Carbohydrate Content of Underground Parts of Grasses as Affected by Clipping[1]

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A grazing system which permits maximum herbage production with a minimum of harm to the plant becomes increasingly important as a growing population demands more and more meat. Sustained herbage production depends to a great extent upon the ability of the plant to withstand moderate to heavy utilization. Preservation of perennial grasses depends upon the manufacture and storage of carbohydrates in excess of those required for growth. Any system of grazing that consistently removes most of the photosynthetic tissue, thus preventing manufacture and storage of carbohydrates, will eventually result in destruction of the grass.

Therefore, it is important to know the effects of defoliation upon the amount of carbohydrates stored in the underground parts. The present study was made to determine the influence of different intensities and season of clipping on the carbohydrate content of roots, rhizomes, and crowns of big bluestem (*Andropogon gerardi* Vitmani.), western wheatgrass (*Agropyron smithii* Rydb.), and a mixture of blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) and buffalo grass (*Buchloe dactyloides* (Nutt.) Engelm.).

Review of Literature

Many workers have found that a moderate system of clipping or grazing is less likely than intense

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utilization to harm the plant and still maintain high yields (Tomanek, 1948; Weaver and Hougen, 1939; Weaver and Darland, 1948; and Weaver, 1950). Hanson and Stoddart (1940) reported carbohydrate food reserves of bunch wheatgrass were reduced 19.4 percent in heavily grazed plants as compared to protected plants. As a result of this weakened condition, its dominant position was taken over by sagebrush. McCarty and Price (1942) found that root reserves of all clipped plants were lower than those of unclipped plants in a study of grasses and herbs of the Wasatch Mountains. McCarty (1935, 1938) concluded that starch and sugars were the most potent stored foods. Sampson and McCarty (1930) reported an inverse correlation between seasonal fluctuations of the carbohydrates and growth rate of *Stipa pulchra*. Graber *et al.* (1927) and Graber (1930) reported retardation of both root and top growth and a decrease of organic reserves in the roots following frequent defoliation. Cook *et al.* (1958) found decreased carbohydrate content in the roots of crested wheatgrass as clipping intensity and frequency increased. Hyder and Sneva (1959) reported the fluctuations of carbohydrate storage with growth of crested wheatgrass. Dodd and Hopkins (1958) studied the carbohydrate content of roots and crowns of young stands of blue grama and found that stored foods declined following defoliation.

Methods of Study

Three plots were staked out in each of the communities of grasses studied. Two plots consisted of 9 square-meter quadrats each and one contained 5 quadrats. The short grasses had not been grazed for 10 years; big bluestem and western wheatgrass had never been grazed by domestic livestock. The clipping treatments were as follows: unclipped; moderately clipped every 3 weeks to a stubble height of 2, 3, and 7 inches, respectively, for the two short grasses, big bluestem, and western wheatgrass; and heavily clipped every 2 weeks to a stubble height of ½, 1, and 3 inches on the same grasses. Samples of underground parts were removed to a depth of 4 inches from each treatment monthly except for 5 winter and early-spring months. The roots were washed free of soil, dried quickly, finely ground, and stored for chemical analysis. Starch was determined in accordance with McCarty and Price (1942), and hemicellulose, sucrose, and reducing sugars by methods outlined in Official Methods (1945) of the Association of Official Agricultural Chemists. Starch, sucrose, and reducing sugars are reported as total readily available carbohydrates.

Environmental Conditions

Climatic conditions during the 2 years of this study varied considerably. Precipitation for April through September in 1951 was 37.45 inches, considerably above the normal of 18.03 inches. Temperatures for the same period were below normal resulting in cool, moist weather, ideal for plant growth. In contrast, during 1952, precipitation was 9.06 inches, far below average. Ample soil moisture was present to a depth of 5 feet for rapid plant growth during the entire 1951 growing season. But in 1952, available moisture was present only in May and June.

Results

Soluble Carbohydrates

Blue grama and buffalo grass

Sugar and starch content of the underground parts in the unclipped quadrats varied with the growth of the grasses (Figure 1). When growth was rapid in the spring, the amount of readily available carbohydrates was low, but as these warm-season grasses were approaching maturity and dormancy in the fall, a peak in stored foods occurred. In 1951 a low of 8.1 percent occurred on July 31, during flowering and seed set. On January 1, 1952, a high of 12.0 percent had been reached, but this decreased to 8.8 percent by May 6 when growth was rapid. Further fluctuations, which can apparently be correlated with growing conditions and phenological de-

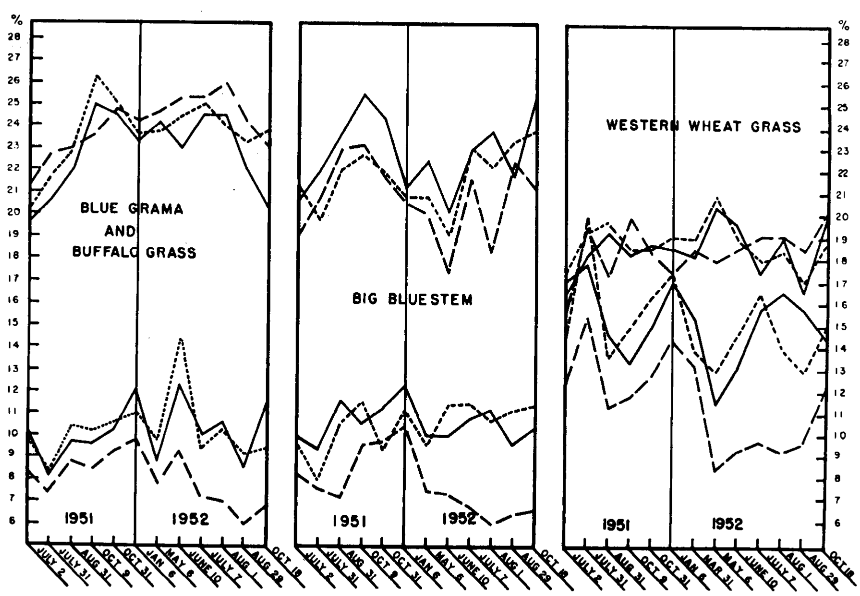

FIGURE 1. Percent total readily available carbohydrates (lower) and hemicellulose (upper) in control (solid line), moderately clipped (short dash), and heavily clipped (long dash), short grass, big bluestem, and western wheatgrass on dates indicated.

velopment can be followed in Figure 1.

The values of readily available carbohydrates from moderately-clipped quadrats parallel those of the control. At several times there were more available carbohydrates in the roots where moderate clipping had occurred than where it had not. However, amounts in the heavily-clipped areas were consistently less than where clipping was only moderate. Decreased amounts were especially significant during the second year. When the experiment was terminated, there was 36 percent less available carbohydrates in heavily clipped plots than in the unclipped plots.

Big bluestem

Trends of storage and utilization of carbohydrates in big bluestem were similar in most respects to those of the short grasses. Carbohydrates decreased on October 9 when flower stalks were forming in the unclipped area, while in the moderately-clipped areas, there was an increase in stored food. This advantage was cancelled after the flowering period in 1951 but not in 1952. On the basis of carbohydrate storage alone, big bluestem was better able to withstand heavy clipping during the first year than were the short grasses. At the end of the first season there was relatively little difference in amounts of stored foods in the heavily- and moderately-clipped big bluestem quadrats. During the second year, however, stored foods declined more quickly and more severely than with the short grasses (Figure 1).

Western wheatgrass

Total amounts of carbohydrates in western wheatgrass were considerably greater than in the other grasses, but nevertheless followed a pattern correlating with the growth habits of a cool-season grass. Largest amounts, up to 17.7 percent, occurred during summer and midwinter when plants were mature or dormant in the unclipped quadrats, while minimums of 13.4 and 11.7 percent were during October and May respectively, when growth was rapid during cool weather. Apparently storage of reserve food occurred rapidly over a short period during the latter part of the growing season.

Again moderate clipping did not hinder seriously the storage of carbohydrates. In fact, in western wheatgrass, there were more carbohydrates present in the roots in the moderately-clipped grass during both the fall and summer storage periods than where unclipped. During the first year the former started storage several weeks earlier than the latter. Samples taken in July and August, 1952, showed that the moderately-clipped grasses started using reserve foods about a month ahead of those unclipped. This is further evidence of the effect of clipping in lengthening the growing season of this grass.

As in the other grasses, effects of heavy clipping became severe only during the second year. For example, on August 1, 1951, there was 12 percent less stored food here than in the unclipped plots; but at the same time in 1952, there was 40 percent less.

Hemicellulose

The role of hemicellulose as a reserve food is uncertain. Changes in the amount of hemicellulose and total readily available carbohydrates are more or less in inverse proportion (Figure 1). Fluctuations suggest that conversions from hemicellulose were added to other carbohydrates and utilized in the metabolic functions of the plant. Hemicellulose could thus be considered as available stored food. However, McCarty (1938) suggests that any transformation is apparently so slow that it would fail to supply sufficient soluble sugars when utilization is rapid.

Discussion

Sugar and starch content of the underground parts varied with the growth of the grasses and the intensity and frequency of herbage removal. When growth was rapid in the spring or fall, available carbohydrates were low, and when the grasses were approaching dormancy, carbohydrates reached their peak. Graber (1927) states that an increase in sugar content as winter approaches has been associated with resistance to winter-killing. McCarty (1938) concluded that large amounts of soluble carbohydrates during the winter months, when the plant is subjected to the desiccating influence of low relative humidity and unavailable soil moisture, results in an increased water-holding capacity of the roots.

Much valuable forage was removed from the moderately-clipped grasses without significant depletion of total reserve foods in their roots; however, the data have indicated that continued removal of a large part of the photosynthetic area of the heavily-clipped grasses could eventually result in their complete destruction. Carbohydrate reserves of the latter averaged 21.2, 26.1, and 23.6 percent less than those of unclipped short grasses, big bluestem, and western wheatgrass, respectively.

Despite the short duration of the study reported here, results indicate that moderate grazing does not decrease root reserves appreciably and, therefore, high yields are maintained. In contrast, heavily-clipped grasses suffered losses in carbohydrates and, consequently, in vigor and productivity.

These lowered reserves will undoubtedly lead to reduced vigor, more winter-killing, a reduced root system, less resistance to drought, and inability to withstand further utilization.

Summary

A field and laboratory study was made in 1951 and 1952 to determine the effects of moderate and heavy clipping upon the carbohydrate root reserves of several grasses. Treatments also consisted of control (unclipped) plots. Evidence is presented that a system of moderate utilization will allow removal of considerable forage without any apparent decrease in root reserves. Heavy utilization two successive years depleted the food reserves 26.1, 23.6, and 21.2 percent in big bluestem, western wheatgrass, and the short grasses, respectively, compared to unclipped plots.

Carbohydrates accumulated after seed formation and when the plants approached dormancy. For the warm-season grasses a peak of stored carbohydrates occurred in the early winter. Stored carbohydrates in the roots of western wheatgrass, a cool-season grass, coincided with summer and early winter dormancy of this species. Decreased amounts of carbohydrates were present in the roots during periods of rapid growth in the early spring or fall.

Amount of carbohydrates in the roots of moderately-clipped plants exceeded those of unclipped plants during several sampling periods. However, roots of heavily clipped plants consistently had less stored food than unclipped or moderately clipped plants.

Although the role of hemicellulose in plant metabolism is unknown, data presented show an inverse proportion between hemicellulose and total readily available carbohydrates suggesting conversions may be made to soluble carbohydrates.

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