Colegio de Postgraduados

The impact of extensive grazing in the behavior of soluble sugars in *Prosopis laevigata* (Humb. & Bonpl. ex Willd.) M.C. Johnst. trees

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ABSTRACT

Objective: To evaluate the impact of extensive grazing in the accumulation of soluble sugars in *Prosopis laevigata* trees, whose leaves and fruits are directly consumed by cattle.

Design/Methodology/Approach: The *ejido* Emiliano Zapata in Durango was the study area. Stem and root samples were collected from a stand of extensive grazing and a stand without cattle. The sampling was carried out in three growth stages: March (flowering), June (fruition), and October (leaf fall). The samples were frozen in liquid nitrogen and were lyophilized. Afterwards, they were ground and 10 mg of dry matter were weighted in microtubes. The total soluble sugars (TSS) concentration was determined following the Van Handel methodology, using a spectrophotometer at 625 nm. The statistical analysis was carried out using an ANOVA and the Tukey's test.

Results: In March, the grazing area had lower TSS concentrations during regrowth than the area without grazing, both at root and stem levels.

Study Limitations/Implications: The intensity of grazing and the pasture rotation should be regulated to favor carbohydrate accumulation in trees, which is required for the formation of the meristematic tissues.

Finding/Conclusions: Extensive grazing has an impact on the synthesis and accumulation of TSS in mesquite trees. Therefore, the consumption of branches, leaves, and fruits decreases TSS concentrations in the stem and the root.

Keywords: vegetative storage, carbohydrates, mesquite tree, herbivory.

INTRODUCTION

The survival of trees is linked to the ordered and periodical accumulation of photosynthetic products and their related compounds (*e.g.*, carbohydrates, fats, and nitrogen compounds). These elements are accumulated during favorable periods and are mainly stored in winter. Subsequently, they are transported inside the plant to generate growth and reproduction

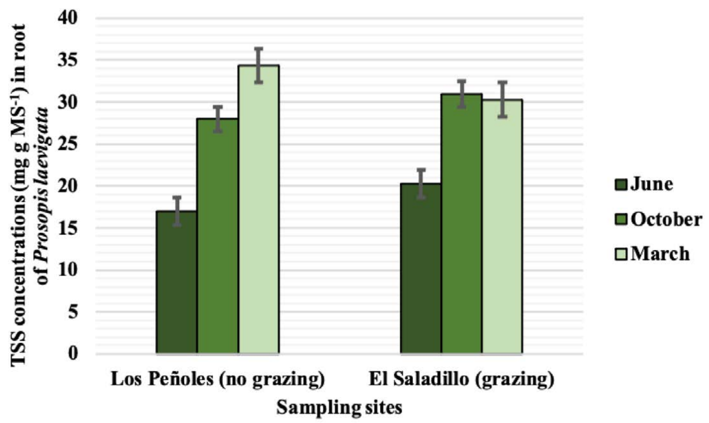
Image by Emilian Robert Vicol at Pixabay during the flowering and fruition stages (Kramer and Kozlowski, 1979; Magel *et al.*, 1997). Carbohydrates are essential for the survival of vegetables. They regulate the physiology of trees in the face of droughts, grazing, or other environmental stress factors (Liu *et al.*, 2019; Pinkard 2018; Tixier *et al.*, 2019; Furze *et al.*, 2019). Therefore, TSS are non-structural carbohydrates, whose function is to provide the carbon and the energy that trees require to maintain their metabolism during winter. They are also needed after the defoliation of the dormant season, because in early spring they form meristematic tissues, which in their turn form new tissues. Consequently, they are responsible for vegetative growth (Hennion *et al.*, 2019; Valenzuela-Núñez *et al.*, 2019). The objective of this study was to evaluate the impact of intensive grazing in the accumulation of total soluble sugars in *P. laevigata* trees, whose leaves and stems have been directly consumed by cattle.

MATERIALS AND METHODS

The study was carried out in the ejido Emiliano Zapata, Cuencamé, Durango, located at 24° 25' 53.09" N and 103° 50' 41.28" W, at 2,020 m.a.s.l. Stem and root samples were obtained from four trees per pasture. The places chosen for the sampling were El Saladillo (extensive grazing) and Los Peñoles (without grazing). The sampling was carried out in three growth stages of *P. laevigata* trees (March=flowering; June=fruition; and October=leaf fall). The samples were frozen with liquid nitrogen and were lyophilized (Labconco Freezone Triad Freeze Dry Systems®). Afterwards, they were ground (Pulverisette 15 Fritsch®) and 10 mg of dry matter were weighted in microtubes. The total soluble sugars (TSS) concentration was determined following the Van Handel methodology (1968), using a spectrophotometer at 625 nm (Thermo scientific® Genesys 20) and taking sucrose as standard. The statistical analysis consisted of a mean comparison test (Tukey's test with a significance level of $P \leq 0.05$), using the SSPS® Statistics 20.0 package (IBM®, 2018).

RESULTS AND DISCUSSION

The TSS concentration in the root of *P. laevigata* showed that the area subjected to grazing had differences in TSS concentrations during March and June ($F=11.741$; g.l.=11; $p \leq 0.001$), while, in the area without grazing, the TSS concentrations were different during the three months under study: March had the highest TSS concentration ($F=179.86$; g.l.=11; $p \leq 0.001$). This difference in the behavior of the accumulation of TSS —both in the phenological stage (Figure 1) and between areas (Table1)— can be the result of direct grazing, because the shoots of the tree have less time to produce new photosynthetic structures (*e.g.*, branches and leaves). This situation causes a decrease in the synthesis and accumulation of TSS that guarantees regrowth at the beginning of next year's sprouting (Piper and Fajardo 2014; Klein *et al.*, 2016). Additionally, they supply the demand of TSS for the development of new tissues during March, at the moment of regrowth and flowering (Hoch 2015). The grazing area had lower TSS concentrations (both in root and stem) than the area without grazing, at the moment of regrowth (March). These results match the findings of Kossola *et al.* (2001) and Endrulat *et al.* (2016), who reported that browsing and herbivory decrease the carbohydrates concentration in trees without chlorophyll functions.



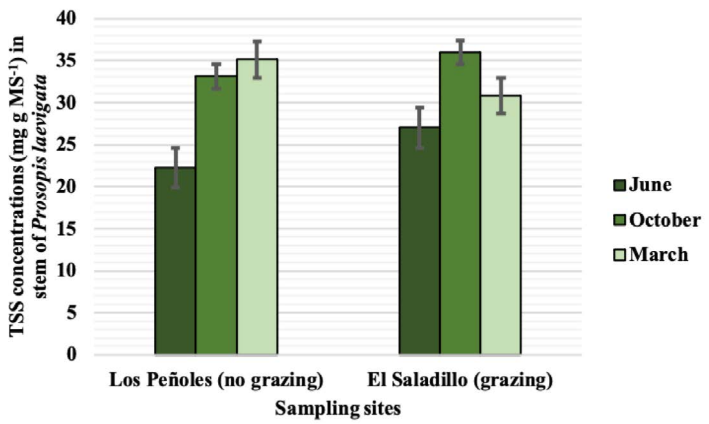


Figure 1. Total soluble sugars (TSS) concentrations in root (first image) and stem (second image) of *P. laevigata* from two areas of Durango, Mexico. One of the areas was used for extensive grazing (El Saladillo), while the other (Los Peñoles) was not used for grazing during the three months of the study. a,b,c: different letters indicate significative monthly differences between organs in each area (Tukey $p \leq 0.05$).

Table 1. Total soluble sugars (TSS) concentration in the root and stem of *P. laevigata* trees, in two areas of Durango, Mexico. One of the areas was used for extensive grazing (El Saladillo), while the other (Los Peñoles) was not used for grazing during the three months of the study.

Phenological stage	Los Peñoles (no grazing)	El Saladillo (grazing)
Root		
March (flowering)	$34.28 \pm 3.40^{a,A}$	$30.28 \pm 3.34^{b,B}$
June (fructification)	$16.98 \pm 4.93^{a,A}$	$20.25 \pm 4.62^{b,B}$
October (leaf fall)	$27.95 \pm 7.15^{a,A}$	$30.95 \pm 5.39^{a,B}$
Stem		
March (flowering)	$35.11 \pm 2.78^{a,A}$	$30.80 \pm 3.81^{b,B}$
June (fructification)	$22.27 \pm 6.19^{a,A}$	$27.04 \pm 6.73^{b,B}$
Octuber (leaf fall)	$33.11 \pm 4.22^{a,A}$	$35.97 \pm 2.40^{a,B}$

a, b: Different low-case letters indicate significative monthly differences between organs.

A, B Different capital letters indicate significative monthly differences between areas ($p \leq 0.05$).

However, in June (the maximum vegetative growth season), the grazing area had higher TSS concentrations, both in root and stem, than the area without grazing. This behavior is the response of trees whose branches, leaves, and fruits are consumed and matches the results of Palacio *et al.* (2012), Piper *et al.* (2015), and Puri *et al.* (2015). Additionally, Piper *et al.* (2015), Puri *et al.* (2015), and Schmid *et al.* (2017) pointed out that, during the maximum vegetative growth season, trees subjected to herbivory tend to store carbohydrate in the reserve organs as a priority. This behavior was also observed in this study for *P. laevigata*, during the maximum vegetative growth season (June).

Analyzing which sugars are transported from the stem and the root is important. Additionally, in the case of the fruits and seeds of mesquite, sucrose is the sugar that is transported inside young plants and functions as a reserve for the growing of seedlings (Gallão *et al.*, 2017).

CONCLUSIONS

Extensive grazing has an impact on the synthesis and accumulation of TSS in mesquite trees. Therefore, the consumption of branches, leaves, and fruits decreases TSS concentrations both in the stem and the root. Consequently, regulating the intensity of grazing and pasture rotation is fundamental to favor the accumulation of carbohydrates required for the formation of meristematic tissues.

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