Relationship of Organic Reserves to Herbage Production in Crested Wheatgrass[1]

JAY D. McKENDRICK[2] AND LEE A. SHARP

Research Associate and Professor of Range Management, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, Idaho.

Highlight

The weight of etiolated growth stimulated in the field by excluding sunlight from crested wheatgrass plants was measured and used as a quantitative index to the organic reserves of plants prior to spring growth. Subsequent herbage yields and vegetative/reproductive tiller composition were measured and statistically compared with the etiolated growth. Etiolated growth, basal area per plant, and number of tillers per unit surface area were all highly correlated to the subsequent herbage production. Protection from grazing for one growing season is apparently sufficient time for crested wheatgrass plants to nearly replenish their organic reserves. The use of etiolated growth in predicting herbage yields may be applicable when organic reserves are the most limiting growth factor.

A rapid and relatively simple method for assessing the effects of grazing treatments on plant vigor and productivity is needed if range managers are to successfully intensify the management of large areas of rangeland. About 1.2 million acres of rangeland in Idaho (Sharp, 1965) have been artificially seeded to adapted species, principally crested wheatgrass (*Agropyron cristatum* and *Agropyron desertorum*). Because of the importance of crested wheatgrass to the Idaho range livestock industry, a physiological basis for judging the impact of grazing treatments on this species is badly needed. This paper presents the results of a field technique used to relate organic reserves of crested wheatgrass to herbage production.

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[2] Present address: Research Assistant, Department of Agronomy, Kansas State University, Manhattan, Kansas 66502.

The production of perennial grass herbage is considered to be strongly influenced by the amount of organic reserve material that is developed during the previous growing season. Frequency, timing and intensity of defoliation are known to influence the amount of material that accumulates during a growing season. These reserves are predominantly non-structural carbohydrates but include quantities of nitrogenous compounds (Reid, 1924; Graber, et al., 1927; Davidson and Milthorp, 1965; and Humphries, 1967) and are accumulated in the roots and crowns of the plant. The nitrogenous compounds are thought to be as essential to regrowth as are the carbohydrates. Even though both types of compounds act as reserves, carbohydrate analyses are commonly used to measure the reserve status of plants. Analysis of only the non-structural carbohydrates yields an erroneous measure of the organic reserve level. The analysis is also laborious and expensive.

Because of the limitations of the laboratory analysis approach, interest has developed to evaluate the reserve level by measuring the amount of etiolated growth a plant is able to produce until its reserve supply is exhausted. This is not an entirely new technique as Reid (1924) used etiolated growth to study reserves in the tomato plant, and Graber et al. (1927) used a similar procedure to determine which organic compounds were utilized to produce regrowth in alfalfa. More recently this technique has been used to evaluate the influence of various organic reserve levels on subsequent herbage production in grasses (Burton, Jackson and Knox, 1959; Burton and Jackson, 1962; MacLeod, 1965; Adgebola, 1966; Raese and Decker, 1966; Lopez, Matches and Baldridge, 1967; and Mitchell, 1967). Index levels of organic reserves were determined by taking sod plugs of various grasses from the field and growing them in darkness. Hedrick (1967) used light-tight covers over individual crested wheatgrass plants in the field to stimulate etiolated growth and used the weight of this material as an index to the reserve carbohydrates.

A preliminary study was conducted in southern Idaho in 1967 to ascertain if there was a relation-

Table 1. Average weight (g) per etiolated tiller and subsequent herbage yield (lb./acre) at six locations in southern Idaho in 1967.

Location	Previous year's treatment	Average weight per etiolated tiller	Herbage yield
Point Springs seeding			
1955 exclosure	ungrazed	0.0172	1,525
1965 exclosure	ungrazed	0.0155	1,096
1963 exclosure	heavily grazed	0.0151	962
1967 exclosure	heavily grazed	0.0084	896
Bliss Point seeding			
1966 exclosure	ungrazed	0.0172	524
1965 exclosure	moderately grazed	0.0097	422

Fig. 1. Inverted plastic pots being used to stimulate etiolated growth of crested wheatgrass as a field method to assess organic reserves.

ship between the amount of reserve material occurring during the spring, as indicated by the etiolated growth under light-tight plastic pots, and subsequent herbage production.

Study Area and Methods

Two rangeland seedings of crested wheatgrass were used in this preliminary study. The Point Springs seeding is located near Malta, Idaho, at an elevation of 4,800 feet; and the Bliss Point seeding is located east of Bliss, Idaho, at an approximate elevation of 3,300 feet. The climate at both areas is similar except temperatures are higher in the spring at Bliss Point, and the annual precipitation is about two inches less than at Point Springs. The soils on the Point Springs seeding are derived from sedimentary material, and areas of saline and alkaline soil occur. The soils at Bliss Point were derived primarily from loess of unknown origin and are nearly neutral in reaction.

Four locations were selected for study on the Point Springs seeding and two on the Bliss Point seeding. Each location had been subjected to different grazing treatments in years prior to 1967:

Point Springs Seeding

1955 exclosure: Ungrazed 12 yr.

1965 exclosure: Heavily spring grazed 1955 to 1965; moderately grazed May 1 to May 23, 1965; ungrazed 1966 and 1967.

1963 exclosure: Heavily spring grazed 1955 to 1963; ungrazed 1963 to 1965; heavily grazed June 20, 1966; ungrazed 1967.

1967 exclosure: Heavily spring grazed 1955 through 1966; ungrazed 1967.

Bliss Point Seeding

1966 exclosure: Heavily spring grazed 1959 to 1966; ungrazed 1966 and 1967.

1965 exclosure: Heavily spring grazed 1959 to 1965; ungrazed 1965; moderately grazed April 25 to May 25, 1966; ungrazed 1967.

Three locations were grazed and three locations were not grazed during the growing season prior to sampling (Table 1).

At each location, twenty crested wheatgrass plants were clipped to remove the remaining stubble and covered with ten-inch diameter plastic pots on March 12 to 15, 1967 (Fig. 1). A groove was cut in the soil to accommodate the pot edge so that the pots would not be overturned by wind. On May 10 to 11 the total number of etiolated tillers per plant was counted, and a sample of ten tillers was clipped from each plant for weight determination.

Herbage yields (air-dried) were obtained at each location in late July. The number of crested wheatgrass plants were counted in thirty 9.6 ft^2 plots at each location on the Bliss Point seeding and then clipped for weight determination. The same procedure was used at Point Springs except that twenty 2.4 ft^2 plots were used at each location because of the smaller size of the exclosures.

At the end of November, 15 to 30 plants were measured to determine the basal area of plants at each location. The number of both fertile and vegetative tillers per plant was counted and then clipped separately for weight determinations. Tillers were considered fertile if an inflorescence had been produced and vegetative if only leaves had been produced.

Results

Etiolated Tiller Weight and Herbage Yield

The average weight per individual etiolated tiller did not show a good relationship to subsequent herbage yield at the six locations studied (Table 1). The 1955 exclosure at Point Springs produced the greatest herbage yield in 1967 and had the highest individual etiolated tiller weight (0.0172 grams). The 1966 exclosure at Bliss Point, however, had an equally high individual tiller weight but produced the second lowest herbage yield.

Average etiolated tiller weight appeared to reflect the previous year's grazing treatment in this study. Those locations grazed the previous year on each seeding had the least weight per etiolated tiller, and this weight increased as the number of years without grazing increased (Table 1).

Using the average weight per etiolated tiller (Table 1) and the number of etiolated tillers per

Table 2. Number of etiolated tillers per plant, etiolated tiller weight (g) per plant and herbage yield (lb.) at each of six locations.

Location	Etiolated tillers per plant	Etiolated tiller weight per plant	Herbage yield per acre
Point Springs seeding			
1955 exclosure	66.4	1.142	1,525
1965 exclosure	42.4	0.657	1,096
1963 exclosure	34.4	0.519	962
1967 exclosure	31.4	0.264	896
Bliss Point seeding			
1966 exclosure	10.2	0.175	524
1965 exclosure	4.8	0.047	422

plant, an average etiolated tiller weight per plant was calculated (Table 2). This tiller weight per plant was strongly correlated ($r = 0.967$) to the subsequent herbage yields at the six locations.

Etiolated Tiller Weight and Subsequent Tiller Production

The total tillers produced (Table 3) follow a pattern similar to the number of etiolated tillers per plant (Table 2) ascertained in the spring of the year.

The percentage of vegetative tillers (not producing an inflorescence) was low at those locations that had been grazed most heavily over a period of years, i.e., the 1967 exclosure at Point Springs and the two sites on the Bliss Point seeding. The number of vegetative tillers in the oldest exclosure (1965) made up 61 percent of the total tillers produced, in contrast to the 29 and 36 percent on the more heavily grazed areas (Table 3).

The average weight of fertile tillers from plants in the area protected from grazing since 1955 was about the same as from plants in areas ungrazed in 1966, i.e., the 1965 exclosure at Point Springs and the 1966 exclosure at Bliss Point. Somewhat lower

Table 3. Average number of tillers produced per plant during the growing season, percent vegetative tillers and average tiller weight (g) at six locations in southern Idaho.

Location	Tillers per plant	Vegetative tillers	Average tiller weight	
			Fertile	Vegetative
Point Springs seeding				
1955 exclosure	42	61	0.28	0.12
1965 exclosure	35	41	0.30	0.06
1963 exclosure	28	56	0.22	0.06
1967 exclosure	25	29	0.17	0.07
Bliss Point seeding				
1966 exclosure	11	29	0.25	0.05
1965 exclosure	12	36	0.21	0.06

Table 4. Plants (per ft^2 of surface soil), plant area (square inch) and number of tillers (per ft^2 of surface soil) at each of six locations in southern Idaho.

Location	Number of plants	Average area per plant	Tillers
Point Springs			
1955 exclosure	1.6	10.5	67.7
1965 exclosure	1.5	8.5	50.9
1963 exclosure	2.2	4.8	60.3
1967 exclosure	1.7	6.2	41.0
Bliss Point			
1966 exclosure	1.1	1.2	12.3
1965 exclosure	1.2	1.4	15.1

fertile tiller weights were found in the other locations which were grazed during 1966. The weights of vegetative tillers were roughly comparable at all locations except in the area protected from grazing since 1955. The weight of the vegetative tillers at this location was approximately twice as great as at the other locations (Table 3). Thus, the area with the greatest number of vegetative tillers also produced the heaviest vegetative tillers.

Plant Numbers, Plant Areas and Tillers Per Unit Area

In the course of gathering herbage yield data, the number of crested wheatgrass plants per unit area was ascertained. Plant area (basal area) and the number of tillers per plant were determined at each location in the fall of the year (Table 4).

Heavy grazing of crested wheatgrass stands often does not reduce the number of plants per unit area, and some studies have shown an increase under heavy grazing (Springfield, 1963; Hedrick, 1967).

This increase in density is somewhat misleading in that it results not from seedling establishment but rather from fragmentation of the grass clumps into smaller units.

The data from Point Springs (Table 4) show as high a plant count in heavily grazed areas as in ungrazed areas. Continuous close defoliation during the growing season over a period of years, however, will ultimately lead to a lower number of plants per unit area. The average number of plants per square-foot within the study area on the Bliss Point seeding was 1.8 in 1958 (McKendrick, 1966) compared to the 1.1 and 1.2 in 1967.

Plant area is more indicative of previous grazing practices than plant numbers as shown in Table 4. The most severely grazed areas at Bliss Point had much the smallest plant area. Those locations at Point Springs most recently and severely grazed generally had a smaller plant size. The slight discrepancy in the 1963 exclosure was due in part to the saline nature of the soil at this location. Plant numbers fluctuate markedly on the saline areas at Point Springs. In years of favorable moisture and no grazing, large numbers of new plants become established. The growing season of 1965 was such a year, and the plants established in that year were still relatively small in this exclosure because of the poor growing condition that occurred in 1966.

Discussion

The relationship of organic reserve levels, as indicated by the amount of etiolated growth in the field, and subsequent herbage production cannot be clearly defined from the results of this preliminary study. Although a high correlation ($r = 0.967$) was found between etiolated growth per plant and subsequent herbage yield, plant area and number of tillers per unit of soil surface area were also well correlated with herbage production—$r = 0.965$ and 0.927, respectively.

As previously indicated, heavy grazing does not greatly alter the number of plants per unit area of soil surface. This study shows, however, that appreciable reductions in plant area, and consequently, a reduced number of tillers per unit of soil surface area occur with heavy grazing treatments. Such reductions in plant area and number of tillers per plant may be related to low organic reserves induced by grazing in previous years. These conditions, however, may also be partly due to the destruction of tiller bud sites by livestock trampling.

If the individual grass tiller is considered as the ecological unit of plant growth as suggested by Evans et al. (1964), then the number of tillers per unit of soil surface area would appear to reflect stand vigor and herbage production better than the number of "plants" per unit area. Tillers per unit of soil surface area is a composite expression of the number of plants per unit soil surface area and plant size in terms of plant basal area.

Factors influencing tillering in crested wheatgrass are not well known. Hyder and Sneva (1963) have shown that grazing or cutting of crested wheatgrass stems such as to remove the growing tip will stimulate tillering providing moisture is available. The number of vegetative tillers produced in a season, as indicated in this study, may also be related to organic reserve levels. At the Point Springs study area, the percentage of vegetative tillers was greatest on the sites where etiolated tiller weight was greatest and least on the site with the smallest etiolated tiller weight (1967 exclosure). Differences were too small on the two sites at Bliss Point to be indicative of any relationship between weight of etiolated tillers and percent of vegetative tillers.

Moisture and temperature conditions during the growing season have been shown to have an influence on tillering in herbage grasses (Langer, 1963). The amount of tillering at each site may have been more directly affected by soil moisture differences resulting from animal trampling and compaction rather than from organic reserve levels.

The previous discussion indicates some of the difficulties that complicate interpretation of organic reserve levels as determined under field conditions. Tillering, growth rate and herbage production are responses affected by a complex of environmental and physiological factors. Organic reserve material is but one of several factors involved and, unless the organic reserves are clearly limiting, they cannot be used alone to predict herbage production. However, the field technique utilized in this study is applicable for detecting relative differences in the quantities of organic reserves in crested wheatgrass plants.

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