



NC Forage and Pasture Technical Note No. 4

Principles of Plant Growth

Factors Which Affect Growth and Persistence of Plants and the Implications for Grazing Management.

The goal of any serious grazer or forage producer is to manage pasture plants to meet the nutritional needs of the herd. This is done through producing **high yields** of **satisfactory quality** forage that can be **grown sustainably for long periods of time**. Grasses and legumes, whether grazed or stored as hay or silage, are the very basic "raw products" being produced, processed and marketed from the farm. Profitable and sustainable livestock production requires a reasonable understanding of the growth processes and management responses of plants, as well as the animals consuming the plants. Therefore, it is important that one understand the interactions of plants with environment, harvest schedules and/or the grazing animal.

UNDERSTANDING PLANT GROWTH

The pasture sward is composed of thousands of individual tillers or plants (often called shoots or stems). The management of a pasture is merely the management of thousands of plants growing in association. It is important that one understands how green leaves, reserve energy storage location and plant "growing points" affect plant survival and production.

This paper will present some aspects of "plant physiology" and "plant morphology" that impact pasture management decisions.

Plant physiology... is the study of chemical and organic functions of plants; it is the understanding of how plants live, grow, age and die in response to various environmental and management factors.

Plant morphology... describes the plant physically; it is the outward appearance or physical stature of the plant as it is growing in place.

The following questions can be answered based on an understanding of the physiological and morphological aspects of plants, and are highly relevant to effective grazing management planning and implementation.

1. How often can a particular forage or pasture be grazed or cut each year?
2. How close to the soil can pasture plants be grazed or cut each time?
3. What is the seeding rate and when is the best time to plant a particular crop or mixture?
4. When is the best time to fertilize, how much should be applied, and how often should it be applied?

5. What is the feed value or expected animal performance when grazing a particular pasture species or mixture?
6. How many years can one expect a particular species to live if it is grazed rather than harvested for hay or silage?
7. How long will a species persist if properly managed: annual or perennial?
8. What season does it make its most growth: cool or warm season?
9. Will the forage type fix nitrogen: grass vs. legume?
10. What type of root system does the species have (tap vs. fibrous), and how does that affect soil adaptation?

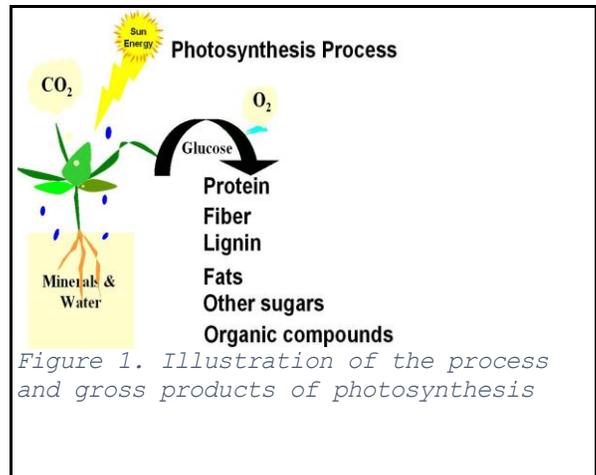


Figure 1. Illustration of the process and gross products of photosynthesis

PRIMARY SITE OF “PLANT FOOD” PRODUCTION....*The Green Leaf*

It's understood that all parts of the plant are critical to optimizing growth. However, the "**green leaf**" is the actual site of "plant food" production (Figure 1). The "physiological" process of "plant food" production is called **photosynthesis**, which means light synthesis or production of organic matter with light and CO₂. The very basic compound produced by photosynthesis is a "simple sugar", and these simple carbohydrates are combined to form the building blocks for protein, wax, cellulose, hemicellulose, pectin, lignin and other materials used in plant maintenance and development. These compounds also provide the basis for nutrition needed by animals.

The root system is critical for the uptake of water and minerals, but the **green leaf** is where the foundation or "food" for growth starts. In other words, all of the increase in "organic matter" which we call **growth or forage dry matter** (and use for food and fiber) comes from the combination of carbon, water, and minerals in the green leaf.

It's estimated that 95% of the raw materials used to assimilate organic matter (feed) comes from the atmosphere (CO₂, in presence of sunlight) and only 5% of it from the soil (minerals and water).

GENERAL PLANT DEVELOPMENT

Plants, like all living organisms, go through various growth phases between germination or birth and maturity. Generally the growth is slow initially, followed by a rapid phase until near maturity, when it slows before dying. This development is often illustrated using an "S-shaped" curve as shown in Figure 2. Generally, managers want to keep plants in the most active growth stage as much as possible. For pastures grown in the Mid-Atlantic region grazing and re-grazing are done when plants reach 6-12 inch height and leaving 2-4 inches of stubble after grazing. The amount of time it takes the plants to recover to the optimum growth phase after grazing will depend on things such as soil moisture, temperature, leaf area remaining following grazing, storage carbohydrates and animal traffic.

Table 1 provides a summary of some of the plant characteristics one might see when plants are in the three phases of growth.

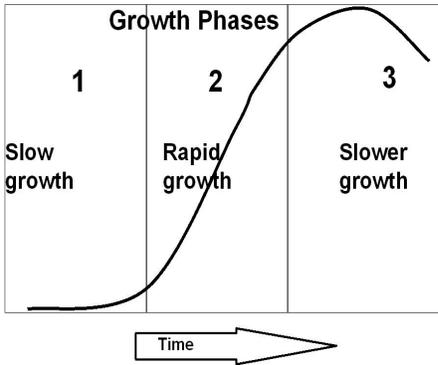


Figure 2. Illustration of plant growth over time following harvest or new seedling development (Voisin, 1959).

WHAT ARE THE FACTORS ESSENTIAL FOR PLANT GROWTH?

All plants require the same things for growth and development:

- A. Sunlight
- B. Favorable temperature
- C. Water
- D. Nutrients
- E. Carbon dioxide
- F. Oxygen

Plants growing in mixtures may actually compete for some of the above resources (such as water, nutrients, light).if they become limiting. Even though all plants require the above resources, they may require them differentially because of physiological or morphological characteristics.

Understanding how plants respond differently to environmental and management factors in various situations is very important to successful production of crops and pastures. The manager who can manipulate the plants or environment to optimize growth and its utilization with the grazing animal will be the most successful.

HOW ARE "ESSENTIAL FACTORS" USED IN PLANT GROWTH?

Sunlight is the energy source for all growth on earth. One cannot control sunlight on the farm (day length, light quality, wave length, or density). However, one can control the amount of energy that is captured by plants and mixtures by controlling the plant density, height of canopy, grazing frequency, degree of defoliation, fertilization and soil moisture.

Rate of plant growth is favored when sufficient **green leaves** can capture 95% of the incoming sunlight; any light striking the earth's surface is essentially wasted in terms of producing organic matter (feed or fiber). Maximum light reception usually occurs when the pasture canopy is between 4-10 inches tall, or when the leaf area is 3-6 times that of the soil area on which it is growing (Tables 1 and 2).

Shading within a canopy can cause the lower leaves to turn yellow; this reduces the plants ability to fix carbon and slows growth rate and reduces feed quality. To minimize shading of leaves within the canopy of fescue, orchardgrass and bluegrass, forage should be grazed from 6-10 inches back to 2-4 inches within a few days. Since plants tolerate different levels of shade, and they actually "compete"

for light, managers can influence the plant species composition of mixtures by controlling the height and frequency of defoliation. For example, shading within the canopy is usually the reason why white clover cannot be maintained in mixtures with grasses; lax grazing or haying management usually allows the grass to shade the growing points of clover which are located on the stolons along the ground surface. Frequent, close grazing will favor clover.

Table 1. Generalized characteristics during the three growth phases (note Figure 2) of plants or canopies.

| CHARACTERISTIC | GROWTH PHASES | | |
|----------------------------|---------------|----------|-----------|
| | I | II | III |
| GROWTH (lbs./acre/day) | LOW | RAPID | MEDIUM |
| LEAF AREA | LOW | MED-HIGH | VERY HIGH |
| GREEN LEAF, mass | LOW | HIGH | MED-HIGH |
| LIGHT INTERCEPTION | LOW | HIGH | VERY HIGH |
| WITHIN CANOPY SHADING | LOW | MEDIUM | VERY HIGH |
| PHOTOSYNTHESIS/LAI | HIGH | MED-HIGH | LOW |
| REGROWTH DEPENDENCE ON CHO | HIGH | LOW | LOW |
| INTAKE, lbs./head/day | LOW | HIGH | MED |
| FEED QUALITY | VERY HIGH | HIGH | MED-LOW |
| YIELD (lbs./acre) | 500 | 2000 | 4000 |

Shade tolerance of species...some plants are more tolerant of shade than others and managing this aspect can help control botanical composition of mixtures.

Tall Fescue is more shade tolerant than **KY Bluegrass** which is more tolerant than **Orchardgrass**

Red clover is more shade tolerant than **Alfalfa** which is more shade tolerant than **White Clover**

Tiller density is markedly affected by the amount of light getting to the base of plants where tiller buds are located on many plants, and those emerging buds cannot develop and survive unless some light periodically reaches them. For example, lawns and frequently grazed pastures have many more tillers/sq. ft. than do hay fields, partially a result of light penetration to the base of plants allowing better survivability.

Flowering is the beginning stage of seed formation, and is a response to day length and/or temperature requirement. For example, some plants (fescue, orchardgrass, bluegrass) normally produce a seed head (inflorescence) only once per year because the tillers have to be vernalized through exposure to long nights and cool temperatures. All tillers that are produced the rest of the growing season will be vegetative. Other plants like alfalfa, clover, bermudagrass, millet, sudangrass crabgrass, and bromegrass will produce a flower or seed stalk after each harvest or grazing through the growing season because they do not need to be vernalized.

Temperature...The optimum temperature for growth of fescue, orchardgrass, bluegrass, ryegrass, bromegrass, timothy, small grains, white clover, red clover and alfalfa is about 70-80° F. (Fig. 3). The optimum range for bermuda, switchgrass, crabgrass, sudan, millet, corn is 85-95° F. (Fig. 4) Since no one specific species grows year-round, it is necessary to have a combination of cool and warm season species in a forage system to provide a long grazing season. For example, a farm may need 15-30% of the acreage in warm-season species and the rest in cool-season crops to provide the longest grazing season.

Some noted exceptions to the optimum temperatures: fescue, rescuegrass and smallgrain rye will grow more

than any other species when temperature is near 40°F; alfalfa will grow quite well at temperatures above 85°F; bermudagrass and crabgrass do not grow rapidly at temperatures below 70°F, with almost no growth at 55°F or less; switchgrass, however, will make significant growth at temperatures in the 70°F and often greens up earlier in spring than other warm season plants.

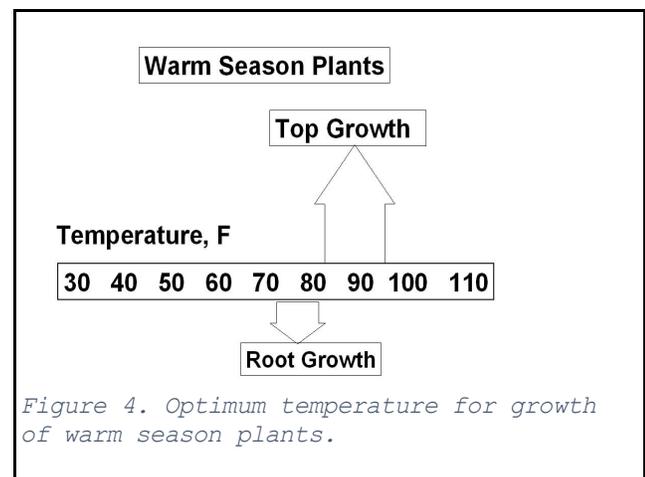
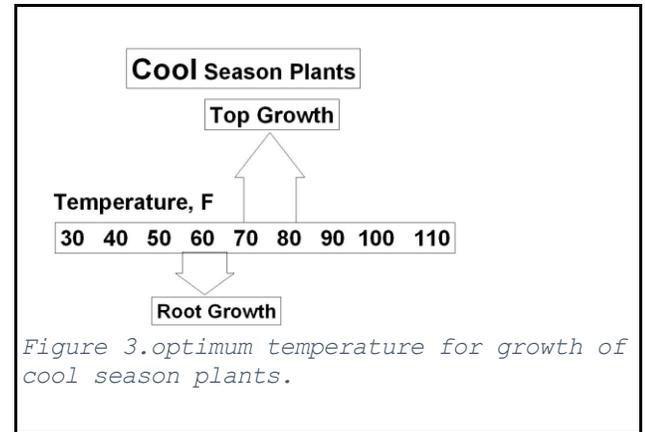
The favorable temperature is not the same for photosynthesis and growth (cell expansion and cell division). For example, when the temperature drops below the optimum range for growth, the rate of photosynthesis may continue at a relatively high level in fescue, orchardgrass, ryegrass, bluegrass and other cool season grasses. This often results in an accumulation of carbohydrates (plant food) in the plants. The quality of most cool season plants will be higher when the temperature is just slightly below optimum for growth, but not low enough to stop photosynthesis.

High summer temperatures cause many plants to become less digestible because of the relative changes in carbohydrate and fiber composition; this often results in accelerated "aging" and "browning" of plant tissue.

Soil Moisture...Moisture is important in the photosynthesis process, but its prime contribution is for plant cooling and nutrient transport. Warm season plants tend to be more efficient in terms of dry matter production per lb. of water than the cool season plants. High temperatures are usually associated with the "dry" conditions which further hampers the growth of the cool season forages.

Some generalizations about moisture and plant growth:

- a. in the early stages of moisture stress in plants growth slows before photosynthesis slows, therefore, plants may actually accumulate carbohydrates; this surplus energy may be used for survival or for regrowth after the stress is relieved or captured in the harvested or grazed forage.
- b. when moisture becomes limiting, growth and metabolic processes slow or stop, resulting in "un-assembled" products within the plant cells. For example, nitrate accumulation may occur when plants have access to soil N and the plant growth is "stalled" because of moisture or temperature stress. Other compounds may also accumulate or form that become toxic to



grazing animals.

- c. during the early stages of moisture stress growth (yield) may be hampered more so than quality. In other words, if plants are young, leafy and green, the feed quality may still be excellent even though yield or forage supply may be low. However, when high temperatures are associated with moisture stress for extended periods of time, quality is adversely affected through increased dead tissue and elevated fiber composition.

Nutrients... Fertilizer or nutrient management is the one aspect of plant growth that everyone recognizes to be important for high yields. Soil testing is the best way to monitor nutrient needs. Below are a few principles which may help in understanding the role of nutrients in the physiology of plant growth.

- a. High N and high temperatures (85-90° F) can cause cool season grasses to die because of high cell respiration rates. This is the reason why it is not recommended to apply N or manure to such crops in summer months of June-August.
- b. Lack of nutrients will restrict yields much more than it will affect feed quality if plants are harvested in early stages of growth. If properly grazed and kept in a leafy condition, the feed quality of low fertility plants may be surprisingly good. This occurs because photosynthesis will be relatively high as compared to "growth", resulting in an accumulation of "plant food" in the storage organs and leaves. This plant food (carbohydrates) is highly digestible.

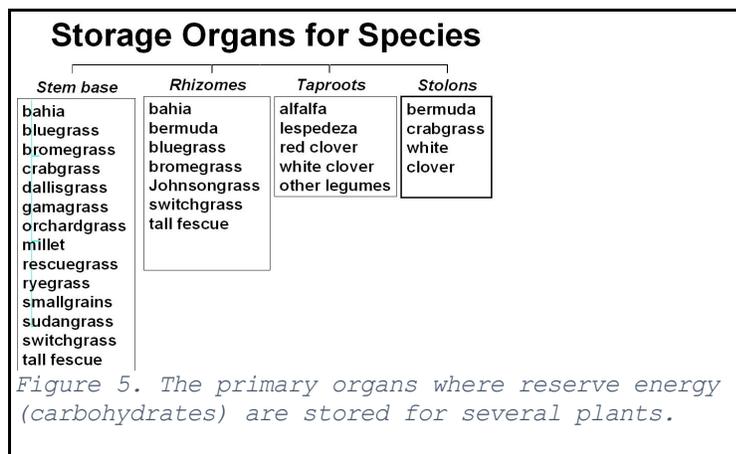
How Do Plants Regrow after Grazing or Harvesting or Dormancy?...when green leaves are not present.

When plants have plenty of young, green leaves "plant food" production from photosynthesis often exceeds growth requirements, therefore the "excess" is stored for use later by new developing buds or regrowing tillers. **Growth of the plant has first priority for use of "plant food"**, but once that need is met, the excess "plant food" being produced by the green leaves is stored somewhere in the plant (Figure 5). The regrowth after cutting, grazing, or dormancy from temperature or moisture stress, depends heavily on "**reserve energy**" which has been previously stored in specific organs of the plant. This "reserve energy" is often referred to as "**root reserves**" or "**energy reserves**" or "**stored energy.**" Fescue/orchardgrass/bluegrass/clover canopies will be roughly 4-8 inches tall and provide between 1000 - 2500 lbs. of dry matter per acre by time plant "replenishes" reserve levels.

WHERE IS THE "RESERVE ENERGY" STORED IN PLANTS

Grazing or harvesting height is primarily based on the location of storage organs in forage plants

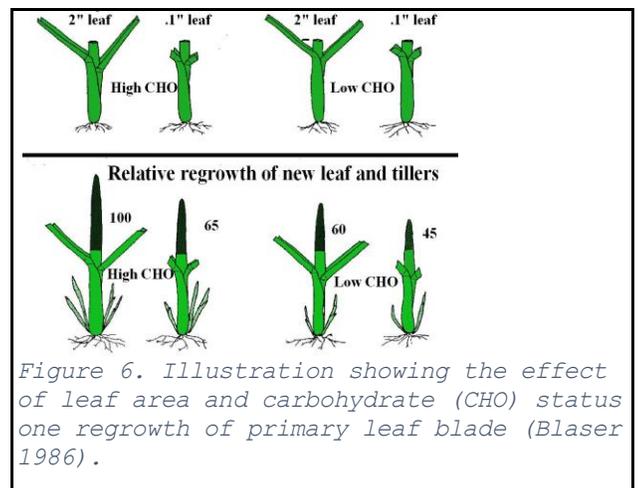
(Figure 5). For example, animals can remove the storage organ in orchardgrass or sudangrass by grazing the lower stem base, but they are not likely to eat the tap root of alfalfa nor the stolon of white clover. Plants like bermuda and quackgrass, which store reserve energy in rhizomes and stolons, are more tolerant of close, frequent grazing, partially because of location of reserve energy and the amount of leaf left following defoliation.



HOW DO PLANTS REGROW AFTER GRAZING OR HARVESTING?

When Leaf Area Is Remaining

All plants are dependent on reserve energy for regrowth following harvesting or natural dormancy, however the number of green leaves remaining after defoliation also has a significant influence on the amount and rate of new growth. Some plants seem to maintain many green leaves near the soil surface (bermuda, bluegrass, endophyte containing fescue), especially under grazing situations. For example, bluegrass and white clover are very tolerant of frequent and close grazing because they have tremendous reserve energy storage capacity (rhizomes, stolons, stem bases), and they can maintain green leaves within a half-inch of the soil surface. Regrowth is boosted by reserve energy in addition to continued photosynthesis from remaining leaf area as illustrated by the orchardgrass tillers in Figure 6.



WHEN TO RE-GRAZE

Regrowth rate will vary by location and environment, so the manager has to constantly observe plant growth to make good decisions.

Plants which usually utilize reserve energy more than leaf area near soil surface for rapid regrowth after harvesting or grazing.

These plants depend heavily on **reserve energy** for rapid regrowth, however, almost all of them will, in various management situations, have some amount of leaf area remaining after grazing. After cutting, most will have very few leaves remaining.

Alfalfa... following harvest new growth primarily comes from crown buds and axillary buds which are dependent on energy from the tap root. Alfalfa does not tolerate frequent grazing except in early spring where many green leaves remain after grazing but it will tolerate “close” grazing if the new tiller buds are not damaged.

Red Clover... relative to alfalfa, it usually has more leaf area near soil surface following grazing, therefore is somewhat more tolerant of frequent defoliation.

White Clover... stolons and tap roots provide large reserves for regrowth, but the plant easily adapts to close frequent grazing by developing new leaves on very short petioles along the stolons. It often thrives under frequent and close grazing, because light penetration to the stolons is so important to survival of developing buds.

Orchardgrass... is largely dependent upon reserves stored in stem bases, but it can adapt by producing leaf area near soil surface when the canopy is frequently grazed. Most varieties cannot tolerate close (<3”) frequent grazing as well as endophyte infected fescue.

Sorghum-sudan or Pearl millet... regrowth is highly dependent upon reserves stored in lower stem base (lower 6” of stem), therefore frequency of grazing and height of stubble are critical to rapid regrowth.

Switchgrass, Indiangrass & gamagrass... these grasses store energy in stem base, but also in the upper root (short rhizomes) system. When cut for hay they retain very few leaves, but when

grazed in the vegetative to preboot stage they remain leafy and tiller more profusely.

Rescuegrass/prairiegrass... stores energy in stem base, and its regrowth is rapid when 3-4 inches of stubble remain after grazing or harvesting. It is a leafy grass, but fairly “upright” with not many prostrate leaves near the soil surface.

Plants which usually utilize leaf area near the soil surface more so than reserve energy for rapid regrowth following harvesting or grazing.

These plants are usually most tolerant of close frequent grazing because they retain significant leaf area near soil surface. However, their regrowth rate following hay harvesting depends upon reserve energy in the stem base since there are few leaves remaining below the harvest height.

Tall fescue... under grazing it can produce leaves within 1-2 inches of soil surface. Endophyte infected fescue can tolerate close, frequent grazing but endophyte free varieties will not be as tolerant; these differences are related to the effects of the endophyte on plant tolerance to stress and adaptability. Endophyte free varieties should be managed similar to orchardgrass.

Kentucky bluegrass... under grazing it is extremely leafy near soil surface and has short rhizomes which store energy reserves in addition to the lower stem base.

Bermudagrass... it is well adapted to close grazing because it can produce leaves within ½ inch of the soil surface. It also has vast reserve energy storage capacity in stolons and rhizomes.

Bahiagrass & Dallisgrass... these grasses retain leaves near soil under most management conditions. Bahia has short rhizomes and very stout stolons which make it well adapted to close grazing. Dallisgrass occasionally has short rhizomes, so most energy is in stem base.

Crabgrass... There are many variations and types of crabgrass. Some are much more prostrate than others. Stems often lodge onto soil surface and root at the nodes with leaves near the soil surface. Generally, there is considerable leaf area remaining after grazing.

MORPHOLOGICAL ASPECTS OF PLANT MANAGEMENT

Definition... Plant morphology describes the plant physically (Figures 7-10); it is the outward appearance or physical stature of the plant as it is growing in place. The following aspects help describe the morphology of plants:

- (1) Size of canopy
- (2) Erect or prostrate growth habit
- (3) Presence of stolons, rhizomes, or tiller branches for propagation
- (4) Kind (tap or fibrous) and depth of root system
- (5) Location and presence of axillary buds that form roots or shoots
- (6) Location of growing point
- (7) Stem: leaf ratio

The Plant Tiller... The grass tiller (**shoot**) is composed of a **growing point** (apical meristem which may turn into a seedhead), a **stem, leaves, roots, nodes** (joint) and **dormant buds (Figure 7)**. **Buds** are located at the nodes which are at the base of the shoot (**basal buds**), on the stem (**axillary buds**) and at the nodes on the stolons or rhizomes. The dormant or inactive buds have potential to produce a **new tiller** (shoot) with a new growing point.

A tiller developing in the spring season from a dormant bud can be compared to an annual plant developing from seed. In effect, the tillers of perennial grasses act as annual plants. The number of tillers in a sward is strongly related to the amount of sunlight reaching the tiller buds at base of plants. All grass tillers begin growth from a growing point arising from a dormant bud **at or below** ground level.

As long as the tiller is vegetative, it has the potential to produce an indefinite number of leaves, however it will rarely have more than 3 to 5 leaves at a time. When the growing point of the tiller is triggered to elevate or become reproductive, there is no further potential for new leaf initiation in that tiller.

Jointing or stem elongation is a transitional stage between the vegetative and reproductive stages of growth. If the tiller has become reproductive, a seed head will emerge. Grasses like fescue, orchardgrass and bluegrass become reproductive once per year (spring) and all subsequent growth is vegetative. As a result, the growing point on these vegetative tillers is always near the soil surface.

Following the removal of the growing point on a tiller, new regrowth may come from the development of buds at one of three places: 1) **an intact growing point** of the defoliated tiller (the most rapid growth occurs here); 2) the **basal and rhizome buds**, are second source of rapid growth; 3) **aerial tillers**, although active on some grasses like switchgrass and reed canarygrass, are the least productive of the new tillers.

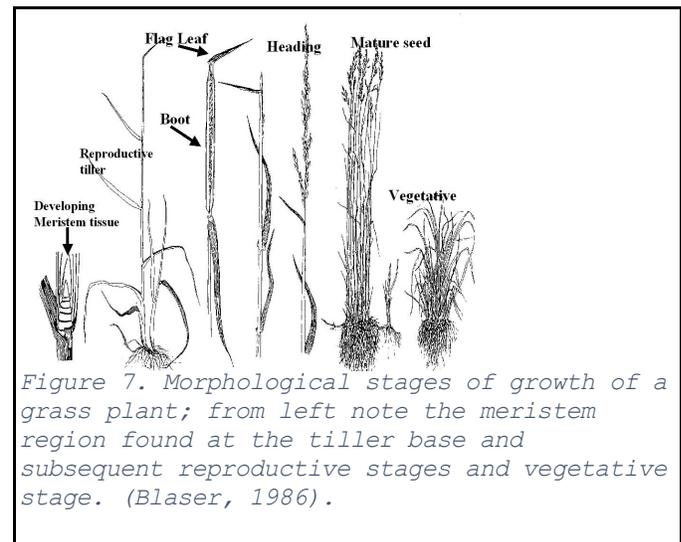
How does understanding plant morphology help in grazing or harvesting management of plants?

The position of axillary shoot and crown buds often determines stand longevity and survival when plants are exposed to extremes in temperatures during winter and summer. The depth of root system influences the plant's adaptation to flooded or very dry soil sites. Rhizomatous species provide protection to buds thus they have survival advantages under stressed environments.

Size of canopy (above ground structure) and its erect or prostrate growth habit help to determine whether a species is useful for silage, hay, grazing, or stockpiling. It also helps determine extent and frequency of defoliation. Nutritional quality is influenced by the leaf: stem ratio of forage on offer.

The rate of seeding is related to morphology.

1. Alfalfa and white clover are not compatible in mixtures because the growing points on the stolons along the soil surface white clover die from shading by the tall and erect alfalfa canopies.
2. Species with rhizomes and/or stolons can be seeded at low rates since they invade bare areas more readily.
3. Differences in seedling growth rate and canopy development helps determine mixture combinations. There may be 5 to 10 fold differences between the growth rates of some species in pasture mixtures.



Plant succession and changes in botanical composition are often controlled by size of

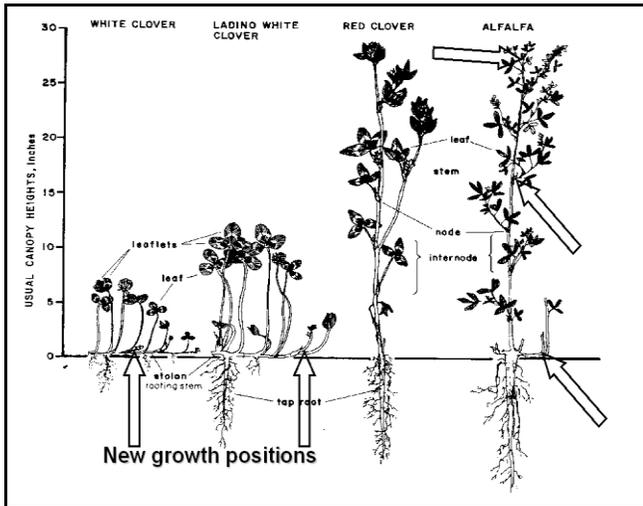


Figure 8. Morphological nature of selected legumes showing prostrate, close growing white clover as compared to the erect red clover and alfalfa; note location of growing points and the tap roots and stolons (Blaser 1986).

species canopies and roots, presence of stolons or rhizomes, and location of storage organs and regrowth tissue, all of which strongly influences competition for light, moisture, and soil nutrients (Figures 8-10).

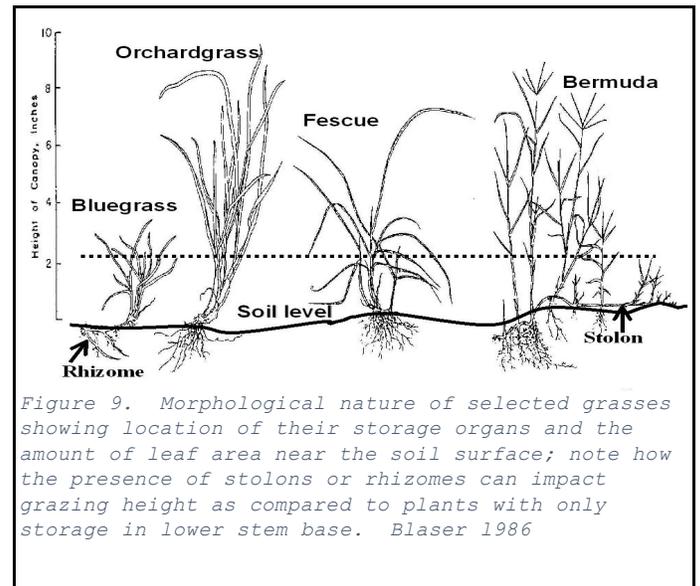


Figure 9. Morphological nature of selected grasses showing location of their storage organs and the amount of leaf area near the soil surface; note how the presence of stolons or rhizomes can impact grazing height as compared to plants with only storage in lower stem base. Blaser 1986

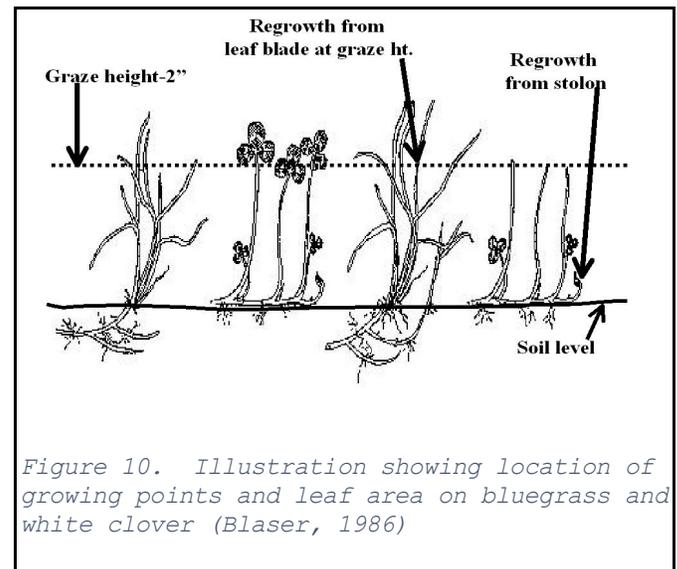
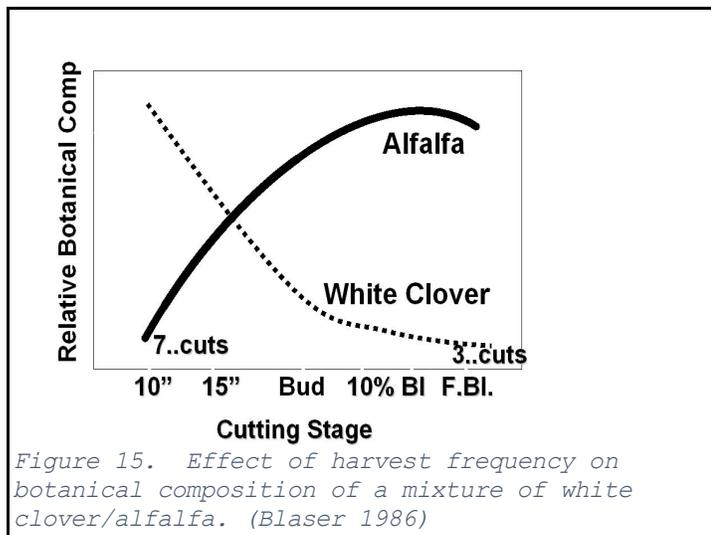
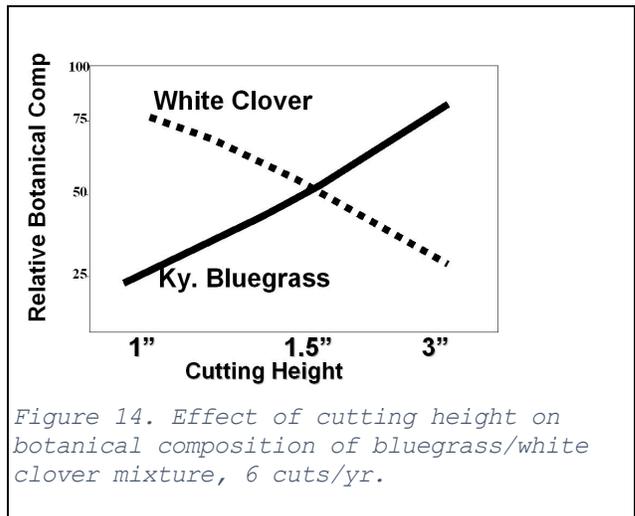
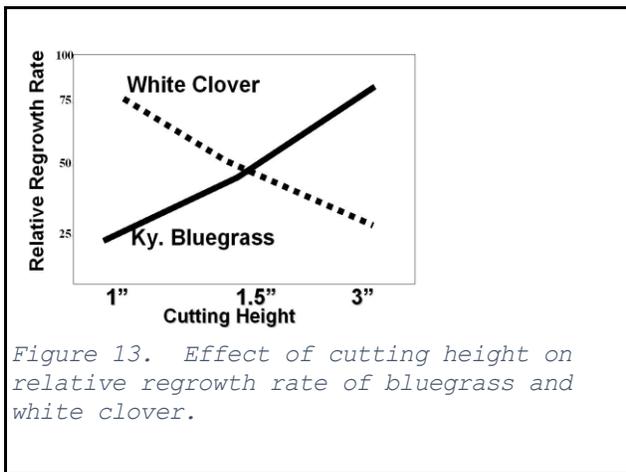
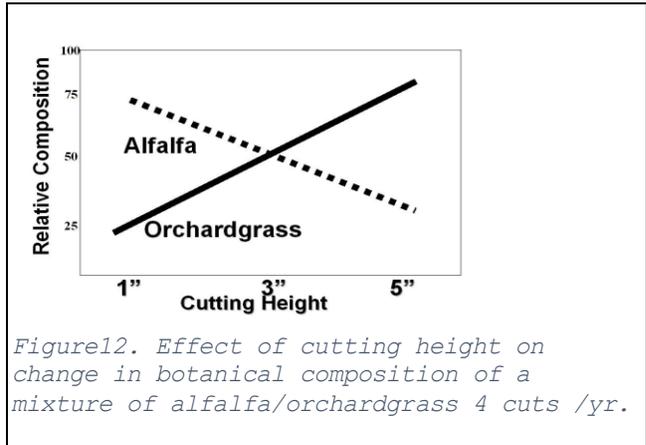
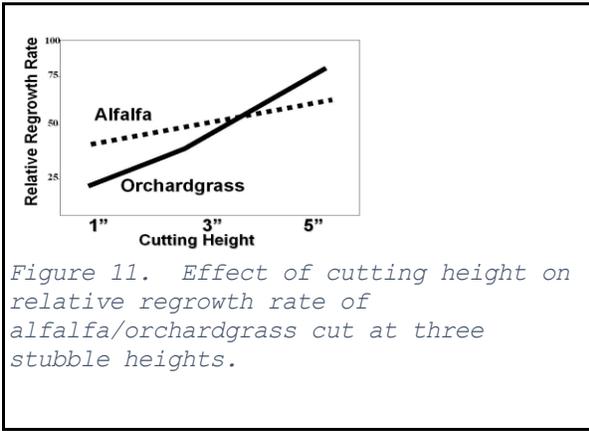


Figure 10. Illustration showing location of growing points and leaf area on bluegrass and white clover (Blaser, 1986)

Figures 11-14 show the effect of cutting height on the relative rate of regrowth and change in botanical composition in two mixtures with widely differing morphological characteristics. Alfalfa and orchardgrass are up-right plants with few leaves near the soil surface after clipping, whereas bluegrass and white clover are much more prostrate with leaves near the soil surface.



Figures 11-12 show the influence of cutting height on alfalfa-orchardgrass. Cutting at 1 inch stubble reduces the amount of energy and leaf area available for regrowth for both species, but it hurts the orchardgrass more than it does alfalfa because of the location of the reserve energy. At the 5-inch height there is plenty of leaf area for photosynthesis and the storage organ of orchardgrass has not been harmed; thus growth rate is maintained. Since most new growth from alfalfa comes from crown bud shoots, which depend upon energy from tap root, the height of cut is not as important as with orchardgrass where the storage is above ground and close cutting reduces leaf area.

The one inch stubble would allow quicker regrowth of alfalfa than of orchardgrass, thereby creating shading of orchardgrass. At the five inch cutting, orchardgrass would shade new bud shoots of alfalfa creating a shift in the botanical composition. If frequency of cutting or grazing changed to 8 times per year, expect alfalfa to be hurt much more than the orchardgrass due to the depletion of reserve energy.

Figures 13-14 show similar responses for a mixture of bluegrass and white clover as with the alfalfa-orchardgrass. The major difference is that the regrowth rate of white clover drops more drastically than alfalfa at the tallest cutting heights; this is related to the location of white clover growing points which are on the soil surface. The bluegrass canopy is very competitive for light near the soil surface (Figure10). Tall stubble heights or lax grazing usually results in less legume in the mixture.

UNDERSTANDING ANIMAL BEHAVIOR AS WELL AS PLANT GROWTH

Grazing managementis the manipulation of animal grazing in such a way that allows one to accomplish certain goals (milk, meat, fiber, stand persistence). It is important to understand that the grazing behavior of animals (cattle, sheep, goats, horses) differs considerably, therefore their grazing effect on the growing plant differs somewhat. Since some of the more useful forages have reserve energy storage organs above ground, the grazing characteristics of specific animals can influence how plants survive various defoliation intensity.

For the most part, animals don't prefer to bite plants off at the soil surface, but when feed availability is limited, they may graze the plants so close that reserve energy storage is consumed. If sufficient rest (time for the plant to replenish reserve energy and leaf area) is not provided prior to the next defoliation the plant cannot maintain its vitality; each successive defoliation makes the plant weaker and weaker.

Under such grazing practices, animals are not able to meet their daily nutrient requirement because of limited intake. In such cases the plant is being sacrificed to provide very limited feed supply, and the animal is not performing because of under feeding. From the animal's standpoint, it is important that enough leaf area be present to allow easy "biting." Usually when the canopy is tall enough for "easy grazing" the leaf mass is sufficient for optimum photosynthesis and growth.

Cattle... can graze plants to 1-inch or less, but they only do that when feed availability is limited. However, they will "spot" graze certain areas within a pasture, and this happens because feed supply is high enough that animals have maximum ability to selectively graze what they want. The "spots" are areas of short, young, green and leafy growth which is of very high quality resulting from continual, frequent defoliation. Plants in those spots will eventually weaken and not produce to their potential because of low leaf area and low reserve energy storage, due to lack of sufficient rest or recovery time. In addition, botanical composition will likely shift to species most tolerant of short frequent defoliation (like bermuda, crabgrass, bluegrass, endophyte fescue, white clover).

Sheep... can be very selective in choosing very specific plant parts because of their lip and teeth arrangement. In situations where the grass may be of an ideal height for cattle to graze easily (leaving 2-4 inch stubble), sheep will often bit the leaves from the stems or even bite the entire tiller off near the soil surface. If animals remain on an area too long, they may bite all plants off to a one-fourth inch stubble. Such grazing will have significant impact on reserve energy storage and regrowth rates. Plants which have underground storage of reserve energy or lots of leaves near the soil surface survive best in sheep pastures. Generally, longer rest periods will be needed between grazings when plants are grazed below their target height. Sheep pastures are usually denser than cattle pastures because they keep the vegetation grazed short allowing plenty of sunlight to reach the basal

tiller buds.

Goats... do not prefer to graze close to the ground and will only do so when feed supply is severely limited. Goats can be the most selective in what plant parts they eat. High animal performance requires high quality forage or browse. Even though goats will graze leaves of grasses, they prefer to browse above their knee height. They will eat seed stalks, heads and other plants which cattle or sheep do not readily eat. They generally prefer grass over clover in mixtures, which may shift the botanical composition toward more legume. Such a shift would favor the performance of cattle and sheep because of the improved forage quality of clover-grass mixtures. Goats tend to graze a canopy from the top down in a fairly uniform manner, therefore they are ideal animals to graze new seedling stands to avoid seedling damage. They do not spot graze as much as other animals.

Horses... can bite plants at the ground surface, which is extremely damaging to plants with reserve energy storage in the stem base. They tend to spot graze regardless of frequency of movement. Because they can bite plants near the soil surface, almost regardless of the amount of forage on offer, it is very important that rotations allow sufficient rest between grazing to allow the plants to fully recovery with several inches of regrowth.

IMPLICATIONS FOR GRAZING MANAGEMENT

A compromise is necessary...Graziers realize that a "compromise" between what is good for the plant and what is good for the animal is necessary for long term successful grazing programs. The management goal is to graze or harvest the canopy in such a way as to meet the needs of the grazing animal, while leaving the plants in a condition for rapid regrowth and long term production. For example:

1. The best quality feed and highest daily animal performance comes from using immature, young leaves. While young, short pasture may be of high quality, its limited availability may restrict consumption and performance of the grazing animal. Keeping the plants in a very young stage of growth can eventually restrict acre production and stand longevity because of low photo synthetic capacity.
2. Because animals preference certain species and because plants compete differentially for nutrients, water and sunlight, the botanical composition of pastures is in a constant state of change. This change may affect animal consumption and performance, as well as acre production.

SUMMARY COMMENTS

Understanding the physiology of plants is the foundation for knowing how to manage them for production and use as animal feed. Knowing why plants respond to various environmental and management factors allows farmers to anticipate changes in growth, persistence and feed quality. Learning about the basics of plant growth allows one to quickly manage any “new” or different plant in a wide range of environments.

Another way to summarize is to think about the similarities between pasture management and lawn or playground management?

Many of the grasses used for pastures are used for lawns, and they each have the same basic requirements for growth and persistence, whether it is for aesthetics, erosion control or animal feed.

How does one maintain grass cover in a lawn or playground?

Fertilize and lime adequately... Many people apply “plenty” of nutrients two or more times per year. Even though this is not necessarily the environmentally friendly thing to do, it keeps the lawn “looking good”.

Soil testing service is the only way to know the nutrient supplying capability of soils. This service is the most cost effective way to grow plants and minimize the potential for nutrient contamination of the environment. This management practice should be routine for any farm or garden operation.

Controlling the mowing activities... The mower on a farm is the grazing animal; the only way to control where it “mows” is with a fence or “leash”.

Height prior to mowing...Most homeowners know that grass should reach 3-5 inches height before it is re-mown; pasture managers should also know how tall grass should be prior to allowing the animals to re-graze. This varies with different plant species.

Knowing how close to the soil to mow... Homeowners know that they cannot mow “too short” or they eventually kill the grass. Plant survival depends on maintaining green leaves for continued photosynthesis (plant food production) after mowing or grazing. The pleasing “green” appearance is the green leaves and they are absolutely essential for survival and growth of the plants.

Knowing how often to mow... Homeowners know that they cannot mow before the plant regrows a “certain amount”; most do not mow every 2-3 days because the plants haven’t had time to recover from the previous defoliation. Yet, many pasture managers will let animals have continuous access to the same pasture thereby allowing repeated “grazings” of new plant growth.

The period between mowing allows plants to “rest” and recover. This rest period is necessary for the plant to accumulate reserve energy and green leaves for rapid regrowth prior to the next defoliation event. **How much corn would one grow in the garden if the leaves were cut off the stalk every few days?**

Controlling the traffic patterns

Homeowners understand why the path around the house or play area is bare; such areas are a result of walking patterns or play areas of people or pets. Everyone knows grass does not survive when traffic is not controlled; grazing animals do the same thing when not controlled.

James T. Green
Professor Emeritus
Crop Science Department (Forages)
North Carolina State University
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