A TRACE MINERAL SURVEY OF SOME ROUGHAGES FED TO CATTLE IN SOUTHEASTERN KANSAS

by

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TABLE OF CONTENTS

INTRODUCTION

During the past several years many farmers in Southeastern Kansas have experienced difficulties in maintaining the health of their livestock, especially dairy animals. In 1948 the Kansas Legislature voted funds for the establishment of a Branch Experiment Station, which was organized in the spring of 1949 as the Mound Valley Branch. It was the purpose of this branch to organize a program of research directed towards a better understanding of the problems of crops and livestock, particularly dairy cattle, which seem to prevail in that area.

Among the difficulties that have been reported by farmers and veterinarians of the Southeastern Kansas area are ketosis, breeding troubles, low milk production, and emaciation. Some stockmen of this area have attributed these difficulties to a trace mineral deficiency in the forages grown in the area.

The purpose of this survey, in cooperation with the Mound Valley Branch Experiment Station, was to evaluate a number of samples of the roughages raised in Southeastern Kansas, especially Labette County, for several trace minerals and, if possible, correlate any mineral deficiencies found with the dairy cattle problems of the farmers.

With this as the aim of the study, roughage samples were taken from nine farms in Labette County. These farms were picked on the basis of general farm condition. The better than average as well as the poorer than average farms were selected, with the consent of the owners. The approximate location of these farms is noted on a map of Labette County (Fig. A-1, appendix). The samples of roughages used for the survey were obtained between March 14, 1952, and November 11, 1952. There were six sampling periods at approximately 6-week intervals. Between these dates, 39 samples consisting of 16 prairie grasses, 11 prairie hays, 6 alfalfa hays, 4 silages, 1 lespedeza hay, and 1 brome grass were obtained. These roughages were analyzed for magnesium, manganese, molybdenum, iron, copper, and cobalt. In order to characterize the feeds further on the basis of mineral content, determinations were made of moisture (at time of sampling) ash, calcium, and phosphorus.

LITERATURE REVIEW

Deficiencies of magnesium, manganese, iron, copper, cobalt, or an excess of molybdenum in feeds from a certain area that may lead to characteristic nutritional troubles in livestock is an indicator of soil deficiencies of those minerals or improper soil characteristics, such as pH. Considerable effort has been made to locate and map the places where such troubles occur (12). The preparation of maps showing where nutritional troubles occur is a difficult undertaking since the adequate mineral nutrition of grazing farm animals depends upon a variety of factors. For example, there must be a sufficient supply of each of the trace minerals required for the normal functioning of body processes, and a proper ratio between certain minerals. Furthermore, harmful effects may be observed when certain minerals are in excess.

The mineral content of feeds from any one area, however, varies and depends upon such factors as stage of maturity (9,74), climate (9,74), soil types (9,68,82), soil amendments (10,11,13, 68), and species of plants (9). Several reviews (6,11,69) with particular reference to the mineral nutrition of plants have been published. However, since this paper is not concerned with the mineral nutrition of plants but rather with the various investigations correlating trace element concentration in roughages and pastures with the possible occurrence of nutritional troubles in animals, further consideration will not be given to mineral nutrition of plants.

This review will be presented by giving separate attention to each of the various minerals that were studied in this survey. The review is not intended to be complete, for voluminous literature has appeared in the journals of plant and animal science presenting the important role that minerals play in animal nutrition.

Calcium and Phosphorus

Calcium and phosphorus are not trace elements. However, a short review of these elements will be given, since it would be difficult to evaluate a roughage on the basis of trace mineral content without a knowledge of calcium and phosphorus content.

Probably the most widespread nutritional deficiency in farm animals is phosphorus. The pioneer work on phosphorus deficiency in farm animals, under natural conditions, was made by Theiler and his associates (76) of South Africa through their study of the phosphorus content of the forages of that area. They reported that the dry matter of deficient forages contained from 0.03 percent to 0.26 percent phosphorus. Phosphorus deficiencies have been reported from several states of the union (8, 25, 29, 38, 44, 45, 46), the British Isles (31), and South America (49).

In cattle the deficiency causes a failure and depravement of appetite, severe emaciation, stiffness and muscular weakness.

In contrast to the situation for phosphorus, there are few reports of areas where calcium deficiency has occurred under natural conditions. Deficiencies of calcium have been reported in Nebraska, Virginia, and Louisiana (46). The apparent calcium deficiency in Nebraska was manifested by depraved appetite, and was corrected by a calcium supplement, type of supplement not stated. The Virginia condition was diagnosed as a calcium deficiency by veterinarians. The deficiency reported in Louisiana does not seem to be due to a lack of calcium since the forage appears to be higher in calcium than found in numerous other instances. These reports are instances of isolated cases, and to the author's knowledge have not been truly substantiated fully.

It is of great importance in animal nutrition to have a proper ratio between the elements calcium and phosphorus. A calcium-phosphorus ratio between 2:1 and 1:2 in the total feed intake is considered satisfactory if sufficient vitamin D is present (62).

The National Research Council (57) has recommended an allowance of 0.15 percent calcium and 0.15 percent phosphorus of the total ration for the maintainence of mature dairy cows. For the production of milk the addition of 1 g of calcium and 0.7 g of phosphorus for every pound of milk produced is recommended.

Magnesium

When an animal is deprived of magnesium, Kruse et al (54) have shown that it becomes irritable, its heart action becomes erratic and, if deprivation is continued, the animal dies in convulsions. Duncan and associates (27) have reported a tetany in calves that was characterized by low blood magnesium content as compared to the blood magnesium content of normal animals (28).

These findings with calves have focused attention on a disease of cattle called "grass tetany" or "grass staggers" (62). Cunningham (22) has reported that such a sickness occurred in New

Zealand in fresh cows within a week or two after they were turned out to pasture, and that the animals responded to administration of salts of magnesium. However, Sjollema, (72) noted that pasturage in Holland on which cows developed this disease was not unusually low in magnesium. The so called "grass tetany" then is possibly not due to a deficiency of magnesium in the herbage, but to some complicating factor preventing absorption.

There appear to be no substantiated reports of magnesium deficiency in cattle under natural conditions (40, 42). Huffman et al (48) have shown that dairy calves require approximately 0.6 g of magnesium per 100 lb. of body weight when supplied by natural feed, which corresponds to approximately 0.06 percent of the dry ration.

Two reviews (26, 33) of the magnesium nutrition of farm animals have been published.

Copper

Several copper deficiency diseases of livestock associated with deficient soils and forages have been reported. More than a decade before the role of copper in hemoglobin formation was discovered (43), investigators in Northern Europe were studying possible mineral deficiencies in the forage areas where a wasting disease of cattle called "lechsucht" was common. In 1933 its cause was established as a copper deficiency by the finding of marked differences in the copper content of the forage from "healthy" and "sick" areas and also that therapy with a copper salt alleviated the trouble (71). The analysis of forages from "sick" regions revealed a shortage of copper, namely, 2-3 ppm or less, whereas forages from "healthy" regions contained 6-12 ppm.

A widespread condition associated with copper deficiency is enzootic ataxia or swayback in lambs. In Australia there is a close association between the diease and areas where copper content of the herbage is low (less than 5 ppm of the dry matter) (30, 60). This disease (swayback) has been reported also in England, Sweden (60), and New Zealand (20, 21). The falling disease of cattle, common in Australia, characterized by a staggering and falling, and resulting after a time in sudden death, is also associated with a very low copper content of pastures. Bennetts and coworkers (15) reported that the analysis of a large number of pasture samples, including mixed grasses collected from the affected areas of Australia,ranged from 1.1 to 3.2 ppm of copper on a dry basis. Cunningham (20) reported that symptoms of copper deficiency were noted on pasture containing less than 5 ppm of copper on a dry basis. However, the possibility of multiple deficiencies in these and other similar studies must not be over looked as will be pointed out later in this paper.

Davis (23) has stated that a copper content of 5 ppm in the forage is satisfactory for the copper nutrition of animals, providing toxic levels of molybdenum are not present.

Cobalt

Cobalt is the latest addition to the list of trace elements known to be essential for the growth and health of ruminants. Its role as an essential element became known through lengthy studies of peculiar diseases of grazing animals from different areas. These diseases all had different names but symptoms were similar. Beeson (9) has listed some of the names by which these diseases were known, as "bush sickness" and "enzootic marasmus" of Australia, "salt sick" of Florida, "pining disease" of Scotland, "nakuritis" of Kenya Colony of Africa, and an unnamed disease of Dartmoor, England. Other reports of deficiencies which appeared to be due to a lack of cobalt include "Burton-ail" of New Hampshire (50) and "Grand Traverse disease" of Northern Michigan (3).

The specific role of cobalt in these diseases was discovered by Underwood and Filmer (79) working on enzootic marasmus and Lines (56) working on the coastal disease of Australia. The history of these experimental studies have been reviewed by Marston (59).

After the aforementioned conditions were shown to be due to a lack of cobalt, many studies were instigated immediately to determine the minimum level of cobalt in forages that was essential for the health of animals. Wunsch (83) reported that the cobalt content of forage from 39 healthy pastures of New Zealand averaged 0.106 ppm on a dry basis, whereas an average content of 0.07 ppm and lower were characteristic of "sick" areas. Underwood and Harvey (78) reported that the mean content of cobalt in pasture from the "affected" areas of Australia was 0.04 ppm on dry matter basis and that from the "healthy" area (outside the affected district) averaged 0.18 ppm of cobalt on a dry basis. Similar cobalt contents of deficient forages have since been reported by

Corner and Smith (19) (England) and Beeson et al (14) (North Carolina Coastal Plain, Buzzard Bay Region of Massachusetts, and Burton-ail region of New Hampshire).

The requirement for cobalt (42) is 0.10 mg per 100 pounds of body weight per day. Davis (23) stated that 0.1 ppm of cobalt in the dry roughage was satisfactory.

Manganese

Although manganese is demonstrably essential to animal life (57), no evidence of deficiencies of this element in cattle have been observed under natural conditions. At the California Experiment Station (18) heifers subsisted throughout the gestation period and gave birth to normal calves on a high energy ration fed in limited amounts and containing 6 ppm of manganese. Davis (24) stated that the manganese requirement for cattle is less than 10 ppm of the dry feed.

An interesting sidelight on manganese nutrition was reported recently by Gallup and coworkers (39). They noted that cattle on a range containing slightly less phosphorus than another range, but 5-10 times as much manganese (amount not stated) developed a severe phosphorus deficiency, whereas no abnormal condition was noted on the second range. During a controlled experiment they noted that increased levels of manganese increased the excretion of phosphorus.

Iron

The iron deficiency studies with cattle, under natural conditions as reported in the literature, have been complicated with the simultaniety of a deficiency of either copper or cobalt or both. Madsen (58) stated that many of the anemic conditions have been found to be alleviated by feeding of certain crude iron salts, which led to the hypothesis that the condition was due to iron deficiencies. Becker et al (8), reporting on the "salt sick" condition of Florida, noted that iron and copper salts produced a response. However, six years later Neal and Ahmann (64) reported that cobalt and not iron was probably the primary deficiency of the earlier experiments and that copper played a secondary role. Also during the first studies of anemic conditions in Australia, limonite, ($Fe_2O_3.H_2O$) was used as a treatment until it was shown by Underwood and Filmer (79) that the condition was alleviated by cobalt, a contaminant of the limonite.

Abbott and Ahmann (1) have found a general nutritional anemia of humans caused by a lack of iron in the foods raised in certain areas of Florida.

Concerning the requirement for iron, Allman and Hamilton (2) have stated that iron salts used as supplements in experiments with cattle usually contained appreciable quantities of cobalt, and therefore, reliable data on the iron requirements of cattle are not available.

Molybdenum

A livestock condition called "teartness", known for over 100 years to be associated with certain areas of England (Somerset) and not with other areas, has been established as a molybdenum toxicity (34, 36, 55). The condition is found in ruminants particularly calves and cows in milk. The physical symptoms are extreme diarrhea, with consequent loss in weight and milk yield. Ferguson et al (36) reported on studies of herbage in unhealthy and healthy areas of England and stated that herbage from healthy areas averaged less than 5 ppm molybdenum on a dry matter basis, whereas that from "teart" areas ranged from 30 to 80 ppm. Ferguson (35) also found that copper sulfate alleviated the diarrhea, which in turn lead to the establishment of the copper-molybdenum relationship. Recently, toxic levels of molybdenum have been reported in the herbage grown in certain areas of California (5). Digestive disturbances were noted on pasture, chiefly Ladino Clover, containing as little as 15 ppm of molybdenum.

Cunningham (21) stated that diseases of cattle on pastures high in molybdenum can be more simply regarded as a quantitative deficiency of copper. However, he also states that this view has been adopted only tentatively, since further study is needed to elucidate the mechanism of the copper-molybdenum antagonism.

METHODS

Sampling of Forages

Three types of roughages, green roughages obtained from the field, harvested hays, and silages, were used in this study. In all cases the prairie hay that was sampled was harvested by baling, and the sampling was done by taking a portion from the center of several bales of the crop. The prairie grasses were clipped from the meadow with a pair of hand shears. The clippings were made at various points in the meadow in an attempt to get a representative sample. Since this study was made to evaluate these samples for cattle feeds, any species of growth that cattle would not graze were not included in the sample. Also, when growth was prolific, an attempt was made to cut only that portion of the growth that was being grazed by the cattle. After sampling, all hays and grasses were transported to the laboratory in clean white cotton sacks. The silages were transported in plastic bags so that the moisture of the sample could be retained.

Immediately after the fresh grass was sampled in the field, a 50.0 g sample was weighed into a small paper sack and taken to the laboratory for a total moisture analysis. Total moisture of the silage was also determined after returning to the laboratory.

When the hay samples arrived at the laboratory, they were mixed thoroughly, quartered, placed in a paper sack, and stored in a sealed barrel until they could be ground for analysis. The alfalfa and prairie hays were first cut into shorter stems (6 inches or shorter) before mixing and quartering so that a more representative sample could be obtained from the large field sample. The fresh grass samples, however, were first placed in an open enameled pan, covered with kraft paper, and dried in a forced draft oven at 100°C for 10 to 12 hours. The prairie grass then was removed from the oven and left open in the room for 3 to 5 days to become stabilized with the moisture of the air. The samples then were mixed, quartered, and stored in the same manner as previously stated until they could be ground.

Analytical Methods

For the analysis of trace minerals, special precautions as described below are required to prevent the introduction of foreign matter into the sample.

The samples were ground in a small Wiley Mill which had a stainless steel seive (20 mesh) and from which the brass bin had been removed and replaced with a 6 inch glass funnel. Iron may still be a contaminant under these precautions as reported by Hood et al (47) in a study of contamination of plant samples by grinding.

Pyrex glassware was used exclusively throughout the various analytical procedures. The last traces of heavy metals were completely removed from the glassware as suggested by Piper (67), by dipping it in dilute hydrocholoric acid and rinsing with several portions of redistilled water. Small amounts of heavy metals are said to be bound to the glass surface, and can be removed only by replacement with other ions, such as hydrogen (67).

All liquid reagents used for the analysis of the trace minerals were distilled (66, 67). Concentrated nitric and sulfuric acids were distilled from an all-pyrex glass still. Concentrated hydrochloric acid was first diluted 1:1.65 with water and distilled as the constant boiling azeotrope (approx. 6 N). All acids were kept in polyethylene bottles after distillation. The ordinary distilled water was redistilled from an all-pyrex glass apparatus and stored in a pyrex carboy. To eliminate contact with rubber, the redistilled water was dispensed through Tygon tubing.[1]

The metal-dye color complexes for the magnesium, iron, cobalt, and molybdenum determinations were developed in a specially modified room to obtain dust free conditions. Also, the preparation of the sample, the arc spectrum of which was used for copper determination, was completed in this room. Work was done in this special room to reduce the chances of contaminating the samples by foreign matter of the air or that introduced by other workers that might be working in the common laboratory. This room had no windows and air was forced into it by a 10-inch aluminum alloy 4 bladed fan placed in front of a 19-inch by 24-inch opening covered by a 2-inch glass fiber filter. The room, therefore, was always under a slight positive pressure which prevented dust from coming in when entering the room. The entire room was painted with a plastic base paint,[2] except the varnished

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[1]U. S. Stoneware Co., Akron, Ohio.

[2]Tygon series K, self priming paint, U.S. Stoneware Co., Akron, Ohio.

door and ceramic sink, which were left in the original state. All iron and copper equipment, except heating equipment, if not already painted, was painted with the plastic paint. The floor of the room was washed at least once a week to remove any dust that may have been carried in on shoes.

Determination of Ash. Duplicate 2-g samples of each roughage were ashed at 550-600° C for 8 to 12 hours in a tared size 00 porcelain crucible. Ash was determined by weight difference.

Determination of Moisture. Duplicate 2-g samples of each roughage were placed in tared flat aluminum dishes and dried at 100° C for 10 to 12 hours in a drying oven. Moisture was determined by weight difference.

Determination of Ca, P, and Mn. Duplicate 10-g samples of each roughage were ashed in 50-ml porcelain crucibles at 550-600° C for 8 to 10 hours. Each ash then was treated with 10 ml of conc. hydrochloric acid, the sample was brought to a boil, filtered into 250 ml volumetric flasks, washed with several portions of distilled water, and made up to volume (65). This constituted the stock solution used for the determinations of calcium, phosphorus, and manganese, and will be designated as stock solution A.

Calcium. Calcium was determined by the A.O.A.C. official method (65) as follows. A 2-g aliquot (50 ml) of stock solution A was placed in a 400 ml beaker, heated to boiling, treated with 10 ml of saturated aqueous ammonium oxalate along with one drop of methyl red indicator. The solution was almost neutralized with 1:1 aqueous ammonium hydroxide and boiled until the precipitate was coarsely granular. It was then left standing until cool and more

1:5 aqueous ammonium hydroxide was added until the solution again appeared faintly pink. After the solution and precipitate stood for 4 hours, it was filtered and the precipitate was washed with distilled water until the filtrate was free from oxalates. The point of the filter paper was broken with a stirring rod and the precipitate washed into a beaker with 20 ml 1:5 hot aqueous sulfuric acid and 10 ml hot water. The resulting solution was then treated with 10 ml 1:5 aqueous sulfuric acid, heated to boiling, diluted to about 50 ml with distilled water, and titrated with 0.05 N potassium permanganate until near the end point. The filter was then placed into the solution and the titration completed as quickly as possible.

Phosphorus. Phosphorus was determined by the A.O.A.C. official method (65). An aliquot (15 ml) of stock solution A, corresponding to 0.6 g of roughage, was placed in a beaker and treated with 10 ml of concentrated nitric acid. The solution was made slightly basic with concentrated ammonium hydroxide and then slightly acid with 1:4 aqueous nitric acid. Twenty ml of molybdate solution[1] was added to the sample, and the mixture then placed in a shaker and shaken for 30 minutes. The solution was decanted at once through filter paper and the precipitate was washed by decantation with several portions of water. The pre-

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[1]The molybdate solution was prepared by dissolving 100 g of MoO_3 in a mixture of 144 ml of NH_4OH and 271 ml of H_2O which was cooled and poured slowly with constant stirring into a cool mixture of 489 ml of HNO_3 and 1, 148 ml H_2O and stored for several days. After several days the solution was decanted from the sediment. Each 100 ml of this solution was treated with 5 ml of HNO_3 which then constituted the molybdate solution.

cipitate was then transferred to the filter paper and washed with cold water until 2 fillings of the filter paper yielded a pink color upon addition of phenophthalein and one drop of standard alkali (0.1 N). Next the precipitate was transferred to a 300 ml Erlenmeyer Flask, dissolved with excess standard sodium hydroxide (Approx. 0.1 N) and then titrated with standard hydrochloric acid (approx. 0.1 N).

Manganese. Manganese was determined by the A.O.A.C. official method (65). A 100 ml aliquot of stock solution A, corresponding to 5 g of feed was treated with 15 ml of concentrated sulfuric acid and the solution was evaporated to about 30 ml. Ten ml of concentrated nitric acid was added and the solution was evaporated until the fumes of sulfur trioxide appeared. Then, while heating, water was added in small portions until all Fe salts were in solution and sufficient water added to make a volume of 150 ml. Approximately 0.3 g of potassium periodate was added in small portions and the solution boiled until the color of potassium permanganate showed no further increase in intensity. The solution was allowed to cool and diluted to 200 ml and transmission determined at 515 mμ were made with an Evelyn Photometer.

A standard absorption curve was prepared by starting with 100 ml of H_2O and 0.0015 g Fe as $FeCl_3 \cdot 6 H_2O$, equal to about the quantity of iron in the sample analyzed. Varying amounts of standard 0.05 N potassium permanganate were added also to this solution to get the series of manganese standards. These solutions were carried through the procedure as outlined above. The standards were diluted to 200 ml and transmission read at 515 mμ

wavelength and absorption curve prepared. The manganese in a majority of the samples ranged from 8 to 200 ppm (dry basis). Determinations had a precision of 1-8 ppm.

<u>Determination of Mg, Mo, Fe, and Cu</u>. Duplicate 10 g samples of each roughage were placed in 50 ml porcelain crucibles, covered with watch glasses, and ashed for 12 hours at 500-550° C. This ash was treated with 2 separate 4-ml portions of hydrogen peroxide (30 percent) and then 10 ml of constant boiling hydrochloric acid to put all salts of the ash into solution. The sample was dried, treated with 3 ml of constant boiling hydrochloric acid, heated to a boil and filtered through a previously acid washed (hydrochloric acid) filter paper into a 100 ml volumetric flask. The filter was washed with two 3-ml portions of constant boiling hydrochloric acid, followed by several washings with redistilled water. This solution, made up to 100 ml, was used as the stock solution for the determinations of magnesium, molybdenum, iron, and copper. This stock solution was designated as stock solution B.

Magnesium. The method of Young and Gill (85), modified slightly by Mason (61) was used for the determination of magnesium. The reagents and method used are as follows:

Reagents

1. Hydrochloric acid 3 N.
2. Sulfuric acid, concentrated.
3. Hydrogen peroxide, 30%.
4. Hydroxylamine, 1% (weight/volume).
5. Compensating solution,

	grams/liter
Calcium Chloride ($CaCl_2$)	1.40
Aluminum Sulfate ($Al_2(SO_4)_3 \cdot 18\ H_2O$	0.37
Manganous Sulfate ($MnSO_4 \cdot H_2O$)	0.16
Sodium Phosphate ($NA_3PO_4 \cdot H_2O$)	0.70

Copper Sulfate ($CuSO_4 \cdot 5H_2O$) 0.059
Hydrochloric Acid, Conc. 5 ml

6. Polyvinyl alcohol, Dupont, Elvanol Grade 71-24, 2% (weight/volume). Mix 20 g with about 400 ml of water, heat to about 90° C and stir until dissolved. Cool, dilute to 1 liter, and filter if not clear. Store in refrigerator.
7. Mixed reagent. Mix equal parts of 4, 5, and 6 just before using.
8. Thiazole yellow (0.01 % weight/volume).
9. Sodium hydroxide 10N. Prepared with low carbonate alkali.
10. Magnesium standard. Magnesium sulfate ($MgSO_4 \cdot 7H_2O$) was dehydrated by heating at 300° C for 7 hours. A standard solution containing 1 mg of Mg per ml was prepared by dissolving 1.2375 g of the anhydrous $MgSO_4$ in water and diluting to 250 ml.

Five ml of the stock solution B were diluted to 50 ml. One ml of this was placed in a colorimeter tube, followed by 4 ml of redistilled water, and 3 ml of the mixed reagent. The magnesium-dye complex was developed by adding 1 ml of the thiazole yellow and immediately adding 2 ml of the 10 N sodium hydroxide to each sample and mixing thoroughly. A blank and series of standards containing 0, 10, 20, 30, and 40 mg of magnesium was prepared for each set of magnesium determinations. After the color complex was developed, the solutions were left standing for 10 minutes and transmission was determined using an Evelyn Photometer at a wavelength of 515 mμ. The majority of samples analyzed had a magnesium content of 0.1 to 0.4 percent dry basis. Determinations showed a precision of 5 parts per thousand or less.

Molybdenum. The molybdenum determinations were made by the revised method of Ellis and Olson (32). A 50-ml aliquot of stock solution B, corresponding to 5 g of roughage, was placed in a beaker and slowly evaporated to dryness. A few ml of water were added, then an excess of concentrated aqueous ammonium hydroxide to precipitate iron. The sample was filtered through filter paper into a 25-ml volumetric flask, and the precipitate was washed several times with small amounts of water. The solution was treated with 5 ml of constant boiling hydrochloric acid, 2 ml of 10 percent potassium thiocynate, 8 ml of redistilled acetone, and made up to volume. These solutions were heated at 60-70° C for 20 minutes in a water bath and allowed to cool. The transmission was read at 420 mμ. A blank and set of standards containing 2, 5, 10, and 15 ppm of molybdenum were prepared for each set of molybdenum determinations.

Iron. The modification of the O-phenanthroline method given by Bandemer and Schaible (4) was employed for the determination of iron. A one ml aliquot of stock solution B, corresponding to 0.1 g of feed, was placed in a standardized Evelyn photometer tube, and treated with 1 ml of aqueous 0.5 percent O-phenanthroline, followed by the addition of 5 ml of sodium citrate (250 g/l). The solution was diluted to 25 ml with redistilled water and allowed to stand for 1 hour before determining transmission at 515 mμ. A blank and series of standards containing 2, 4, 6, 8, and 10 ppm iron per sample and 1 ml of constant boiling hydrochloric acid was prepared for each set of iron determinations. The iron standards were prepared with the use of 99.95 percent pure iron wire. The precision of these determinations over the range of 50 to 180 ppm was 1 to 11 ppm.

Copper. Copper was determined spectographically using the method developed by the Federal Soft Wheat Laboratories as described by Morris et al (63).

Reagents

Buffer salt[1]	g/l
$AlCl_3$[2]	2.85
$Li_2SO_4 \cdot H_2O$	31.0
$CdCl_2$	0.175
HCl(conc.)	89 ml

Stock Standard Solution

Element	g/l	Salt used	g salt/l
K	6.285	KH_2PO_4	21.95
P	5.00		
Ca	0.050	$CaCl_2$	1.385
Mg	2.500	$MgSO_4$	25.339
Mn	0.030	$MnCl_2.4H_2O$	0.108
Fe	0.100	$FeSO_4(NH_4)_2SO_4.6H_2O$	0.702
Na	0.427	NaCl	1.085
B	0.010	H_3BO_3	0.0572
Cu	0.020	$CuCl_2.2H_2O$	0.0537

All salts of the stock standard solution[3] were dissolved in approximately 200 ml of water and 40 ml of concentrated hydrochloric acid, except potassium dihydrogen phosphate which was dissolved separately and added. An additional 49 ml of concentrated hydrochloric acid was added and solution brought up to 500 ml with distilled water.

Series of Standards

Standard No.	ml Buffer	ml Stock St'd.[4]	mg Cu
Blank	4.00	0.00	0.00
0	3.95	0.05	0.001
1	3.90	0.10	0.002
2	3.75	0.25	0.005

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[1]All salts used for reagents were reagent grade

[2]$AlCl_3$ was first added to the water (slowly and with caution under hood in order to prevent spattering).

[3]The stock standard was prepared with these salts to simulate the same salt concentration as the samples analyzed

[4]Stock standard solution diluted 1:1 with distilled water before use.

Standard No.	ml Buffer	ml Stock St'd.	mg Cu
3	3.50	0.50	0.010
4	3.25	0.75	0.015
5	3.00	1.00	0.020

Two ml of the stock sample B were placed in a small vial and evaporated slowly to dryness on a hot plate. Four ml of buffer solution were added to the residue, and the resulting solution used for the sample. Duplicate electrodes for each of the above samples were prepared by placing 0.1 ml of the buffer solution on a previously prepared and waxed electrode.[1] This electrode was placed in an oven at 70-80° C for 5 to 6 hours after which time the oven was turned up to 100-110° C and left for another 4 to 6 hours. The arc spectrum of each sample placed on the electrode was taken at position 5 (focus 108, tilt 242) on the Littrow Spectrograph using a slit width of 60 μ, 1/2 sector, and 30 second exposure. To avoid deliquescence of moisture, the electrodes were placed in a desiccator after they were removed from the oven and previous to being arced. Eastman 33 photographic plates were used and were developed for 5 minutes at 20° C in x-ray developer. The density of the copper line (3274 Å) and internal standard cadmium line (3406 Å) was determined with the use of the densitometer.[2] The log of the Cd/Cu ratio for each line of the standard was plotted against the log of concentration

[1]One end of each electrode was cupped by the use of a lathe. An excess of a concentrated carbon tetrachloride carnauba wax solution was placed in the cut and the CCl_4 evaporated in a drying oven.

[2]A. R. L. Dietert, Applied Research Laboratories.

of the copper for that line. The amount of copper in each sample was determined from this plot by means of the Cd/Cu ratio for each electrode arced. The precision obtained by this method over the range of 8 to 45 ppm was 0 to 6 ppm.

Determination of Cobalt. The procedure employed for the determination of cobalt was a modification of one used by Gregory and Beeson (41). Ten grams of the finely ground plant material were placed in 50 ml porcelain crucibles and treated with 5 to 8 ml of redistilled concentrated sulfuric acid. The crucibles were heated slowly on an electric heater to drive off the excess sulfuric acid and then placed in a muffle furnace and ashed at 550-600° C for 8 to 12 hours. The ash was treated with 10 ml of constant boiling hydrochloric acid, heated to boiling, filtered into 50 ml beakers, washed several times with redistilled water and evaporated slowly to dryness. Ten ml of a solution containing 0.05 ml of concentrated nitric acid and 3.00 ml of constant boiling hydrochloric acid were added to the residue. The solution again was boiled and filtered. To this filtrate was added 2 ml of 0.1 percent nitroso-R-salt and about 2 g of sodium acetate. The solution was placed on an electric heater and boiled for 45 seconds and then sufficient hydrochloric acid (constant boiling) to effect the solution of excess sodium acetate plus 3 ml of acid in excess were added. The solution was boiled again for 45 seconds, placed in the dark and allowed to cool. A blank and series of standards containing 1, 2, 3, 4, and 5 ppm of cobalt was made for each set of samples analyzed. The standard was prepared with dehydrated reagent grade $CoCl_2 \cdot 6\ H_2O$. Each solution was brought to 20 ml and the transmission determined at a wave-length of 515 mμ. The precision of these determinations over the range of 0.08 to 0.36 ppm was 0.00 to 0.03 ppm.

RESULTS

Climatological Data

The total rainfall recorded for the year of 1951 at several stations in Labette County was considerably above the normal, approximately 40.00 inches (80). The Parsons Station recorded a total precipitation of 51.55 inches, 11.33 inches above normal, and the Oswego Station recorded 56.73 inches, 16.45 inches above normal. In October, 1951, the U. S. Weather Bureau established a weather station at the Mound Valley Branch Experiment Station (81). During 1952, this station recorded a total rainfall of 26.53 inches, 13.47 inches below normal, and the Oswego Station recorded 25.43 inches, 14.85 inches below normal. The average for the Southeastern division was 22.74 inches, 14.57 inches below normal. The relative locations of these stations is noted on the map of Labette County, Fig. A-1, appendix.

Soil Data

According to the map (52), most of the soils of Labette County are Parsons Silt Loam and all samples were taken from farms that were of this same soil type. All the soils of this area were, in general, acidic at one time, according to Smith (73), but in recent years much of the cultivated ground has been limed so that many recent soil tests indicate a less acidic condition. However, many of the meadows of this area were never limed, and therefore are probably acidic.

Calcium Content of Roughages

The results of the calcium determinations, (Table 1) indicate that the alfalfa hay contained considerably more calcium than the other forages which were analyzed. On the average the alfalfa hay samples contained 3 times as much calcium as the prairie grasses and about 4 times as much as the silages. Alfalfa hays ranged from 1.26 to 1.70 percent calcium, dry basis. The prairie grasses varied from 0.17 to 0.82 percent calcium and the prairie hays 0.28 to 0.75 percent. The 4 silages had a calcium content ranging from 0.28 to 0.41 percent on a moisture free basis.

On a dry matter basis the calcium content of the prairie grasses did not vary with the time of the season that the samples were taken. However, a variation in calcium content of the prairie hays was observed. Hays harvested during the summer of 1951 averaged 0.39 percent calcium on a moisture free basis whereas hays of the summer of 1952 averaged 0.63 percent.

Phosphorus Content of Roughages

The phosphorus content of the roughages of this study fall within a wide range (Table 1). The phosphorus content of the alfalfa hays varied from 0.25 to 0.49 percent and on the average were slightly higher than the phosphorus content found in the other roughages. The prairie grasses ranged from 0.15 to 0.48 percent phosphorus and the silages varied from 0.18 to 0.44 percent phosphorus on a moisture-free basis.

Table 1. The moisture, ash, calcium, and phosphorus content of roughages (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-9-52	Prairie grass[2] 5-1-52	72.05	8.85	0.41	0.33
MVS-10-52	Prairie grass 5-3-52	67.00	8.45	0.44	0.24
MVS-11-52	Prairie grass 5-3-52	74.52	9.00	0.38	0.48
MVS-12-52	Prairie grass 5-3-52	73.30	7.95	0.48	0.34
MVS-13-52	Prairie grass 5-3-52	70.99	8.00	0.42	0.22
MVS-15-52	Prairie grass 6-9-52	63.05	7.00	0.60	0.19
MVS-16-52	Prairie grass 6-10-52	64.36	8.85	0.81	0.17
MVS-17-52	Prairie grass 5-10-52	60.45	6.50	0.55	0.15
MVS-20-52	Prairie grass 6-10-52	62.64	6.75	0.32	0.21
MVS-22-52	Prairie grass 6-9-52	62.46	7.04	0.43	0.16
MVS-23-52	Prairie grass 7-28-52	59.30	9.30	0.82	0.24
MVS-18-52	Prairie grass 7-28-52	56.98	7.70	0.42	0.26
MVS-27-52	Prairie grass 7-28-52	44.05	6.95	0.39	0.17
MVS-24-52	Prairie grass 7-28-52	60.80	7.45	0.41	0.25
MVS-31-52	Prairie grass 10-3-52	53.56	7.35	0.53	0.15

Table 1. (Con't.)

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-32-52	Prairie grass 10-3-52	49.17	6.45	0.17	0.23
Range, prairie grasses	Low	44.05	6.45	0.17	0.15
	High	74.52	9.30	0.82	0.48
MVS-1-52	Prairie hay[3] 3-14-52	7.26	6.45	0.33	0.19
MVS-3-52	Prairie hay3 3-14-52	7.51	6.40	0.50	0.19
MVS-5-52	Prairie hay[3] 3-14-52	7.56	6.00	0.44	0.22
MVS-6-52	Prairie hay[3] 3-14-52	7.09	7.85	0.39	0.19
MVS-7-52	Prairie hay[3] 3-14-52	7.38	5.95	0.28	0.23
MVS-30-52	Prairie hay[3] 3-14-52	7.31	6.20	0.30	0.13
MVS-38-52	Prairie hay[3] 4-11-52	8.42	7.00	0.44	0.13
Average for 1951 harvested hays[3]		7.50	6.55	0.39	0.18
MVS-25-52	Prairie hay[4] 7-28-52	8.94	6.15	0.59	0.14
MVS-35-52	Prairie hay[4] 11-11-52	7.28	8.37	0.75	0.17
MVS-36-52	Prairie hay[4] 11-11-52	6.99	8.20	0.58	0.13
MVS-39-52	Prairie hay[4] 11-11-52	7.31	8.00	0.61	0.09
Average for 1952 harvested hays[4]		7.63	7.68	0.63	0.13

Table 1. (Concl.)

Sample number	Sample and date sampled	Sample moisture	Ash %	Ca %	P %
MVS-2-52-	Corn silage 3-14-52	35.05	6.85	0.28	0.34
MVS-33-52	Corn silage 11-11-52	28.20	6.67	0.41	0.44
MVS-34-52	Cane silage 11-11-52	32.90	6.05	0.41	0.18
MVS-37-52	Cane silage 11-11-52	29.90	6.42	0.36	0.22
Range, silages	Low	28.20	6.05	0.28	0.18
	High	35.05	6.85	0.41	0.44
MVS-8-52	Alfalfa hay 3-15-52	8.20	8.90	1.45	0.43
MVS-21-52	Alfalfa hay 6-9-52	10.58	7.50	1.26	0.49
MVS-28-52	Alfalfa hay 7-28-52	9.97	8.25	1.31	0.27
MVS-29-52	Alfalfa hay 7-28-52	9.68	7.95	1.26	0.38
MVS-26-52	Alfalfa hay 7-28-52	8.82	8.70	1.70	0.36
MVS-19-52	Alfalfa hay 7-28-52	9.19	6.32	1.54	0.25
Range, Alfalfa hay	Low	8.20	6.32	1.26	0.25
	High	10.58	8.90	1.70	0.49
MVS-4-52	Lespedeza hay 3-14-52	7.77	5.45	0.94	0.23
MVS-14-52	Brome grass 5-3-52	78.28	8.35	0.53	0.45

[1]Analytical data and the descriptions of each sample are summarized for each farm in the appendix.

[2]All prairie grass and prairie hay samples were principally bluestem.

[3]These hays were harvested in 1951 but sampled in 1952.

[4]These hays were harvested in 1952 and sampled in 1952.

The phosphorus content of some of the prairie hays harvested during the summer of 1951 were greater than any sampled during 1952. Hays harvested during 1951 contained an average of 0.18 percent phosphorus on a dry basis whereas those of the 1952 summer contained 0.13 percent.

The calcium/phosphorus ratios for the prairie hays that were harvested during the summer of 1951, ranged from 1.22 to 3.38, average 2.19. Hays harvested during the summer of 1952 had ratios ranging from 4.21 to 6.78, average 4.97. The calcium/phosphorus ratios for the other roughages, except the legumes, fell, with few exceptions, between 2:1 to 1:2. The legumes, which on an average contain considerably more calcium than phosphorus, had ratios varying from 2.57 to 6.16.

Magnesium Content of Roughages

The magnesium content (Table 2) of the prairie grasses ranged from 0.13 to 0.37 percent of the dry matter. The magnesium content of the prairie hays ranged from 0.11 to 0.34 percent and the alfalfa hays ranged from 0.16 to 0.42 percent (moisture free basis). The silage samples had a higher average magnesium content than any of the other forages analyzed.

There were no apparent differences in the magnesium content of the samples obtained at different stages of growth or at different times of the year.

Cobalt Content of Roughages

The cobalt content of the prairie grasses which were sampled

Table 2. The magnesium, cobalt, copper, iron manganese, and molybdenum content of roughages (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-9-52	Prairie grass[2] 5-1-52	0.20	--[3]	26	148	185	1.3
MVS-10-52	Prairie grass 5-3-52	0.14	0.21	12	250	107	1.3
MVS-11-52	Prairie grass 5-3-52	0.23	0.17	8	187	84	1.0
MVS-12-52	Prairie grass 5-3-52	0.25	0.19	21	135	177	1.2
MVS-13-52	Prairie grass 5-3-52	0.16	0.21	16	147	219	1.4
MVS-15-52	Prairie grass 6-9-52	0.37	0.10	6	90	113	1.2
MVS-16-52	Prairie grass 6-10-52	0.36	0.15	19	262	66	0.8
MVS-17-52	Prairie grass 6-10-52	0.27	0.22	10	66	127	1.2
MVS-20-52	Prairie grass 6-10-52	0.13	0.13	17	89	88	1.8
MVS-22-52	Prairie grass 6-9-52	0.23	0.13	26	67	118	0.8
MVS-23-52	Prairie grass 7-28-52	0.34	0.17	52	86	74	0.7
MVS-18-52	Prairie grass 7-28-52	0.23	0.18	13	171	86	2.4
MVS-27-52	Prairie grass 7-28-52	0.15	0.11	14	123	105	1.6
MVS-24-52	Prairie grass 7-28-52	0.18	0.08	50	70	144	0.6
MVS-31-52	Prairie grass 10-3-52	0.20	0.12	12	90	99	0.6

Table 2. (Cont.)

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-32-52	Prairie grass 10-3-52	0.16	0.11	31	102	96	1.0
Range, prairie grasses	Low	0.13	0.08	6	66	66	0.6
	High	0.37	0.22	52	262	219	2.4
MVS-1-52	Prairie hay[4] 3-14-52	0.11	0.20	30	66	24	2.2
MVS-3-52	Prairie hay[4] 3-14-52	0.24	0.17	24	76	197	1.6
MVS-5-52	Prairie hay[4] 3-14-52	0.25	0.24	18	46	116	1.5
MVS-6-52	Prairie hay[4] 3-14-52	0.20	0.28	24	41	131	1.5
MVS-7-52	Prairie hay[4] 3-14-52	0.17	0.21	39	22	59	2.0
MVS-30-52	Prairie hay[4] 3-14-52	0.18	0.12	19	62	85	1.5
MVS-38-52	Prairie hay[4] 4-11-52	0.24	0.13	16	70	142	0.7
Average for 1951 harvested hays[4]		0.20	0.19	24	55	108	1.6
MVS-25-52	Prairie hay[5] 7-28-52	0.24	0.09	8	78	130	1.1
MVS-35-52	Prairie hay[5] 11-11-52	0.22	0.11	32	111	158	0.3
MVS-36-52	Prairie hay[5] 11-11-52	0.34	0.16	30	198	172	0.5
MVS-39-52	Prairie hay[5] 11-11-52	0.28	0.13	34	124	364	1.0
Average for 1952 harvested hays[5]		0.27	0.12	26	128	206	0.7

Table 2. (Con't.)

Sample number	Sample and date sampled	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-2-52	Corn silage 3-14-52	0.17	0.36	17	252	53	1.0
MVS-33-52	Corn silage 11-11-52	0.38	0.11	32	108	54	1.1
MVS-34-52	Cane silage 11-11-52	0.39	0.11	35	161	50	0.9
MVS-37-52	Cane silage 11-11-52	0.45	0.12	33	134	60	0.8
Range, silages	Low	0.17	0.11	17	108	50	0.8
	High	0.45	0.36	35	252	60	1.1
MVS-8-52	Alfalfa hay 3-15-52	0.29	0.20	36	34	32	1.3
MVS-21-52	Alfalfa hay 6-9-52	0.16	0.12	17	131	9	0.8
MVS-28-52	Alfalfa hay 7-28-52	0.34	0.14	16	122	18	1.3
MVS-29-52	Alfalfa hay 7-28-52	0.20	0.14	19	89	19	1.2
MVS-26-52	Alfalfa hay 7-28-52	0.28	0.09	19	83	18	1.2
MVS-19-52	Alfalfa hay 7-28-52	0.42	0.29	8	160	6	1.9
Range,	Low	0.16	0.09	8	34	6	0.8
Alfalfa hays	High	0.42	0.29	36	160	32	1.9

Table 2. (Concl.)

Sample number	Sample and date sampled	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-4-52	Lespedeza hay 3-14-52	0.27	0.30	16	97	90	1.3
MVS-14-52	Brome grass	0.21	0.17	26	150	32	2.9

[1]Analytical data and the descriptions of each sample are summarized for each farm in the appendix.

[2]All prairie grasses and prairie hay samples were principally bluestem.

[3]Not sufficient sample for cobalt determination.

[4]These hays were harvested in 1951 but sampled in 1952.

[5]These hays were harvested in 1952 and sampled in 1952.

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for this study varied from 0.08 to 0.22 ppm on a moisture free basis (Table 2). Those prairie hays that were harvested during the summer of 1951 ranged from 0.12 to 0.28 ppm of the dry matter, and those harvested during the summer of 1952 ranged from 0.09 to 0.16 ppm of the dry matter. The alfalfa hays ranged from 0.09 to 0.29 ppm of cobalt, dry basis, and the silages varied from 0.11 to 0.36 ppm. The one sample of alfalfa hay that was harvested in 1951 (MVS-8-52) had a higher cobalt content than 4 of the other 5 samples harvested in 1952. One corn silage sample, (MVS-2-52) that was harvested during 1951 had a cobalt content of 0.36 ppm compared to the sample of silage harvested in 1952 which contained 0.11 to 0.12 ppm cobalt.

Copper Content of Roughages

The copper content of the prairie grasses ranged from 6 to 52 ppm, the prairie hays ranged from 8 to 39 ppm, the alfalfa hays ranged from 8 to 36 ppm and the silages ranged from 17 to 35 ppm, all on a moisture free basis (Table 2). The average copper content of silages was greater than that of other roughages analyzed in this study, although some individual samples of other roughages contained more copper than any of the silages.

There were no apparent trends in copper content of the roughages with the stage of growth or maturity of sample.

Iron Content of Roughages

The iron content of the roughage samples analyzed for this survey varied over a wide range (Table 2). The iron content of the prairie grasses varied from 66 to 262 ppm. Most of the lower values were observed in the more mature plant. The prairie hays that were harvested during the 1951 summer averaged 55 ppm iron, and ranged from 22 to 76 ppm, on a moisture free basis. Prairie hays harvested during the 1952 summer averaged 128 ppm, and ranged from 78 to 198 ppm on a moisture free basis. The iron content of the alfalfa hay samples varied between 34 and 160 ppm and the silage samples from 108 to 252 ppm on a dry basis.

The samples of silages contained, on the average, more iron than the other roughages analyzed.

Manganese Content of Roughages

The manganese content of the forages sampled for this study showed a wide range (Table 2.) The prairie grasses varied from 66 to 219 ppm, the prairie hays from 24 to 364 ppm, the alfalfa hays from 6 to 32 ppm and silages from 50 to 60 ppm of dry matter. The prairie hays that were harvested during the summer of 1951 averaged 108 ppm manganese, range 24 to 197 ppm, on a moisture free basis. Those hays harvested during the 1952 summer averaged 206 ppm manganese, range 130 to 364 ppm.

No distinctive relationships in the concentration of manganese and stage of growth or maturity of the forages were observable.

Molybdenum Content of Roughages

The range in the content of molybdenum found in the samples analyzed was rather narrow (Table 2). The prairie grasses varied between 0.6 to 2.4 ppm molybdenum on a dry matter basis, the silages from 0.8 to 1.1 ppm and the alfalfa hays from 0.8 to 1.9 ppm. The prairie hays that were harvested during the 1951 summer contained, on an average, twice as much molybdenum as those hays harvested during the 1952 summer; 1.6 ppm compared to 0.7 ppm, on a dry matter basis.

DISCUSSION

The National Research Council (57) has recommended for the maintenance of mature cows an allowance of 0.165 percent calcium of the total dry matter intake. Also, for every pound of milk that any cow might be producing it should receive, in addition to the allowance for maintenance, 1.0 g of calcium. Calculating from these allowances, it was recommended by the council that if a 1200 pound cow is producing 30 pounds of milk a day, the ration should contain 0.57 percent calcium on a dry basis. From an examination of the data of this study, it is apparent that the prairie grasses, silages, and prairie hays harvested during the 1951 summer do not satisfy these allowances whereas the prairie hays harvested during 1952 and the alfalfa hays contain sufficient calcium to meet the recommended daily allowance for optimum production. If a cow is capable of producing more milk per day, the calcium intake from the forages, except the alfalfa hays, might limit production if not supplemented with calcium.

In the case of phosphorus the National Research Council (57) recommends 0.165 percent phosphorus for the maintenance of a mature cow and for every pound of milk produced, it should receive 0.7 g of phosphorus in addition to the maintenance allowance. If one again assumes that a 1200 pound cow produces 30 pounds of milk and consumes 16 pounds of dry matter per day (57) it would need a ration containing 0.45 percent phosphorus in the dry matter. The National Research Council (57) also recommends that a pregnant cow should receive a ration containing 0.23 percent calcium and 0.18 percent phosphorus during the last 3 months of pregnancy.

It is apparent that the roughages taken would satisfy these allowances, only in a few instances, if fed alone. In many cases the prairie grasses and especially the prairie hays do not meet even the minimum requirements of phosphorus (0.13 percent of dry matter) as determined by Black et al (16). Indeed, Hart et al (44) have noted symptoms of phosphorus deficiency in cattle on sweet clover pasture containing 0.098 to 0.124 percent phosphorus. Eckles et al (29) noted that roughages from a phosphorus deficient area contained in the case of alfalfa, 0.19 percent phosphorus on a dry matter basis; timothy hay, 0.107 percent; and prairie hay, 0.100 percent.

The National Research Council (57) also tentatively recommends that the ratio of calcium to phosphorus in the total ration fed to dairy cattle be between 1:1 and 2:1, since wider ratios have been shown to depress utilization of these elements. The calcium to phosphorus ratios for the prairie grasses are in this range. However, the prairie hays analyzed had much wider ratios, especially those hays harvested during the summer of 1952. These wide ratios seem to be the result of increased calcium content and decreased phosphorus content of forages harvested during 1952.

Dairymen will usually feed a grain supplement to dairy cattle producing milk. If these roughages were fed with no grain or phosphorus supplement or with a supplement high in calcium, the high calcium content of the ration as compared to the phosphorus content might depress the utilization of phosphorus which is present in less than optimum amounts and cause symptoms of a phosphorus deficiency. Therefore, in supplementing these rations, attention should be given to the calcium/phosphorus ratio; in other words these rations should include a feed high in phosphorus and fairly low in calcium, for example cereal grains. A calcium and phosphorus mineral supplement may be used also. If grain is not fed milk production may be limited both from the standpoint of energy and phosphorus intake.

The samples analyzed in this study contain cobalt in excess of the satisfactory level of 0.1 ppm of dry matter, as given by Davis (23). Wunsch (83) found that the forages from "healthy" pastures contained on an average 0.106 ppm cobalt, whereas those from "unhealthy" pasture contained 0.07 ppm.

The copper contents of the forages sampled in Labette County were in excess of those observed in the forages of areas (15) in which a copper deficiency has been reported. The molybdenum contents of the forages were lower than the upper concentrations of forages reported by Ferguson et al (37) to be typical of the molybdenum content of pastures from healthy areas. Since the molybdenum contents of the forages sampled for this survey are apparently not great enough to markedly increase copper requirements, it appears that there is no inherent copper deficiency in the natural forages of Labette County.

The approximate requirement that the Eastern Feeds Exchange (84) has accepted as a guide for iron nutrition of dairy cattle is 30-50 ppm on a dry basis, as calculated from requirements of other animals. All the roughages analyzed, except one prairie hay, had an iron content in excess of 30 ppm. From this it seems probable that one can assume no inherent iron deficiency in the roughages of Labette County.

The average iron content was higher in the silages than in the other forages. This might be due to contamination of the feed during the processing in which iron could be introduced by soil or by the processing.

The magnesium and manganese contents of all samples analyzed were in excess of the requirements that have been tentatively adopted as brought out in the review. Neither does the manganese content reach levels that have been demonstrated by Gallup and his coworkers (39) to disturb phosphorus metabolism. Molybdenum concentrations averaged much less than 5 ppm of dry matter, which was reported by Ferguson et al (36) to be the average molybdenum content of the healthy pastures of England.

It is interesting to note that the calcium, iron, and manganese contents of the prairie hays were higher, on the average, for those hays harvested during the dry summer of 1952 than the hays harvested during the summer of 1951, the year in which above average rainfall was recorded. The growth of the forages was probably much greater during the 1951 summer and one might expect a dilution of the mineral content under these conditions. The cobalt and molybdenum content of the prairie hays were, however, higher for those hays harvested during the summer of 1951. More detailed studies will need to be made of the climate and soils of this area, Labette County, before a satisfactory postulation of the interrelationships of these data can be given.

According to Smith (73) the soils of Labette County are generally acidic, especially the meadows. Therefore, since it is known that acidic soils tend to increase the availability of manganese and iron (17), this might account in part for the wide ranges of manganese and iron content of the forages from different farms.

According to information from local agricultural specialists (51, 53) several farmers of Labette County, especially dairy men, are supplementing their feeds with trace minerals. This practice seems to be more prevalent during the winter than during the summer grazing months. Also, several commercial feeds manufactured in this area are fortified with trace minerals.

The contents of each of the trace minerals in the roughages, that were sampled from Labette County and were analyzed in this survey, meet the allowances, requirements or recommended amounts that have been adopted by leading nutritionalists of this country and abroad as presented in the literature review. The feeding of trace minerals to livestock, therefore, as mentioned above, probably is not necessary, if the practice is judged by the results of this study. However, the supplementation of the roughages of Labette County with calcium and phosphorus, as judged by the calcium and phosphorus content of the samples analyzed is indicated. The amounts to be used must be decided by taking into account the type of cattle, production level, and type of feeds being used.

SUMMARY

The purpose of this study was to evaluate the trace mineral contents of roughages grown in Southeastern Kansas, especially Labette County. Thirty-nine roughage samples (16 prairie grasses, 11 prairie hays, 6 alfalfa hays, 4 silages, 1 lespedeza hay, and 1 brome grass) were obtained from 9 farms in Labette County and analyzed for cobalt, copper, iron, magnesium, manganese, and molybdenum. In order to characterize the mineral content of feeds further, determinations were made of moisture (at time of sampling), ash, calcium, and phosphorus.

The ranges in the contents of the various minerals of the prairie grasses were as follows (dry basis): calcium, 0.17 to 0.82 percent; phosphorus, 0.15 to 0.48 percent; magnesium, 0.13 to 0.37 percent; cobalt, 0.08 to 0.22 ppm; copper, 6 to 52 ppm; iron, 66 to 262 ppm; manganese, 66 to 219 ppm; and molybdenum, 0.6 to 2.4 ppm.

The prairie hay samples were obtained from crops that were harvested during both 1951 and 1952. Hays harvested during 1951 had an average mineral content (dry basis) as follows: calcium, 0.39 percent; phosphorus, 0.18 percent; magnesium, 0.20 percent; cobalt, 0.19 ppm; copper, 24 ppm; iron, 55 ppm; manganese, 108 ppm; and molybdenum, 1.6 ppm. The hays harvested during 1951 averaged (dry basis): calcium, 0.63 percent; phosphorus, 0.13 percent; magnesium, 0.27 percent; cobalt, 0.12 ppm; copper, 26 ppm; iron, 128 ppm; manganese, 206 ppm; and molybdenum, 0.7 ppm. The contents of calcium, magnesium, copper, iron, and manganese

were higher in the hays harvested during the dry summer of 1952 whereas the phosphorus and molybdenum contents were lower than in the hays harvested during the summer of 1951.

The ranges in the contents of the various minerals of the silages were as follows (dry basis): calcium, 0.28 to 0.41 percent; phosphorus, 0.18 to 0.44 percent; magnesium, 0.17 to 0.45 percent; cobalt, 0.11 to 0.36 ppm; copper, 17 to 35 ppm; iron, 108 to 252 ppm; manganese, 50 to 60 ppm; molybdenum, 0.8 to 1.1 ppm. The iron content of the silages was higher than any of the other roughages analyzed, possibly due to contamination of the feed during processing. The ranges in the contents of the various minerals of the alfalfa hays were as follows (dry basis): calcium, 1.26 to 1.70 percent; phosphorus, 0.25 to 0.49 percent; magnesium, 0.16 to 0.42 percent; cobalt, 0.09 to 0.29 ppm; copper, 8 to 36 ppm; iron, 34 to 160 ppm; manganese, 6 to 32 ppm and molybdenum, 0.8 to 1.9 ppm.

The calcium and phosphorus content of the forages analyzed in this survey, with few exceptions, did not meet the National Research Council's recommended allowance for a good lactating cow (1200 pound, 30 pounds milk daily), if fed with no supplement. Whereas calcium content of the forage is sufficiently high for maintenance of the normal animal, the phosphorus content does not satisfy the maintenance requirement in many instances.

The comparison of the level of each trace mineral found in the roughages of this survey with the accepted allowances or recommended trace mineral amount for optimum production, indicate that there probably are no general trace mineral deficiencies in the roughages of Labette County. Therefore, the trace mineral supplementation of roughages of Labette County is probably not necessary, if judged by the results of this survey.

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APPENDIX

DESCRIPTION OF SAMPLES

MVS-1-52

Prairie hay, principally bluestem, sampled 3-14-52 from the Roy Nelson Farm. The hay was harvested during the 1951 summer by baling and the bales were left on the ground as dropped from the baler through the winter of 1951-1952.

MVS-2-52

Corn silage. Sampled 3-14-52 from the Roy Nelson Farm. Fairly dry corn, which was harvested from ground that was limed about 6 years ago, and fertilized about 3 years ago, was put in the silo.

MVS-3-52

Prairie hay, principally bluestem, sample obtained from the Arthur Lavender Farm 3-14-52. Hay was harvested in summer of 1951 from ground which had not been fertilized.

MVS-4-52

Lespedeza hay. Sampled 3-14-52 from Arthur Lavender Farm.

MVS-5-52

Prairie hay, principally bluestem, sampled from William Hunter Farm from crop that was harvested in August, 1951. The meadow is adjacent to a creek, and the ground may be classified as semi-creek bottom.

MVS-6-52

Prairie hay, principally bluestem, sampled 3-14-52 from Walter Peterson Farm from hay that was harvested during summer of 1951.

MVS-7-52

Prairie hay, principally bluestem, sampled 3-15-52 from Wayne McNickle Farm, harvested during summer of 1951, from meadow that had not, to knowledge of owner, been limed.

MVS-8-52

Alfalfa hay, sampled 3-15-52 from Wayne McNickle Farm from crop that was harvested during the summer of 1951. The plot had been limed 3 years ago.

MVS-9-52

Prairie grass, principally bluestem, sampled 5-12-52 from Arthur Lavender Farm. Sample taken from meadow adjacent to meadow that MVS-3-52 was sampled. The growth was very short, and the pasture contained considerable buck brush.

MVS-10-52

Prairie grass, principally bluestem, sampled 5-3-52 from same meadow that MVS-5-52 was harvested. The pasture which was being pastured at the time of sampling belonged to William Hunter.

MVS-11-52

Prairie grass, principally bluestem. Sampled 5-3-52 from Floyd Hunter's pasture and was being grazed at time of sampling.

MVS-12-52

Prairie grass, principally bluestem, sampled 5-3-52 from the meadow that the Mound Valley Branch Experiment Station was harvesting for their local hay.

MVS-13-52

Prairie grass, principally bluestem, sampled 5-3-52 from Roy Nelson's pasture from which MVS-7-52 was harvested.

MVS-14-52

Brome grass sample obtained from Orville Bussman Farm. The grass looked hearty and had a good growth. Sampled 5-3-52.

MVS-15-52

Prairie grass, principally bluestem. Sampled 6-9-52 from same meadow as MVS-12-52 and growth was about the same.

MVS-16-52

Prairie grass, principally bluestem sampled 6-10-52 from same meadow as MVS-9-52. The growth was very short and was not being grazed.

MVS-17-52

Prairie grass, principally bluestem, sampled 6-10-52 from same meadow as MVS-10-52. Pasture was not being grazed at time of sampling.

MVS-18-52

Prairie grass, principally bluestem, sampled 7-28-52 from same plot that MVS-11-52 was sampled. The pasture had a good growth.

MVS-19-52

Alfalfa hay sampled 7-28-52 from 1st cutting of hay harvested by Floyd Hunter. Yield was good, but hay was stemmy and rank.

MVS-20-52

Prairie grass, principally bluestem, sampled 6-10-52 from same plot as MVS-13-52.

MVS-21-52
Alfalfa hay sampled 6-9-52 from the 1st cutting harvested by Orville Bussman during the 1952 summer. Hay was stemmy.

MVS-22-52
Prairie grass, principally bluestem, sampled 6-9-52 from Joseph Oakleaf Farm. Growth of grass was short.

MVS-23-52
Prairie grass, principally bluestem, sampled 7-28-52. Same conditions as MVS-16-52.

MVS-24-52
Prairie grass, principally bluestem, sampled 7-28-52 from meadow which had a cutting of hay removed, and same meadow from which MVS-17-52 was sampled.

MVS-25-52
Prairie hay, principally bluestem, sampled 7-28-52 from 1st cutting of hay mentioned under MVS-24-52.

MVS-26-52
Alfalfa hay sampled from the second cutting that Orville Bussman harvested. Sample obtained 7-28-52. First crop sample was MVS-21-52.

MVS-27-52
Prairie grass, principally bluestem, sampled 7-28-52. Same conditions apply as sample MVS-20-52.

MVS-28-52
Alfalfa hay, sampled 7-28-52 from 1st cutting that Wayne McNickle harvested, from same field that MVS-8-52 was harvested. The yield was good, but the hay was stemmy.

MVS-29-52
Alfalfa hay, sampled 7-28-52 from second cutting of hay harvested by Wayne McNickle. First cutting sample was MVS-28-52.

MVS-30-52
Prairie hay, sampled 3-14-52 from crop harvested during fall of 1951. Sample was ground with a large Wiley Mill, which may have increased the iron and copper content.

MVS-31-52
Prairie grass, principally bluestem, sampled 10-3-52. Same conditions as MVS-10-52.

MVS-32-52
Prairie grass, principally bluestem, sampled 10-3-52. Same conditions as MVS-22-52.

MVS-33-52
Corn silage sample obtained 11-5-52 from William Hunter Farm.

MVS-34-52
Silage sample (cane) obtained 11-11-52 from Roy Nelson Farm. The sample contained a considerable amount of grain.

MVS-35-52
Prairie hay, principally bluestem sampled from crop that was harvested from same meadow as MVS-6-52. Sample obtained 11-11-52.

MVS-36-52
Prairie hay, principally bluestem sampled 11-11-52 from crop that was harvested from same meadow that MVS-7-52 was harvested.

MVS-37-52
Silage (cane sorghum) sampled 11-11-52 from Floyd Hunter Farm.

MVS-38-52
Prairie hay, principally bluestem, sampled 4-11-52. Same hay as MVS-30-52, but sampled at a later date.

MVS-39-52
Prairie hay, principally bluestem, sampled 11-11-52 from crop that was harvested from same plot as MVS-3-52.

LABETTE COUNTY KANSAS MAP

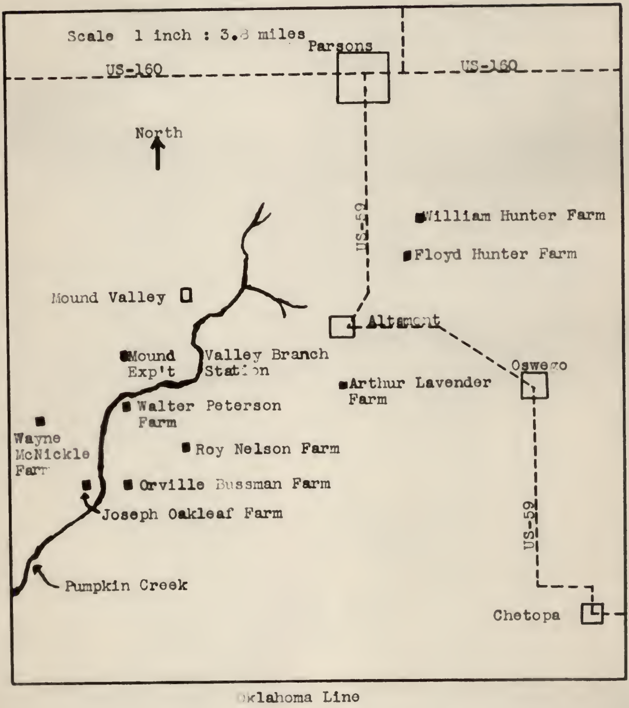

Fig. A-1. The map of Labette County, Kansas, with the approximate location of farms from which samples were obtained. Basic map from (52).

Table A-1. The moisture, ash, calcium, and phosphorus content of forages from the Roy Nelson Farm (dry basis).

Sample Number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-1-52	Prairie hay 3-14-52	7.26	6.45	0.33	0.19
MVS-13-52	Prairie hay 5-3-52	70.90	8.00	0.42	0.22
MVS-20-52	Prairie grass 6-10-52	62.64	6.75	0.32	0.21
MVS-27-52	Prairie grass 7-28-52	44.05	6.95	0.39	0.17
MVS-2-52	Corn silage 3-14-52	35.05	6.85	0.28	0.34
MVS-34-52	Cane silage 11-11-52	28.20	6.05	0.41	0.18

Table A-2. The moisture, ash, calcium and phosphorus content of forages sampled from Arthur Lavender's Farm (dry basis)

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-3-52	Prairie hay 3-14-52	7.51	6.40	0.50	0.19
MVS-39-52	Prairie hay 11-11-52	7.31	8.00	0.61	0.09
MVS-16-52	Prairie grass 6-10-52	64.36	8.85	0.81	0.17
MVS-23-52	Prairie grass 7-28-52	59.30	9.30	0.82	0.24
MVS-9-52	Prairie grass 5-1-52	72.05	8.85	0.41	0.33
MVS-4-52	Lespedeza hay 3-14-52	7.77	5.45	0.94	0.23

[1]The description of each sample is found in appendix.

Table A-3. The moisture, ash, calcium, and phosphorus content of forages from Orville Bussmann's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-14-52	Prairie grass 5-3-52	78.28	8.35	0.53	0.45
MVS-21-52	Alfalfa hay 6-9-52	10.58	7.50	1.26	0.49
MVS-26-52	Alfalfa hay 7-28-52	8.82	8.70	1.70	0.36

Table A-4. The moisture, ash, calcium, and phosphorus content of forages from Mound Valley Exp't. Station Meadow (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-12-52	Prairie grass 5-3-52	73.30	7.95	0.48	0.34
MVS-15-52	Prairie grass 6-9-52	63.05	7.00	0.60	0.19
MVS-30-52	Prairie hay 3-14-52	7.31	6.20	0.30	0.13
MVS-38-52	Prairie hay 4-11-52	8.42	7.00	0.44	0.13

Table A-5. The moisture, ash, calcium, and phosphorus content of forages from Floyd Hunter's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-11-52	Prairie grass 5-3-52	74.52	9.00	0.38	0.48
MVS-18-52	Prairie grass 7-28-52	56.98	7.70	0.42	0.26
MVS-19-52	Alfalfa hay 7-28-52	9.19	6.32	1.54	0.25
MVS-37-52	Cane silage 11-11-52	29.90	6.42	0.36	0.22

[1]The description of each sample is found in appendix.

Table A-6. The moisture, ash, calcium, and phosphorus content of forages from William Hunter's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-5-52	Prairie hay 3-14-52	7.56	6.00	0.44	0.22
MVS-25-52	Prairie hay 7-28-52	8.94	6.15	0.59	0.14
MVS-10-52	Prairie grass 5-3-52	67.00	8.45	0.44	0.24
MVS-17-52	Prairie grass 6-10-52	60.45	6.50	0.55	0.15
MVS-24-52	Prairie grass 7-28-52	60.80	7.45	0.41	0.25
MVS-31-52	Prairie grass 10-3-52	53.56	7.35	0.53	0.15
MVS-33-52	Corn silage 11-11-52	32.90	6.67	0.41	0.44

Table A-7. The moisture, ash, calcium, and phosphorus content of forages from Wayne McNickle's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-7-52	Prairie hay 3-15-52	7.38	5.95	0.28	0.23
MVS-36-52	Prairie hay 11-11-52	6.99	8.20	0.58	0.13
MVS-8-52	Alfalfa hay 3-15-52	8.20	8.90	1.45	0.43
MVS-28-52	Alfalfa hay 7-28-52	9.97	8.25	1.31	0.27
MVS-29-52	Alfalfa hay 7-28-52	9.68	7.95	1.26	0.38

[1]The description of each sample is found in appendix.

Table A-8. The moisture, ash, calcium, and phosphorus content of forages from Walter Peterson's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-6-52	Prairie hay 3-14-52	7.09	7.85	0.39	0.19
MVS-35-52	Prairie hay 11-11-52	7.28	8.37	0.75	0.17

Table A-9. The moisture, ash, calcium, and phosphorus content of forages from Joseph Oakleaf's Farm (dry basis).

Sample number	Sample and date sampled[1]	Sample moisture	Ash %	Ca %	P %
MVS-22-52	Prairie grass 6-9-52	62.46	7.04	0.43	0.16
MVS-32-52	Prairie grass 10-3-52	49.17	6.45	0.17	0.23

Table A-10. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Wayne McNickle's Farm. (dry basis)

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-7-52	Prairie hay 3-15-52	0.17	0.21	39	22	59	2.0
MVS-36-52	Prairie hay 11-11-52	0.34	0.16	30	198	172	0.5
MVS-8-52	Alfalfa hay 3-15-52	0.29	0.20	36	34	32	1.3
MVS-28-52	Alfalfa hay 7-28-52	0.34	0.14	16	122	18	1.3
MVS-29-52	Alfalfa hay 7-28-52	0.20	0.14	19	89	19	1.2

[1]The description of each sample is found in appendix.

Table A-11. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Orville Bussmann's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-14-52	Prairie grass 5-3-52	0.21	0.17	26	150	32	2.9
MVS-21-52	Alfalfa hay 6-9-52	0.16	0.12	17	131	9	0.8
MVS-26-52	Alfalfa hay 7-28-52	0.28	0.09	19	83	18	1.2

Table A-12. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Mound Valley Expt. Station Meadow (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-12-52	Prairie grass 5-3-52	0.25	0.19	21	135	177	1.2
MVS-15-52	Prairie grass 6-9-52	0.37	0.10	6	90	113	1.2
MVS-30-52	Prairie hay 3-14-52	0.18	0.12	19	62	85	1.5
MVS-38-52	Prairie hay 4-11-52	0.24	0.13	16	70	142	0.7

Table A-13. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Walter Peterson's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-6-52	Prairie hay 3-14-52	0.19	0.28	24	41	131	1.5
MVS-35-52	Prairie hay 11-11-52	0.22	0.11	32	111	158	0.3

[1]Description of samples in appendix.

Table A-14. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Roy Nelson's Farm (dry basis)

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-1-52	Prairie hay 3-14-52	0.11	0.20	30	66	24	2.2
MVS-13-52	Prairie grass 5-3-52	0.16	0.21	16	147	219	1.4
MVS-20-52	Prairie grass 6-10-52	0.13	0.13	17	89	88	1.8
MVS-27-52	Prairie grass 7-28-52	0.15	0.11	14	123	105	1.6
MVS-2-52	Corn silage 3-14-52	0.17	0.36	17	252	53	1.0
MVS-34-52	Cane silage 11-11-52	0.39	0.11	35	161	50	0.9

Table A-15. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Arthur Lavender's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-3-52	Prairie hay 3-14-52	0.24	0.17	24	76	197	1.6
MVS-39-52	Prairie hay 11-11-52	0.28	0.13	34	124	364	1.0
MVS-16-52	Prairie grass 6-10-52	0.36	0.15	19	262	66	0.8
MVS-23-52	Prairie grass 7-28-52	0.34	0.17	52	86	74	0.7
MVS-9-52	Prairie grass 5-1-52	0.20	---[2]	26	148	185	1.3
MVS-4-52	Lespedeza hay 3-14-52	0.27	0.30	16	97	90	1.3

[1]Description of samples in appendix.
[2]Not sufficient sample for determination.

Table A-16. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from William Hunter's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-5-52	Prairie hay 3-14-52	0.25	0.24	18	46	116	1.5
MVS-25-52	Prairie hay 7-28-52	0.24	0.09	8	78	130	1.1
MVS-10-52	Prairie grass 5-3-52	0.14	0.21	12	250	107	1.3
MVS-17-52	Prairie grass 6-10-52	0.27	0.22	1	66	127	1.2
MVS-24-52	Prairie grass 7-28-52	0.18	0.08	50	70	144	0.6
MVS-31-52	Prairie grass 10-3-52	0.20	0.12	12	90	99	0.6
MVS-33-52	Corn silage 11-11-52	0.38	0.11	32	108	54	1.1

Table A-17. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Floyd Hunter's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-11-52	Prairie grass 5-3-52	0.23	0.17	8	187	84	1.0
MVS-18-52	Prairie grass 7-28-52	0.23	0.18	13	181	86	2.4
MVS-19-52	Alfalfa hay 7-28-52	0.42	0.29	8	160	6	1.9
MVS-37-52	Cane silage 11-11-52	0.45	0.12	33	134	60	0.8

[1]Description of each sample in appendix.

Table A-18. The magnesium, cobalt, copper, iron, manganese, and molybdenum content of forages from Joseph Oakleaf's Farm (dry basis).

Sample number	Sample and date sampled[1]	Mg %	Co ppm	Cu ppm	Fe ppm	Mn ppm	Mo ppm
MVS-22-52	Prairie grass 6-9-52	0.23	0.13	26	67	118	0.8
MVS-32-52	Prairie grass 10-3-52	0.16	0.11	31	102	96	1.0

[1]Description of each sample in appendix.

A TRACE MINERAL SURVEY OF SOME ROUGHAGES FED TO CATTLE IN SOUTHEASTERN KANSAS

by

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B. S., Kansas State College
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During the past several years many farmers have reported breeding troubles, low milk production and emaciation in the cattle, especially dairy cattle, raised in Southeastern Kansas. In 1949 the Mound Valley Branch Exp't. Station was organized in Labette County to initiate an active research program in an attempt to identify and develop solutions for these problems.

Since many farmers have attributed their difficulties to a deficiency of trace minerals, the purpose of this survey, in cooperation with the Mound Valley Branch, was to evaluate a number of samples of the roughages raised in Southeastern Kansas, especially Labette County, for several trace minerals and, if possible, correlate any mineral deficiencies found with the dairy cattle problems of the farmers. Thirty-nine samples (16 prairie grasses, 11 prairie hays, 6 alfalfa hays, 4 silages, 1 lespedeza and one brome grass) were obtained from 9 farms in Labette County, and analyzed for cobalt, copper, iron, magnesium, manganese, and molybdenum. In order to characterize the feeds further on the basis of mineral content, determinations were made of moisture (at time of sampling) ash, calcium and phosphorus.

Calcium, phosphorus, and manganese were determined by A.O.A.C. official methods. Magnesium, iron, cobalt, and molybdenum were determined by the development of a colored metal-dye complex and determining the concentration of each element from the per cent transmission of light. The dyes used for each of the metals were: magnesium, thiazole yellow; iron, O-phenanthroline; cobalt, nitroso-R-salt; and molybdenum, potassium thiocyanate. Copper was determined spectrographically.

The ranges in the contents of the various minerals of the prairie grasses were as follows (dry basis): calcium, 0.17 to 0.82 percent; phosphorus, 0.15 to 0.48 percent; magnesium, 0.13 to 0.37 percent; cobalt, 0.08 to 0.22 ppm; copper, 6 to 52 ppm; iron, 66 to 262 ppm; manganese, 66 to 219 ppm; and molybdenum, 0.6 to 2.4 ppm.

The prairie hay samples were obtained from crops that were harvested during both 1951 and 1952. Hays harvested during 1951 had an average mineral content (dry basis) as follows: calcium, 0.39 percent; phosphorus, 0.18 percent; magnesium, 0.20 percent; cobalt, 0.19 ppm; copper, 24 ppm; iron, 55 ppm; manganese, 108 ppm; and molybdenum, 1.6 ppm. The hays harvested during 1952 averaged (dry basis): calcium, 0.63 percent; phosphorus, 0.13 percent; magnesium, 0.27 percent; cobalt, 0.12 ppm; copper, 26 ppm; iron, 128 ppm; manganese, 206 ppm; and molybdenum, 0.7 ppm. The contents of calcium, magnesium, copper, iron, and manganese were higher in the hays harvested during the dry summer of 1952, whereas the phosphorus and molybdenum content were lower than in the hays harvested during the summer of 1951.

The ranges in the contents of the various minerals of the silages were as follows (dry basis): calcium, 0.28 to 0.41 percent; phosphorus, 0.18 to 0.44 percent; magnesium, 0.17 to 0.45 percent; cobalt, 0.11 to 0.36 ppm; copper, 17 to 35 ppm; iron, 108 to 252 ppm; manganese, 50 to 60 ppm; molybdenum, 0.8 to 1.1 ppm. The iron content of the silages was higher than any of the other roughages analyzed, possibly due to contamination of the feed during processing. The ranges in the contents of the various minerals of the alfalfa hays were as follows (dry basis): calcium, 1.26 to 1.70 per cent; phosphorus, 0.25 to 0.49 per cent; magnesium, 0.16 to 0.42 per cent; cobalt, 0.09 to 0.29 ppm; copper, 8 to 36 ppm; iron, 34 to 160 ppm; manganese, 6 to 32 ppm; and molybdenum, 0.8 to 1.9 ppm.

The calcium and phosphorus contents of the forages analyzed for this survey, with few exceptions, do not meet the National Research Council's recommended allowance for a good lactating cow (for example a 1200 pound cow, 30 pounds of milk daily), if no supplement is fed. Where calcium content of the forage is sufficiently high for maintenance of the normal animal, the phosphorus content does not satisfy the maintenance requirement in many instances.

The comparison of the level of each of the trace minerals found in the roughages of this survey with the accepted allowances or recommended trace mineral amount for optimum production, indicate that there are probably no general trace mineral deficiencies in the roughages of Labette County. The trace mineral supplementation of roughages of Labette County is, therefore, probably not necessary, if judged by the results of this survey.