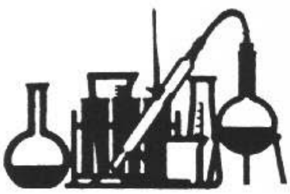

Poa annua in Creeping Bentgrass

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A popular topic among golf course superintendents is *Poa annua*—creeping bentgrass conversion programs. The intent here is not to evaluate these programs, but to provide the background needed to make an informed decision regarding the design and implementation of a conversion program. The best way to approach this subject is to recognize that we're really dealing with four different aspects of the *Poa annua* (PA) problem. These are: (1) the preconditions for PA invasion of creeping bluegrass; (2) factors affecting PA seedling survival; (3) factors affecting spread of PA; and (4) the means for controlling PA once established in creeping bentgrass.

The Preconditions

The preconditions for PA invasion of any turf are very simple but too often overlooked. They are the presence of viable seed and an environment that favors germination. Because PA is so prolific, even when mown at putting green height, seed abounds on golf courses. A single PA seedhead typically contains about 80 seeds (9) and a single PA plant will produce about 320 to 360 seeds per season in Wisconsin (2).

Even if one were to suddenly halt all new PA seed production, there would still remain tremendous reserves of older seed in soil on the golf course. Soil seed banks have been reported for bentgrass (6) and perennial ryegrass (11) turfs. The numbers are remarkably similar—somewhere in the range of 600 to 4,200 PA seeds per square foot of soil surface. To put these numbers in perspective, a recommended creeping bentgrass seedling rate of 1.4 pounds seed per 1,000 square feet (1) translates into about 8,000 seeds per square foot.

Simply because there is an abundance of PA seed elsewhere on the golf course does not automatically signify that there will be rapid invasion into new creeping bentgrass turf. First there is the matter of seed viability. Research has shown that when PA seed heads are mown off on a regular basis, many of the seeds are immature and the initial germination rate is only about 50 percent. Unfortunately, this percentage typically rises to as much as 95 percent in a few months time. There is some evidence that PA seed germination percentages vary substantially with the source of the seed. A study conducted in Australia (9) revealed that as long as four months after production, PA seeds from fairways and roughs had no viability while the germination of seed from putting greens was nearly 100 percent. This suggests that roughs and fairways do not represent major seed sources for PA invasion of putting greens. However, the same study (9) also showed that chilling increased the viability of fairway and rough PA seeds to approximately 95 percent within six months after seed production. The implications here are that PA seeds from fairways and roughs may not be a threat to creeping bentgrass putting greens the season of production but certainly will be after a single Wisconsin winter.

> ***"For those of you contemplating a PA to bentgrass conversion program, be mentally prepared for a long-term and, quite likely, a never-ending process."***

What about the viability of PA seed in soil? Concise information is lacking but the general picture is one of germination percentages of about 90 percent one year after seed production, a rapid decline in year two to about 50 percent germination and smaller declines in viability in each successive year to a germination percentage of about 25 percent in year six (11). This is a very disconcerting observation because it suggests that if we were to suddenly halt all PA seed production in a PA-infested turf, six years later the soil might still contain 150 to 1,000 viable seeds per square foot of that turf.

Professional turf managers have long noted that field germination of spring-produced PA seed often peaks about three months after production (2). This is the result of two things—increases in PA seed viability over time, and the on-set of edaphic conditions favorable for germination.

Included among the edaphic factors favoring PA seed germination are contact with a continuously moist soil surface, soil temperatures in the range of 55 to 60°F, a soil pH above 5.0 and light (1,2,3,11). Thus, low turf density, thatch removal, turf injury, earthworm activity and cultivation, including topdressing, are factors that favor PA seed germination. Our research has shown that in creeping bentgrass grown on a silt loam soil that is a good earthworm habitat, earthworm casts are prime sites for invasion by PA.

Germination of PA declines rapidly as soil temperatures drop below 40 or exceed 85°F (2,11). This is one reason why PA populations peak in spring and fall (8). Another reason is improved moisture supply. Light, frequent rainfall or irrigation that keeps soil surfaces moist favors PA germination (10,11).

Lowering of soil pH through application of elemental sulfur has been proposed as a method for controlling PA (7,13). Significant reductions in PA germination have been observed at soil pH values of 5.0 or less (7). Since this pH is outside the range recommended for bentgrass (1), concern has to be shown for the long-term impact of deliberately reducing soil pH to 5.0 for the purpose of controlling PA.

Early indications that high light intensity is essential PA germination have proved erroneous (11). It is true, however, that burying PA seed and thereby excluding light reduces germination by approximately one-half (2).

Seedling Survival

Ecological studies have repeatedly shown that PA seed germination is just the starting point. Successful invasion of creeping bentgrass is also strongly dependent on seedling survival rates. These rates are determined by the relative competitiveness of the two grasses. In the absence of adverse environmental conditions, the competitiveness of PA is directly related to the numbers and sizes of invasion gaps in the creeping bentgrass turf (12).

Invasion gaps arise in many different ways. The more common ones are declining bentgrass stand density, mechanical or pest injury, core aeration,

(Continued on page 33)

(Continued from page 31)
chemical burn, winter injury and earthworm activity. We have observed that at creeping bentgrass verdure levels above 1.1g per/ft^2, PA populations are suppressed. Such verdures are possible in bentgrass fairways receiving 4 to 5 pounds N/1000ft^2/season. They are not attainable at the cutting heights of putting greens.

Once PA seed germinates in an invasion gap, seedling survival is influenced by several edaphic factors. Recent research suggests that root competition for nitrogen is a prime factor (12). In contrast, supplies of phosphorus and potassium have no influences on PA seedling survival and growth rates (5,12). Soil acidity reduces seedling survival only if soil pH is below 5.5 (13).

Professional turf managers are well aware that PA is less heat tolerant than is creeping bentgrass. Signs of heat stress begin to appear in PA shoots as air temperatures exceed 80°F (2). Roots of PA begin to discolor and decline when soil temperatures climb about 70°F (2), but only if the root surfaces are colonized by fungi responsible for PA summer patch diseases (pers. comm. D. H. Wilkinson, Univ. Ill). Regardless, heat stress is likely the major reason why PA seedlings have very low summertime survival rates.

Poa annua seedling survival has often been associated with moisture supply (1,2,14) and has led to the idea that PA has a higher moisture requirement than does bentgrass. This is a questionable assumption. The association between moisture and PA survival is strongest where soil is compacted. Bentgrass thins out in these compacted areas and PA invasion gaps develop. Because of the compaction, rooting of the PA is very shallow and ample moisture becomes a necessary condition for seedling survival. In the absence of soil compaction, PA roots just as deeply and vigorously as does creeping bentgrass (1,10).

Spread

Once PA has invaded creeping bentgrass, spread is largely governed by seed supply and the presence of invasion gaps at key times during the season. The key times are those when PA seed viability is high and edaphic conditions favor germination and seedling survival. In the upper Midwest these key times occur from about late April to mid-June and from late August through the month of September.

Evidence for the existence of key times for PA spread lie in the observations of Dr. D.B. White and his co-workers at the University of Minnesota (8). They have carefully documented natural shifts in PA populations at multiple sites on golf courses. One example of what they have observed on a putting green is shown in the chart below.

TIME OF YEAR	PERCENT PA IN BENTGRASS TURF
Early May	90
Mid-summer	24
Late fall	81

Recognition of these dynamics of PA populations during the season is extremely important, especially when it comes to evaluating the effectiveness of PA control measures. Large reductions in PA populations between spring and summer are natural occurrences and cannot be taken as evidence for the effectiveness of a PA control program. Permanent shifts in PA populations can only be verified over several growing seasons.

Control

Clues as to how one might assemble a PA control program lie in the foregoing discussion of the preconditions for PA invasion, factors involved in seedling survival, and subsequent spread in pre-existing bentgrass turf. Some readily identifiable possibilities are reduction of seed supply, creation of less favorable conditions for germination and enhancement of the relative competitiveness of the bentgrass.

Researchers at Michigan State University (6) are using this knowledge in a comprehensive investigation of ways to reduce PA populations in bentgrass turf. Their observations are very illuminating and illustrative of what regulation of PA seed supply, modification of certain cultural practices, and introduction of new practices can do to PA populations in creeping bentgrass.

Reduction of seed supply: Two possibilities exist for reduction of the PA seed supply; removal of clipped seedheads and chemical suppression of seedhead formation. The Michigan State studies have quantified the effects of clipping removal on PA populations in bentgrass and the PA seed bank. Over a three year period clipping removal reduced PA populations an average of 12 percent and the PA seed bank declined 31 percent.

The effects of plant growth regulators (PGR's) on PA seedhead formation and growth have proved erratic. In one study conducted by Michigan State researchers, application of a PGR at six different locations reduced PA populations an average of 28 percent in two year's time (3). A second study failed to show any significant influence of two PGR's applied for three successive years on PA populations in bentgrass (6). Two PGR's failed to reduce PA populations during the summer of 1990 (4). These observations collectively convey the message that the role of PGR's in PA control programs is unclear at this time.

Germination and seedling survival: The fact that a continuously moist soil surface favors PA germination (2) suggests that frequency of irrigation has an effect on PA populations. Michigan State researchers have examined this possibility by observing PA populations under three different irrigation regimes. In comparison to daily irrigation of a bentgrass fairway, tri-weekly irrigation reduced PA populations 6.5 percent over a three-year period. Irrigating only when the bentgrass showed signs of wilt led to an additional 3.1 percent reduction in the PA population. Statistically, only the 9.6 percent PA difference between daily irrigation and irrigation at wilt was significant (6). Thus, a change in irrigation scheduling alone does not appear to be an effective means for reducing PA populations in bentgrass turf.

High rates of N application have often been cited as a factor that favors PA. Recent evidence that competition between PA seedlings and the grass being invaded arises from rootzone competition for N (12) lends support to this idea. However, when Michigan State University researchers observed changes in the PA populations in bentgrass turf supplied with either 2 or 6 lb. N/1000ft^2/season for three years, a significant difference occurred in only one of the three years and PA populations were identical at the two N rates when averaged over the three year period (6). This does not disprove rootzone competition for N, but suggests that even 2 lb N/season are sufficient to overcome whatever competition exists.

Another possible means for controlling PA invasion of bentgrass turf is to reduce the number or size of invasion gaps. Researchers at Michigan State sought to minimize invasion gaps by annually overseeding the turf with bentgrass (6). The practice led to only a 2.8 percent reduction in PA populations over three years. While this does not encourage overseeding as a PA control practice, it needs to be pointed out that the research site was not subjected to the normal wear and tear of golf course fairways.

Turfgrass agronomists have long recognized that there is no single cultural practice that can control PA in bentgrass turf. Rather, successful control requires implementation of a combination of cultural practices. This was taken into account in the design of the Michigan State University study (6). The effectiveness of various combinations of clipping removal, irrigation frequency, fertilizer N rate, overseeding, and TGR use in reducing PA populations in bentgrass turf was examined. Among all the combinations studied, the most effective was that of clipping removal and broadcast overseeding with bentgrass in August of each year. The combined effect of these two cultural practices was a 28 percent reduction in the PA populations after three years.

Clearly, there are some cultural practices that aid in the control of PA in bentgrass turf and have potential for reducing PA populations. We do need to recognize, however, that other cultural practices deemed essential on today's golf courses probably favor PA. Included among these PA-favoring cultural practices are daily irrigation, low cutting heights, aeration, and topdressing. Add to these practices the normal abuse that golfers impose on turf and you have a situation in which PA quickly becomes a permanent resident.

For those of you contemplating a PA to bentgrass conversion program, be mentally prepared for a long-term and, quite likely, a never-ending process. Some of the cultural practices discussed here are the heart of any conversion program. To what extent PGR's can aid in this effort is not clear at this time.

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