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Pasture Management to Minimize the Risk of Equine Laminitis

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Introduction

Grass breeders have historically developed improved cultivars with an increased ability to accumulate high concentrations of sugar, starch and fructan, collectively known as non-structural carbohydrates (NSC) (1) (2). Grasses high in NSC have increased calories, stimulate microbial fermentation, and increase utilization of excess nitrogen in the rumen of cattle (3). Higher NSC concentrations lead to increased animal intake and subsequent increased animal daily gain (4). While these increases in carbohydrate content of forages have benefited meat and milk producers, they have not necessarily been good for domesticated equids.

If animal managers better understand the effects of environmental conditions and cultural practices they are in a better position to successfully manage horses prone to laminitis. Most horses that have recovered well from a bout with laminitis can tolerate some grazing if the pasture is properly managed, and horses are removed to a dirt paddock during times when NSC peak to due uncontrollable environmental conditions. These same conditions will affect the NSC of hay as well, so avoidance of green grass will not always prevent a relapse.

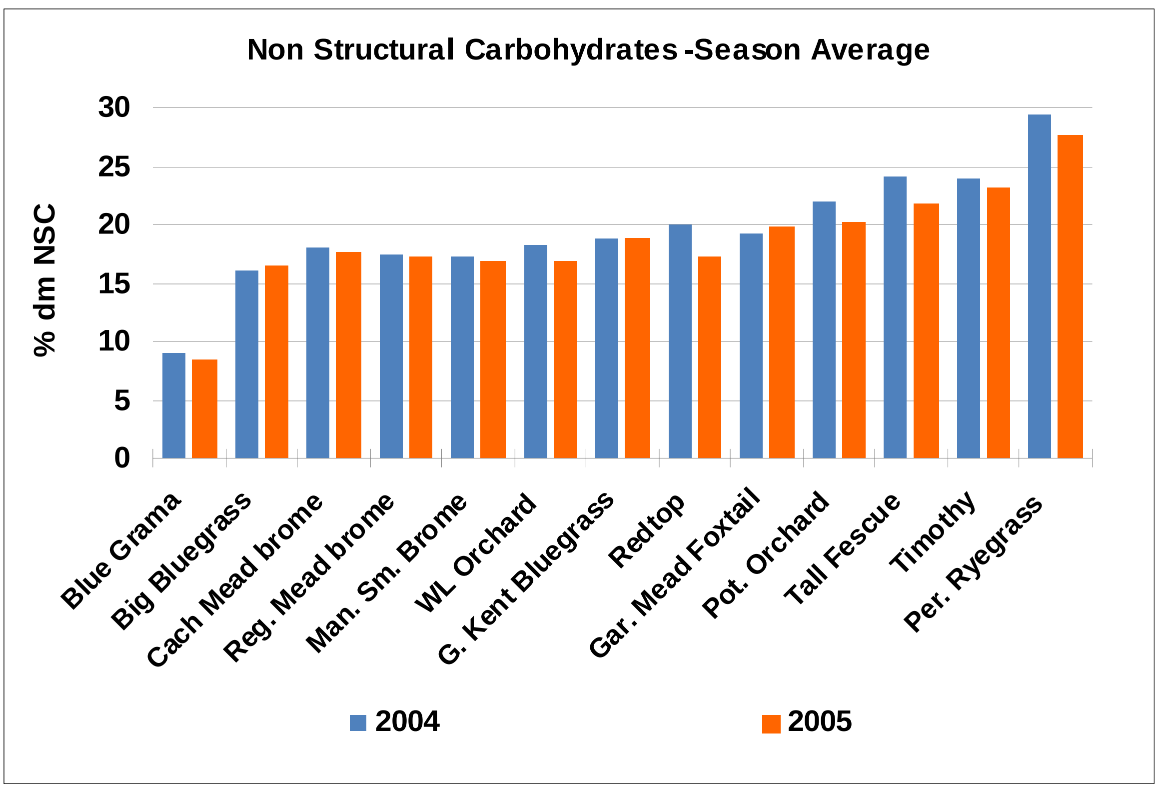
Factors Affecting NSC Content of Grass

Concentrations of NSC are highly dependent on environment, plant species, and stage of development. Cool-season grasses grown in cool temperatures accumulate sugars, starch, and fructan (5). Warm-season grasses accumulate only sugars and starch. Accumulation of NSC in grass occurs in response to stress, allowing those that accumulate the most to have a competitive advantage when the stress is over. Cool season grasses that evolved in climates with severe cold or frequent drought tend to be highest in the ability to accumulate NSC. Many warm season grasses go completely dormant under severe stress and therefore do not need to fuel long periods of low level metabolism to survive winter. NSC concentrations have been shown to vary over time being low in the morning and high in the afternoon (6). Temperatures at or below 10ºC caused increased WSC (sugar+ fructan) levels in perennial ryegrass (7). Perennial ryegrass with increased WSC levels are more competitive in mixed stands, more persistent after grazing with increased regrowth rates than perennial ryegrasses lower in WSC (8). In orchardgrass, water-soluble carbohydrates increased by 40% of dry matter as drought stress increased (9).

Species

A study to compare NSC concentration of various grass selections was conducted in Colorado, USA in a high mountain valley where the sunny, cool climate creates optimum conditions for accumulation of NSC. Four replications of 24 species in randomized blocks were sampled in the late afternoon for maximum daily NSC concentration. The site was cut twice per season to simulate hay production. Plots were fertilized 3 times per growing season and irrigated to simulate optimum commercial production. Samples were analyzed by a modified Megazyme method that included acid hydrolysis to better quantify the long chain fructan inherent to grass. The varieties grown commercially in the area contained between 17-22% NSC on a dry matter basis when averaged over 8 harvests throughout the growing season. Perennial Ryegrass (*Lolium perenne*) > Timothy (*Phleum pretense)* > Crested Wheatgrass (*Agropyron cristatum)* > Tall Fescue (*Festuca arundinacea* ***)*** > Orchard (*Dactylis glomerata)* > Redtop (*Agrostis alba)* > Garrison Meadow Foxtail (*Alopecurus pratensis)* > Kentucky Bluegrass (*Poa pretense)* > Meadow brome (*Bromus riparius)* > smooth brome (*Bromus inermis*) > blue and Sideoats grama (*Bouteloua gracilis and B. curtipendula)*. The five lowest in NSC out of 24 were species native to the region, and had not gone through any selection programs for increased nutritional density or increased production. The two Grama grasses both averaged < 10 % NSC dm.

Fig. 1. NSC of some selected grass species averaged over 8 harvests, 2 consecutive years.



There is a tendency to incorrectly assume that NSC concentration is inherent to a species of grass. It is more correct to view NSC content as genetic potential that must be triggered by appropriate conditioning before the characteristic is expressed. Grass grown under one set of conditions can vary widely in carbohydrate content when grown in a different environment. Perennial Ryegrasses, known for being very high in sugar in the United Kingdom, were found to be only average when grown in New Zealand's warmer climate (7). Most improved species of grass, common in pastures and hay fields around the world, are capable of accumulating levels of NSC that are inappropriate for laminitic horses under certain conditions but may be safe under other conditions. When seeking low sugar forage, it is best to focus on conditions that do not trigger high sugar traits.

Temperature

Temperature has a great effect on NSC content of pasture plants. Amount of fructan accumulated is greatly influenced by day/night temperatures, particularly just prior to harvest. The enzymes that facilitate respiration of sugars slow below 5° C and cease below freezing. When grown for 4 weeks under controlled conditions, leaf tissue from cool season grasses subjected to 10º C days and 5º C nights averaged 3 times higher in NSC compared to 25º C days and 15º C nights (10). Grasses grown under cool conditions accumulate sugars, which in turn triggers the formation of storage carbohydrates. Under cool conditions fructan formation will commence in most cool season grasses and certain broadleaf weeds, while starch will accumulate in warm season grasses and clover. Even mature, high fiber grasses can contain high levels of NSC when subjected to cold temperatures as long as some green tissue remains (11). The same respiratory enzymes become more efficient under the influence of warm temperatures. Sugars may be rapidly metabolized in hot weather, making C3, cool season grasses in summer much lower in NSC, especially if other inputs such as water and nutrients are not limiting growth.

This is demonstrated by the data in Fig. 2 which was generated from the same study mentioned previously. Kentucky Bluegrass (*Poa pratensis*), that averaged 25% dm NSC in early spring, decreased to 15% under optimum growing conditions during summer, NSC returned to 20% after the onset of freezing temperatures in fall. The average NSC dm across 24 species was approximately 21% in spring, 13% in summer, and 18 % in early fall. The highest total NSC at any harvest date was 37.8% dm in Perennial Ryegrass during late fall after repeated freezes and desiccating winds. Perennial Ryegrass is not sustainable in the region where this study was conducted, and was probably under more stress than the better adapted species.

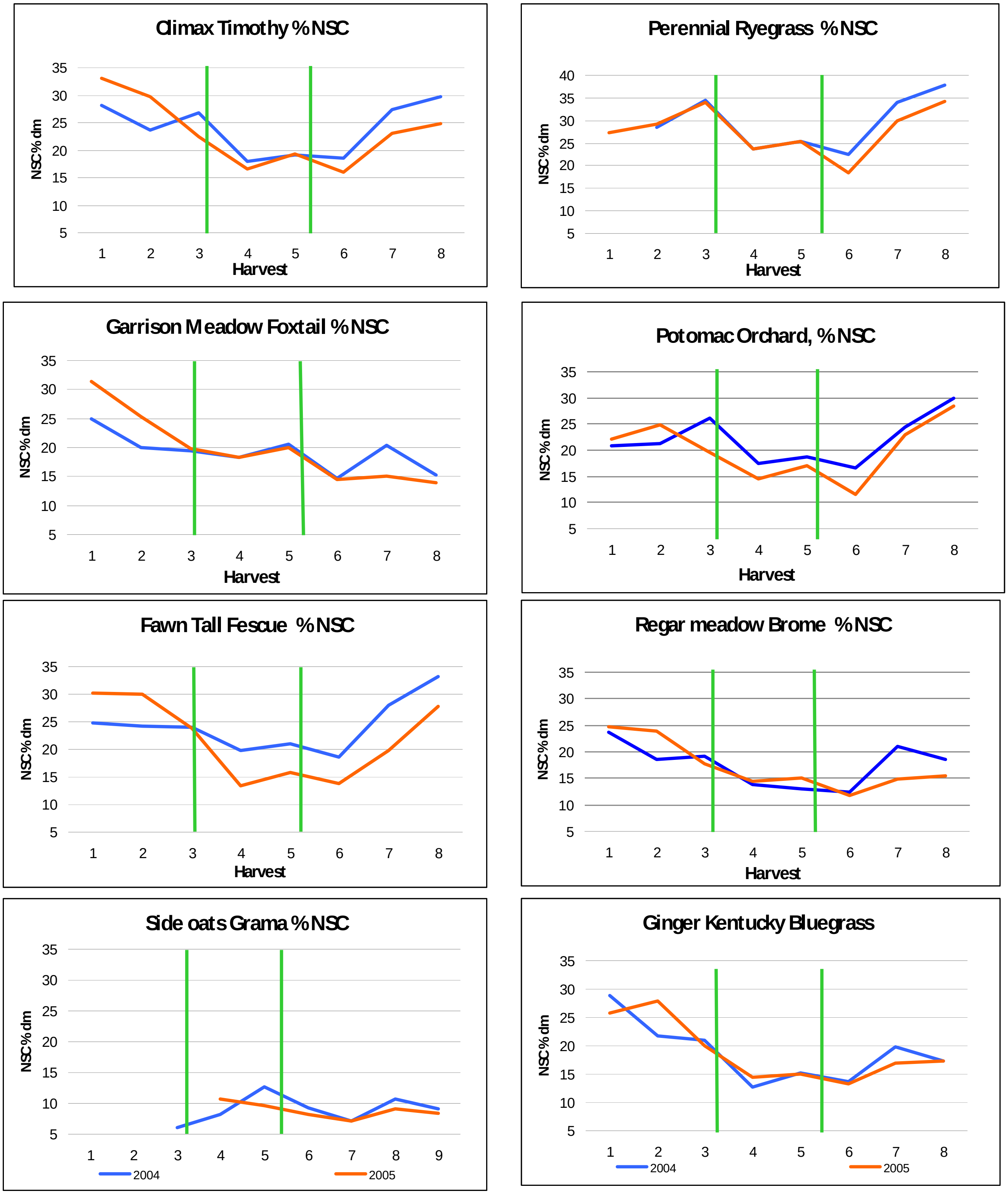


Figure 2. Seasonal variation of nonstructural carbohydrate (NSC) in grasses grown in Colorado, USA. The green vertical lines represent removal of hay crop, and application of nitrogen fertilizer. Harvest 1, 2, 3 - May, Harvest 4 - July, Harvest 5 - August, Harvest 6 - September, Harvest 7- October, Harvest 8 – November.

Conversely, C4, warm season grasses commonly grown in tropical regions may peak in starch with up to 19% in leaf tissue, when conditions are sunny and hot (12). C4 grasses have a different morphology and metabolism than C3 grasses. Tropical regions often have a cloudy, rainy season and a season of drought when grass goes dormant. Plants that evolve there must be able to make better use of sunlight when it is available during the wet season. C4 grasses native to temperate regions, such as the Grama grasses in the intermountain region of the USA, grow very quickly in response to warm soil and summer rains and go dormant after the soil dries or cold weather returns. These grasses have no need to accumulate NSC. As illustrated by the data in Fig. 2 the Grama grass remained low in NSC throughout its life cycle. C4 grasses will not grow during cold weather; therefore data was missing during periods when C3 grasses were peaking in NSC.

Stage of Growth

Hay growers try to cut just as grass starts to develop seed heads. This is when grass has maximum yield, but before nutritional quality start to decrease. In pastures, this is when both NSC per acre and per bite are at maximum. In temperate regions this occurs in late spring (Harvest 3 in Fig. 2) which often coincides with increased incidence of laminitis. Horses are known to selectively graze emerging seed heads. Horses prone to laminitis must not be allowed to graze seed heads. Mowing or grazing by cattle, sheep or low risk horses in a rotational grazing program will remove the NSC-rich heads. Leafy regrowth after mowing is lowest in all components of NSC, especially if it occurs during warm weather. However, rapidly growing grass in overgrazed pastures may represent a significant increase in NSC per acre, removing limitations to intake, and representing a sudden change in dietary components.

Rate of Growth

Frequently people think that fast growing grass is higher in NSC, although this contradicts our basic understanding of plant physiology. Rapidly growing, fertilized grass after grazing or mowing is lowest in NSC concentration (Fig 2: Harvests 4 - 6), because sugars are utilized by the plant as quickly as they are formed to make fiber, protein and energy. Researchers of grazing management warn against grazing new, low NSC regrowth before the plant has an opportunity to replenish reserves, as depletion of NSC at this vulnerable stage reduces the ability of grass to survive subsequent environmental stress (13). Nitrogen availability is the most common limiting factor to growth in grass. Nutrient deficiency is another plant stress that limits growth and causes NSC to accumulate. Increasing amounts of applied nitrogen, expressed as crude protein in grass was inversely related to WSC (sugar + fructan) content in Perennial Ryegrass (14).

Native species

Native species are often, but not always, lower in NSC than those species that have been improved for higher nutrient density and production. They are generally less productive and may only grow in those environments under which they are perfectly adapted. Native grasses are less competitive and may be taken over by sod forming invasive species like Fescue or Kentucky Bluegrass that come up from seed lying dormant in the soil. Native grass seed is very expensive, and may take two years to completely establish before it is strong enough to survive grazing or harvesting for hay. As most native grasses have low tolerance for overgrazing, they require sophisticated, intensive management programs for sustainable production. Native grass production is not within the budget, ability or patience level of the average horse owner. Managing the existing stand of grass to minimize stress and lower overall NSC concentration is more likely to be successful for most horse owners than trying to grow low NSC species of native grass.

Management to Minimize NSC Content

Very large seasonal variations in NSC concentration per mouthful and amount of NSC per acre occur in pastures. Understanding the environmental effects on NSC in grass can allow caretakers to limit grass intake for high risk horses and ponies during times when either NSC concentration or NSC/acre peaks in their particular climate. The worst season for laminitis cases will vary globally depending on climate, and may vary from one year to the next in the same region due to variations in weather. The times most apt to trigger laminitis are when temperatures are below 40º F (5º C) for 2-3 weeks during the night, coupled with grass in such excess that horses have the opportunity to overeat. In many climates maximum NSC concentration and NSC per acre coincide in late spring, when nights are still cool and grass is just starting to head out. In areas with summer drought, the onset of drought stress may create high NSC pastures. In areas with fall rains, the combination of cool temperatures and increase in biomass may trigger laminitis. In regions with marine climates, such as the United Kingdom, mild winters allow grass to remain green and fructan concentrations to peak in mid-winter (15).

Prevent heading

Grass has two types of reproduction; seed production or vegetative reproduction from new sprouts called tillers. If developing seed heads are removed before head emergence, grass will switch its reproductive strategy and develop more tillers from crowns or stolons (underground stems). Mowing or intensive grazing by cattle or sheep have similar effects, and there is an optimum stage for mowing (Fig. 3).

Set equipment height just low enough to remove embryonic seed heads still within the stem. Mowing any closer to the ground is not necessary. Timely mowing or grazing can keep grass in a vegetative stage. As long as grass is not heading out, additional mowing is not necessary, and may be counterproductive to producing grass with lower sugar concentration. Tall thick grass is self-shading. Only the top portions of the plant have potential for maximum photosynthetic rate. Short, thin grass has every blade in a position to make use of any light available to make sugar.

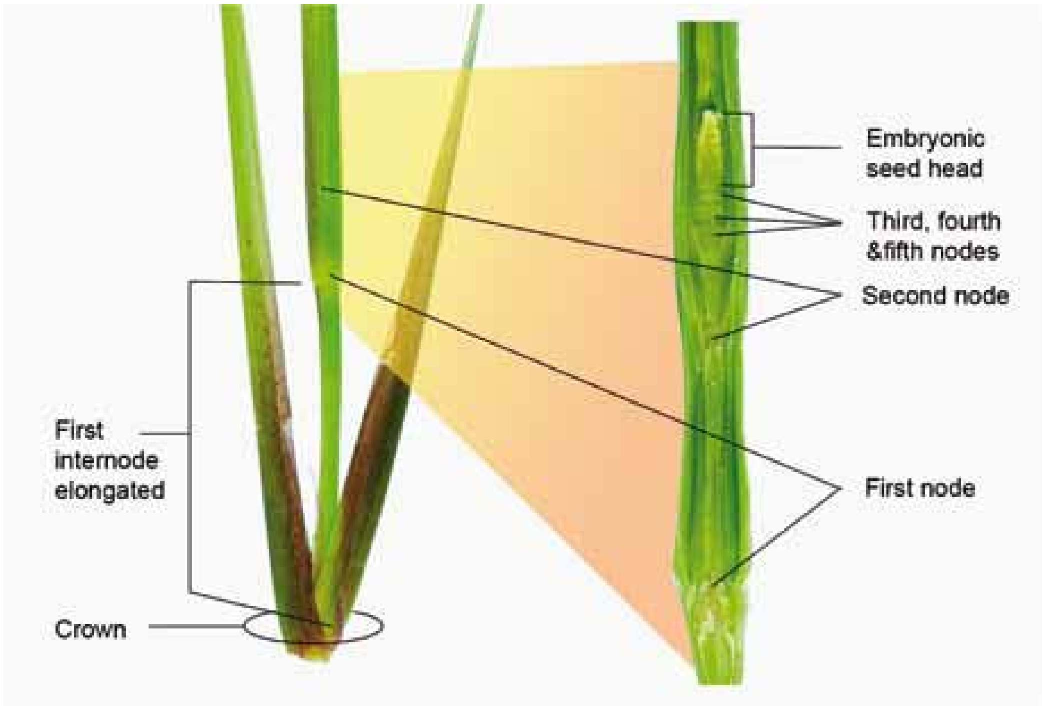


Fig. 3. A grass plant with the first stem internode elongated, raising the developing seed head above the level of the crown. Lengthening of the remaining nodes will raise the seed head above the rest of the plant. Unelongated nodes and the undeveloped seed head are meristematic tissues, comparable to embryonic tissue in the animal world. They await hormonal signals to trigger growth and development. From Watts KA, Pollitt cc. Managing pasture to minimize the risk of laminitis in horses. RIRDC publication no. 10/063

Graze in Shade

Light intensity has a direct effect on the ability of plants to produce sugar. Grass grown in shade is lower in sugar (16) (17.) When possible, utilize existing shade in woodlots or adjacent to hedges or buildings, as depicted in Fig. 4. Fast growing trees may be planted to create more shade in desired areas. Make sure to give shaded grass a rest period from grazing to prevent killing the grass from depletion of limited NSC resources.

Control high sugar weeds

Many broadleaf weeds contain high levels of sugars and inulin under the same conditions that cause NSC to accumulate in grass; cold and drought stress. Dandelion (Taraxacum officinale) (fig 5), Plantain (Plantago sp.) and members of the thistle families (Cirsium and Sonchus sp.) may contain very high levels of fructo-oligosaccharides (FOS) and sugars. Cold treatment caused concentration of NSC in Plantain (*Plantago lanceolata* L.) to increase from 135 to 230 mg/g dm(18). These weeds may escape control by mowing because of their low growth habit, but are easily controlled with appropriate herbicides.

Fig. 4 Pasture in paddocks shaded from direct sunlight produces less NSC. From Watts KA, Pollitt CC. Managing pasture to minimize the risk of laminitis in horses. RIRDC publication no. 10/063 with permission.

Fig. 5

Dandelion (Taraxacum officinale), a palatable pasture weed may contain up to 25% sugars and fructans as dry matter in its aboveground leaves and stems.

Limiting Intake of Grass

When environmental stress occurs that may increase the NSC in pasture, monitoring of susceptible animals on a daily basis for subtle signs of lameness is advisable. The progress of mild laminitis may often be halted by moving the animal from the pasture to a bare dirt paddock at the first sign of lameness, and feeding tested hay lower than average (<11 % dm) in NSC. No access to weeds or even very short, overgrazed grass can be allowed for horses in acute stage laminitis. Proactive owners may choose to remove high risk animals completely during times when NSC peaks, such as when night time temperatures are below 40° F (5° C) or at the onset of severe drought. When the environmental stress is over, and grass growth resumes, sugar concentration will begin to diminish, although NSC per acre may increase due to increased biomass. Availability of excess grass may warrant some means to limit intake, depending on the tolerance of individual animals. This may be accomplished by use of grazing muzzles, limiting grazing time, or strip or cell grazing.

Summary

The sugar, starch and fructan content (collectively referred to as NSC) of pasture plants is very dependent on the environmental conditions under which they have grown. Pasture that is stressed by cold, drought, or lack of nutrients can be 2-3 times higher in NSC than pasture that grows quickly in warm weather and is adequately watered and fertilized. Horses at risk for laminitis should have access to pasture limited or be removed completely when environmental conditions are conducive to high levels of NSC accumulation.

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