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Influence of Fertilizer on Two Grass/Legume Mixtures in the Big Horn Basin

By Rulon D. Lewis

Wyoming Agricultural Experiment Station

October 1955 Bulletin 337

In cooperation with U. S. Department of Agriculture
Two rates of phosphate, with and without nitrogen, were applied on soils of high, medium, and low productivity levels. Two grass/legume hay mixtures were seeded on the soils and the fertility response was measured by hay and crude protein yields. The percentages of dry matter, crude protein, calcium, and phosphorus were also determined.

The yield of hay and crude protein from each grass/legume mixture differed greatly between locations. These differences were related to the estimated productivity level of the soil. The mixture of alfalfa bromegrass produced the highest hay yield from the soils of high and medium fertility, and the complex mixture produced the highest hay yield on the soil of low productivity.

Phosphorus applied at Powell at rates of 100 and 200 lbs. of \( \text{P}_2\text{O}_5 \) per acre caused substantial increases in the yield of hay from each grass/legume mixture on soil of low fertility. Nitrogen fertilizer applied at the rate of 40 lbs. of nitrogen per acre in combination with phosphorus caused a slight increase in the yields of hay from the grass/legume mixtures at each location. The yield data from the fertilizer treatments indicate that hay and crude-protein yields may be increased by nitrogen and phosphate fertilizer. The magnitude of the increases depends upon the productivity level of a particular soil and on the rate of fertilizer applied.

Chemical analyses of the hay from the two grass/legume mixtures varied among locations. There was a gradual decrease in the percentage of crude protein, calcium, and phosphorus in the hay produced on soil of high to low productivity levels.

The productivity level of the soil caused greater differences in the chemical composition of the hay than did the different fertilizer treatments. Differences in the chemical composition of the hay, comparing fertilizer treatments, were masked because of the variation in the vegetative composition of the hay.
Influence of Fertilizer on Two Grass/Legume Mixtures in the Big Horn Basin*

By Rulon D. Lewis


WIDESpread interest has developed in recent years in Wyoming in the value and use of irrigated pastures consisting of mixtures of grasses and legumes. Such pastures make it possible to keep more livestock on the farm and help to maintain soil productivity.

Farmers and ranchers in the Big Horn Basin have become especially interested in grass/legume mixtures adaptable to the area. They are also concerned with fertilizers that should be used on various grass/legume mixtures grown on soils of different productivity and how fertilizers would affect the protein and mineral content of the hay.

From 1950 through 1953 experiments were conducted to investigate the effects of commercial fertilizer applications on the yield, crude protein, calcium, and phosphorus contents of hay from two grass/legume mixtures at each of three locations in the Big Horn Basin.

*This work is the result of cooperative investigations between the Extension Service, the Wyoming Agricultural Experiment Station, and the Soil and Water Conservation Research Branch, Agricultural Research Service, U.S.D.A. The author expresses appreciation to County Agents J. M. Nicholls of Park County and Arvil D. Ashment of Big Horn County for their valuable assistance in selecting the locations, applying the fertilizer, and harvesting the plots. Through their cooperation this information has been made available.
EXPERIMENTAL PLAN AND PROCEDURE

Experiments began in April 1950 in the Big Horn Basin at three locations: one on Howard Flitner's ranch, 20 miles northeast of Greybull; one on Glen Neilson's farm, one-half mile south of Cody; and one on Bruce Murray's farm, 7 miles southwest of Powell. These sites were chosen because it was desirable to seed the grass/legume mixtures on soils of high, medium, and low productivity.

The soil at Greybull is Billing's loam. It is highly productive and has never been intensively farmed. The crops grown in the past were grain and sweet-clover pasture.

The soil at Cody is Ralston gravelly loam. Of medium productivity, it has been irrigated for many years. The main crops grown in the past were grain and pasture.

The soil at Powell is Ralston sandy clay loam. This soil was known to be very low in productivity. It has been irrigated and intensively cropped with alfalfa, beans, sugar beets, and grain for about 25 years.

Table 1 shows the physical and chemical characteristics of the soils at the three experimental locations. The pH and soluble salts were measured on soil paste, lime was determined by CO₂ displacement, and available phosphate (P₂O₅) was estimated by the sodium-bicarbonate method.¹

At each location the cooperators plowed, disked, harrowed, and leveled the soil, then seeded it to each of two grass/legume mixtures:—

**ALFALFA/BROMEGRASS:**
- Ranger alfalfa, 4 pounds; Lincoln bromegrass, 12 pounds

**COMPLEX MIXTURE:**
- Lincoln bromegrass, 5 pounds; orchardgrass, 5 pounds; Alta fescue, 4 pounds; Ranger alfalfa, 2 pounds; Ladino clover, 3 pounds; and Cumberland red clover, 3 pounds

They seeded mixtures at the rate of about 18 pounds per acre with a companion crop of barley seeded with a drill at the rate of 40 pounds per acre, 2 to 3 inches deep. After the barley was planted, the grass/legume mixture was seeded about ½ inch deep. The grass seed was placed in the grain hopper and the clover seed in the grass-seed attachment. Continual stirring helped to distribute the seed uniformly. Stands of grasses and legumes were uniform at each location (Figs. 1 and 3).

The workers arranged the fertilizer treatments in a randomized block design with seven replications. Nitrogen fertilizer was applied annually in two equal applications: one in April and one at time of the first harvest as ammonium sulfate (20.5 percent nitrogen). Phosphorus fertilizer was applied in single applications in 1950 and 1952 as double super-phosphate (43 percent P₂O₅). Minor elements were applied in 1950 in a "shotgun" mixture made up of copper, iron, manganese and zinc sulfates, and boron. The fertilizer treatments in—

eluded: (1) 40 pounds of N plus 200 pounds of \( \text{P}_2\text{O}_5 \), plus 50 lbs. of minor elements; (2) 40 lbs. of N plus 100 lbs. of \( \text{P}_2\text{O}_5 \); (3) 40 lbs. of N plus 200 lbs. of \( \text{P}_2\text{O}_5 \); (4) 100 lbs. of \( \text{P}_2\text{O}_5 \); (5) 200 lbs. of \( \text{P}_2\text{O}_5 \); (6) check plot without fertilizer.

All plots had uniform irrigation when the plants showed signs of needing moisture.

Workers collected data from a strip, 34 in. wide and 21.8 ft. long, cut from each plot. Samples for analysis were collected from a strip 6 in. wide and 21.8 ft. long, cut within the plot and dried in an oven at 65° C. for 24 hours. All hay yields were based on oven-dry weights.

Hay yields were not obtained in 1950, nor from the first cutting in 1951 from any of the locations. Yields were obtained at Greybull from the second and third cuttings in 1951 and from the first, second, and third cuttings in 1952 and 1953. At Cody, workers gathered yield data from second and third cuttings in 1951, from first, second, and third cuttings in 1952, and from first and second cuttings in 1953. Shortage of moisture prevented sufficient regrowth for a third cutting in 1953.

At Powell, experimenters took yield data from the second cutting in 1951 and from the first and second cuttings in 1952 and 1953. There wasn't
FIG. 2—Average yield of hay from two grass/legume mixtures at three locations (Average of 1951, 1952, and 1953)
enough growth for a third cutting of hay at Powell at any time. This may be due to low fertility, since temperature and moisture were favorable.

At each location the workers made the first cutting of hay when the crop was about at one-tenth bloom, the second when approximately one-fourth third before any blooms were showing.*

RESULTS AND DISCUSSION

Hay Yields

Figure 2 shows the average yield of hay in tons per acre from each grass/legume mixture, at each location, for each fertilizer treatment, for 1951, 1952, and 1953.

Yield data from the treatment, which included 40 lbs. of nitrogen plus 200 lbs. of $P_2O_5$ plus 50 lbs. of minor elements, were not included in Figure 3 because the data are not comparable to that shown. In 1951 there was no significant increase due to the minor elements. It was concluded, therefore, that minor elements were not needed at these locations. They were eliminated from the experiment, and 80 lbs. of nitrogen was added in place of the 40 lbs. originally used.

Applications of phosphorus caused slight to substantial increases in the yield of hay. Significant increases in yield were obtained in four of the six trials. On the soils of low productivity at Powell, the 200-lb. rate of $P_2O_5$ caused significant increases over the 100-lb. rate of $P_2O_5$ on both mixtures.

Nitrogen applied at the rate of 40 lbs. per acre, and in combination with phosphorus, caused a substantial increase in yield of hay from the alfalfa/bromegrass at Powell and a slight increase from the complex mixture. At the other locations, this treatment had little effect on yield.

*In 1953 the samples of hay collected for determining percentage of moisture were composited by treatments for chemical analyses. The Gunning modification of the Kjeldahl method was used for determining total nitrogen, the results being expressed as percentage of crude protein ($N \times 6.25$). Calcium and phosphorus were determined from an extract obtained by digesting the ground plant samples in nitric-perchloric-sulfuric acid.²

### TABLE 1 — Properties of Three Soils Used in Fertilizer Studies

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Types</th>
<th>Texture</th>
<th>pH</th>
<th>Soluble salts</th>
<th>Lime</th>
<th>Soluble P.O₅</th>
<th>Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Lbs./acre</td>
<td></td>
</tr>
<tr>
<td>Greybull</td>
<td>0-10</td>
<td>Billings</td>
<td>Sandy clay loam</td>
<td>8.1</td>
<td>0.08</td>
<td>4</td>
<td>46</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>10-17</td>
<td>Sandy clay loam</td>
<td></td>
<td>8.0</td>
<td>0.07</td>
<td>4</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17-50</td>
<td>Clay loam</td>
<td></td>
<td>8.0</td>
<td>0.11</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Cody</td>
<td>0-10</td>
<td>Ralston</td>
<td>Gravelly loam</td>
<td>7.5</td>
<td>0.05</td>
<td>2</td>
<td>7</td>
<td>Excessive</td>
</tr>
<tr>
<td></td>
<td>10-18</td>
<td>Gravelly clay loam</td>
<td></td>
<td>7.5</td>
<td>0.04</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18-60</td>
<td>River washed gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powell</td>
<td>0-9</td>
<td>Ralston</td>
<td>Sandy clay loam</td>
<td>8.1</td>
<td>0.05</td>
<td>4</td>
<td>&lt;0.1</td>
<td>Very good</td>
</tr>
<tr>
<td></td>
<td>9-17</td>
<td>Sandy loam</td>
<td></td>
<td>8.2</td>
<td>0.05</td>
<td>4</td>
<td>&lt;0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17-26</td>
<td>Loamy fine sand</td>
<td></td>
<td>7.4</td>
<td>0.02</td>
<td>4</td>
<td>&lt;0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26-60</td>
<td>Clay loam</td>
<td></td>
<td>8.3</td>
<td>0.02</td>
<td>4</td>
<td>&lt;0.1</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 2 — Chemical Composition of Hay from Three Locations for 1953, Mean of all Fertilizer Treatments and Cuttings

<table>
<thead>
<tr>
<th>Location</th>
<th>Productivity level of soil</th>
<th>Alfalfa/Brome grass</th>
<th>Complex Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry matter</td>
<td>Crude protein</td>
<td>Calcium</td>
</tr>
<tr>
<td>Greybull</td>
<td>High</td>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td>Cody</td>
<td>Medium</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Powell</td>
<td>Low</td>
<td>28</td>
<td>11</td>
</tr>
</tbody>
</table>
FIG. 4—The ratio of grasses to legumes was increased with 40 lbs. of nitrogen per acre applied at Powell, Wyoming

The highest yield of hay from the two grass/legume mixtures at Powell was produced with 40 lbs. of nitrogen and 200 lbs. of phosphate per acre. The yield from alfalfa bromegrass for this treatment, however, was less than that produced at Greybull without fertilizer. The yield from the complex mixture was only slightly more than that produced without fertilizer at Greybull. Higher rates of nitrogen may have increased the yields of each grass/legume mixture, since recent studies have shown that these soils respond to higher rates of nitrogen.

The differences in the average yield of hay from each grass/legume mixture without fertilizer at the three locations are of interest. The average yield from the alfalfa/bromegrass mixture at Greybull was 4.5 tons; Cody, 3.5 tons; and Powell, 2.2 tons per acre. The yield from the complex mixture at Greybull was 4.1 tons; Cody, 3.5 tons; and Powell, 2.2 tons per acre. These differences in yield between locations were closely related to the available phosphate found in the soil at beginning of the study (Table 1).

A comparison of the yield data from Greybull and Cody for the two mixtures shows that alfalfa/bromegrass produced the highest yield of hay for three consecutive years; at Powell the complex mixture produced the highest yield.

From observations made on the site, it appeared that the nitrogen applied at Powell definitely increased the ratio of grasses to legumes in each mixture, and the phosphate increased the ratio of legumes to grass (Figs. 4 and 5). Where nitrogen and phosphorus were applied in combination, or where no fertilizer was used, the

FIG. 5—The ratio of legumes to grasses was increased with 100 or more lbs. of phosphorus per acre at Powell
ratio of grasses to legumes was about equal (Fig. 6).

In comparison, at Greybull and Cody, there was no evidence of changes in the ratio of grasses to legumes due to application of fertilizer. These data indicate that where the soil is deficient in nitrogen and phosphorus, nitrogen stimulated the grasses which crowded out the legumes in a mixture, and phosphorus stimulated the legumes and retarded the yield of grasses.

It may be of interest to note here that at each of the three locations, approximately 8½ acres of each of the hay mixtures were seeded in 1950. At Cody and Powell, cattle and sheep grazed each of these hay mixtures in 1951. Several head of each died from bloat on the alfalfa/bromegrass mixture, but no losses occurred from the complex mixture. The two farmers believe that the alfalfa in the mixture caused the bloating. The amount of alfalfa in the forage from the alfalfa/bromegrass mixture was considerably more than that in the complex mixture. (See Figures 1 and 3.)

Crude Protein

Figure 7 shows the yield of crude protein in pounds per acre for each fertilizer treatment from each hay mixture at each location for 1953. The differences in the yield of crude protein for the three locations are the most interesting features of the data. The yield of crude protein for the alfalfa/bromegrass mixture was highest at Greybull and lowest at Powell. The average yield of crude protein without fertilizer at Greybull was 702 lbs. more than that produced at Cody and 1,322 lbs. more than that produced at Powell. The average yield of crude protein from the complex mixture was also highest at Greybull. It was, however, only 42 lbs. more than that produced at Cody and 735 lbs. more than that produced at Powell.

The hay yield data in Figure 2 and the protein-yield data in Figure 7 show the differences in yields that one may expect to receive from similar pasture mixtures, fertilized with the same kinds and rates of fertilizer but grown at different locations and on different soil types. These data illustrate the problem involved when recommending fertilizer for irrigated hay mixtures in the Big Horn Basin of Wyoming.

FIG. 6—The ratio of grasses to legumes was about equal when fertilized with 40 lbs. of nitrogen and 200 lbs. of phosphorus per acre applied at Powell.
FIG. 7—Average yield of crude protein from two grass/legume mixtures at three locations (Average of 1951, 1952, and 1953)
It is probable that, on each field on each individual farm, the fertility level of the soil will vary; when this is true, the fertility requirements for each field will differ.

### Chemical Composition of Hay

Table 2 shows the chemical composition of hay produced from the two grass/legume mixtures at the three locations for 1953. The data include the average chemical composition of the hay for all fertilizer treatments and cuttings. The chemical constituents include the percentage of dry matter, crude protein, calcium, and phosphorus.

A brief summary, comparing the data for each grass/legume mixture at the three locations, shows that the dry-matter percentage was highest in the hay produced at Cody. There was general decrease in the percentage of crude protein, calcium, and phosphorus in the hay produced on the soils of high to low productivity levels. The productivity level of the soil caused great differences in the composition of the hay between locations.

Differences in the chemical composition of the hay, due to fertilizer treatments, were masked by the variation in the vegetative composition of the hay. The ratio of grasses and legumes varied considerably between fertilizer treatments at each location.

A preliminary study of the chemical composition of alfalfa, brome, and orchardgrass samples collected from the first cutting of hay from the complex mixture from the no-fertilizer check plot at each location shows the following average results:

<table>
<thead>
<tr>
<th></th>
<th>Crude Protein</th>
<th>Calcium</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>19</td>
<td>1.6</td>
<td>.22</td>
</tr>
<tr>
<td>Brome-grass</td>
<td>10</td>
<td>.23</td>
<td>.24</td>
</tr>
<tr>
<td>Orchard-grass</td>
<td>9</td>
<td>.24</td>
<td>.25</td>
</tr>
</tbody>
</table>

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