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THE PHOSPHORUS, CALCIUM, AND PROTEIN CONTENT OF SOME
NATIVE PRAIRIE GRASSES AS AFFECTED BY
FERTILIZATION AND STAGE OF MATURITY

by

John Simon Williams

A THESIS

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CONTENTS

	Page
Introduction	1
Review of literature	3
Experimental methods	11
Results	22
Phosphorus content	23
Calcium content	41
Crude protein content	53
Discussion	64
Summary	71
Literature cited	73

PREVIEW

TABLES

Table	Page
1. Seasonal variation in phosphorus content of Junegrass	24
2. Seasonal variation in phosphorus content of western wheatgrass	25
3. Seasonal variation in phosphorus content of needlegrass	26
4. Seasonal variation in phosphorus content of prairie dropseed	27
5. Seasonal variation in phosphorus content of little bluestem	28
6. Seasonal variation in phosphorus content of big bluestem	29
7. Seasonal variation in phosphorus content of blue grama	30
8. Seasonal variation in phosphorus content of side-ots grama	31
9. Array of grasses according to phosphorus content in vegetative growth and in post-flowering growth	33
10. The phosphorus content of smooth bromegrass as affected by nitrogen, phosphorus and potassium fertilization	37
11. The phosphorus, calcium and crude protein content of nodding wild rye and switchgrass at one growth stage	39

12. Effect of nitrogen and phosphorus fertilization upon oven-dry yields and phosphorus and calcium content of mixed herbage from prairie	40
13. Seasonal variation in calcium content of Junegrass	42
14. Seasonal variation in calcium content of western wheatgrass	43
15. Seasonal variation in calcium content of needlegrass	44
16. Seasonal variation in calcium content of prairie dropseed	45
17. Seasonal variation in calcium content of little bluestem	46
18. Seasonal variation in calcium content of big blue- stem	47
19. Seasonal variation in calcium content of blue grama	48
20. Seasonal variation in calcium content of side-oats grama	49
21. Array of grasses according to calcium content in vegetative growth and in post-flowering growth	51
22. The calcium content of smooth bromegrass as affected by nitrogen, phosphorus, and potassium fertilization	52
23. Seasonal variation in crude protein content of Junegrass	54
24. Seasonal variation in crude protein content of western wheatgrass	55
25. Seasonal variation in crude protein content of needlegrass	56
26. Seasonal variation in crude protein content of prairie dropseed	57

27. Seasonal variation in crude protein content of little bluestem	58
28. Seasonal variation in crude protein content of big bluestem	59
29. Seasonal variation in crude protein content of blue grama grass	60
30. Seasonal variation in crude protein content of side-oats grama	61
31. Array of grasses according to protein content in vegetative and post-flowering growth stages	63

PREVIEW

FIGURES

	Page
Figure 1. Location of experimental plots	12
Figure 2. Phosphorus and crude protein percentages in nitrogen-treated grasses at successive growth stages	34
Figure 3. Average phosphorus content in vegetative growth and post-flowering growth	35

PREVIEW

PLATES

	Page
Plate 1. View of experimental plots	13
Plate 2. View of experimental plots	14
Plate 3. Native prairie treated with 60 pounds of nitrogen per acre	15
Plate 4. Untreated prairie plot	16

PREVIEW

INTRODUCTION

There is an extensive and rapidly growing literature relating to native prairie grasses of Nebraska, but there are no studies especially pertaining to the effect of fertilization on seasonal trends of minerals and protein of this vegetation in undisturbed prairie. There is, furthermore, a voluminous literature on chemical composition of herbage from other grasslands of the world; but the results have a limited application under a Nebraska environment, as chemical constituents of grazing forages may vary markedly, particularly with differences in species, climate, and soil. Consequently, relatively little information is available for estimating the nutritive quality of Nebraska's prairie grasses growing under natural conditions.

The most reliable criteria known for evaluating protein and minerals in pasture vegetation are nutrition balance studies and controlled grazing trials; but such methods are laborious and expensive, particularly when more than a few species are being tested. A practical and inexpensive agronomic method for estimating the adequacy of protein, phosphorus, and calcium for animal production is that of chemical analysis. Although by no means a perfect substitute for actual assays with livestock, chemical analysis is widely used as a convenient alternative approach for securing information on certain soil-plant-animal relationships.

With the chemical approach for estimating the nutritive quality of prairie grasses in mind, and in view of the limited knowledge concerning seasonal changes in minerals and protein in Nebraska's native

grassland forage, it was deemed appropriate to inquire into this problem. The present study, then, reports the effect of surface applications of nitrogen and phosphorus fertilizers on seasonal variation and differential concentration of calcium, phosphorus, and protein in eight dominant grass species found growing in a native prairie habitat. The general object of the investigation was to relate the variation in quantity of these nutritive constituents to differences in stage of maturity of the forage and to recommended nutritional requirements of cattle.

PREVIEW

REVIEW OF LITERATURE

Since the days of Liebig, there have been many investigations pertaining to nutritional disorders and the requirements of grazing animals for certain constituents in pasturage. However, many of the objectives of earlier studies were hindered because of the complexity of the problem. It was difficult in early times to attribute various livestock disorders to any exact and specific cause, for many factors operated toward complicating the problem and confusing the investigators. Symptoms in livestock of what is well known today as aphosphorosis were easily confused with the effects of external or internal parasites. Certain essential, deficient nutritive elements probably involved were unknown as essential to livestock or undetected by laboratory techniques used by early investigators.

The literature today relating to phosphorus, calcium, and protein content of grazing forages is extensive, and there are excellent reviews from various grazing regions of the world concerning this subject. Among the more comprehensive of these are the reviews of Theiler (31, 32)^{1/}, Orr (23), Watkins (34), Stanley (26), Vandecasteele (33), Maynard (18), and Eason (1). The present study is related to this wide field of investigation; however, since chemical elements in grasses, as estimated for livestock requirements, vary markedly among different species and the climatic and edaphic environments under which

^{1/} Figures in parenthesis refer to literature cited, page 73.

they are grown, only those investigations conducted with native species in grassland associations with environmental factors similar to those of the present work will be discussed and evaluated comparatively.

In many of the early studies on the nutritive quality of hay or pasturage, samples of the total mixed vegetation were taken at arbitrary dates without regard to differences in the botanical composition of the herbage nor in the chemical composition of the different species at different stages of growth. In many cases the total ash was determined rather than the content of specific elements. Information which is thus incomplete in many ways is necessarily difficult to interpret and of limited significance.

Studies dealing with range grasses of the world were greatly accelerated following the investigations in 1920 of Theiler (30), who showed that the etiology of a widespread disease of cattle on South African grasslands was directly related to the phosphorus content of the vegetation consumed. By feeding bone meal to animals on phosphorus deficient veld, or by fertilizing the range with phosphatic materials, he was able to prevent the widespread outbreaks of this disease. He further found that the concentration of phosphorus in the South African vegetation was associated with the total and available phosphorus content of the soil. The effect of rainfall, which initiated new growth containing higher levels of phosphorus, was also pointed out to be an important factor in temporarily alleviating the nutritional disorders in that region.

Schmidt (25), in 1924, substantiated Theiler's work by showing that a similar disease prevalent in cattle in the coastal prairies of Texas could be prevented by feeding a phosphorus supplement, such as

bonemal, to range animals subsisting solely on the vegetation of that area. Almost simultaneously, Welch (38) demonstrated that certain parts of Montana were producing range herbage of suboptimal phosphorus content for normal growth of livestock. Schles et al (8), in 1926, secured similar results in Minnesota. He concluded that mineral deficiency among cattle in Minnesota was caused by low phosphorus content of grasses and not by suboptimal calcium levels. He further believed that the phosphorus content of prairie hay was affected by the soil and the effective rainfall during the growing season. Subsequently Orr (25) reviewed the attention given this subject by many investigators and first called attention to the world-wide seriousness of the several mineral deficiencies known at that time.

As a result of this work, many studies were made to determine whether low levels of phosphorus, calcium, or protein in grazing forages were factors in cattle production in various regions of the North American continent. Virtually every state in the United States reported malnutrition in cattle attributable to phosphorus or protein deficiencies in grazing plants.

During the decade 1922-1932 many important contributions on the nutrition of livestock revealed by an analysis of range forages appeared in the literature. Theiler (32), in 1932, reviewed the world situation pertaining to phosphorus nutrition uncomplicated with various other nutritional deficiencies. This review, Aphosphorosis in the Ruminant, adequately covers the field of chemical analysis of range grasses related to the optimum levels of phosphorus for normal cattle production. Clarifying many of the discrepancies and difficulties encountered in interpreting much of the earlier data, Theiler linked

phosphorus deficiency in vegetation and soil definitely to the defective animal. He further pointed out that it is extremely unlikely that calcium deficiencies ever exist in cattle subsisting solely on grassland forage.

Moreover, he asserted that when one interprets phosphorus or protein concentration in grasses, he should stress the importance of considering the quantity of edible vegetation consumed by the animal. In his words, "The naturally-grazing animal adjusts its food intake to its requirements for energy purposes and, as the grass deteriorates in value, does its best to make up for the poor quality by eating increased quantity. With increased quantity of grass comes increased total phosphorus, so that a low 'percentage phosphorus' on the grass of low 'fuel value' is much the same as a higher percentage in a better grass".

On this basis many of the discrepancies in the results of various studies in the United States may be explained, as there is a lack of agreement on the proposed requirements of cattle for nutritive constituents in different grazing regions (1). In Theiler's discussion of the importance of seasonal variation of phosphorus content in herbage there is shown a correlation between deficiency in the animal and the diminishing amounts of this element as grasses matured on phosphorus deficient soil. South African grassland vegetation varied from 0.26% phosphorus in young growth to 0.03% in mature grasses after the seed had shattered. The soil producing vegetation of this quality contained 0.12% total phosphorus and 0.0005% available phosphorus. A soil producing vegetation of optimum concentration for cattle requirements contained 0.009% available phosphorus. However, Theiler pointed