Forage Growth and Its Relationship to Grazing Management

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Introduction

All green plants have the ability to make and store their own energy via a process called photosynthesis. Using energy from the sun, carbon dioxide in the air and water in the soil, green plants make sugars (carbohydrates). A portion of this photosynthate is used for stored energy and the remainder for building cell walls. The stored energy (nonstructural carbohydrates) in the basal plant tissues (roots, rhizomes, stolons, and tillers) provides nutrients for growth, and allows the plants to survive periods of stress. The types and amounts of nonstructural carbohydrates in basal parts of plants fluctuate due to the dynamic relationship between respiration and photosynthesis.

Vegetative growth

Growth is a change (usually an increase) in biomass. Growth of both individual plants and the sward generally follows a sigmoidal curve from the time of establishment until annuals die or a "steady state" is reached in perennials. Three stages make up this growth curve: (1) an early period of slow growth, (2) a central period of rapid growth, and (3) a final period of slow growth (Bonner and Galston, 1959). As a plant emerges from its seed, it grows slowly and then accelerates its growth until it reaches the flowering stage, when growth slows down again. A plateau occurs when the canopy is intercepting all incoming radiation and growth of new leaves, stems, and roots is approximately equaled by the death of old organs.

The regrowth of a plant after grazing (defoliation) follows the same sigmoidal curve growth pattern. After grazing or mechanical harvesting, plants' recovery from this stress is compounded by their reduced ability to capture sunlight. Furthermore, they also have lost a lot of stored carbohydrates; consequently growth is slowed.

If the apical meristem remains intact, new leaf production continues. But if the apical meristem is removed, then lateral tillering or branching is necessary before resumption of leaf production. Thus, the height of grazing or cutting changes the location of shoots which support regrowth. The residual leaf area is the factor that is most important in determining regrowth, but mechanistic understanding is available to devise optimum management strategies for grazing under seasonally changing conditions.

During the central rapid growth period, forages are in a vegetative state with high amounts of green-leaf area exposed to the sun. The third phase is when the growth rate slows down, plants flower, and produce seed. The total yield of dry matter from the pasture is at its highest during this stage, but nutrient ***quality*** is low.

Interception of radiation

The amount of carbohydrates that a plant can produce in a given time period is dependent on the amount of the sun's energy it can capture and convert to tissue. The radiation available for grassland growth depends on the amount of solar radiation at the top of the atmosphere, which changes in a seasonal pattern according to latitude. It is attenuated by depth of atmosphere, clouds and particulate matter, leading to a certain amount of net radiation on the herbage. A plant maximizes radiation absorption by accumulating leaves. A common expression that denotes the amount of leaf area a plant has is *leaf area index* (LAI). When the leaf area exposed to the sun rays equals the area of ground on which the plants are growing, the LAI is 1. When the LAI is approximately 4, most forages will have maximum growth, provided nothing else is limiting. Beyond a LAI of 4, the production tends to decline somewhat (Smith et al., 1986). Very high leaf areas do not give additional increases in production because basal leaves are shaded, old, or inefficient. Perennial grasses with semi-erect leaves need larger leaf areas than legumes with horizontal leaves. Grasses may intercept virtually all (95%) radiation at LAI 6 to 9, whereas temperate legumes will do so at LAI 2.5 to 4 (Pearson and Ison, 1987).

Certain subtropical grasses such as bermudagrass maintain high leaf areas with a wide range of managements. Under continuous close grazing, sods may form dense horizontal stems with short leaf blades while, under lax grazing or hay production, they form erect canopies with fewer stems and basal leaves. Therefore, close grazing is important in bermudagrass, bahiagrass, etc, to attain leafy growth that is high in nutrition.

Water Availability

Water, temperature, soil structure, and fertility directly affect the rate of grassland growth. They also affect growth indirectly through their influences on development. Available soil water is that volume of water held between field-capacity and wilting-point. It is influenced by the amount of rainfall, the water-holding capacity of the soil, and the losses of water from the herbage and soil. Root penetration and the total volume of available soil water for the plants are greatest in soils that have a medium texture, low-bulk density, and good aeration.

Temperature

Temperature affects the growth rate of grasslands, separately affecting each process of development as well as the rates and directions of the metabolic pathways associated with growth. Species may be grouped into broad types according to the responsiveness of their growth rate to temperature (see Figure 2). There are important differences in response to temperature within and between genera, with much varietal variation.

Morphology and Growth Habit

Each pasture species has a unique morphology and growth habit. Both determine how a plant regrows after grazing. As pastures are grazed, forages are eaten in horizons "from the top down," with the remaining stubble containing progressively less ***leaf area***. Plants that have upright growth habits--with easily grazed leaves, high on the stems, that do not contain much leaf area in the grazed stubble--include legumes like alfalfa and red clover. Conversely, sod grasses and prostrate-growing legumes, like white clover, that send out runners or stolons contain a high amount of leaf area in the stubble. Also cool-season grasses usually have high amounts of leaf area in the grazed stubble. This is because a portion of the leaves remains intact after grazing, assuming the pasture is grazed correctly. Grasses like Kentucky bluegrass and bermudagrass tolerate close grazing, probably because they are low-growing and maintain leaf area below the grazing height.

The warm-season grasses of tropical or semitropical origin produce seedheads repeatedly during summers because of short nights. The physiological demands at seedhead production cause significant reduction in new leaf growth. Thus, grasses such as bermudagrass decline rapidly in quality with maturity unless grazed to maintain leafy foliage in a vegetative state.

Morphology and growth habit also determine how well individual plants compete in a mixture. Tall-growing grasses and legumes such as tall fescue, alfalfa, and red clover can form a canopy that covers low-growing plants like Kentucky bluegrass and white clover. If the canopy is not occasionally removed, the taller plants will capture most of the light while the low-growing plants remain shaded. When this happens, taller plants eventually crowd out the shorter plants like white clover and bluegrass (Roberts, 1994).

Intake

Animal intake is affected by sward height, leafiness, density, and plant distribution. Rate of intake is higher when the herbage is high, leafy, and dense. Animals will select food that they can eat more quickly. Herbage quality and animal intake are closely linked, and animal intake is closely linked with production. Animal production will be maximized by management that produces a "best-compromise," matching grassland growth, forage quality and animal intake. Animal performance is associated with total energy intake. Daily forage intake increases as digestibility increases. Overall forage quality tends to be greater under a controlled grazing system when compared with continuous grazing because, throughout the season, more of the available forage is vegetative growth. Under controlled grazing, the sward is grazed much more evenly so subsequent regrowth is more uniform.

Conclusion

Grazing management affects the form of regrowth, which in turn affects photosynthetic rates and carbon balance (Pearson and Ison, 1987). And these, together with the selectivity shown by grazing animals and uneven return of nutrients to the grassland, influence the competition between species and the composition of the sward. Canopy height should be controlled to allow maximum species diversity. Grazing-management factors that are used to control canopy height include number of paddocks in a grazing cell, number of animals on a paddock (stock density), and speed of grazing rotations. Season of year and changing weather regulate total forage production and canopy height. Rapid growth in spring requires that the canopy be removed rapidly. "When the grass grows fast, move animals fast, and when the grass grows slow, move animals slow" is the most important managerial guideline for a producer to follow.

References

Bonner, J., and A.J. Galston. 1959. Principles of Plant Physiology. W.H. Freeman and Co., San Francisco, CA.

Fitzpatrick, E.A., and H.A. Nix. 1970. The climate factor in Australian grassland ecology. In: R.M. Moore (Ed.) Australian Grassland. Australian National University Press, Canberra.

Pearson, C.J., and R.L. Ison. 1987. Agronomy of Grassland Systems. Cambridge University Press, Cambridge.

Roberts, Craig. 1994. Plant growth and forage quality. In: 1994 Missouri Grazing Manual (M157). University of Missouri, Forage Systems Research Center.

Simpson, R.J., and R.A. Culvenor. 1986. Photosynthesis, carbon partitioning and herbage yield in pastures. In: Wheeler, J.C., C.J. Pearson, and C.E. Robards (Eds.) Temperate Pastures:

Their Production, Use and Management. Melbourne, Australia.

Smith, Burt, PingSun Leung, and George Love. 1986. Intensive Grazing Management: Forage, Animals, Man, Profits. The Graizers Hui, Kamuela, Hawaii.

Summerfield, R.J., and H.C. Wein. 1980. Effects of photoperiod and air temperature on growth and yield of economic legumes. In: Summerfield, R.J., and A.H. Bunting (Eds.) Advances in Legume Science. Royal Botanic Garden, KEW.

Table 1. Classification of forages[a]

Forage Type	Description
Cool-season	Forages that grow best during the cooler portions of the year
Warm-season	Forages that grow best in warm or hot summer conditions
Tropical	Plants that are killed by freezing
Temperate	Plants that can tolerate freezing
Subtropical	Plants that can handle light and(or) occasional freezes
Annual	Plants that complete the life cycle from seed in one (year-long) growing season
Perennial	Plants that, under suitable conditions, have the ability to live for more than one year, persisting without relying on reseeding for survival

[a]From Smith et al., 1986.

Fig. 3.1. Developmental events (a) and growth (b) during the life of a herbage plant. Nitrogenase activity refers to upper nodules of an annual legume. The Development index is a scalar ranging from 0 at emergence to 1 at maturity. (Adapted from Summerfield & Wein, 1980, and Bergersen, 1982)

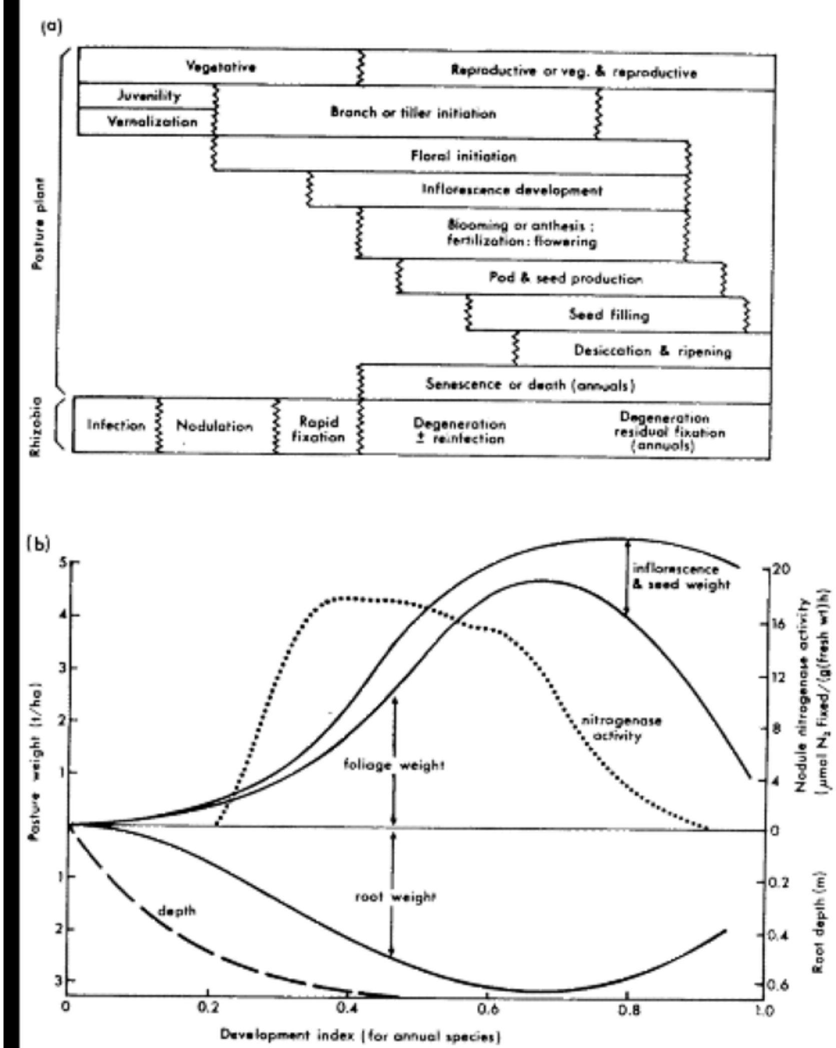
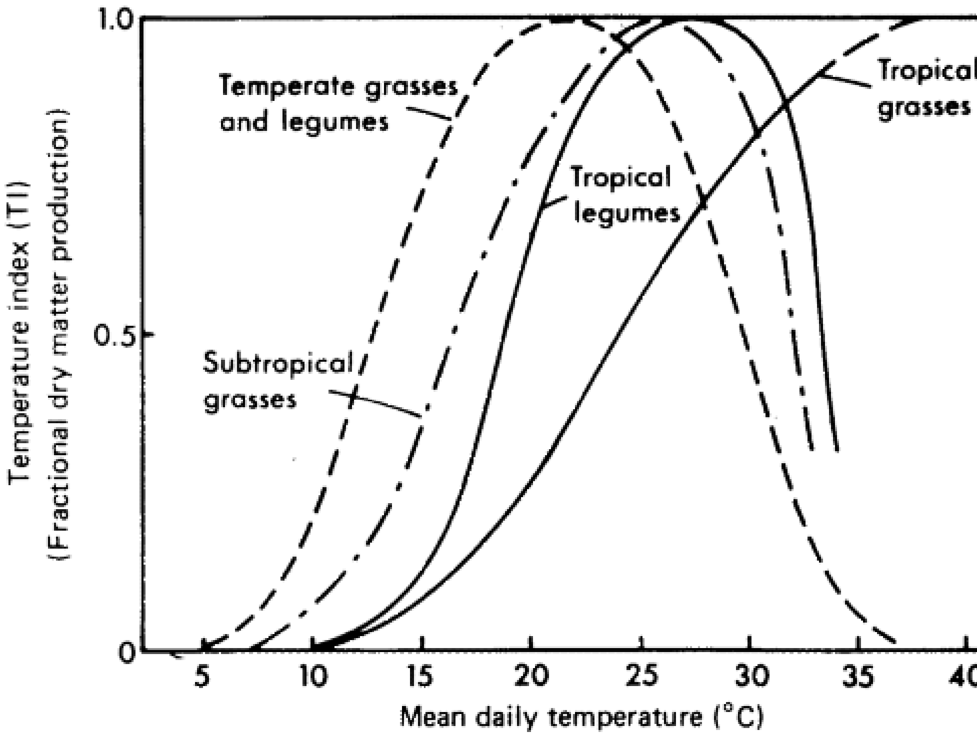


Fig. 3.10. Temperature index (TI): herbage growth expressed as a fraction of the growth potential of the species at optimum temperature. Grassland species are grouped into temperate grasses and legumes, tropical legumes, subtropical grasses and tropical grasses. (Adapted in part from Fitzpatrick & Nix, 1970.)



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