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BACK TO BASICS

Mowing
Its Impact on Turfgrasses

By Richard J. Hull, University of Rhode Island

No activity is more synonymous with turf management than mowing. Turf is defined as a grass sward subjected to close regular mowing so it can serve an aesthetic or utilitarian function. The greatest single expense in maintaining a high quality turf is often the cost of mowing and mowing equipment. However, for all its importance to turf maintenance, mowing is rarely viewed as a significant management variable. To what extent can the turf manager adjust mowing frequency, height, and timing so as to maximize turf quality? This Back-To-Basics article will attempt to answer this question.

Mowing, along with fertilization and irrigation, is regarded as one of the three primary cultural practices in turf management (Turgeon 1999). However, mowing is unique in often being regarded as negative or harmful to the well-being of grass. Turgeon (1999 p. 150) states the problem as follows: "From a purely botanical standpoint, mowing is detrimental to turfgrasses. It causes a temporary cessation of root growth, reduces carbohydrate production and storage, creates ports of entry for disease-causing organisms, temporarily increases water loss from cut leaf ends, and reduces water absorption by the roots." There is evidence to support all of these negative consequences from mowing but this does not necessarily mean that a regularly scheduled partial defoliation is harmful to turf or constitutes a true stress. I will return to this argument later.

Mowing Height and Turfgrass Morphology

Partial defoliation is nothing new to turfgrasses. Most of our grasses have come to us from open grasslands where grazing animals and wild fires regularly defoliated them. These grasses evolved under conditions of periodic defoliation and adapted by responding in a positive manner. Mowing tends to stimulate tillering and this results in a thicker turf with more shoots per square foot. Mowing also removes culms that have been induced to flower and begin to elongate. The apical meristem is removed and the culm dies so the stand remains largely vegetative as basal tillers are promoted (Hull 1998).

Some years ago, K.M. Sheffer and colleagues (1978) at Pennsylvania State University compared the morphologic responses of 62 Kentucky bluegrass cultivars to three mowing heights: 0.5, 1.0 and 2.0 inches. In general, they observed blade angles increased (leaves became more horizontal) as cutting height was lowered. However, Kentucky bluegrasses vary considerably in their leaf blade angle and the tendency toward a more horizontal leaf blade with lowered cutting height was only a few degrees. A more significant impact of mowing height was on tiller number (Fig. 1). Although for this part of the study, only a

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few cultivars were compared, they all exhibited a marked increase in tiller density as mowing height was lowered. Some showed the greatest increase when mowing was lowered from 2 to 1 inch. Others responded more when the cutting height was decreased from 1 to 0.5 inches.

In a more recent study, Razmjoo et al. (1995) compared stand density with mowing height on 43 Kentucky bluegrass cultivars under the mild conditions of Japan. They evaluated turf responses to mowing heights of 0.4, 0.8, 1.0 and 1.6 inches over a two-year period and compared initial and final shoot density. They noted a decline in density when mowing heights were more or less than 1.0 inch. When mowed at 0.4 inches, shoot density decreased an average of 24 percent below the initial density. While this study appears to disagree with the Penn State report, the growing conditions were much warmer in Japan and stand density was determined by visual estimates rather than by actual tiller counts. Both of these factors could contribute to different results.

Turfgrasses are less tolerant of low mowing heights when subjected to stress conditions: drought, high temperature, disease, etc. It is likely that the high temperatures experienced during the growing season in Japan made cool-season Kentucky bluegrass less able to maintain a dense stand when mowed at less than one inch.

Most grasses, when grown within their range of adaptation, respond to mowing height as outlined above. However, low mowing was reported not to promote increased tillering in tall fescue, but this was related to lower numbers of basal buds which limited the ability of that grass to respond to defoliation by greater tillering (Laude and Fox 1982). For this reason, tall fescue has a mowing range of 1.5 inches and higher (Table 1).

When turfgrasses are cut at heights below their tolerance range, the stand thins and weed invasion occurs. When mowed above the tolerance range, the turf often becomes puffy, tends to lie down, is more prone to disease and produces excess thatch. In general, cool-season grasses can tolerate lower mowing heights than can warm-season grasses — Bermudagrass and seashore paspalum being notable exceptions (Table 1). Differences in ranges of

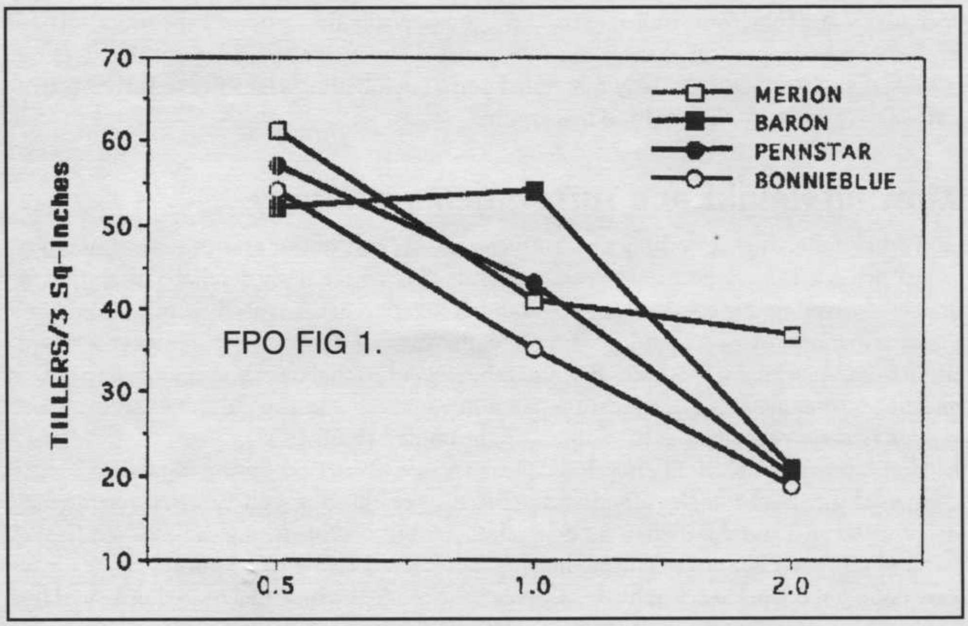

Figure 1. Effect of mowing height on tiller density of four Kentucky bluegrass cultivars. (Sheffer et al, 1978).

TABLE 1. MOWING TOLERANCE RANGES

Turfgrass	Species	Mowing tolerance range (in)	
Creeping red fescue	*Festuca rubra ssp. rubra*	1.5-2.0*	0.5-2.0**
Chewings fescue	*F. rubra ssp. commutata*	1.5-2.0	0.5-2.0
Tall fescue	*F. arundinacea*	>1.5	1.75-3.0
Kentucky bluegrass	*Poa pratensis*	0.75-2.5	1.5-2.25
Rough bluegrass	*Poa trivialis*	0.5-1.0	-
Annual bluegrass	*Poa annua*	<1.0	-
Perennial ryegrass	*Lolium perenne*	1.5-2.0	1.5-2.0
Creeping bentgrass	*Agrostis palustris*	0.2-0.5	0.12-0.8
Colonial bentgrass	*Agrostis capillaris*	0.3-0.8	0.3-0.8
Velvet bentgrass	*Agrostis canina*	0.2-0.4	-
Bermudagrass	*Cynodon dactylon*	-	0.25-1.5
Buffalograss	*Buchloë dactyloides*	0.5-1.2	>1.0
Japanese lawngrass	*Zoysia japonica*	0.5-1.0	0.5-2.0
Bahiagrass	*Paspalum notatum*	2.5-3.5	1.5-3.0
Seashore paspalum	*Paspalum vaginatum*	0.15-0.5	0.45-2.0
St. Augustinegrass	*Stenotaphrum secundatum*	2.5-3.5	3.0-4.0
Centipedegrass	*Eremochloa ophiuroides*	1.0-2.0	1.0-3.0

* Based on Turgeon (1999)
** From Christians (1998)

mowing heights suggested by the two authors cited in Table 1 probably reflect their perception of how these grasses are utilized and what represents acceptable turf quality for those uses.

As a general rule, those turfgrasses that respond to mowing by increased tiller production will become more competitive against grasses that produce fewer tillers when cut at the same height (Danneberger, 1993, p. 123). Reporting on a study by Lush, Danneberger noted that during the heat of summer, creeping bentgrass is more competitive than annual bluegrass because, under such conditions, creeping bentgrass produces more tillers than annual bluegrass. During cooler conditions of fall and spring, annual bluegrass produces more tillers than creeping bentgrass. At those times, annual bluegrass will compete effectively and spread. When turfgrasses tolerant of a low cutting height are cut below their tolerance range, their tiller number and stand density decreases. The same is true for weedy competitors making them less competitive. This can occur on putting greens mowed below the tolerance range for creeping bentgrass. The bentgrass suffers some stand thinning. Annual bluegrass is similarly affected and loses its competitiveness allowing the two species to coexist with neither grass increasing at the expense of the other (Danneberger 1995 p. 141).

Mowing Frequency

The other management variable associated with mowing is frequency. The general rule-of-thumb guiding mowing frequency is to mow when no more than one-third of the vertical shoot growth will be removed (Turgeon 1999). Presumably, removing that much of the photosynthetic surface does not disrupt the energy balance of turfgrass plants so as to cause adverse physiological responses.

Mowing frequency is often dictated by the use to which turf is put rather than sound agronomic principles. Putting greens are mowed daily to maintain ball speed, not to insure a healthy resilient turf. Many utility turf areas are mowed whenever the maintenance staff can schedule it with little regard for the one-third rule. Consequently such areas are sometimes managed more like a meadow, where hay is harvested three or four times per year and mowing involves almost total defoliation. Many of our better turfgrass cultivars likely will not perform well under such a mowing schedule. On the other hand, mowing more frequently than indicated by the one-third rule may result in:

1. Less root, rhizome or stolon growth
2. Increased shoot density
3. Decreased shoot growth rate
4. Reduced carbohydrate reserves
5. Greater leaf succulence

Height of cut also dictates frequency of cut. Turf maintained at a low cutting height will have to be mowed more frequently to follow the one-third rule. Conversely, greater mowing heights will permit less frequent mowing and still observe the one-third rule (Christians 1998 p. 150).

Because turfgrasses do not grow at the same rate throughout the growing season, the one-third rule dictates a variable mowing schedule: more frequently in the spring and fall and less frequently during midsummer for cool-season grasses. The opposite pattern would apply to warm-season grasses. For this reason, most turf managers adjust their mowing schedule to accommodate the turf growth rate. Failure to do so may result in scalping the turf during the spring and excess weed invasion during the summer.

Because turfgrasses do not grow at the same rate throughout the growing season, the one-third rule dictates a variable mowing schedule

Year-to-year climatic variability will also influence mowing frequency. During a very dry season, as was experienced last year by most of the East and Midwest, mowing frequency could be decreased to two- or three-week intervals unless warm-season weed growth dictated more frequent mowing. During a cool, wet summer, mowing frequency might remain fairly constant if growth is maintained.

Plant Energetics: Is Mowing a Stress?

The primary impact of mowing turf is the removal of photosynthetic leaf surface. As most authors have argued (Christians 1998; Turgeon 1999), the removal of leaf area reduces the plant's ability to capture light energy and use it to synthesize carbohydrates. These carbohydrates are then used to power shoot and root growth and provide the means to respond favorably to stress conditions. When turf is mowed, the argument continues, carbohydrate reserves are mobilized to support regrowth and this diminishes the supply of stored energy making the plants less able to tolerate stress conditions. To be sure, a lower mowing height does produce turfgrass plants that are smaller, have less root mass and in many cases appear less able to tolerate stresses. Closely mowed turf simply has less energy than turf allowed to maintain a greater leaf area and that is that. Or is it?

The classical definition of a plant stress is the imposition of any condition that causes a plant to grow less than that allowed by its genetic constitution. A casual application of that definition to mowing a turfgrass would seem to qualify mowing as a stress. Clearly, a closely mowed turfgrass will not produce the biomass that it would if it were not mowed. Therefore, mowing must constitute a stress to the grass.

Just a minute now! There is a lot less turfgrass present at any given time than there would be in an unmowed grass stand. Therefore, absolute dry matter production values cannot be compared. In some of my research, clipping yields of about 300 grams/sq-meter were obtained from Kentucky bluegrass turf mowed at ~1.75 inches. This translates into 2,679 pounds/acre/year. Forage yields of Kentucky bluegrass pastures are about 7,000 pounds/acre/year. However, the leaf area index (LAI) of an unmowed grass is about 5-7 while that of a turfgrass cut at two inches is 2.3 ft^2 of leaf/ft^2 of ground surface (Madison 1971, p. 97-98). If we assume the LAI of my Kentucky bluegrass turf is 2.0 ft^2 leaf/ft^2 ground while that of unmowed grass is 6.0 (a 3X difference) than the yield per leaf surface of the turf is 1,340 lbs/acre leaf/year while that of unmowed grass is 1,167 lbs/acre leaf/year. In other words, the closely mowed turf produced 15 percent more dry matter on a leaf area basis than the unmowed grass. I realize that no provision was made in this analysis for shading of lower leaves in the unmowed grass. However, I also did not consider the yield of that grass to be based on two or three harvests, so the forage grass was mowed and regrew two or three times and leaf shading was not a constant factor. The point is that frequent mowing of a turfgrass does not markedly reduce its productivity below that of a less frequently mowed grass.

To test the extent to which turfgrasses are stressed by a routine mowing, we conducted a field experiment in which Kentucky bluegrass turf was exposed to 14C-labeled CO_2 at 2, 24 or 72 hours following mowing. This enabled us to determine by how much current photosynthetic product was diverted away from roots and stem bases to support regrowth after mowing (Hull 1987). The data summarized in Table 2 show that the percent of current photosynthate retained in leaves (including newly expanding leaves) was only 6 percent greater two hours after mowing than it was 72 hours after mowing. When plants were harvested 24 hours after exposing the turf to $14CO_2$ two hours after mowing, there was no detectable difference in photosynthate partitioning between the first 24 hours after mowing and the fourth day after mowing. This experiment was conducted during late spring, summer and early fall on two Kentucky bluegrass cultivars and, except for minor variations, the impact of mowing never produced a marked change in photosynthate partitioning. We conclude that a regularly scheduled mowing does not impose any significant stress to a turfgrass stand.

Frequent mowing does not markedly reduce the productivity of a turfgrass below that of one mowed less frequently.

This conclusion requires some explanation because it defies logic. Partial defoliation must impose a stress on any plant. Normally this would be true but turfgrass plants are not grown under normal conditions. They are mowed once or twice a week. If mowed on a regular schedule, according to the one-third leaf removal rule, turfgrass plants achieve a dynamic

TABLE 2. PHOTOSYNTHATE DISTRIBUTION

Carbon-14 photosynthate distribution within Baron Kentucky bluegrass turf 2, 24 and 72 hours after a routine mowing.

Hours after $14CO_2$ exposure	Hours after mowing	Percent of recovered carbon-14 in: Leaves	Stems	Roots	Rhizomes
2	2	84	16	0.7	0.12
	24	80	19	0.6	0.15
	72	78	21	1.2	0.31
Significance		**	**	**	n.s.
24	2	65	33	2.2	0.22
	24	65	31	3.7	0.44
	72	67	30	2.1	0.31
Significance		n.s.	n.s.	n.s.	n.s.

From Hull (1987), ** Significant at p = <0.01, n.s. = not significant

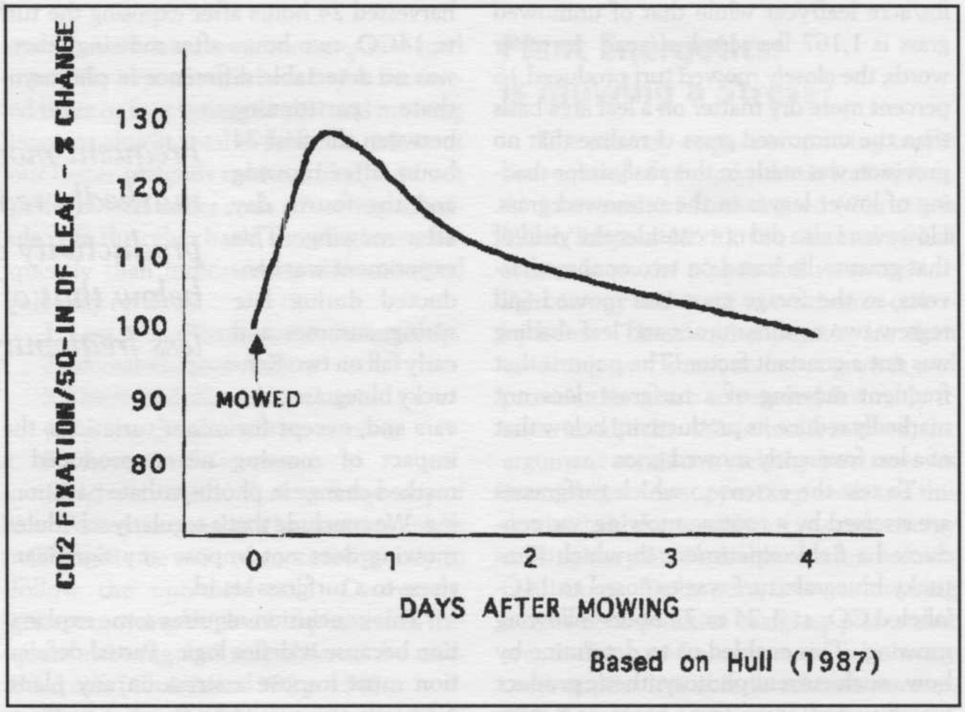

Figure 2. Change in net photosynthetic rate of turf per unit leaf area in response to mowing.

equilibrium between their roots and shoots. This equilibrium is determined by the amount of photosynthetic product the plants can generate from the leaf surface retained after mowing and that which will grow until the next mowing.

Because the photosynthetic surface of each grass plant is pretty much fixed by the mowing regime, it dictates how much root growth can be supported. To be sure, root growth will be less than that produced by an unmowed plant but it will be in energetic balance with the leaf surface available. As a result of this root:shoot balance, a regular mowing places no particular stress on turfgrass plants.

Grasses have a mechanism for accommodating the modest (one-third) change in leaf surface that occurs between mowings. As illustrated in Fig. 2, after a mowing the CO_2 fixed by the remaining leaves increased by 10 percent over what it was 72 hours after mowing (shortly before the next mowing). This 10 percent increase in photosynthesis was achieved by two-thirds of the leaf surface that existed prior to mowing. Therefore, the remaining leaves must have increased their photosynthetic rate by about one-third. Some of this increase was due to less leaf shading resulting from partial leaf removal. Also, some increase resulted from a greater demand on the remaining leaves for photosynthate by those parts of the plant (roots and crown tissues) that are not green and are dependent on the leaves for their energy and material needs.

Normally, when demand is not so great, photosynthate accumulates in leaves as starch or fructans and this tends to slow the rate of further photosynthetic CO_2 fixation. Often called product inhibition, this photosynthetic rate reduction is reversed when photosynthate withdrawal from the leaves is accelerated by increased demand from the rest of the plant. Thus, photosynthesis itself can respond to changes in plant need and apparently can compensate for any decline in photosynthetic output caused by partial defoliation.

For the reasons outlined above, it is probably wrong to view a routine mowing as a stress imposed on turfgrass plants. On the other hand, scalping or removing more than one-third of the leaf surface or abruptly lowering the height of cut, will impose a stress on the turf. Such departures from the normal mowing routine will disrupt the energy balance between roots and shoots and the plant may be forced to draw upon storage carbohydrates. Certainly defoliation associated with forage harvesting or leaf striping by insects constitute a major stress to plants.

Mowing and Water Use

Transpiration is the evaporative water loss from the wet cell surfaces within leaves that diffuses through the open stomates and is lost to the atmosphere. The greater the leaf surface, the more water will be lost via transpiration. Consequently, turf mowed at a greater height of cut will lose more water per day than turf maintained at a lower height (Kneebone et al. 1992). In field studies, Kentucky bluegrass mowed at heights of 1.0 and 2.0 inches transpired 15 and 27 percent more water, respectively than turf maintained at a 0.5 inch height. Most research has demonstrated a similar direct relationship between mowing height and transpirational water loss from turf.

From the above, it would appear that a lower mowing height is a good strategy for water conservation. In general, that may be true but the well being of turf must also be considered. This was best noted by Feldhake et al. (1983) who observed that Kentucky bluegrass mowed at a 2.0 inch height lost 15 percent more water than turf cut at 0.75 inches. Turf maintained at the 2.0 inch height of cut experienced very little loss in quality when irrigation was reduced by 37 percent of moisture deficit compared to well watered turf. However, the 0.75 inch turf declined sharply in quality when irrigation was reduced by 27 percent of deficit. Apparently, the shallower root system of the more closely mowed turf could not obtain sufficient water under moisture deficit conditions and excessive leaf heating resulted in injury.

Turf normally will respond to moisture shortage by allocating more photosynthate to roots, producing a deeper root system that can capture more water and forestall moisture stress. The closely mowed turf having a smaller root system was less able to respond appropriately to impending drought and suffered greater injury.

If water conservation is an important element in a turf management program, a balance must be struck between reducing water use by lowering mowing height or accepting a greater water use rate by maintaining a higher cutting height while being able to practice a deficit irrigation strategy. The latter approach will probably conserve more water.

Turfgrass cultivars that have a more horizontal leaf angle and aggressive, prostrate growth habit will transpire less than those exhibiting upright growth.

A modest increase in transpiration has been noted immediately following mowing (Kneebone et al. 1992) due to water loss from injured cells at the cut ends of leaves. This can be aggravated if a dull mowing blades are used. This additional water loss can be significant if turf is mowed frequently, as on putting greens, but not very important when turf is mowed once each week or less.

Turfgrass cultivars that have a more horizontal leaf angle and aggressive prostrate growth habit, will transpire less than those exhibiting more upright growth. Such grasses maintain higher humidity within the turf canopy thereby reducing the transpiration rate. Such grasses will experience little change in transpiration by lowering cutting height and thus are better adapted to areas of low humidity and high evaporative demand.

Management Considerations

Clipping removal is essential on putting greens and other turf areas where surface quality is important. However, in most situations, clippings can be retained on the turf. They will cause no problems with air circulation or leaf shading if mowing frequency follows the one-third rule and grass is not cut when wet. There is no evidence that clippings contribute to thatch accumulation. Rather, clippings can return to the turf about one-third of their annual nitrogen requirement (Starr and DeRoo 1981).

The only potential problem with clipping retention can be the spread of disease. Leaves infected with leaf spot, leaf blotch, strip smut or red thread can serve as inoculum for expanded or continued disease incidence (Schumann and Wilkinson 1992). Although there is some controversy over the importance of clipping removal as a disease management strategy, most specific studies indicate that disease pressure is lowered by removing infected clippings.

One must weigh the benefits of clipping retention with the cost and possible disease decrease involved in their removal. It is probably wise to remove clippings when a foliar disease is sufficiently serious to require fungicide applications. Reducing the inoculum pressure can only improve the situation and an occasional clipping removal should cause few problems with turf nutrition or waste disposal.

From what has been determined through research and practice, it is obvious that mowing strategy can have a large impact on the quality of turf. It is important to know the height of cut tolerance range for your grasses and recognize that deviating from their range may cause a loss in turf quality or place the grass under stress. Within the tolerance range, a routine mowing probably subjects the turf to little stress, but departure from the routine may be stressful. When environmental stresses are likely, raising the mowing height is good insurance because it increases the ability of grass to respond and adapt to stressful conditions.

While mowing is a primary turf management practice, it also can be a useful tool for maintaining turf quality and avoiding injury caused by environmental and some biological stresses.

Richard Hull is Professor of Plant Physiology in the Department of Plant Sciences at the University of Rhode Island, Kingston. His major research efforts have centered on turfgrass nutrition and discovering factors controlling nutrient use efficiency in turf. He is a frequent contributor to TurfGrass Trends.

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