Effects of Mulch upon Certain Factors of the Grassland Environment

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Most ranchers realize that one aspect of keeping our ranges in productive condition is the maintenance of a mulch of dead vegetation on the soil. Many ecological papers in range management have emphasized composition and yield of vegetation, but most have not secured data on amounts or effects of mulch. Dyksterhuis and Schmutz (1947) have clarified concepts and furnished quantitative data. They included a comprehensive review of literature, much of which referred to forest research. A study of effects of mulch in true prairie has recently been completed (Weaver and Rowland, 1952).

Studies were conducted in the college pasture 2.5 miles west of Hays, Kansas, to obtain quantitative data concerning mulch and its effect upon certain ecological factors of the mixed prairie. Determinations were made on amounts of mulch, rate of decomposition, and effects on infiltration, temperature, evaporation and soil moisture. Mulch was considered as any dead vegetation lying on the soil, free of the parent plant and easily distinguishable as of organic origin.

Amounts of Mulch

During April, 1950, and June, 1953, mulch was removed by hand from plots on upland, hillside, lowland and natural revegetation sites with varying vegetational types and treatments. Samples varied in number from 5 to 20, and in size from 0.25 to 1 square meter depending upon uniformity of sites. The ungrazed upland short-grass site (Table 1) had not been grazed since 1941 and was dominated by a mixture of blue grama and buffalo grass. Samples taken in 1950 and 1953 showed 4,780 and 5,070 pounds of mulch per acre, respectively. This would indicate that rates of accumulation and decomposition had approached equilibrium after 9 years of protection. In the nearby moderately grazed area, samples taken in 1950 showed 2,790 pounds of mulch per acre, but only 1,230 pounds in 1953. On grazed areas, yearly fluctuations are caused by variations in the degree of grazing. Occasionally, 75 percent or more of the forage may be returned to the soil, while in other years only 20 percent or less will be left. The 1952 season was relatively unfavorable for plant growth accounting in part for the reduction of mulch in 1953 as compared with 1950. Rate of decomposition would also be retarded in an unfavorable growing season, but probably not enough to compensate for reduced yield or heavy grazing. On the heavily grazed area, only 1,680 pounds per acre was recorded in 1950—39 percent less than that on the moderately grazed area.

In a lowland relict area, a pure stand of big bluestem produced 22,610 pounds per acre of mulch. This compares with about 14,000 pounds on the unmowed banks of ravines in the mixed prairie of the Nebraska loess hills (Hopkins, 1951). On the rocky hillsides ungrazed big bluestem produced only 9,060 pounds of mulch per acre. On grazed sites, side-oats grama made up about half the cover and mulch was reduced to 900 pounds. In an ungrazed lowland, western wheatgrass and buffalo grass produced 3,960 pounds of mulch per acre. On grazed portions the understory of short grasses predomi-
Table 1. Air-dry weights of mulch on various sites in a mixed prairie. Samples from first 4 sites were taken in April, 1950; others in June, 1953

<table>
<thead>
<tr>
<th>Condition, Site and Vegetation</th>
<th>Wt. of Mulch Lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland</td>
<td></td>
</tr>
<tr>
<td>1. Ungrazed short grass</td>
<td>4,780</td>
</tr>
<tr>
<td>2. Moderately-grazed short grass</td>
<td>2,790</td>
</tr>
<tr>
<td>3. Heavily-grazed short grass</td>
<td>1,080</td>
</tr>
<tr>
<td>Lowland</td>
<td></td>
</tr>
<tr>
<td>4. Ungrazed big bluestem</td>
<td>22,610</td>
</tr>
<tr>
<td>5. Grazed western wheatgrass and short grass</td>
<td>3,900</td>
</tr>
<tr>
<td>6. Grazed western wheatgrass and short grass</td>
<td>1,740</td>
</tr>
<tr>
<td>Hillside</td>
<td></td>
</tr>
<tr>
<td>7. Ungrazed big bluestem</td>
<td>9,000</td>
</tr>
<tr>
<td>8. Grazed big bluestem and side-oats grama</td>
<td>900</td>
</tr>
<tr>
<td>Hillside (natural revegetation)</td>
<td></td>
</tr>
<tr>
<td>9. Ungrazed western wheatgrass</td>
<td>6,870</td>
</tr>
<tr>
<td>10. Grazed western wheatgrass and buffalo grass</td>
<td>2,380</td>
</tr>
<tr>
<td>11. Ungrazed sand dropseed</td>
<td>3,600</td>
</tr>
<tr>
<td>12. Grazed sand dropseed</td>
<td>1,400</td>
</tr>
<tr>
<td>13. Ungrazed buffalo grass</td>
<td>2,290</td>
</tr>
<tr>
<td>14. Grazed buffalo grass</td>
<td>1,280</td>
</tr>
</tbody>
</table>

nated and mulch amounted to only 1,740 pounds. Structure of the surface soil appeared good in contrast to areas where wheatgrass was regularly mowed and relatively little mulch returned to the soil (Hopkins, 1951).

The "natural revegetation area" mentioned in Table 1 was cultivated during the early part of the century and abandoned in 1920. A portion was excluded from grazing in 1932. The vegetation consisted mostly of patches of sand dropseed and buffalo grass, each occurring in nearly pure stands. Western wheatgrass had become established in certain areas in the last 10 years. Under protection wheatgrass had eliminated most competing species, but a short-grass understory was present where grazed. On ungrazed areas, wheatgrass, sand dropseed and buffalo grass had accumulated 6,870, 3,600 and 2,290 pounds of mulch per acre, respectively, on the same soil. On grazed portions, the respective amounts were 2,380, 1,400 and 1,280 pounds (Table 1).

Comparative amounts of mulch can be used as indicators of degree of utilization. On the ungrazed upland and hillside sites, the amounts of mulch were 313 and 908 percent, respectively, greater than where each was moderately grazed. In this pasture hillsides are usually utilized more fully than the uplands (Hopkins, Albertson and Riegel, 1952). Also, since the short grasses of the upland produce a much greater portion of their total yield near the ground (Launchbaugh, 1948), more mulch would be accumulated than under the taller grasses of the hillsides even if grazing heights were similar.

Decomposition

From three to four years were usually required for the decomposition of vegetative material on the soil. Where large amounts were present three layers of mulch could readily be distinguished. Mulch of big bluestem produced in 1952 and examined in June, 1953, was yellowish-gray and somewhat mouldy except at the surface which had the appearance of cured forage. Leaves of the second layer, produced in 1951, were dark gray and crumbled easily. Stems were mostly intact and quite resistant to breaking. Leaves in the third layer were mostly disintegrated into very small pieces and stems were black, soft and easily broken. Organic material beneath this layer, in its fourth year of decomposition, was finely disintegrated and more or less intermingled with mineral particles.

These observations were verified experimentally by placing known amounts of mulch, ranging in air-dry weight from 200 to 1,800 grams, on each of 20 square-meter quadrats denuded of natural mulch in April, 1950. Mulch was of a different species than the vegetation in the quadrats in order that it might be observed for several years. Portions removed in June of the second year showed that from 40 to 60 percent of the initial weight had been lost. Leaves of all grasses had disintegrated leaving fibrous material. By the third year the basal portion was intermixed with mineral soil; leaves were mostly decomposed, and stems were very fragile. This experiment was carried out under favorable conditions for decomposition with above-average rainfall.

Infiltration

Infiltration or water intake of soils is regulated to a considerable extent by their vegetational and mulch covers. Duley and Kelly (1941) stress the importance of the condition of the soil surface in regulating water intake and point out that the presence of a mulch greatly improves infiltration as compared to bare soils.

Measurements of water intake on grazed and ungrazed sites in the short grass and wheatgrass types were made with 6-inch metal cylinders during June, 1953. Perforated metal baffles were placed on the soil surface in the cylinders which were driven three inches into the soil. Water was applied as fast as absorbed and rates measured for half-hour intervals for a 2-hour period. Three or more determinations were made at each location.

Differences in water intake on the grazed and ungrazed areas were evident immediately and increased with time (Fig. 1). The decrease in infiltration rate during the 2-hour period was much greater on grazed than on ungrazed sites.

To determine if factors other than the amount of mulch influenced water intake, all mulch was removed from one sample area in the short grass type and replaced on half the plot. Water was applied directly to the soil or mulch in tests of water intake on the mulched and denuded portions of the plot. On the mulched half,
infiltration was 183 percent greater than on the denuded half at the end of the 2-hour period. Mulch alone was not the controlling factor in water intake since this difference was not as great as that between the grazed and ungrazed areas.

Rate of water intake was relatively higher in the ungrazed areas in the short grass than in the wheatgrass type although the latter had a somewhat heavier mulch cover (Table 1). Differences in infiltration between the grazed and ungrazed sites were much more pronounced in the wheatgrass area than in short grass. These differences were proportional to the relative amounts of mulch on the grazed and ungrazed areas in these types. Weaver (1942) reported that infiltration rates in normal prairie were 2.4 times as fast as in wheatgrass. Absorption of water in the adjacent sand dropseed area was considerably slower than in the wheatgrass type. Less difference between grazed and ungrazed areas was found in the sand dropseed type as compared with the wheatgrass type. Differences in the sites occupied by the two grasses were apparently caused by amounts of mulch and the effects which the grasses had upon soil structure.

**Temperature**

Mulch prevents high surface temperatures and thus retards evaporation and improves the soil as a habitat for organisms. Conversely, deep mulch may retard initiation of growth by causing the soil to warm slowly.

Soil surface temperatures were found to be proportional to the amount of mulch present in a series of comparative temperature readings taken on July 22. With an air temperature of 90°F., maximum surface temperatures were recorded on a west-facing grazed hillside, which, though dominated by big bluestem and side-oats grama, had less mulch than any other area (Table 1, no. 8). In an adjacent exclosure, surface temperature under four inches of mulch was 84°F. Temperatures in the upland short grass were 99°F and 90°F., respectively, on the grazed and ungrazed sites.

**Evaporation**

The effects of mulch depth on water loss were measured on uniform sods of short grass fitted into 1-gallon containers. Mulch was added to triplicate containers to the following depths: 0, 0.5, 1 and 3 inches. Water loss was recorded for a 4-week period at weekly intervals, under laboratory conditions (Table 2).

Mulches appeared to be most effective when the soil was moist at the surface and had comparatively little influence on water loss after the surface soil dried. Mulch 0.5 inch in thickness reduced evaporation 41 percent from that of bare soil during the first week, but an additional 2.5 inches of mulch reduced evaporation only 67 percent from that of bare soil. During the fourth week losses from bare soil were similar to those of the mulched soils except for the 3-inch depth.

**Soil Moisture**

In their comprehensive survey of ecological conditions during drought, Weaver and Albertson (1944) stress the importance of soil moisture as the limiting factor in plant production in the mixed prairie. Tomanek (1948), in a correlation of mulch and soil moisture, found that a moderately grazed short-grass pasture had 1,454 pounds per acre of "litter and debris," while a heavily grazed pasture had only 30 pounds. During August, the former had from 3 to 7 percent available moisture in the upper two feet of soil, but there was none in the latter.

Soil moisture determinations were made during the summer of 1950 on mulched and denuded plots in ungrazed upland to evaluate the relative effects of mulch on available moisture. Duplicate samples were taken to a depth of five feet each two weeks from a 9-square-meter plot from which mulch was removed on April 22 and from an adjacent undisturbed plot. The hygroscopic coefficient, determined for this area

| Table 2. Evaporation losses from sods with various depths of mulch |
|-----------------------------|-----------------|-----------------|
| Mulch Depth | Daily Evaporation Loss | Total (26 days) |
|              | 1st week | 4th week |                  |
| None         | 15.8     | 7.5     | 303              |
| 1/2 in.      | 9.3      | 7.5     | 242              |
| 1 in.        | 7.5      | 7.2     | 224              |
| 3 in.        | 5.1      | 6.5     | 181              |
by Albertson (1937), was subtracted from total moisture content to find approximate available moisture. Data on available moisture content on the mulched and denuded quadrats in the upland short-grass habitat are presented in Table 3. The data are averages of two readings per month, but in several cases the biweekly data are more revealing.

There were no significant differences in moisture content by May 9, but on May 22 the surface 6-inch depth under mulch contained 18.2 percent available moisture as compared to 12.5 percent in the bare quadrat. Near the end of June, under unusually high temperatures and deficient rainfall, available moisture in the top 2 feet of the mulched area was 6 percent but less than 1 percent on the bare area. Rainfall during July and August was above average. By early September, moisture had penetrated the mulched soil nearly to the 4-foot depth, and there was 8 percent available moisture from 3 to 4 feet. In the bare area only the top 2 feet of soil was moistened and there was less than 1 percent at the 3 to 4 foot level. Thus, mulch was apparently effective in retarding loss of moisture during dry weather and increasing infiltration when the rains came. In Oregon, Stephenson and Schuster (1945) found that a straw mulch saved moisture equivalent to 2 or 3 inches of rainfall in dry weather.

Summary

Amounts of mulch on mixed prairie grassland ranged from 900 to 22,610 pounds per acre due to variations in site, species and condition of grazing. Tall grasses produced larger amounts of mulch than short grasses on ungrazed areas, but less mulch remained on grazed tallgrass sites.

Vegetation placed on the soil and allowed to decompose under natural conditions was mostly disintegrated after three years. Approximately half the initial weight was lost during the first year.

Mulch reduced soil temperatures and retarded evaporation. Its effectiveness in reducing evaporation was greatest when the surface soil was moist; evaporation losses were not in direct proportion to depth of mulch.

Rates of infiltration and soil moisture content were consistently greater on soils with mulch than without mulch. At the end of the growing season a mulched plot had available moisture to nearly 4 feet; an unmulched plot to only 2 feet.

LITERATURE CITED


FIRST KODACHROME SLIDE CONTEST

Eighth Annual Meeting of the American Society of Range Management
San Jose, California, January 25-28, 1955

Society members are invited to enter Kodachrome slides that they have taken in two classes:
1. Range condition class
2. Wildlife of the range

Kodachrome slides may be 2 x 2, or larger, mounted or unmounted. Contestants may enter one slide in each class. Slides will be projected at an evening session. Thereafter, they will be displayed for competition, with awards for the three slides placed highest in each class and the top slide of the display.

Rules of the photograph contest shall prevail with regard to typed description, contestant’s name and address, and his responsibility to take the slides to and from the display booth.

—Les Albee, Chairman, Slide Contest