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.

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.

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.

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
Seedling Growth of Three Switchgrass Strains

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Highlight: Seedlings of Pathfinder, Nebr. 28, and experimental ey switchgrass (Panicum virgatum L.) strains were grown in a growth chamber and harvested 1, 2, 3, 4, 6, 8, and 10 weeks following emergence for detection of seedling growth differences among strains. Leaf areas and dry weights of leaf blade and stem axis (stem and leaf sheath) generally increased significantly with each harvest from 4 to 10 weeks. Stem axis and leaf blade dry weights were significantly greater with Pathfinder and ey, respectively, than with Nebr. 28. Final leaf area was significantly greater with ey than with the other strains. Thus, Nebr. 28 (early-maturing) would be less competitive with weeds during establishment than Pathfinder or ey (both are late-maturing). Relative growth rate (RGR), net assimilation rate (NAR), and leaf area ratio (LAR) were similar for all strains, although at the first harvest Nebr. 28 had a lower LAR than the other two strains. RGR, NAR, and LAR generally declined with each successive harvest. The strains appeared to have the same capacity to produce above ground biomass but photosynthetic partitioning differed as indicated by leaf and stem comparisons.

Difficulties in establishment of warm season perennial grasses present a major problem in the improvement of existing pasture and range areas, or in establishing pastures on land currently used for field crops in the Great Plains. Rapid seedling growth of these warm-season perennial grasses is essential for successful stand establishment. The development and evaluation of strains having improved seedling growth characteristics needs urgent attention. The use of growth analysis formulae offers a quantitative way to document rapidity of seedling growth characteristics (Cooper, 1967, and Johnston et al., 1972).

The dry weight yield of a plant depends on: (a) initial capital, (b) relative growth rate, and (c) length of the growing season (Watson, 1952). The initial amount of photosynthetic area and seedling vigor is determined largely by the amount of initial capital, which is measured as seed weight (Black, 1956; Beveridge and Wilsie, 1959; and Stickler and Wassom, 1963).

Relative growth rate (RGR) has been reported to be a useful tool in studying differences in seedling vigor (Cooper, 1967; Johnston et al., 1972; and Radford, 1967). RGR is a measure of the weight increase per unit of plant weight present per unit of time (g/g/wk). Since it is based upon initial weight, differences due to seed or seedling size are eliminated. Other growth parameters include net assimilation rate (NAR), the net increase in dry weight per unit of leaf area per unit of time (g/dm²/wk) and leaf area ratio (LAR), the ratio of leaf area to...