Yield, Survival, and Carbohydrate Reserve of Hardinggrass in Relation to Herbage Removal

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Highlight

Frequent removal of herbage from hardinggrass plants during the most active period of growth resulted in reduced yields and an increase in plant death. Intensive clipping also appeared to reduce the concentration of carbohydrate reserves in stem bases. Total sugar percent was higher and fructosan percent was lower in intensively clipped plants than in plants clipped only at maturity.

Holdinggrass (Phalaris tuberosa var stenoptera (Hack.) Hitchc.) is an important perennial grass species for seeding annual rangelands and also for the conversion to grassland of forage areas. (Love et al. 1956). Growth initiation in the fall and continuation during cool winter months plus a high production level of palatable nutritious forage are reasons for the favored status of hardinggrass. Another important characteristic often ascribed to hardinggrass is its ability to withstand intense grazing use and is the basis for the following study.

Obviously, limits exist in the capacity of hardinggrass to produce large amounts of herbage without ill effects on the longevity or vigor of the plant. The grazing manager should have background information relative to production limits and should know of the detriment that occurs to the stand with improper use. Where hardinggrass is present in a pasture dominated by resident annual species, the intensity of grazing may be determined by availability of the annual forage. Weather variability may often determine the intensity of use in any given season although hardinggrass may receive less grazing use when a mixed stand of annual species and hardinggrass is grazed during peak production and palatability of the annual species.

One of the problems in recommending a pattern of grazing use for hardinggrass is the lack of fundamental information concerning the effect of herbage removal during critical growth periods. One such period appears to be the time of maximum leaf production when greatest replenishment of food reserves takes place. In areas where hardinggrass is on the margin of its adaptation, intensive use during this time may be most critical, especially during years of environmental stress (McKell et al. 1965).

Experimental evidence to guide grazing management of hardinggrass stands is meager. The three-phase system proposed by Chohls (1954) is very logical since it allows for early-season use of perennial grasses, mid-season use of annual forage species and late-season use of perennial grasses. The principal objective of the three-phase system is to utilize separate pastures or range units to provide green forage for a longer period than would be available with only annual forages. This system incidentally allows the perennial grasses to build up food reserves during the midseason rest period.

Further information on hardinggrass management was provided by Miller et al. (1957). On the basis of a 4-year clipping study comparing yield and stand vigor in response to continuous, rotational, or early-late herbage removal, they recommended a system of early-late grazing.

A key factor in maintaining productivity and stand density is the amount of carbohydrate reserves carried through the dormant season to provide for growth in the following season (McCarty and Price, 1942).

To study the effect of three intensities of herbage removal upon productivity, survival, and storage of carbohydrate food reserves of hardinggrass in a marginal area of adaptation, a 4-year experiment was conducted in San Diego County, California. The results are reported here.

Methods

A previously established stand of hardinggrass was chosen for study at the Tule Springs Ranger located approximately 16 miles north of Alpine in San Diego County at an elevation of 2500 feet. Average rainfall for the 12-year period, 1951-62, at the site was 17.00 inches. During the study, however, considerably less rainfall was received and at the nearby El Capitan reservoir the records indicated 6.69 inches in 1960-61, 17.40 in 1961-62, 8.66 in 1962-63, and 13.37 in the 1963-64 growing seasons. The soil is a Fallbrook sandy loam and at the specific study site the depth was found to be no greater than 30 inches.

In 1959 a preliminary study was conducted to determine individual...
plant variation and productivity at the study site. The yield and size of 20 randomly-selected hardinggrass plants were obtained. With the sample variation in the first study as a guide, 96 plants in a fenced 0.25 acre area were randomly selected and identified with a numbered stake (Fig. 1). Each group of 24 was considered to be a replication. Two clipping treatments were imposed randomly within each replication; plants were clipped 3 times at monthly intervals prior to and at anthesis, and plants were clipped only at anthesis. Plants were clipped to a 2-inch stubble height. The size of each plant was also recorded at the initiation of the study.

Forage yields were obtained each year for 4 years. In the fourth year when plants were in the soft dough stage, the lower 1.5 inch of stem bases and the main roots of 6 plants from each clipping treatment and from randomly selected non-clipped plants within the fenced area were dug, washed, and frozen in dry ice for laboratory analysis. Since the plants at that time were still actively growing, an additional sample of stem bases and roots of 6 non-clipped plants was obtained 1 month later when leaves were turning brown and seeds were mature.

Stem bases and roots were freeze-dried and ground with a Wiley mill through a 6-mesh screen. The ground plant material was stored in tightly-capped glass jars until laboratory analyses were made.

The alcohol soluble fraction of the ground plant material was extracted from a 0.1 g sample of plant material which was placed in a Soxhlet extraction thimble with 120 ml of 80% ethanol and refluxed for approximately 12 hours. According to Laidlaw and Reid (1952) this procedure removes all sucrose, glucose, and fructose. The liquid was evaporated to 10 ml and 50°C under reduced pressure and the resulting mixture washed into a beaker and brought to 100 ml with distilled water. To clear the solution 5 ml of 0.3N Ba(OH)2 was added and stirred. After 2-3 minutes, 5 ml of 5% ZnSO4 was added; the solution was again stirred, then filtered through Whatman No. 2 paper into a 250 ml volumetric flask and brought up to volume with distilled water.

Reducing sugars (principally glucose and fructose) were determined from a 2 ml sample of the alcohol soluble fraction by following the procedures outlined by Nelson (1944).

Total soluble sugar was determined in 2 ml samples of ethanol-extracted solutions by using 4 ml of freshly prepared Anthrone reagent according to procedures outlined by Yemm and Willis (1954) and Nowakowski (1962).

Alcohol insoluble sugar (fructosan) was determined by washing the residue from the alcohol extraction into a beaker with about 75 ml of distilled water and agitating the mixture for 2 hours at 75°C water bath. The mixture was then filtered and the residue washed with boiling water. The filtrate was made up to a liter volume and fructosans determined by treatment of a 2 ml sample with anthrone reagent (Yemm and Willis, 1954).

Results

Intense clipping during the last 3 months of the growth period resulted in a decrease in yield of individual plants of hardinggrass (Fig. 2). In contrast, a single harvest at the peak of growth appeared to favor an increase in forage yield. After 4 years, the effect of the intense clipping treatment was so great that average forage production from the remaining live plants was reduced to about 16% that of the single clipped plants.

Differences in plant survival were partly responsible for the total yield reduction even though the main impact of clipping was on plant vigor and productivity.
From the original 48 plants in each treatment, 44 remained in the single-clipping treatment and 34 were alive in the three-clipping treatment (Table 1). In addition to reduced yields and increased mortality of plants in the intense clipping treatment, the size of the living grass plant was greatly reduced. In many cases only a small portion of the plant remained alive where previously a larger crown area had been productive.

The severity of weather during the 4 experimental years must also be considered in relation to plant productivity and survival. Very low precipitation was undoubtedly an important factor in the decline of the perennial grass stand reported previously. (McKell et al., 1965).

Carbohydrate reserves in the stem bases and roots clearly reflect the effect of clipping intensity on hardinggrass. The percentage of reducing sugars was higher in all plants, sampled at the early date, than in plants sampled at seed maturity (Table 2). The level of non-reducing sugars was highest in the intensively clipped plants. In contrast, the nonclipped plants sampled at anthesis had the lowest level of nonreducing sugar. One month after anthesis the level of nonreducing sugar had increased significantly in the nonclipped plants.

When reducing and nonreducing sugars were considered together as total sugars the only observed difference was that plants clipped 3 times had the highest concentration of total sugars.

The pattern of fructosan occurrence in the stem bases and root crowns of hardinggrass plants, in this study, was almost opposite that of the reducing and nonreducing sugars (Table 2). Intensively-clipped plants were lower in fructosan than plants of any other treatment. Conversely, nonclipped plants sampled at seed maturity had the highest fructosan level.

In terms of total carbohydrate reserve, the lowest value was obtained in the analysis of the intensively-clipped plants. The single-clipped plants and nonclipped plants had about equal reserves but nonclipped plants sampled one month later indicated a substantial increase in total carbohydrate content of stem bases and roots.

**Discussion**

The clipping treatments used in this study were arbitrarily established to simulate the effects of intensive grazing during the active growth period of early spring at the peak of forage production. Plants protected from grazing and which were not clipped for 4 years, were used as a standard of comparison. Results indicate the deleterious effects of intensive herbage removal during the most active growth period which occurred from approximately March 15 to May 30 at the study location. Not only was there a 29% loss in number of intensively-clipped

### Table 1. Total yield and survival of hardinggrass plants as influenced by herbage removal.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Year of Sampling</th>
<th>Year of Sampling</th>
<th>Year of Sampling</th>
<th>Year of Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1961</td>
<td>1962</td>
<td>1963</td>
<td>1964</td>
</tr>
<tr>
<td></td>
<td>Total Live</td>
<td>Total Live</td>
<td>Total Live</td>
<td>Total Live</td>
</tr>
<tr>
<td></td>
<td>Total yield (gm)</td>
<td>Live plants</td>
<td>Total yield (gm)</td>
<td>Live plants</td>
</tr>
<tr>
<td>Clipped 3 times*</td>
<td>27.4</td>
<td>48</td>
<td>6.2</td>
<td>43</td>
</tr>
<tr>
<td>Clipped once</td>
<td>30.9</td>
<td>48</td>
<td>25.5</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>3.60 ab</td>
<td>2.21 hi</td>
<td>2.60 u</td>
<td>27.47 q</td>
</tr>
<tr>
<td></td>
<td>.60 ab</td>
<td>2.21 hi</td>
<td>2.60 u</td>
<td>30.27</td>
</tr>
<tr>
<td>Not clipped (sampled at anthesis)</td>
<td>.96 a</td>
<td>1.99 i</td>
<td>2.94 u</td>
<td>26.03 q</td>
</tr>
<tr>
<td>Not clipped (sampled at seed maturity)</td>
<td>.27 b</td>
<td>2.59 h</td>
<td>2.87 u</td>
<td>34.01 p</td>
</tr>
</tbody>
</table>

*Values followed by the same letter are not significantly different from each other at the 5% level.

### Table 2. Carbohydrate reserves of hardinggrass plants in relation to herbage removal. Carbohydrate values are means of 5 plants expressed on the basis of percent of dry matter.

<table>
<thead>
<tr>
<th>Clipping treatment and growth stage</th>
<th>Reducing sugars</th>
<th>Nonreducing sugars</th>
<th>Total sugars</th>
<th>Total fructosan</th>
<th>Total carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clipped 3 times (vegetative &amp; at anthesis)</td>
<td>.82 a*</td>
<td>4.17 g</td>
<td>4.99 t</td>
<td>18.40 r</td>
<td>23.39</td>
</tr>
<tr>
<td>Clipped once (sampled at anthesis)</td>
<td>.60 ab</td>
<td>2.21 hi</td>
<td>2.60 u</td>
<td>27.47 q</td>
<td>30.27</td>
</tr>
<tr>
<td>Not clipped (sampled at anthesis)</td>
<td>.96 a</td>
<td>1.99 i</td>
<td>2.94 u</td>
<td>26.03 q</td>
<td>28.97</td>
</tr>
<tr>
<td>Not clipped (sampled at seed maturity)</td>
<td>.27 b</td>
<td>2.59 h</td>
<td>2.87 u</td>
<td>34.01 p</td>
<td>36.88</td>
</tr>
</tbody>
</table>

*Values followed by the same letter are not significantly different from each other at the 5% level.
plants, as compared with 9% attrition of single-clipped plants, but the average productivity per plant was also reduced.

The effect of simulated intense grazing, during the period when hardinggrass plants produce maximum leaf growth and photosynthate, appears to be most noticeable on reducing the levels of stored carbohydrate in the stem bases and roots. Nonreducing sugar predominated. It appears that repeated foliage removal prevents the utilization of readily available sugars in producing new tissue, resulting in an accumulation in storage areas. Whether such sugar accumulation renders the storage areas more palatable for over-use by livestock and small vertebrate pests is not known.

Reduction of fructosan storage is probably the most critical aspect of intense grazing since there is some evidence that fructosan is the principal form of carbohydrate reserve in grasses (Waite, 1958). In the present study, the reduction in fructosan concentration appears to explain the loss in vigor and survival of plants subjected to the intense clipping treatment during the early spring months. In a grazing trial in Australia, Willoughby (1959) attributed the success of a hardinggrass and subterranee clover (Trifolium subterraneum) sward to the high rate of growth in excess of defoliation. He observed that defoliation obviously placed a demand on carbohydrate reserves. However, in our study, even though the percentage of fructosan was relatively high, the total amount of fructosan stored was low because of the reduced size of the plants. Further study of the minimum percentage and total amount of fructosan necessary for regrowth in seasons to follow is desirable.

Management of hardinggrass stands should take into account the effect that prolonged and intensive grazing has on the shift in carbohydrate composition in storage areas and on the general reduction of reserves. Timing of use can be of great benefit to a stand of hardinggrass. As shown in this study, a delay in clipping for 4 weeks beyond anthesis resulted in 7.9% more reserve carbohydrate being translocated from leaves and stems into storage areas. Where early-maturing annual forage species are available in separate grazing units they should be utilized first, leaving such species as hardinggrass for late, green forage. Mixtures of annual species and hardinggrass should not be stocked at a rate that will result in overuse of the palatable hardinggrass at a vulnerable period in its phenology.

Summary

Composition of carbohydrate reserves of hardinggrass was determined after a 4-year period of intensive spring clipping versus a single clipping at anthesis. Nonclipped plants at anthesis and at full maturity were used as a standard of comparison. The 4 years during the clipping trials were below average in rainfall and constituted a severe environmental stress.

Plant mortality and reduced production occurred as a result of intense clipping, which also appeared to upset the amount and composition of carbohydrate reserves. The total sugar percentage was higher, and the fructosan level was lower, in plants clipped successively during late spring than in plants clipped at or after anthesis.

Grazing management plans for pastures and ranges seeded to hardinggrass should avoid excessive defoliation of this plant during its period of most rapid growth.

LITERATURE CITED


