# FORAGE COMPOSITION IN RELATION TO PHOSPHORUS DEFICIENCY IN RANGE BEEF CATTLE IN SOUTHEASTERN OKLAHOMA[1]

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## INTRODUCTION

In the course of an investigation of the phosphorous requirements of range beef cattle begun at this station several years ago (1, 2, 3) similar groups of cattle were placed at two locations in the state with native grass pastures and native hays as the sole roughage in the ration. One group was located at the Range Cattle Minerals Station near Wilburton in southeastern Oklahoma, where the soils are generally deficient in available phosphorous. The other group was placed at the Lake Carl Blackwell Experimental Range, near Stillwater in north-central Oklahoma, in the transition zone of soil phosphorous deficiency. The types of pasture grasses native to both these areas were quite similar, Little Bluestem, Big Bluestem, Indian and Switch grasses being the predominant species.

The cattle at each location consisted of thirty bred three-year-old Hereford cows and thirty weanling heifer calves equally divided into three lots. All lots were grazed on the native grass pastures in summer and fed in traps

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[1]This study is reported as part of an investigation of the mineral supplement requirement of range beef cattle conducted cooperatively by the Department of Animal Husbandry and Agricultural Chemistry Research and supported in part by a research grant from Swift and Company, Chicago, Illinois. Details of the investigation are described in references given under "Literature Cited."

during winter. The winter ration consisted of locally-grown native hay supplemented with 1.25 pounds of corn gluten meal, daily. Lot I was allowed only salt as a mineral supplement. Lot II was fed salt and enough dicalcium phosphate to provide a total phosphorous intake slightly over half the recommended daily requirement. Lot III was fed salt and dicalcium phosphate in amounts sufficient to meet the recommended daily requirement. The average daily phosphorous intakes of 1.5 gm. and 2.5 gm. per 100 pounds liveweight of the animals in lots II and III, respectively, were reasonably well regulated during the winter by mixing the minerals with the corn gluten meal supplement but were only approximated during the summer grazing season when the dicalcium phosphate was mixed with the salt and offered free-choice.

At the end of the second year it was evident that the cattle at Wilburton, not given a mineral phosphorous supplement, were suffering from a deficiency of phosphorous and were unthrifty even when this nutrient was supplied. A deficiency of some additional factor was suggested (3). A supplementary investigation was undertaken, therefore, to explore other possible causes of the condition of the Wilburton cattle by making a more complete study of the composition of forage from the two areas and of the blood of the cattle.

## Experimental

In the fall of 1948 and 1949 representative samples of native hay grown in each area and to be fed during the winter months were taken soon after baling. Precautions were taken to protect these samples from dust and other sources of mineral contamination during collection, sampling and storage. The hay obtained in 1949 for chemical analysis was separated into climax grasses, weedy grasses (*Panicum*) and foreign matter made up of heavy stems and weeds. For mineral analysis, samples were clipped into short lengths with shears. For proximate analysis and other determinations a duplicate sample was ground in a Wiley mill. Determinations were made of the major feed constituents including carotene, cellulose and lignin, and the minerals calcium, phosphorous, silica, iron, aluminum, manganese, magnesium, potassium and sodium.

Blood samples were taken from the cattle at about 56-day intervals for the determination of carotene and phosphorus. Additional determinations were made of calcium, magnesium, copper, plasma protein, hemoglobin and red cell volume of blood of a representative number of the cows in lots I and III. These latter determinations were made during February and April, 1950, when the cattle were on winter feed and in June after they had been on native grass pasture for two months.

## Results and Discussion

Table I shows the composition of native hay produced in 1948 and 1949 at the Lake Carl Blackwell and Wilburton areas. Differences between the hays in their content of protein, crude fiber and other major feed nutrients were small and unrelated to location. The hay produced in the Blackwell area in 1949 contained a small percentage of weedy grasses whereas that produced in the same year at Wilburton contained 40 per cent of weedy grasses, stemmy material and weeds. The Wilburton hay was higher in calcium and magnesium, and somewhat lower in phosphorous than the Blackwell hay. Similar small differences in phosphorus have been found in the summer grass from the two areas. It is questionable whether these differences in phosphorus content would alone account for the difference in the condition of the cattle at the two areas.

Differences in iron, aluminum, potassium and sodium content between the hays from the two areas are probably not of nutritional significance. The most striking and consistent difference found was in the manganese content. The Wilburton hay contained over three times as much manganese as the Blackwell hay in 1948 and nine times as much in 1949. Analysis of other

TABLE I

*Composition of Hays Produced at Lake Carl Blackwell and Wilburton Areas.*

| YEAR AND DESCRIPTION | LOCATION | ASH | PROTEIN | ETHER EXTRACT | CRUDE FIBER | N-FREE EXTRACT | LIGNIN | CELLULOSE | CAROTENE | CA | P | MN | FE | AL | K | NA | MG | $SIO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | P.P.M. | % | % | P.P.M. | P.P.M. | P.P.M. | % | % | % | % |
| 1948 | | | | | | | | | | | | | | | | | | |
| Native hay | B[2] | 7.52 | 4.43 | 2.05 | 32.82 | 53.18 | 8.82 | 40.28 | 9.1 | .420 | .061 | 75 | 91 | 148 | .549 | .010 | .159 | 5.63 |
| Native hay | W[3] | 7.16 | 4.28 | 2.10 | 35.01 | 51.45 | 8.83 | 37.82 | 12.2 | .520 | .053 | 253 | 96 | 152 | .438 | .037 | .561 | 4.04 |
| 1949 | | | | | | | | | | | | | | | | | | |
| Native hay[4] | B. | 7.80 | 4.95 | 2.11 | 34.82 | 50.32 | 9.56 | 45.33 | 15.3 | .460 | .064 | 32 | 91 | 131 | .685 | .010 | .188 | 5.00 |
| Climax grass | B. | 8.37 | 5.11 | 2.06 | 32.71 | 51.75 | — | — | 15.0 | .400 | .067 | 48 | — | — | .672 | .022 | .162 | 5.52 |
| Weedy grass | B. | 10.11 | 6.25 | 3.59 | 29.69 | 50.36 | — | — | — | .370 | .069 | — | — | — | — | — | .234 | 6.64 |
| Native hay[5] | W. | 7.55 | 4.15 | 3.29 | 31.24 | 53.77 | 9.66 | 39.16 | 14.4 | .750 | .047 | 287 | 82 | 136 | .366 | .046 | .431 | 4.45 |
| Climax grass | W. | 7.43 | 3.86 | 2.61 | 31.28 | 54.82 | 9.80 | 42.15 | 14.5 | .570 | .045 | 309 | 77 | 69 | .399 | .037 | .351 | 5.30 |
| Weedy grass | W. | 8.81 | 5.58 | 4.38 | 30.89 | 50.84 | 9.92 | 38.14 | 27.4 | .410 | .056 | — | — | — | .507 | .011 | .318 | 6.27 |
| Foreign M. | W. | 6.31 | 4.30 | 3.95 | 32.61 | 52.83 | 11.84 | 33.85 | 12.8 | 1.22 | 0.52 | 486 | — | — | .628 | .021 | .544 | 2.27 |
| Native hay[6] | W. | 8.21 | 4.82 | 2.14 | 30.93 | 53.90 | 9.42 | 41.22 | 9.2 | .530 | .086 | 182 | 42 | 153 | .385 | .017 | .358 | 6.11 |
| Native hay[7] | B. | 8.35 | 5.41 | 2.02 | 33.11 | 51.11 | 13.24 | — | — | .400 | .052 | 34 | 433 | 670 | .521 | .015 | .165 | 6.05 |
| Native hay[8] | B. | 6.74 | 7.91 | 2.77 | 31.44 | 51.14 | 9.94 | — | — | .570 | .083 | 27 | 200 | 169 | .446 | .015 | .235 | 3.01 |

[1]Average values for entire winter feeding period.
[2]"B" denotes Lake Carl Blackwell area.
[3]"W" denotes Wilburton area.
[4]Composed of 92% climax grass and 8% weedy grass.
[5]Composed of 60% climax grasses, 15% weedy grasses and 25% foreign matter (see text)
[6]Purchased in area to complete winter feeding.
[7]From an unfertilized meadow.
[8]From a fertilized meadow.

samples of hay from these two areas, shown at the bottom of Table I, revealed similar differences in manganese content. Weeds and unclassified grasses collected from the Wilburton range in the fall of 1950 have been found to contain over 800 p.p.m. of manganese. In view of the known effect of manganese deficiency and excess on calcium and phosphorus metabolism in a number of animal species, it may be that some of the disorders observed in the Wilburton cattle are related to the high manganese content of the forages of that area, or to some other condition associated with manganese accumulation. Further studies to determine the effects of rations high in manganese are in progress.

Data presented in Table II show the seasonal change in the carotene and phosphorus content of the blood plasma of cows at the two areas during 1948 and 1949.

TABLE II

*Seasonal Variation in Carotene and Inorganic Phosphorus Content of Blood Plasma of Beef Cows at Lake Carl Blackwell and Wilburton Areas.*

| | LOT I | | | | LOT II | | | | LOT III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | CAROTENE[1] | | PHOSPHORUS[2] | | CAROTENE | | PHOSPHORUS | | CAROTENE | | PHOSPHORUS | |
| | B[3] | W[4] | B | W | B | W | B | W | B | W | B | W |
| WINTERING PERIOD, 1948 | | | | | | | | | | | | |
| February | 74 | 186 | 2.8 | 1.8 | 85 | 200 | 5.8 | 5.1 | 77 | 182 | 5.9 | 6.1 |
| April | 278 | 427 | 3.4 | 1.8 | 284 | 335 | 6.3 | 5.4 | 339 | 351 | 5.4 | 6.5 |
| GRAZING PERIOD, 1948 | | | | | | | | | | | | |
| June | 746 | 679 | 4.3 | 3.0 | 781 | 475 | 4.7 | 4.7 | 866 | 442 | 4.6 | 4.1 |
| August | 841 | 810 | 5.1 | 3.9 | 702 | 787 | 4.9 | 4.7 | 728 | 707 | 5.0 | 4.3 |
| November | 357 | 283 | 4.4 | 3.1 | 380 | 232 | 5.6 | 4.3 | 348 | 219 | 5.4 | 4.5 |
| WINTERING PERIOD, 1949 | | | | | | | | | | | | |
| January | 142 | 133 | 5.6 | 2.3 | 126 | 138 | 7.4 | 6.4 | 96 | 92 | 7.5 | 6.5 |
| February | 152 | 170 | 3.4 | 2.3 | 110 | 198 | 5.4 | 7.0 | 112 | 142 | 6.6 | 5.7 |
| April | 248 | 218 | 2.4 | 2.7 | 153 | 251 | 5.3 | 5.0 | 138 | 184 | 6.3 | 7.2 |
| GRAZING PERIOD, 1949 | | | | | | | | | | | | |
| June | 996 | 836 | 4.7 | 3.2 | 832 | 503 | 4.4 | 4.4 | 899 | 703 | 5.2 | 3.3 |
| Septemb'r | 662 | 490 | 4.4 | 3.1 | 583 | 753 | 4.0 | 3.0 | 510 | 479 | 4.7 | 3.6 |
| November | 678 | 734 | 3.4 | 2.7 | 549 | 791 | 3.9 | 3.1 | 554 | 631 | 3.7 | 2.5 |

[1]Values in micrograms per 100 ml.
[2]Values in milligrams per 100 ml.
[3]Lake Carl Blackwell Area.
[4]Wilburton Area.

It can be readily noted in Table II that during corresponding months of the year the cows in lot I quite consistently had lower plasma phosphorus values than those in lots II and III, and that these values were usually lower for the cows at Wilburton than for those at the Blackwell area. The average daily phosphorus intake of the cows in lot I during the wintering period of 1948-49 at the Wilburton and Blackwell areas was 7 gm. and 9 gm., respectively. During this period, and also during the winter of 1949-50 (Table III), plasma phosphorus decreased in cows of lot I at both areas; and in those at Wilburton it reached critically low levels, below 3 mg. per cent for extended periods. An increase in plasma phosphorus to about 3 mg. per cent during the summer was associated with an increase in the phosphorus content of the forage.

Plasma phosphorus in the cows of lots II and III, however, was higher during the wintering periods than during the summer grazing season. These values, which varied from 5 to 7 mg. per cent during the winter, were influenced largely by phosphorus intake; but the lower values for the cows at

Wilburton, especially during summer grazing when they had free access to a phosphorus supplement, are believed also to reflect impaired phosphorus utilization.

Table III shows average values for a number of constituents determined in the blood of ten representative cows in lots I and III during the spring of 1950. Blood carotene and phosphorus values followed the same trends as shown in Table II. Calcium values were within the normal range. The variability of magnesium values within treatments was relatively great. The lowest values were obtained in the blood of cows in lot I at the Blackwell area. Symptoms characteristic of magnesium deficiency were not observed among any of the cattle and it seems that a hypomagnesia did not exist. The results of copper determinations indicated a decrease in plasma copper during winter feeding. Because of inaccuracies in the method of determination the values are considered as only relative and have been omitted from Table III. Values for plasma protein, hemoglobin and hematocrit were generally lower for cows at Wilburton than for those at the Blackwell area on comparable rations; and this difference was especially noticeable during the winter feeding period. Similar differences in hemoglobin values have been obtained in other years.

TABLE III

*Composition of Blood of Cows in Lots I and III at Lake Carl Blackwell and Wilburton Areas[1], 1950.*

| MONTH | CAROTENE | | INORGANIC PHOSPHORUS | | CALCIUM | | MAGNESIUM | | PLASMA PROTEIN | | HEMOGLOBIN | | RED CELL VOLUME | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B[2] | W[3] | B | W | B | W | B | W | B | W | B | W | B | W |
| LOT I | | | | | | | | | | | | | | |
| February | 179 | 177 | 3.8 | 2.5 | 9.7 | 11.0 | 1.28 | 1.72 | 7.2 | 6.5 | 9.9 | 9.3 | 34 | 32 |
| April | 323 | 253 | 4.3 | 2.8 | 10.1 | 10.6 | 1.87 | 1.72 | 7.1 | 6.9 | 10.0 | 8.7 | 33 | 30 |
| June | 861 | 889 | 3.6 | 2.9 | 10.2 | 12.0 | 1.27 | 1.97 | 7.0 | 7.5 | 10.6 | 9.7 | 37 | 34 |
| LOT III | | | | | | | | | | | | | | |
| February | 166 | 170 | 5.0 | 6.5 | 9.7 | 9.3 | 1.54 | 1.69 | 7.0 | 6.0 | 10.1 | 9.3 | 33 | 33 |
| April | 462 | 192 | 6.6 | 6.0 | 9.4 | 9.6 | 2.28 | 1.73 | 7.4 | 6.1 | 10.1 | 8.6 | 33 | 30 |
| June | 739 | 904 | 3.9 | 3.1 | 9.3 | 10.9 | 2.05 | 2.24 | 7.3 | 7.2 | 10.7 | 10.5 | 37 | 35 |

[1]Carotene is expressed in micrograms; phosphorus, calcium and magnesium in milligrams; and plasma protein in grams, per 100 ml. of plasma. Hemoglobin and red cell volume (hematocrit) are expressed in grams and milliliters.

[2]Lake Carl Blackwell area.

[3]Wilburton area.

## Summary

Cattle at the Lake Carl Blackwell range in north central Oklahoma, grazed on native grass in the summer and fed hay produced in the area supplemented with protein during the winter, did not require a mineral phosphorus supplement for satisfactory production. Under similar conditions of management, cattle in a phosphorus deficient area near Wilburton, in southeastern Oklahoma, required additional phosphorus and were unthrifty even when this element was supplied. To investigate the cause of this unthriftiness, studies were made of the composition of native grass hay produced at each area and of the blood of representative cows grazed and fed at these areas.

The hay at Wilburton contained similar amounts of the major feed nutrients, less phosphorus, more calcium and magnesium and from three to nine times as much manganese as the hay at the Blackwell area. A possible adverse effect of high manganese intake on phosphorus metabolism was suggested.

The cows at Wilburton, which were not fed a phosphorus supplement, showed characteristic symptoms of phosphorus deficiency and had critically low plasma phosphorus levels. A phosphorus supplement fed during the wintering period and offered free-choice during the grazing season increased plasma phosphorus values of cows at both areas; however, these values were consistently lower for the cows at Wilburton than for those at the Blackwell area during the grazing season.

Low values for hemoglobin and red cell volume in the blood of the Wilburton cattle indicated a milk anemia.

## LITERATURE CITED

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