245	1245	2-20	M	72	485
20	1455	1420	3-4	M	60	470
21 1/	1275	1280	4-28	F	83	430
22 1/	1175	1260	1-21	F	68	died 3-11-54
24	1500	1330	3-17	M	84	495
25	1220	1140	2-12	F	65	420
Av. Wt. (lb.)	1310	1282			71	447
			Fertilized			
Original Cows						
7 1/	1240	1195	3-6	M	70	505
8	1455	1435	10-24-53	M	94	died 1-1-54
10 1/	1130	1165	4-12	M	76	455
12	1285	1260	1-31	M	78	430
15 1/ 2/	1125	970	2-14	F	72	455
19 1/	1250	1245	2-14	F	73	475
26	1380	1455	12-10-53	M	51	died 4-19-54
28	1285	1255	12-8-53	F	67	died 4-16-54
32	1330	1295	12-3-53	F	69	died 11-10-54 3/
Av. Wt. (lb.)	1278	1253			72	464
Blackwell Cows						
10	1335	1385	3-7	F	89	500
13	1095	1200	3-30	M	64	420
30	1100	1110	2-2	M	75	440
32	1180	1190	6-2	M	86	420
59	1180	1305	1-7	F	83	died 3-12-53
Av. Wt.	1178	1238			79	445

1/ Cows that were switched in December, 1953.

2/ Cow removed from experiment in October, 1954 because of a pleural abscess.

3/ Calf had prolonged sickness, weaning weight not included in average.

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