FALL FERTILIZATION OF TURFGRASS Part I. The Rationale

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This is the first of a two-part series of articles on fall fertilization of turfgrass. In this Part I, the rationale for focusing on fall as the starting time for a turf fertilization program is developed by examining how turfgrass responds physiologically to weather and to temperature in particular. Part II, planned for the next issue of *Grass Roots*, will translate these physiological responses into recommendations for fall fertilization of turfgrass in Wisconsin. Research reports on the consequences of fall fertilization on turf quality and various cultural problems will be reviewed as well.

Biochemical Responses to Temperature

Turfgrass, like any other biological system, responds to changes in temperature. At very low temperatures, biochemical reactions leading to growth occur at such a slow rate that, for all practical purposes, growth ceases and the plant enters a dormant stage. At the other extreme of very high temperature, growth also virtually stops because certain biochemical reaction rates are so high that plants exhaust food and energy supplies required for growth. In essence, the plants "run out of gas." Somewhere between these extremes lies a temperature range where reaction rates are optimum.

The two biochemical processes largely responsible for temperature effects on turfgrass growth are photosynthesis and respiration. Photosynthesis is the process whereby carbon from carbon dioxidee is combined with hydrogen from water to form carbohydrates. The reaction can be summarized as follows:

$$\text{Carbon dioxide} + \text{water} \xrightarrow[\text{Green Plant}]{\text{Sunlight}} \text{Carbohydrate} + \text{oxygen}$$

The carbohydrate then becomes the basic building material and energy source for plant growth and development.

Respiration is the process by which the energy in carbohydrates is released to fuel plant synthesis of substances such as starch, amino acids, proteins and all other organic compounds that make up plant tissues. Respiration can be depicted as follows:

$$\text{Carbohydrate} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} + \text{energy}$$

In a sense then, respiration is the reverse of photosynthesis.

Figure 1 shows how photosynthesis and respiration in cool-season turfgrasses relate to changes in air temperature. The key features of these relationships are:

1. Photosynthesis reaches a maximum rate at a lower air temperature than does respiration; and
2. Respiration continues (albeit at very low rates) at temperatures below which photosynthesis ceases.

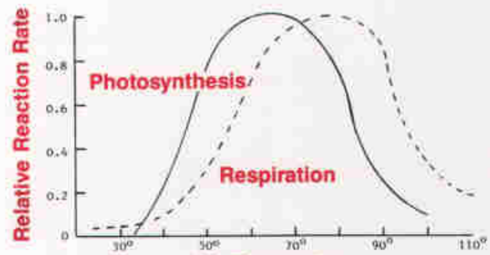

Fig. 1 Effects of air temperature on the rates of photosynthesis and respiration in cool-season turfgrasses.

The significance of Figure 1 lies in the balance between photosynthesis and respiration. As long as more photosynthate (carbohydrate) is being produced than is being broken down in respiration, there is a net production of carbohydrate for turfgrass growth and development. However, this is not always the case.

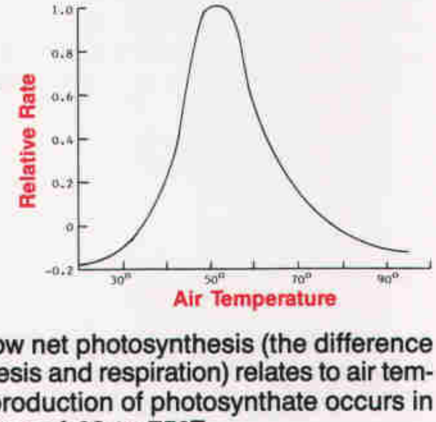

Fig. 2 Effects of air temperature on the net photosynthesis of cool-season turfgrass.

Figure 2 shows how net photosynthesis (the difference between photosynthesis and respiration) relates to air temperature. Peak net production of photosynthate occurs in the temperature range of 60 to 75°F.

At low air temperature (below about 35°) and high air temperatures (above about 80°F), net photosynthesis can be less than zero. Under these circumstances, the only way the turfgrass plant can initiate new growth is to draw upon carbohydrate reserves previously stored in stem, sheath and root tissues.

Growth Responses to Temperature

Turfgrass managers are well aware that the shoot growth rate of cool-season grasses peaks in late spring and early fall and declines markedly in mid-to-late summer. This growth pattern reflects the fact that optimum temperature range for cool-season grass shoot growth is 60 to 75°F (Fig. 3). To a large extent, this shoot growth pattern is a direct consequence of the effects of temperature on net photosynthesis (Fig. 2).

What turfgrass managers cannot readily observe and are often unaware of is the fact that turfgrass root and rhizome or stolen growth rates peak at temperatures approximately 10 degrees less than do shoot growth rates

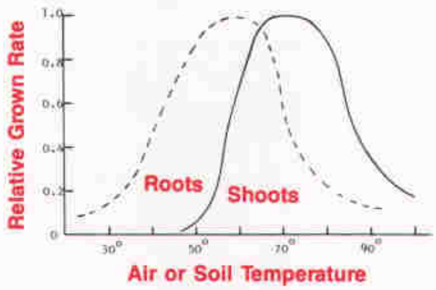

Fig. 3 Effects of air and soil temperature on the root and shoot growth of cool-season turfgrasses.

(Fig. 3). The reasons for this are two-fold. One is the effect of temperature on net photosynthesis. The other is the fact that roots must compete with shoots for photosynthate. As air temperatures rise, net photosynthesis declines and eventually a point is reached where virtually all net photosynthate goes toward shoot growth. The end result is not only a cessation of root growth, but an actual decline in the size of the root system. In fact, research suggests that it is not unusual for turfgrass root systems to decline an average of 60 percent by weight during the heat stress periods of July and August. No wonder it's so difficult to prevent wilting on a 95°F day in August! Not only is plant demand for water exceptionally high, but this water has to be absorbed by one-half or less of the number of roots that were present earlier in the season.

Before continuing with the main theme here, let me digress for a moment. On a hot, clear day in late summer, have you ever experienced extensive turfgrass wilt even though the soil is very moist and additional water only seems to lead to more wilting? If so, you've seen the effects of oxygen stress on water absorption by the roots. Roots need oxygen to respire and unless they are respiring, they are incapable of absorbing water fast enough to prevent wilting. Under these circumstances, withholding irrigation and thereby allowing for drainage and restoration of a properly aerated root environment is the only logical course of action to follow.

Roots lost during the heat stress periods of July and August will not be restored until net photosynthesis increases as a result of a decline in air temperatures and a more favorable balance exists between photosynthesis and respiration. This, then, is why fall is a crucial period for turfgrass. But regrowth of root systems is not the only reason. Growth conditions that favor root development also favor rhizome, stolon and tiller bud development. Fall is also the period for restoring carbohydrate reserves in turfgrass plants and for an adequate level of hardening to occur prior to the onset of winter.

Inadequate, excessive or improperly timed fall fertilization of turfgrass can curtail any or all of these processes. When this happens, the results are readily predictable; extensive winter injury from cold or disease, noticeable thinning of the turfgrass stand, slow spring regrowth and recovery from injury and reduced tolerance to heat and water stress the subsequent summer.

Proper fall fertilization of turfgrass is clearly one of the keys to maintaining top quality turf on a sustained basis. The next article in this series will focus on using the information in this article to define what constitutes a sound fall fertilization program for turfgrass in Wisconsin.