Carbohydrate Reserves in Roots of Sand Shin Oak in West Texas

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Highlight: *Total nonstructural carbohydrate (TNC) concentrations in the root system of sand shin oak (*Quercus havardii*) were analyzed from January, 1972, through December, 1973. Effects of shredding on root reserves were also explored. In both years root TNC varied with the different phenological growth stages. Reserves were gradually depleted throughout the dormant season, November to April, until the low of 6.5 and 7.0% was reached in early May of 1972 and 1973, respectively. TNC then began to accumulate in the roots when the leaves were from 1/3 to 1/2 full size. Shredding significantly reduced root reserves for 6 months. Early leaf expansion is a good indicator of downward carbohydrate translocation and may be the best guideline available for the application of systemic herbicides to effect oak control.*

Seasonal variations of carbohydrate reserves have been analyzed for many plants, and in many cases results have been similar. Some of the variability between species has been attributed to growth behavior and environmental conditions (Cook, 1966). Coyne and Cook (1970) concluded that the most important factor influencing carbohydrate reserves in plants is stage of growth.

McConnell and Garrison (1966) working with bitterbrush (*Purshia tridentata*) reported root carbohydrate reserves to be depleted during the early growing season and during seed formation. Root carbohydrates then accumulated until leaf fall. Similar results were found by Woods et al. (1959) with turkey oak (*Quercus laevis*) and bluejack oak (*Q. incana*). Jones and Laude (1960) found a decrease in root reserves of chamise (*Adenostoma fasciculatum*) coinciding with early spring twig growth.

Carbohydrate reserves are rapidly utilized to produce growth in early spring. If the species is defoliated during growth, reserve carbohydrates are further utilized to promote photosynthetic organs. When root reserves are limited, the rate of growth may be reduced. Donart and Cook (1970) analyzed carbohydrate reserve levels in snowberry (*Symphoricaropos vaccinioides*) and rabbitbrush (*Chrysothamnus viscidiflorus*) after foliage was removed. Rabbitbrush produced fewer stems and regrowth was slower when it was clipped at the low reserve level. Both shrubs were able to replenish root reserves if allowed to produce 20% of their anticipated regrowth. Berg and Plumb (1972) further stated that vigor of sprouting is lowest if shrubs are cut at the time reserves are lowest.

Sand shin oak (*Quercus havardii*) is a low-growing, rhizomatous, deciduous shrub seldom growing more than 1 m tall. The root system consists of both taproots and widespread laterals capable of sprouting along their entire length (McIlvain, 1956). The lateral roots have been described as rhizomes which assume a vertical growth upon reaching the soil surface (Muller, 1951). Root:shoot ratios approach 10:1 (Pettit and Deering, 1971). An example of the root mass is found in Figure 1 (top) while typical aboveground shin oak growth is noted in Figure 1 (bottom).

Herbicide effectiveness in killing this oak has been eratic, and at times very little top kill has occurred. Objectives of this research were to study seasonal variations in sand shin oak root reserve carbohydrates and to monitor the effects of shredding upon these reserves.

Methods and Materials

The study area, owned by Robert Beasley, was located 15 km north of Plains in Yoakum County, Texas. Climate of the area is continental with an average precipitation of 49 cm. Much of this precipitation results from brief but intense spring and late summer thunderstorms. Topography is level to slightly undulating with numerous wind-eroded pockets up to 30 cm deep.

Dominant soils of the area are Patricia fine sand with inclusions of Brownfield fine sand. They are characterized by having an A horizon with over 90% fine sand to a depth of 40 to 50 cm. A well-developed argillic horizon is found in the subsoil. These soils are Aridic Paleustalfs of the fine mixed thermic family. Water infiltration and percolation are rapid until the wetting front reaches the subsoil.

This sandyland range site supports in addition to the sand shin oak, varying densities of sand sagebrush (*Artemisia filifolia*), broom snakeweed (*Xanthocephalum sarothrae*), fall witchgrass (*Leptoloma cognatum*), little bluestem (*Schizachyrium scoparium*), purple threeawn (*Aristida purpurea*), sand dropseed (*Sporobolus cryptandrus*), and sideoats grama (*Bouteloua curtipendula*).

On each sampling date, stems from five oak plants were randomly selected, then excavated to obtain root materials. From January, 1972, through December, 1973, roots were collected at weekly or biweekly intervals during the growing season and at

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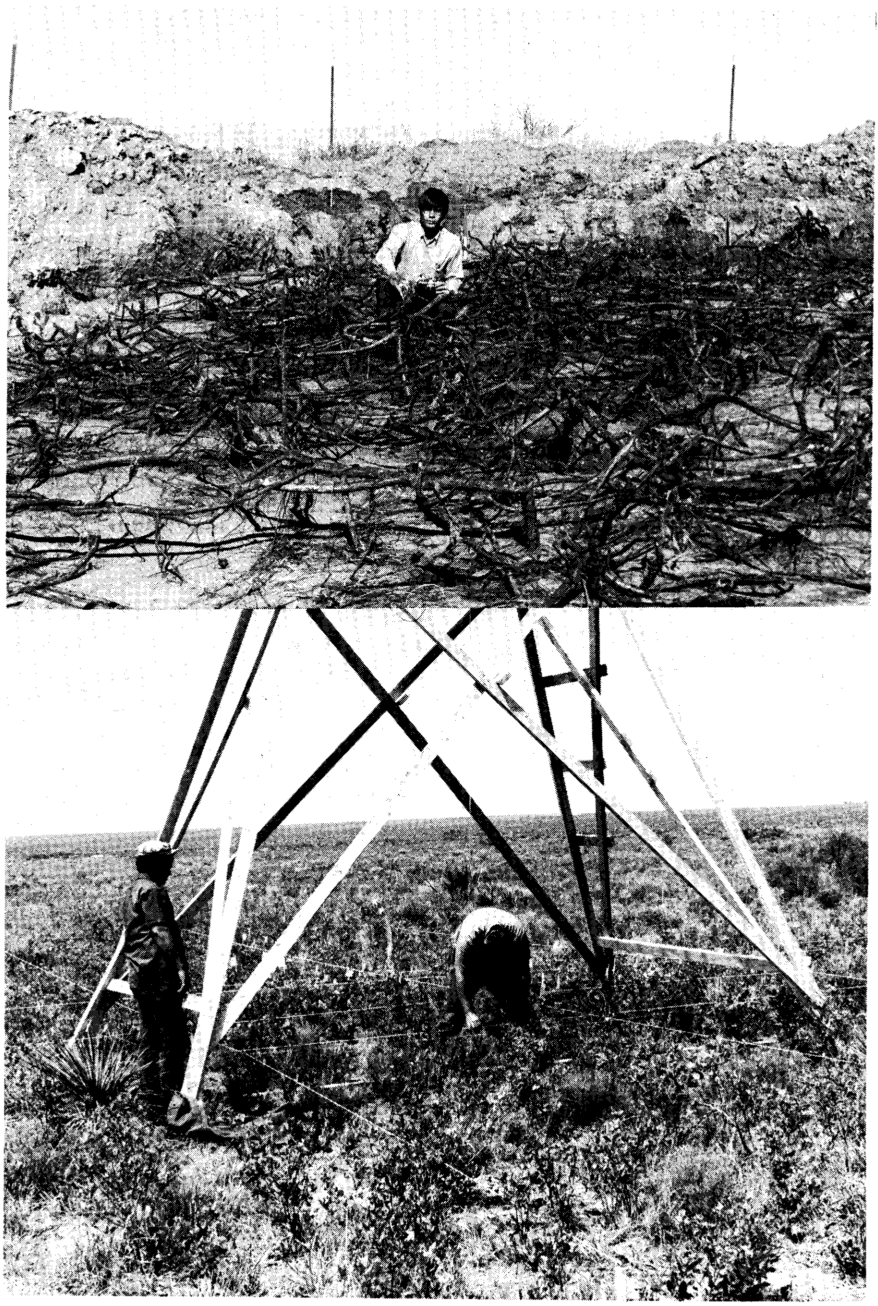

Fig. 1. *(*Top*) Water was used to expose roots within the sand shin oak community. These roots are capable of producing new shoots along their entire length. Only soil in the A horizon has been removed. (*Bottom*) Typical sand shin oak community in West Texas. This view corresponds to plot where roots were exposed (*Top*).*

monthly intervals in the dormant season. Two size classes of roots were taken from each plant and separated using the following criteria: (a) small; roots directly connected to the aerial portion of the plant with a diameter of 0.5 to 1.0 cm, (b) large; ramifications of roots defined as small and larger than 1 cm in diameter. The roots were excised into 10 to 15 cm sections and placed upon dry ice in an airtight container. They were kept here for at least 5 hours before being transferred to a forced-air drying oven set at 65°C. After drying for a minimum of 2 days, the samples were cleaned to remove rhytidome and wood appearing dead. They were then ground with a Wiley Mill to pass a 1-mm screen before storing in hermetic containers.

On June 1, 1973, 2 ha of the study area were shredded with a power-take-off driven "flail-type" shredder. After regrowth occurred, samples were taken and processed similarly to the unshredded samples.

Samples weighing 0.5 g were hydrolized and extracted with 0.2 *N* hydrochloric acid. Total nonstructural carbohydrates (TNC) contained within this extract were assayed using the anthrone method described by Yemm and Willis (1954).

On each sampling date aboveground stems were collected to accurately describe the phenological growth stage. Anatomical development of each leaf could also be studied. Experimental units used in this study were completely randomized with five replications of each treatment. Data were analyzed as a split-plot factorial, and the means were compared using Duncan's multiple range test. Level of precision used was 0.05.

Results and Discussion

Data analyses comparing carbohydrate concentrations of the large and small roots showed that they were not significantly different. For this presentation, all datum points for each sampling date represents the average of 10 analyses of root material collected on each date.

Root Carbohydrate Concentrations

Shin oak root TNC concentrations varied throughout both years in response to phenological changes. With few exceptions this finding is coincident with those already cited for other species (Jones and Laude, 1960; Cook, 1966; and McConnell and Garrison, 1966).

Data from 1972 showed no significant change in root TNC during the first five sampling dates (Fig. 2). On March 16, buds began to enlarge and open. This corresponded to a TNC concentration of 10.7% on a dry weight basis. After this date, root TNC's decreased significantly to a low of 6.5% on May 6. Carbohydrate concentration within the roots were below 7.5% for a month, which is atypical in woody plant roots. This prolonged low TNC level is believed to be due to a killing freeze on March 21. This freeze, 5 days after bud break, delayed the phenological progression.

From May 6 until June 29, TNC's accumulated to 13.8% as photosynthate was rapidly being translocated from leaf tissue into the roots. Root carbohydrates decreased from 12.9 to 8.0% between the July 6 and July 20 sampling dates. No new aboveground growth occurred during this time. Also no acorn production was observed as most flowers had aborted much earlier. Perhaps the most plausible explanation for this decrease would be rapid root growth into a moister subsoil. The upper portion of the soil profile was very dry at this time. It has been suggested that drought could convert all TNC's into mono-saccharides (Stocker, 1961); respiratory losses, then, could be large. We feel, without evidence, that this conversion did not occur within this species.

Between July 20 and August 17 root TNC's increased to over 17%, which was the highest concentration recorded this year. Root carbohydrates were then again utilized for new aboveground growth. Typically, no new top growth of this species occurs in late summer; however, between August 17 and September 15, 16.8 cm of precipitation were received. This precipitation was instrumental in initiating new growth from shallow rhizomes. TNC's then increased slightly until November 11 at which time leaf fall was occurring.

During the dormant season from January 19 to March 30, 1973, no significant difference in root carbohydrates was found (Fig. 2). Root reserves decreased until April 13 after which they again accumulated in the roots. On April 28 plants were visibly breaking dormancy, which accounted for the carbohydrate depletion until May 12. Leaf expansion was then sufficient to produce enough photosynthate to accumulate in the roots until November.

The increase in TNC's before the plants broke dormancy is difficult to explain as this is contradictory to other carbohydrate research. Environmental factors such as water, temperature, light, and possibly soil oxygen levels may affect the physiology of the plant and reduce or stop growth. According to Wardlaw (1968), this could lead to an accumulation of carbohydrates in the storage organs. This, however, appears not to be a tenable explanation for the apparent anomaly in our data. Because of very limited perennial aboveground living tissue, carbohydrate translocation to the roots from aboveground stem storage does not seem plausible. Perhaps there were roots in the soil that act as carbohydrate sinks which could provide a continuum of carbohydrate flow into the root samples.

Prior to bud swelling in the spring it is difficult to differentiate between living and recently dead roots. The xylary tissue varies from white to light brown, thus color is not a good indicator of root condition. Variability between samples on each date during dormancy was greater than was obtained during the growing season. However, this variation was also present in the first 3 months of the year.

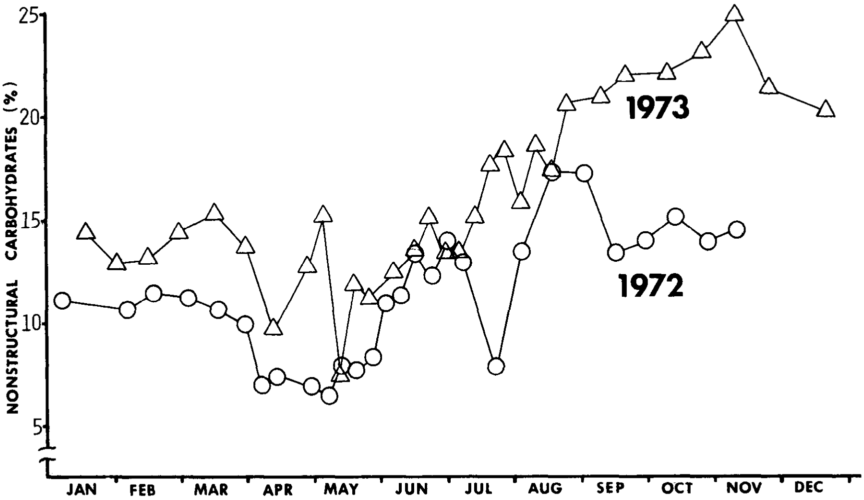

Fig. 2. *Averaged TNC concentration of sand shin oak roots collected in 1972 and 1973 from a west Texas sandyland range site.*

Relationship of Root Carbohydrates to Leaf Blade Expansion

Leaf blade expansion in relationship to net downward translocation of photosynthate is often used as a guideline for systemic herbicide applications. On many undesirable shrub species, it has often been assumed that to get downward translocation of these herbicides, they should not be applied until leaves were fully expanded. Herbicide application time suggested for sand shin oak is from May 1 to June 15 or when plants are fully leaved.

Our data in 1973 showed that roots began accumulating TNC's when leaves were only 20 mm long, or approximately 1/3 full size (Fig. 3). Similarly root carbohydrates began accumulating in 1972 when leaves were only 1/2 full size. As the leaves expand, wax accumulates very rapidly on the adaxial side which might make the leaf less penetrable by chemicals. Second, all stomata are located on the bottom (abaxial) side of the leaf. Perhaps, then, we might be able to maximize

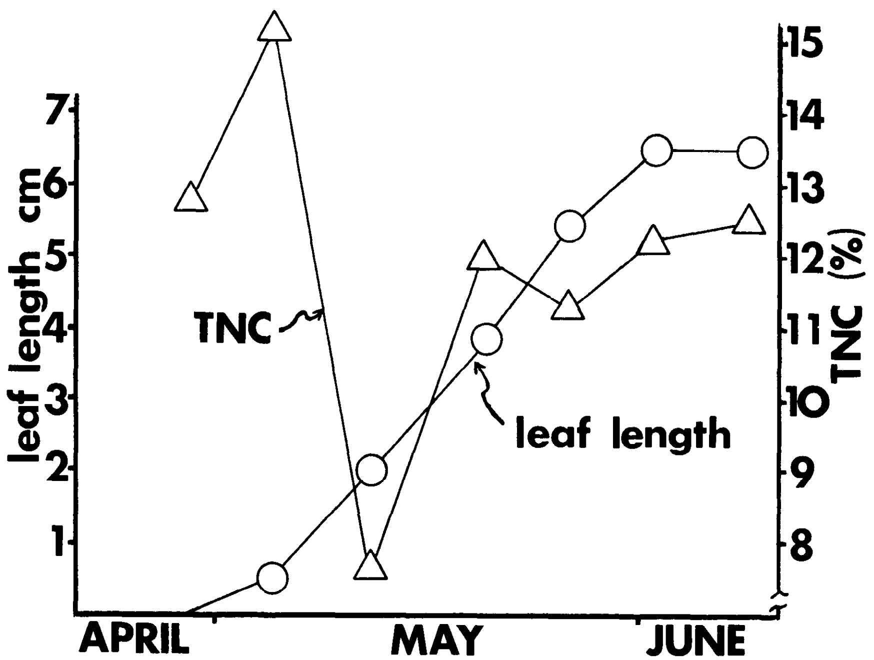

Fig. 3. *Relationships between oak leaf length and root TNC show that reserves begin accumulating in oak roots when leaves are only partially expanded.*

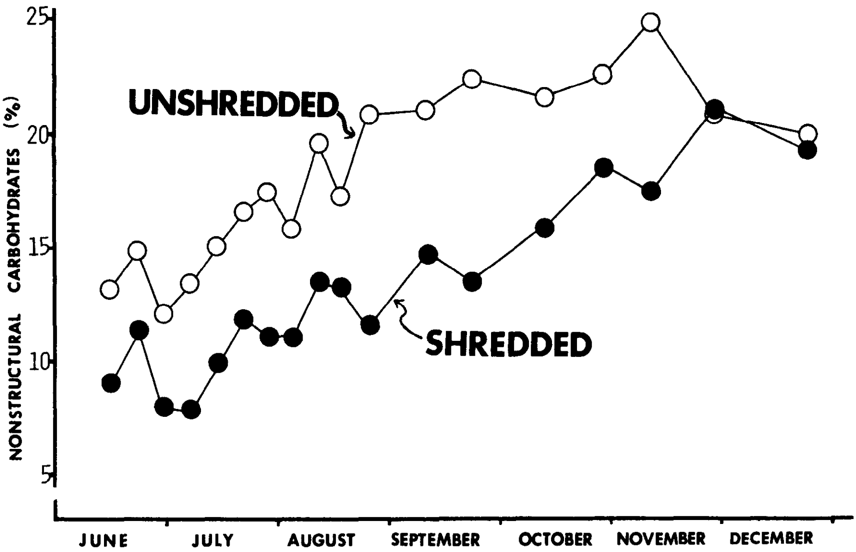

Fig. 4. *Shredding the oak once to near ground level effectively has reduced the roots' TNC content until near leaf fall in November.*

downward translocation of systemic herbicides into this plants root system by applying herbicides when leaves are from 1/3 to 1/2 of full size.

Effect of Shredding on Root Reserves

On June 15 or 2 weeks after 2 ha of the oak was shredded, oak roots were collected and analyzed for TNC's. The average TNC concentration of root tissue on this date was 8.9% as compared to 13.2% in the nontreated oak roots (Fig. 4). Root carbohydrates in the shredded oak roots decreased until July 6; then accumulation of reserves began and continued until leaf fall in late November.

On each sampling date, except late November and December, root carbohydrate concentration in the unshredded oak was significantly higher than in the roots of shredded oak. For the most part, both TNC curves paralleled each other until late summer. Shredded oak roots then accumulated reserves at a more rapid rate than roots of the nonshredded plants. These results demonstrated that shredding can effectively reduce energy reserves in sand shin oak; however, the effect can only be described as ephemeral.

Management Implications

Over 3 million acres of sand shin oak are found on west Texas rangelands. On many of these acres this oak has essentially formed a monoculture—most forages have been grazed out. In these areas the oak should not be completely controlled in order to prevent active sand dune formation. The oak also provides livestock and wildlife forage; but because of its toxic properties, particularly during budding and new leaf formation, alternative forage resources must be made available.

Personal observations of herbicide application to this oak in June show it to be very resistant to these chemical applications. If ranchers are going to expend monies for oak brush control, we suggest that the chemical be applied before leaves are fully developed. We will begin testing the effectiveness of herbicide applications as related to leaf size in the spring of 1975. Then specific application recommendations can be made.

We do not recommend shredding as a sand shin oak control technique. Rapid and prolific rhizome sprouting following top removal further complicates the rancher's brush problem.

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