CHAPTER 5

How Grasses Grow[1]

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The grass plant

Grass plants consist of a collection of shoots called tillers. In the vegetative stage, before flowering begins, the tillers are made of leaf blades and sheaths; *what appears to be a stem is really a collection of sheaths and blades rolled or folded one inside the other.* The bundle of leaves and sheaths are referred to as pseudostems because they resemble stems. The leaves arise in succession from growing points located at the base or crown of the plant (see Fig. 1). The leaves start out as little bumps or nodes on the growing zone. Between these nodes are tiny internode zones, which elongate during the reproductive phase.

Just inside the base of each leaf is a tiny bud that may grow into a new tiller. In bunchgrasses (orchardgrass, perennial ryegrass) the new tiller grows within its leaf. In creeping grasses (quackgrass, Kentucky bluegrass), new tillers grow laterally outward through the leaves.

When the grass becomes reproductive, each of the compressed internodes, located between the leaf nodes, elongate in succession, beginning from the bottom. The resulting elongated internodes become the true stems of the plant. Elongation of the internodes causes the attachment points for all the leaf sheaths or blades to be separated vertically.

Germination

A grass seed or grain is actually a fruit called a *'caryopsis'*. The seed is composed mostly of a large store of carbohydrates, called the endosperm, the embryo which is to become the new plant, and a shield-like structure called the scutellum. Just inside the seed coat is a thin layer of cells called the aleurone layer. After the seed takes up water, these cells produce the enzymes that digest the starch of the endosperm into sugars for the growing embryo. The primary root *(radicle)* emerges from the embryo, followed by the shoot, called the *coleoptile.* Annual grasses absorb water and nutrients through the primary roots whereas perennial grasses absorb by secondary roots that emerge from the lowest nodes of each new tiller. When seeds are planted deeper in the soil, a short rhizome-like stem is produced to connect the primary root with the secondary root.

Leaf growth

One of the secrets for success of grasses as forages is that leaf growth continues during and after defoliation, until flowering begins. This is possible because the growth zone is at the bottom end of the leaves and sheaths thus remaining close to the soil surface during vegetative growth. Hence, if some of these growth zones are removed, they can be readily replaced with new tillers. No other plant family is so well designed to recover from defoliation.

At the very base of each tiller is the tiny region of growth called the 'apical dome' (see Fig. 1). New leaves initiate in succession on opposite sides of the apical dome.

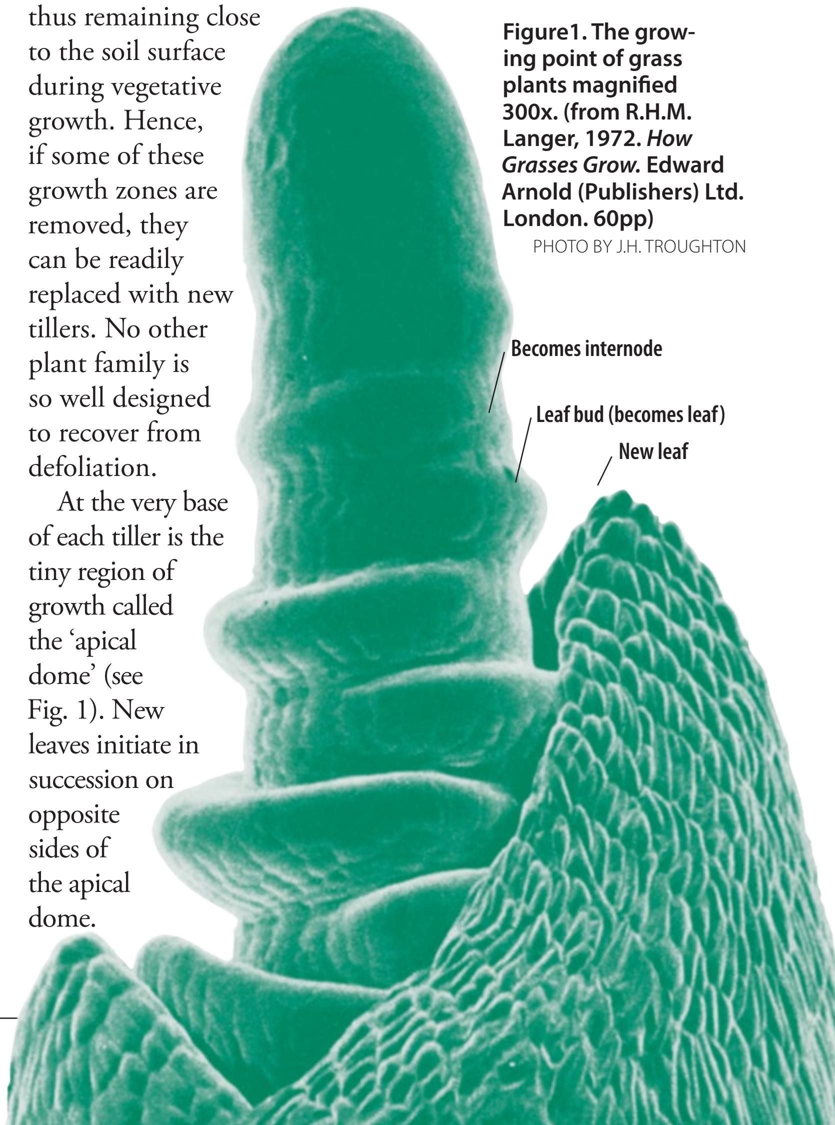

Figure1. The growing point of grass plants magnified 300x. (from R.H.M. Langer, 1972. *How Grasses Grow.* Edward Arnold (Publishers) Ltd. London. 60pp)

PHOTO BY J.H. TROUGHTON

1. Originally published in *Advanced Forage Management,* Bittman et al. 1999.

Leaf Growth: consequences for management

1. **During the vegetative phase, growing zones are at the lowest portion of each structure. When fully grown leaves are clipped they cannot resume growth. Leaves with active growth zones that have escaped defoliation will rise above the level of cutting.**
2. **The tip is the oldest and the base the youngest part of a leaf; hence the tips are first to senesce (die).**
3. **The lowest leaves tend to escape clipping but these leaves are oldest and least active. These leaves contribute to new growth more by supplying some stored nutrients (sugars, nitrogen, phosphorus, potassium) than by producing new sugars.**
4. **Nitrates are converted to protein in the bases of leaves, consuming much of the energy captured by the rest of the leaf.**

Leaf initiation is a continuous process so that at any time there is a series of new leaves at various stages of development. Just inside each new leaf is a bud that can potentially develop into a new tiller.

The growing zone for leaves is actually made up of two parts, the upper producing the leaves and the lower producing the sheaths. As the sheath grows, it raises the leaf until the growth zone at the bottom emerges from the bundle of older sheaths. When the bottom of the leaf, including the ligule, is exposed, leaf cells no longer divide and the leaf is fully formed. The sheath continues to grow after the leaf has stopped. Meanwhile, the next leaf is already moving up. For most grasses, no more than three leaves are growing at one time. Once a leaf is fully formed, its main function is photosynthesis and production of protein.

Growth rate of grasses is determined by rates of leaf initiation and leaf growth. Leaf initiation of our temperate grasses is influenced by temperature (best at 20-24°C for perennial ryegrass and slightly higher for orchardgrass.) Nutrients (especially nitrogen) and water are needed to make the new leaves grow.

How does leaf death affect forage production?

Soon after a leaf is fully expanded, its photosynthetic activity gradually declines. About one-third of the food energy produced is shuttled to young leaves, tillers and roots. Aging leaves at the bottom of the sward do not contribute much food energy, but some of their soluble nutrients are eventually shifted to new plant growth.

The longevity of grass leaves is lower than many broadleaf plants. Leaf death is hastened by deficiency of water and nutrients (especially nitrogen and sulphur) and especially by shading. The rate of leaf appearance is generally balanced with leaf death, so that the number of live leaves on a tiller is rather consistent and usually less than five. Recent studies have shown that productivity of grasses is often under-estimated because the contribution of dying leaves is neglected.

Stem growth and reproduction

True stems are produced only when grass plants become reproductive, although some of these stems produce only leaves and no seeds. New, well-nourished stands produce a greater proportion of reproductive tillers than old, unfertilized ones. Stems are formed when the cells between the leaf-attachment nodes (i.e. internode) in the apical dome begin to elongate (see Fig. 1). These elongating regions are the stem internodes. The leaf sheaths elongate at the same time.

Another change that occurs when the plants initiate reproduction is that the apical dome converts from forming new leaves to forming the floral structures. Once this change occurs, no new leaves can be formed on that tiller so reproductive tillers rarely support more than 3-4 live leaves. In contrast, elongated stems that don't form seed heads support seven or more leaves, with several appearing as an apical rosette of diminishing leaf size.

What triggers the reproductive phase in grasses? Many temperate grasses (e.g. orchardgrass, bromegrass, reed canarygrass, winter cereals) require chilling of tiller buds in the fall or winter to render them ready for floral induction. These grasses flower but once in a year. Some grasses (tall fescue) produce more flowers with chilling than without. Grasses that do not have a chilling requirement (timothy and some ryegrass varieties) flower more than once in a season. Most of the familiar temperate grasses used for forage production require long days (actually, short nights) for floral induction. The actual length of day required depends on the genetic origin; varieties originating in Scandinavia require longer days than those from Spain.

Rhizomes (sometimes mistakenly called creeping roots) and stolons are actually laterally growing stems that can produce new tillers at their nodes. Stems of many grasses can form new tillers if they come into contact with soil, e.g. due to lodging. Chopped stems may be used to establish

Bunching or creeping grasses?

Bunchgrasses are usually more productive than creeping grasses because they do not invest in underground stems that cannot be harvested. As plant numbers decline, bunchgrass swards are subject to invasion by weeds, including some creeping and non-creeping grasses. Some farmers use seed mixtures that include creeping grasses to forestall invasion. Tall fescue is a popular choice because it is not aggressive and has good agronomic features. However, maintaining a balanced sward with several species is more challenging than maintaining pure stands. Aggressively creeping grasses such as creeping foxtail and smooth bromegrass can become weed pests.

new stands of grasses that are hard or slow to propagate from seed (e.g. reed canarygrass)

Root growth

Grasses have two root systems. In annual grasses, only the first roots that emerge from the seed absorb nutrients and water. In perennial grasses, the primary roots are active for a few months and then die off. After that, the roots that form at the stem bases take over, but they also generally last only one year.

The root system is continuously 'turning over' as old tillers die and new ones are formed. Low soil temperature, poor shoot growth and frequent defoliation reduce root growth. The turnover of grass roots contributes greatly to nutrient cycling and build-up of soil organic matter. Some temperate grasses produce as much or more growth below than above the ground.

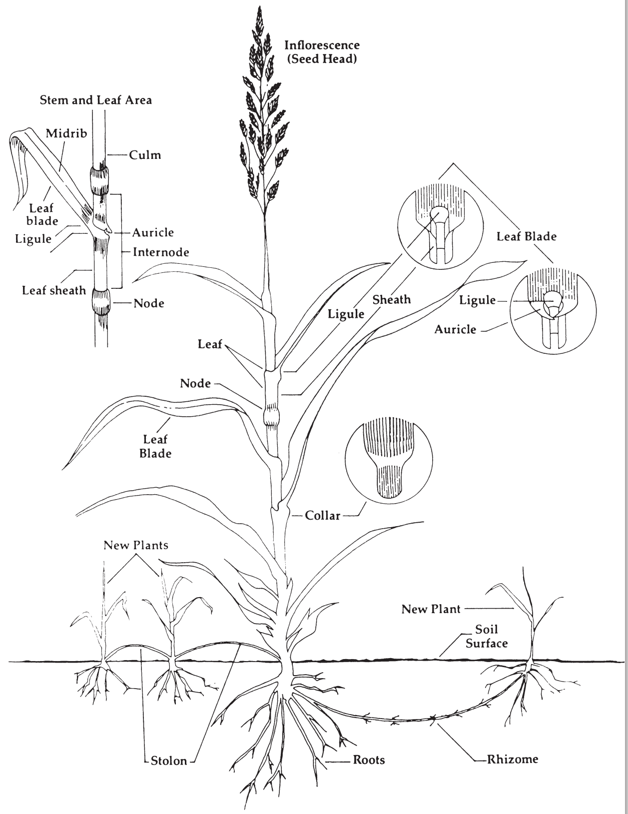

Figure 2. Structures of grass plants. This is a composite drawing of several grass species. From D.M. Ball, C.S. Hoveland and G.D. Lacefield. 1991. Southern Forages. Potash and Phosphate Institute and Foundation for Agronomic Research, Norcross, GA. 256pp.

Tiller growth

Number and size of tillers determine yield of grasses. Tall species, such as orchardgrass, timothy and bromegrass, harvested for conservation, can produce high yields with comparatively few tillers because each tiller can be large. Short, pasture-type grasses, such as perennial ryegrass, bluegrass and fine-leafed fescues, must produce many tillers to attain high yield. *Under grazing management, grasses are usually kept short so tiller density is very important.*

A new tiller arises from the bud located just inside the leaf base that surrounds it. The tiller emerges from the encircling leaf sheath in one of two ways. In 'bunch' grasses (timothy, orchardgrass, perennial ryegrass) the tiller grows upwards within the sheath and emerges near the base of the parent leaf. Each new tiller may also give rise to other tillers called secondary tillers, and so on. In 'creeping grasses' (reed canarygrass, Kentucky bluegrass, quackgrass), the tiller breaks through the protecting sheath and gives rise to a lateral stem called a stolon (when on the soil surface) or rhizome (below the ground surface). The creeping grasses can also form 'bunch' type tillers.

During vegetative growth, every leaf supports a bud that can potentially develop into a new tiller. The number of tillers that actually form depends first on genetics. For example, timothy tends to produce fewer tillers than perennial ryegrass. Indeed, new varieties of perennial ryegrass are selected for tiller abundance. But environmental factors may be more important than genetics for regulating tiller number, probably through the action of the anti-aging hormone called cytokinin. As with leaf growth, tiller numbers are affected by mineral nutrition (especially nitrogen), water status and light levels, but tiller initiation may also be influenced by colour of light falling on the crown.

Tiller formation usually ceases during the reproductive phase (beginning with stem elongation), probably due to hormonal suppression by the stem apex. This means that when grasses are most likely to be cut (boot stage), they have relatively few new tillers. Orchardgrass maintains more active tiller buds than other grasses and tall fescue usually has many elongated tillers that escape cutting.

Energetics of growth

Grasses store food as a sugar-like molecule (fructosan), not so much in roots (they're too skinny) as in the crown and fleshy stem bases (or rhizomes). Timothy and some wild grasses have a storage organ called the haplicorm. The haplicorm can be felt as a swelling just below the ground.

Plants use carbohydrate reserves stored in stem bases, crown and roots to support new regrowth after cutting. Grasses feed on these reserves for 2 – 7 days after harvesting to produce enough new leaf surface to provide for new growth. Harvesting grasses at the boot stage offers the best compromise between yield and quality but, because food reserves and new tillers are in low supply at this stage, recovery growth is delayed. Orchardgrass, perennial ryegrass and tall fescue are better adapted to harvesting at this stage than timothy and bromegrasses.

References available online at www.farmwest.com

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