Rhizomes and Roots Below Clipped Pinegrass Tillers Have a Higher Percent Carbohydrate when Attached to Other Nonclipped Tillers

DARRYL G. STOUT AND BARBARA BROOKE

Abstract

Percent total nonstructural carbohydrate (TNC) was measured in rhizomes plus roots of pinegrass (*Calamagrostis rubescens* Buckl.). The influence of connecting rhizomes on % TNC was evaluated by comparing results from sods with severed rhizomes to results from sods with intact rhizome connections. Severing rhizomes had no effect on % TNC of rhizomes plus roots of non-clipped sods. However, for clipped sods, % TNC was lower if rhizomes had been severed. Presumably, when rhizome connections are left intact, surrounding nonclipped tillers translocate carbohydrates to rhizomes plus roots of clipped tillers within a sod. This result has important implications in the grazing resistance of pinegrass. Since grazing typically involves an uneven utilization of a grass stand, the ungrazed or lightly grazed tillers should play an important role in maintaining the overall vigor of a pinegrass stand.

A knowledge of carbon translocation within a tiller and between tillers is important in that it gives a range manager a better understanding of the primary production process (Moser 1977). Clipped annual ryegrass (*Lolium multiflorum* Lam.) tillers import photoassimilate from nonclipped tillers (Marshall and Sagar 1965). In contrast to these results for ryegrass where the plant acts as an integrated unit, little photoassimilate is translocated between tillers of timothy (*Phleum pratense* L.) (St. Pierre and Wright 1972). However, carbohydrate is transported within a tiller to all aerial parts and to the associated roots. Sosebee and Wiebe (1971) observed that clipping crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.) and barley (*Hordeum vulgare* L.) increased both the amount of import of carbohydrate from unclipped leaves and the proportion allocated to the shoot within the plant. Interestingly, partial defoliation of the exporting (source) leaf increased to total amount of translocation (Sosebee and Wiebe 1971). An increase in the upward to downward ratio of translocation is believed to cause root die-back (Steinke 1969).

To increase our understanding of the grazing resistance of pinegrass (*Calamagrostis rubescens* Buckl.), we conducted a study on the role of rhizome connections on the level of total nonstructural carbohydrate (TNC) stored in rhizome plus roots. TNC is reported

to play a role in plant vigor (Ward and Blaser 1961, White 1973, and Trlica 1977). A procedure involving severing rhizome connections and measuring rhizomes plus roots % TNC was used. The interpretation of results from such an experiment is not as straight forward as from experiments (St. Pierre and Wright 1972, Sosebee and Wiebe 1971, and Marshall and Sagar 1965) where radioisotopes are used to measure translocation. Nevertheless, the procedure has the advantage of being simple and not requiring expensive equipment.

Materials and Methods

A 0.2-ha enclosure adjacent to the Poison Creek site (Stout et al. 1980) was fenced in 1978. Within this enclosure, 24 70 × 20-cm plots were marked to accommodate 4 treatments replicated 6 times. The 4 treatments were as follows: (1) rhizomes intact, tillers not clipped; (2) rhizomes intact, tillers clipped; (3) rhizomes severed, tillers not clipped; and (4) rhizomes severed, tillers clipped. Plots for a particular replicate were located close to each other so that soil, aspect, and cover would be similar for all treatments.

Twelve of the 24 plots were selected for rhizome severing. The rhizome connections were severed by excavating a 15 cm wide trench to a depth of 15 to 20 cm around each plot. The trench was then filled with soil and covered with forest floor organic matter. Clipping to a 5-cm stubble height was done on 1, 16 and 30 June. On 8 August, sods (entire plot areas) were dug and % crude protein and % TNC of rhizomes plus roots were measured using methods by Stout et al. (1983). Although it is useful to know the total amount of TNC stored, it was not possible to determine this for pinegrass because it was not possible to remove all of the pinegrass roots from the forest soil. In 1979 the experiment was repeated within a new enclosure adjacent to the 1978 enclosure. Clipping and harvesting dates were within 2 days of those used in 1978. The data were analyzed using a three-way analysis of variance (ANOVA), with a random block design.

Results and Discussion

The ANOVA revealed (at $P < 0.05$) that clipping decreased % TNC, and serving rhizome connections further decreased % TNC of clipped sods (Table 1). Only when the source sink relationship was altered by removing photosynthetic tissue (the clipped treat-

Authors are research scientist and technician, Agriculture Canada, Research Station, 3015 Ord Road, Kamloops, B.C., Canada, V2B 8A9.

Authors are indebted to Dr. Dee Quinton for critically reviewing an early draft of this note and to Dr. John Hall for advice on statistical analysis.

Manuscript accepted July 24, 1984.

Table 1. Influence of neighboring pinegrass tillers on the % TNC and % crude protein content of pinegrass rhizomes plus roots.

Measurement	Clipping treatment	Rhizome connections ¹	
		Intact	Severed
TNC (% of dry wt.)	Not clipped	6.7	6.5
	Clipped	4.6	3.5
	SE	0.3	
Crude protein (% of dry wt.)	Not clipped	4.6	4.5
	Clipped	4.4	4.4
	SE	0.4	

¹Values are $\bar{x}$ from 6 plots per treatment and 2 years (1978 and 1979).

ment) was the effect of severing rhizome connections revealed (the severing by clipping term in the ANOVA was significant at $P < 0.05$). This rhizome severing treatment effect is not due to a wounding response, or some other factor related to the actual severing of rhizomes, since rhizomes plus roots of nonclipped sods had a similar concentration of TNC whether they were severed or not severed. We propose that clipping decreased the supply of carbohydrate to the rhizomes plus roots connected to the clipped tillers and, therefore, these clipped tillers provided a sink for carbohydrate from the surrounding intact tillers. Where rhizome connections were intact the sink was partially replenished from the adjacent intact tillers. This proposal is consistent with the observation that assimilate is translocated from the main shoot of annual ryegrass to defoliated tillers (Gifford and Marshall 1973).

Neither clipping nor severing rhizome connections around sods affected crude protein level (Table 1). It is frequently found that herbage removal causing a decrease in TNC has no effect on protein reserve level (Owensby et al. 1977). Despite the fact that protein level was not altered by clipping in this study, proteins may still represent an important reserve constituent (White 1973).

Although this study does not show that carbohydrate can be translocated from one tiller to the aerial part of another tiller, the results have important implications in the grazing resistance of pinegrass. Grazing typically results in a mosaic of stubble heights (Matches 1966). The untouched or lightly grazed tillers of pinegrass left after grazing are likely to play a role in maintaining the overall vigor of a stand. For example, leaving intact tillers on clipped tall fescue (*Festuca arundinacea* Schreb.) plants increased tillering, regrowth (dry matter), and food reserves (Matches 1966).

Even if the pinegrass translocation is mainly to the roots, as for timothy, and not to other tillers, as for annual ryegrass, it will benefit the stand. Since aerial portions of pinegrass tillers do not survive more than one year (personal observations), growth in the spring must depend upon stored reserves in rhizomes and roots.

In conclusion, when a pinegrass sod was clipped to create a carbohydrate sink, intact tillers outside the sod appeared to act as a source for this sink and supplied carbohydrate through connecting rhizomes. Thus ungrazed or lightly grazed tillers should play a role in maintaining the overall vigor of a pinegrass stand.

Literature Cited

- Gifford, R.M., and C. Marshall. 1973. Photosynthesis and assimilate distribution in *Lolium multiflorum* Lam. following differential tiller defoliation. Aust. J. Biol. Sci. 26:517-526.
- Marshall, C., and G.R. Sagar. 1965. The influence of defoliation on the distribution of assimilates in *Lolium multiflorum* Lam. Ann. Bot. 29:365-370.
- Matches, A.G. 1966. Influence of intact tillers and height of stubble on growth responses of tall fescue (*Festuca arundinacea* Schreb.). Crop Sci. 6:484-487.
- Moser, L.E. 1977. Carbohydrate translocation in range plants, p. 47-71. In: R.E. Sosebee (ed), Rangeland plant physiology. Soc. for Range Manage., Denver, Colorado.
- Owensby, C.E., E.F. Smith, and J.R. Rains. 1977. Carbohydrate and nitrogen reserve cycles for continuous, season-long and intensive early stocked Flint Hills Bluestem range. J. Range Manage. 30:258-260.
- Sosebee, R.E., and H.H. Wiebe. 1971. Effect of water stress and clipping on photosynthate translocation in two grasses. Agron. J. 63:14-17.
- Steinke, T.D. 1969. The translocation of ¹⁴C-assimilates in *Eragrostis curvula*: an autoradiographic survey. Grassl. Soc. S. Africa 4:19-34.
- Stout, D.G., A. McLean, B. Brooke, and J. Hall. 1980. Influence of simulated grazing (clipping) on pinegrass growth. J. Range Manage. 33:286-291.
- Stout, D.G., M. Suzuki, and B. Brooke. 1983. Nonstructural carbohydrate and crude protein in pinegrass storage tissues. J. Range Manage. 36:440-443.
- St. Pierre, J.C., and M.H. Wright. 1972. Distribution of ¹⁴C photosynthates in timothy (*Phleum pratense* L.) during the vegetative stage of growth. Crop Sci. 12:191-194.
- Trlica, M.J. 1977. Distribution and utilization of carbohydrate reserves in range plants, p. 73-96. In: R.E. Sosebee (ed), Rangeland plant physiology. Soc. for Range Manage., Denver, Colorado.
- Ward, C.Y., and R.E. Blaser. 1961. Carbohydrate food reserves and leaf area in regrowth of orchardgrass. Crop Sci. 1:366-370.
- White, L.M. 1973. Carbohydrate reserves of grasses: A review. J. Range Manage. 26:13-18.