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FORAGE PRODUCTION: COMPROMISES AMONG YIELD, QUALITY, AND PERSISTENCE

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Introduction

Deciding when to harvest or graze forages is anything but simple. As with many things in life, a compromise is necessary to optimize yield and forage quality, while maintaining acceptable plant persistence. In general, forage yield increases and persistence improves with advanced maturity of most forages; however, forage quality declines with maturity. Understanding how yield, quality, and persistence change during growth in spring or regrowth after harvest can be useful in designing management strategies that meet the goals of individual producers.

Two key factors impact forage regrowth after harvest: (1) energy reserves to sustain plants; and (2) meristems for shoot regrowth. Both must be present for forage plants to regrow after harvest. Understanding how environment and management (including mis-management) affect these key factors, and how they in-turn differ among forage species will help producers achieve their forage performance goals on their farm.

Energy Reserves: Providing Energy and Substrates For Survival and Regrowth

Forage plants survive the incredible stress caused by near-complete defoliation in part, because they store large quantities of sugars, starches, and proteins in specialized storage organs. In forage legumes like alfalfa this includes a large taproot and a well-developed crown (Fig. 1).

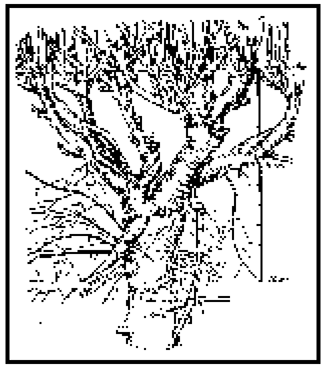

Figure 1. Below-ground organs of a forage legume showing crown and large taproot where starch, sugars and proteins accumulate.

In grasses a great variety of storage organs that exist including rhizomes (underground stems), stolons (aboveground horizontal stems), crowns, and stem bases (2 to 3 inches of plant tissue immediately above the soil surface) (Fig. 2).

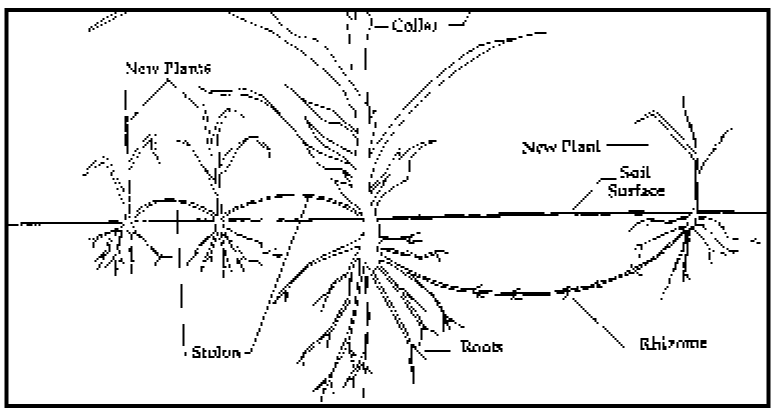

Figure 2. Schematic of a forage grass showing the specialized storage organs where energy reserves accumulate.

While all grasses have stem bases and crowns, not all grasses possess stolons and rhizomes. Kentucky bluegrass, smooth bromegrass and reed canarygrass all have well-developed rhizomes, and as a result, form dense sods. Tall fescue has very short rhizomes, whereas rhizomes are not found on orchardgrass and timothy. This absence limits the ability of orchardgrass, timothy, and to a certain extent, tall fescue to fill in open areas in a pasture. Bermudagrass has both rhizomes and stolons, aiding the persistence of this warm-season grass. Close grazing or cutting may remove or damage stolons and stem bases, and reduce the availability of stored energy reserves. This can limit forage regrowth, and result in poor persistence.

These storage organs can amass large amounts of sugar, starch, and protein that supplement traditional sources of carbohydrate (photosynthesis) and nutrients (root mineral uptake) after harvest. Stored energy reserves are used to support initial growth in spring and regrowth after harvest (Fig. 3) times when photosynthesis and nutrient uptake are impaired or very low. Alfalfa and red clover exhibit a similar pattern of root energy use after harvest. Root reserves decline for 2 to 3 weeks after harvest, then increase rapidly during Weeks 3 and 4. The high levels of root reserves present Week 4 and beyond permit alfalfa and red clover to tolerate another harvest. Close cutting near the surface of the soil is tolerated in these species whenever root reserve levels are high. By comparison, birdsfoot trefoil does not accumulate large amounts of energy reserves in roots in summer (Fig. 3). Therefore, it must be grazed no closer than 4 inches. This ensures that sufficient leaf area remains on the stem bases to permit photosynthesis to continue. Permitting close grazing of trefoil is one of the primary reasons for poor persistence of this species. A similar cyclic pattern of root protein depletion after harvest followed by re-accumulation during late regrowth also occurs (data not shown).

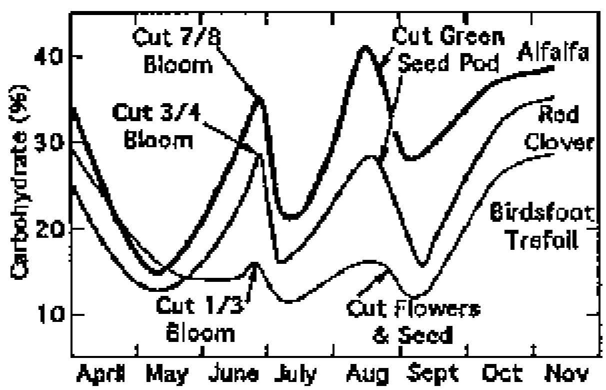

Figure 3. Use of stored carbohydrate in roots to support initial spring growth and regrowth after harvest of alfalfa, red clover and birdsfoot trefoil.

So far we have focused on changes in energy reserves that occur after harvest, however, large changes in yield and forage quality also occur during forage regrowth after harvest. As yield increases there is a marked shift in leaf:stem ratio, from high values (very leafy forage) initially to ratios less than 1 where stems dominate the forage (Fig. 4). This transition occurs about Week 4 (Fig. 4, Harvest 7 to 8) as plants begin to flower. Leaf production is essentially complete by the end of Week 5 (Fig. 4, Harvest Interval). Thereafter, increased yield is due almost entirely to accumulation of stem dry matter.

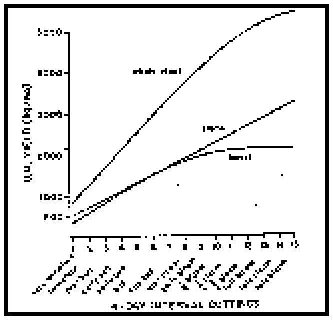

Figure 4. Increase in leaf, stem, and total forage yield of regrowing alfalfa sampled at 4-day intervals after harvest.

During the earliest stages of regrowth digestibility of stems and leaves are nearly equal (Fig. 6). While leaves maintain this very high level of digestibility through regrowth, stem digestibility declines rapidly with maturity. To maximize forage quality producers should be harvesting before stems dominate the forage (Fig. 4, Harvest Interval 7), and prior to the extensive decline in stem digestibility (Fig. 5). However, this typically is prior to the maximum accumulation of energy reserves in storage organs. As a result of early harvesting to maximize forage quality, slow regrowth and poor plant persistence may occur. If harvest is delayed until high levels of energy reserves accumulate, stems become the dominate component of the forage and forage quality can decline to unacceptable levels.

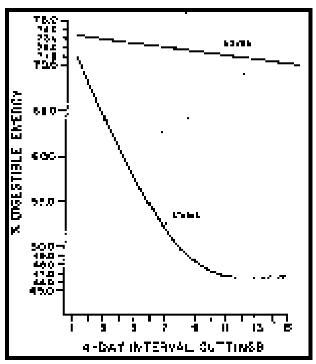

Figure 5. Changes in stem and leaf digestibility for alfalfa forage sampled at 4-day intervals after harvest.

Given these relationships, how can a compromise be attained between the high quality available from immature forage, and the high yield and persistence obtained by cutting late? One approach is to calculate yield of digestible nutrients per acre (yield x % digestibility or % protein) and compare these values as forage regrows after cutting. When this is done, maximum yield of protein (Fig. 6) and digestible nutrients per acre are obtained at first flower to 1/10th bloom in legumes or heading in grasses.

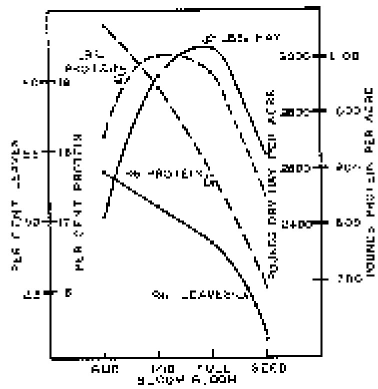

Figure 6. Changes in dry matter yield, leafiness, and forage protein (both concentration and protein per acre) of alfalfa forage during late regrowth.

Meristems: Where Shoots Find New Beginnings Stored energy reserves are important, but meristems are also essential for forage growth in spring and regrowth after harvest. These axillary meristems as they are called exist as small budding protrusions on crowns of legumes (Fig. 1) and inside leaf sheaths that form the stem bases of grasses (Fig. 7). Rhizomes and stolons also have axillary meristems on their surfaces, allowing new plants to form some distance from the parent plant (Fig. 2).

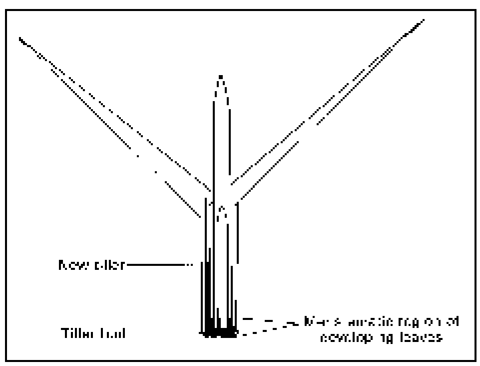

Figure 7. Schematic of a grass plant showing the meristem of the growing leaf and the axillary meristem ("tiller bud") that develops into new tillers.

Meristems can be damaged and this can impair forage regrowth in spring and after harvest. Meristems exposed to severe winter weather can die. Crowns heaved out of the ground by freeze-thaw action in later winter may be frozen or removed by the mower at 1st harvest; both of which eliminate regrowth. Cattle can damage meristems by overgrazing which physically removes these buds or by excessive treading, especially when the soil is wet. One can view these meristems and the before mentioned energy reserves in a manner analogous to an automobile where the meristems represent the engine and the energy reserves the gasoline in the tank. Without both components the car does not move. With limited fuel (energy reserves) the engine (forage regrowth) cannot run long. By comparison, all the fuel (energy reserves) in the world cannot overcome limitations imposed by a few horsepower (few meristems). However, with a tank full of fuel (high energy reserves) and a high horsepower (large, well-developed meristems) forage plants can regrow like a speedster.