Trends of Nonstructural Carbohydrates in the Stem Bases of Switchgrass

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Highlight: *Carbohydrate reserves in the stem bases of switchgrass (*Panicum virgatum *L.) reached their minimum percent in the spring growth, and in the regrowth after cutting, when the young tillers began to initiate their elongation (jointing). Cutting or grazing at this stage would weaken the plants as compared with cutting at the flowering stage, or later, when carbohydrate reserves have been restored to a high level.*

The primary source of reserve energy for the growth of perennial grasses is the nonstructural carbohydrates stored in their vegetative organs, primarily in the basal portion of the stems (Smith, 1968; Smith, 1972; White, 1973). Carbohydrate reserves are essential for survival and for the production of new tissues in the spring and after cutting or grazing. Percent nonstructural carbohydrates in the stem bases of perennial grasses usually decrease with the beginning of growth in spring and after cutting, and increase with advance in maturity to flowering and seed formation (Aldous, 1930; Sullivan and Sprague, 1943; Weinmann, 1948, 1961; Lindahl et al., 1949; Sprague and Sullivan, 1950; Smith, 1972). A knowledge of the trends of the energy-providing carbohydrates in the stem bases of perennial grasses is of basic importance to cutting and grazing management. It will indicate the periods of low and high carbohydrate reserves and when cutting or grazing can be practiced with least reduction of plant growth and productivity.

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The kinds and trends of reserve carbohydrates stored in the stem bases of many native perennial grass species have not been fully explored. The current study involved switchgrass (*Panicum virgatum* L.), an important grass in the grazing lands of the Great Plains, and a species being investigated for summer forage in the humid areas of the United States.

Materials and Methods

A stand of switchgrass established on the University Farms at Madison was used. The stand was sown in 1967 in rows 45 cm apart with seed obtained from North Dakota. Plants were sampled during 1969 at intervals from April 7 to October 15 from rows cut to a 7.6 cm stubble height at early anthesis on July 11. In 1971, plants were sampled from April 6 to mid-anthesis on July 29.

At each sampling date, a short section of a row was cut to a 7.6 cm stubble height, and the plants were removed from the soil, washed in the laboratory, and all roots removed and discarded. Stem bases were separated from all dead leaf blades and sheaths, and the stem bases (rhizomes included) were dried at 70°C. The dried tissue was ground to 40-mesh size, placed in glass bottles, redried at 70°C, and the bottles sealed. Sugars were removed by mechanically-shaking with 80% (V/V) ethanol. After removing the alcohol, an aliquot was analyzed for reducing sugars, and a second aliquot was analyzed for total sugars after acid hydrolysis. Nonreducing sugars were calculated by subtracting the reducing sugar values from that for total sugars. Residues from the ethanol extraction were analyzed for starch with the enzyme method of Smith (1969). Total nonstructural carbohydrate values were obtained by addition of the total sugar and starch values.

Reducing power of each carbohydrate fraction was determined by copper-reduction-iodine titration as described by Smith (1969). Carbohydrates were expressed as percent glucose on a dry weight basis.

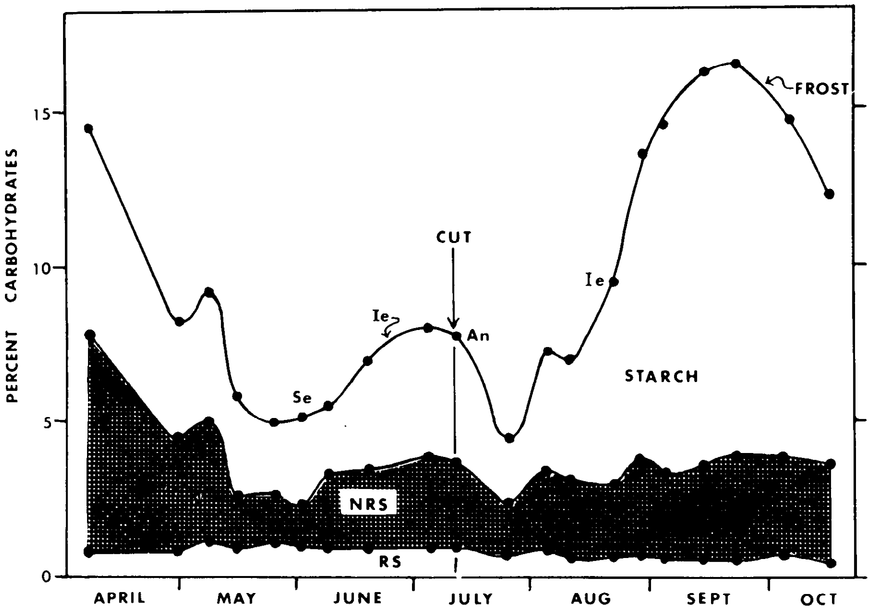

Fig. 2. *Percent (dry wt) of reducing sugars (RS), nonreducing sugars (NRS), and starch in the stem bases of switchgrass from early spring of 1969 to October 15 for plants cut at early anthesis on July 11. Se = beginning of stem elongation, An = early anthesis, and Ie = inflorescences beginning to emerge.*

Results

Carbohydrates in Uncut Plants

Trends of various nonstructural carbohydrates in the stem bases of uncut plants of switchgrass during 1971 from the first spring sampling (April 6) to mid-anthesis (July 29) are shown in Figure 1. Trends of uncut plants during 1969 are shown in Figure 2 from the first sampling (April 7) until they were cut at early anthesis on July 11. Carbohydrate trends were quite similar during both years. Percent total nonstructural carbohydrates (TNC, summation of the carbohydrate fractions) in the stem bases decreased with the growth of new shoots during early spring and reached a minimum when tillers began to elongate (joint) during early June. The decrease in TNC was due to the use in growth of both starch and nonreducing sugars (NRS, primarily sucrose), which also reached their minimum percent at the beginning of stem elongation. Changes in reducing sugars (RS) were very small during both years, varying between 0.6 and 1.8%.

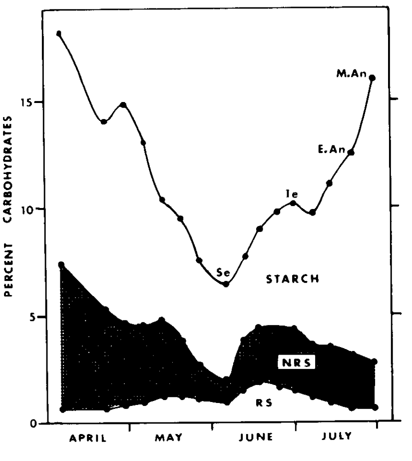

Fig. 1. *Percent (dry wt) of reducing sugars (RS), nonreducing sugars (NRS), and starch in the stem bases of switchgrass from the initiation of growth in the spring of 1971 to mid-anthesis. Total sugars are the sum of the RS and NRS values; total nonstructural carbohydrates are the sum of the RS, NRS, and starch values. Se = beginning of stem elongation, Ie = inflorescences beginning to emerge, E. An = early anthesis, and M. An = mid-anthesis.*

After reaching a low level at the beginning of stem elongation, percent TNC increased steadily to the last sampling made at mid-anthesis (July 29) in 1971, and to just before anthesis (July 11) in 1969. There was a slight decrease in 1969 just prior to anthesis, at which time the plants were cut. Most of the increase in TNC was due to the accumulation of starch. Percent sugars increased for a very short period after the beginning of stem elongation. They then decreased slightly during 1971, but changed very little during 1969.

Carbohydrates in Plants Cut at Anthesis

In 1969, stem bases of switchgrass plants that had been cut at early anthesis were analyzed for nonstructural carbohydrates from early spring (April 7) to late autumn (October 15) (Fig. 2). Trends of carbohydrate fractions in the stem bases from early spring to the time plants were cut at early anthesis (July 11) were discussed above. After cutting at early anthesis, the cyclic pattern of TNC decrease and increase was repeated as in the uncut spring growth. Again, the decrease in percent TNC was due to decreases in percent of both starch and NRS, reaching minimum levels about 2 weeks after cutting. This was probably the time that the second-growth tillers were beginning to elongate, but the exact stage could not be accurately determined as it was in the primary growth. After reaching minimum levels, percent of both starch and NRS increased for a short time. Thereafter, percent of sugars remained more or less constant. However, percent starch increased rapidly, reaching 13% by late September (16% for TNC). Subsequently, frost killed the green foliage so that percent of both TNC and starch in the stem bases decreased, since respiration now exceeded photosynthesis.

Discussion

Trends of total nonstructural carbohydrates (TNC) in the stem bases of switchgrass were essentially the same as those reported previously with temperate perennial grass species, namely bromegrass (*Bromus inermis* Leyss.) and timothy (*Phleum pratense* L.) (Smith, 1972). Percent TNC reached the minimum level at the time the tillers began to elongate in both the spring growth and in the regrowth after cutting the primary growth at early anthesis. Thus, cutting or grazing switchgrass at the beginning of stem elongation could materially weaken the plants because of the low level of carbohydrate reserves at that stage, as opposed to cutting at flowering or later when carbohydrate reserves are at a high level.

The primary nonstructural carbohydrate fraction was starch, as would be expected in a grass of tropical origin (Smith, 1968, 1969). Starch was the fraction that fluctuated most as carbohydrates in the stem bases were used for growth or were stored as the plant approached maturity.

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