

Carbohydrate Reserves: What You Learned May Be Wrong



For many years, managers have used the carbohydrate reserve theory to decide when grazing should occur to maintain healthy plants. This theory states that the soluble carbohydrates stored in the roots and crowns of plants indicate plant health and ability to regrow following grazing. According to the theory, during the early vegetative stage of plant growth, carbohydrate "reserves" are low, so plants should not be grazed. During late vegetative and early reproductive stages of growth, carbohydrate "reserves" are higher, and plants can better tolerate grazing (see figure 1). Over the years, a great deal of research has been conducted to produce carbohydrate concentration curves for grasses, forbs, and shrubs, as illustrated below.

Unfortunately, carbohydrate reserves in plant tissue are poor indicators of a plant's ability to tolerate grazing for several reasons:

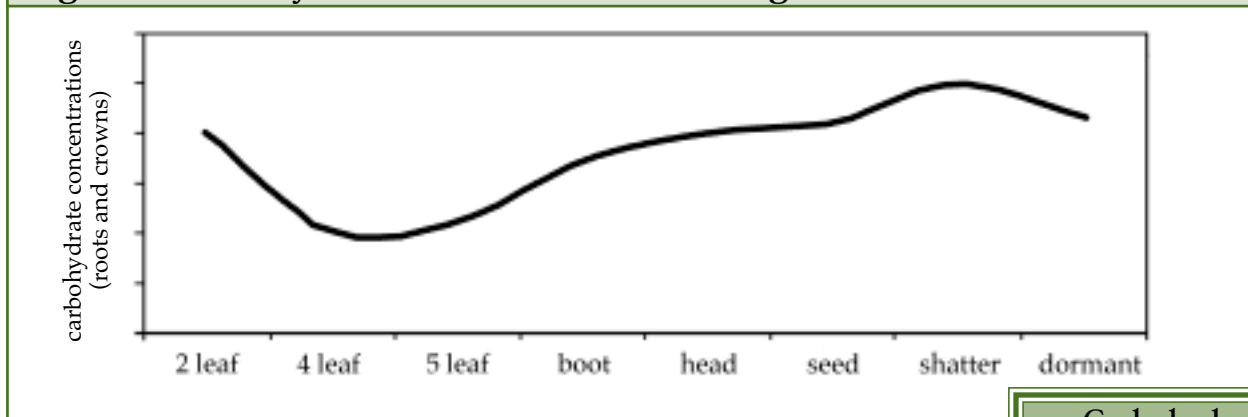
1. Carbohydrates are typically measured as concentrations that change only a small amount

over the year, but fluctuate widely during the day.

2. Concentrations do not reflect the total amount of carbohydrate available for regrowth following grazing. To accurately measure the total pools of carbohydrate available for regrowth, the concentration of carbohydrates in different plant tissues - roots, crowns, leaves, stems - must be multiplied by the amount of biomass in each of those tissues. Most studies analyzed only the roots and crowns of plants, but stems in grasses and twigs in shrubs are also important storage sites for soluble carbohydrates.

3. Carbohydrate reserves, whether expressed as concentrations or as total pools, are not correlated with the ability of a plant to regrow after it has been grazed. Nor are the rate and amount a plant can regrow in the absence of light - regrowth that depends entirely on stored reserves - correlated with either the concentration or the total amount of carbohy-

Figure 1. Carbohydrate concentration curve for grasses, forbs and shrubs.



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drate reserves stored in the roots or crowns of the plant.

4. The carbohydrate reserve stored by bunchgrasses is small - equal to about 1 to 2 days of photosynthesis by a bunchgrass during the summer.

So, what factors are important for a plant to tolerate grazing?

Plant morphology. Differences in morphology enable some plants to better tolerate grazing.

1. Grass, forb, and shrub species that produce and maintain many viable axillary buds tolerate grazing because they have the potential to regrow following grazing.
2. Grass, forb, and shrub species that protect meristems (growing points) have the potential to regrow quickly following grazing, thus reducing the amount of nutrients and water needed to regrow. Some grasses and forbs do not elevate apical meristems until late in the growing season, thereby protecting meristems from grazing.
3. Grasses that develop tillers at different times during the grazing season tolerate grazing better than plants that do not, because not all tillers can be grazed at the same time.

Plant physiology. Differences in physiology enable some plants to tolerate grazing better than others.

1. The ability to regrow quickly following grazing is important because it enables plants to quickly reestablish leaf tissue that creates energy through photosynthesis. Plants that regrow quickly often have increased photosynthetic rates in regrowth and remaining foliage.
2. A superior ability to compete for resources - water and nutrients - needed to quickly regrow enables some plants to tolerate grazing better than others.
3. In some plants, grazing stimulates absorption of nutrients like phosphorus, which enables those species to tolerate grazing better than others. However, in many species, removal of leaves and stems decreases nutrient

absorption because of a decrease in the root surface area.

4. Plants that quickly move resources among shoots or from roots to shoots tolerate grazing better than plants that do not. This enables rapid adjustment of carbon and nutrient distribution among plant parts, which enhances competitive ability and survival.

So, what does this mean for managers? Based on carbohydrate reserve theory, grazing was delayed until forage reached the boot stage of growth, which is the most detrimental time to graze plants in arid regions. When plants are grazed during the boot stage, apical and intercalary meristems responsible for plant growth are removed and regrowth must occur from axillary buds at the base of the plant, a slow process that requires moisture and nutrients at a time when those resources are dwindling. Conversely, grazing during the boot stage in wetter regions stimulates tillering from axillary buds in grasses and forbs, resulting in the production of nutritious forage.

References

Briske, D.D. and J.H. Richards. 1995. Plant responses to defoliation: A physiological, morphological and demographic evaluation. Pages 635-710. In D.J. Bedunah and R.E. Sosebee (editors). *Wildland Plants: Physiological Ecology and Developmental Morphology*. Society of Range Management.

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