FOR RICHER, FOR *POA*

Cultivar development of greens-type Poa annua.

by DR. DAVID R. HUFF

"FOR RICHER, for poorer. In sickness and health . . . ." These simple words underscore one of life's greatest commitments. It also describes the golf course superintendent's daily commitment to maintaining golf greens that are comprised of *Poa annua*.

Poa annua has been part of the golf industry for a long time, probably ever since the inception of the game. Sometime around the early 1900s, bentgrass became the chosen or preferred grass to grow and maintain on golf course putting greens. Yet, *Poa annua* continues to be a major component, and in many cases a dominant component of golf course putting greens.

By virtue of its prolific seed head production, occurring under even the closest of mowing heights, *Poa annua* has been able to evolve a competitive edge against creeping bentgrass in terms of shoot density, verdure biomass, and photosynthetic surface area. Moreover, under shady, moist, cool temperature conditions, *Poa annua* thrives and continues to gain a competitive edge against bentgrass until it ultimately dominates many golf green putting surfaces.

Observations such as these have played a key role in initiating Penn State's breeding program for developing commercial sources of *Poa annua* for use on golf greens. Yet some people view this idea as ridiculous; *Poa annua* is, after all, the enemy, isn't it? Nevertheless, an underlying truth is undeniable: superintendents who have *Poa annua* greens simply do not have a hope of obtaining a seed source for the types of *Poa annua* that are adapted to their golf green environments for use in routine overseeding, repair work, or new green construction. This industry need is the motivation and spirit that drives our breeding program towards what we hope will produce commercially available seed sources of greens-type *Poa annua*. Only time will tell if we will be successful.

Genetic diversity abounds in the multiple selections of Poa annua. *One goal of the Penn State University breeding program is to provide golf course superintendents with a commercially available seed source of greens-type* Poa annua.

Natural Selection

Nature, coupled with the intense selection pressure provided by superintendents and golfers, has performed a tremendous amount of evolutionary change in *Poa annua* during the past 100 years — from the wild and weedy annual bluegrasses that first invade a green, to the highly specialized, high-quality, greens-type *Poa annua* that we can find today. Our breeding program utilizes this *natural* evolutionary process by collecting and screening its products. We regularly collect samples from old, closely mowed greens from several regions of the U.S. and Canada.

Due to the reproductive biology of annual bluegrass, we believe this is a fruitful approach. *Poa annua* has a self-pollinating type of breeding system that results in true breeding strains through inbreeding. Eggs within the flowers (florets) are often fertilized before the florets ever open (cleistogamy). Such an inbreeding system of sexual reproduction is unique among the grasses we typically use for turf, and is most similar to that of wheat or soybeans. *Poa annua* also is a polyploid grass species, meaning that each of its cells carries multiple copies of its ancestors' chromosomes. Polyploidy is rare among animals and insects, but is common among plants. Among grasses, polyploidy is often the normal state of being.

Poa annua is believed to have had two ancestors, *Poa supina* and *Poa infirma*. Both of these species are considered to be diploid organisms, and each carries 14 chromosomes (denoted as $2n=2x=14$ chromosomes). Because they are different species, the 14 chromosomes are very different between species and, upon hybridization, result in sterile offspring. A similar event happens when a donkey is mated with a horse to obtain a mule, which also is sterile. In plants, however, and probably due to their modularity, events may occur which restore fertility by doubling all of a cell's chromosomes. This is the situation with *Poa annua*. The two species, *Poa supina* and *Poa infirma*, mated to produce a sterile hybrid plant ($1n=2x=14$ chromosomes) whose chromosome number spontaneously doubled to yield *Poa annua* ($2n=4x=28$ chromosomes).

Such hybridization and doubling events generate extreme amounts of variability (i.e., 100%). The level of this variability is reduced by 50% within a particular strain after every generation of self-pollination. Thus, after the first generation of selfing, the amount of variability is reduced to 50%; the second reduces it to 25%; the third to 12.5%, and so on. A similar reduction in variability is necessary after making hybrids between distinct, true-breeding strains of greens-type *Poa annua*. Thus, after mating two different strains of *Poa annua*, it takes a minimum of six to eight generations before we regain strains that are uniform, stable, and true breeding. In producing one generation every two years, which includes some limited trial evaluation, it is easy to see that artificially breeding improved strains of *Poa annua* is a long-term process. However, much of this work has already occurred on old golf greens because of natural hybridizations, close mowing heights, the traffic provided by golfers, and the competition among all grasses for the limited resources of a golf green environment. With every generation, *Poa annua* has been evolving to tolerate low cutting heights and increased foot traffic. This evolutionary process has resulted in strains we call greens-type *Poa annua*.

Such greens-type *Poas* probably were not present back in the early 1900s when bentgrass was chosen as the grass to plant on golf course putting greens because it has taken the past 100 years of evolution and competition to produce them. In fact, the selection pressures of the green environment are so intense that we believe we are starting to observe a "reverse" evolutionary process that is resulting in the appearance of the original interspecific hybrid (1n=2x=14 chromosomes). These unique specimens have only half the amount of DNA of *Poa annua* and represent some of the densest, finest, highest quality strains we've observed to date. Like the mule, however, these unique strains are sterile, and our breeding program is investigating research avenues that may enable us to restore fertility while retaining their favorable attributes. Thus, in addition to simply collecting samples of *Poa annua* that have evolved naturally on golf greens, we also have begun the long-term process of actively breeding greens-type *Poa annuas* using traditional methods and some of the newer molecular genetic technologies.

Challenges such as seedhead production, disease and insect resistance, and rooting potential need to be resolved in the breeding program.

Growing Limitations

Just as the farmer who decided to grow dandelions for the natural food market discovered, when a weed is grown as a crop you find out your *indestructible weed* has a list of problems all its own that need to be overcome. One of the major limitations of growing *Poa annua* is its limited range of favorable growing temperatures. *Poa annua* tends to grow poorly when temperatures are either too hot or too cold. As part of our breeding program, we are actively investigating the variability within the species for tolerance to extreme temperatures. Working on temperature tolerance in plants is not as straightforward as it might seem. To simply plunge a grass plant into an extreme temperature does not allow the plant's natural defense mechanisms to incrementally adjust. In order to gain insight into *Poa annua*'s tolerance mechanisms, we first need to acclimatize the plants before exposing them to extreme temperatures. To evaluate for cold tolerance, the *Poa annuas* are pre-hardened at 2°C for one to two weeks, followed by -2°C for another two weeks. Temperatures are then lowered down to critically cold levels.

This cold-tolerance research is being performed as a collaborative research project with the Canadian Turfgrass Research Foundation (CTRF), Laval University at Quebec, and Agricultural Canada at St. Foy. At Laval University, co-investigator Julie Dionne's preliminary findings suggest that there are differences among greens-type *Poa annuas* in their ability to tolerate critically cold temperatures. The least cold-tolerant *Poa annua* showed a 50% survival rate at 1.4°F, while the most cold-tolerant *Poa annua* showed a 50% survival rate down to -8.3°F. These tolerances are far less than creeping bentgrass, which is capable of demonstrating 50% survival down to -18.4°F. Only by discovering differences among *Poa annuas* will we be able to discover the underlying genetic and physiological mechanisms responsible for these differences, which might enable us to improve *Poa annua*'s inherent cold-tolerance mechanisms.

Throughout our work, it has been helpful to look at other systems of cold tolerance. Fortunately, one of the only two plants known to grow in Antarctica happens to be a grass — Antarctic hairgrass (*Deschampsia antarctica*). Antarctic hairgrass has quite literally only a few hours each day during the middle of summer in which temperatures get above freezing, enabling photosynthesis to occur. The remarkable finding is that there seems to be no "silver bullet" cold-tolerance mechanism at work inside Antarctic hairgrass. Rather, cold tolerance is ascribed to a substantial ability to store naturally occurring carbohydrates called fructans.

We also have begun to observe differences in fructan levels among the *Poa annuas* and are currently correlating this information with our cold-tolerance studies. If it's discovered that fructan storage is a major component of cold tolerance in *Poa annua*, as it appears to be in Antarctic hairgrass, then we may be able to breed for the ability to store fructans and thereby begin to realize improved tolerance to cold temperatures in *Poa annua*.

Tolerance to Ice

Another important area of our cold-tolerance research is to determine *Poa annua*'s tolerance to ice coverage. Many factors may be related to *Poa*'s ability to tolerate ice coverage. Crown hydration, lack of oxygen, release and buildup of toxic gases, the frequency and modulation of freeze-thaw cycles, duration of coverage, and carbohydrate reserves are all potential factors that may work independently or may interact to yield the observation that, in general, ice coverage often kills *Poa annua*.

Our research to date has been inconclusive. During some experiments the *Poa annua* dies, in others it does not. Could other factors be responsible or interacting with those previously mentioned? What are the hydrodynamics at the interface between the soil and ice? Is it just ice or is it a combination of ice over a saturated soil that kills *Poa*? Are native soils more susceptible to ice damage than are sand-based greens?

Currently, we have more questions than answers. Even so, we know that visual differences in ice may appear. For example, warm water freezes slowly and is generally free of trapped air, making it appear clear or transparent (i.e., black ice); cold water freezes more quickly and often has pockets of trapped air which make it appear cloudy or white. Perhaps it is not whether ice is black or white that is important, but rather how quickly water freezes and what the potential is for soil drainage to occur before ice develops. We are only beginning to establish those conditions in which we are capable of killing *Poa annua* repeatedly with ice coverage at slightly freezing temperatures (approximately 27°F). Once these conditions are established, we will begin to screen the *Poa annua* collection for differential tolerances. After tolerant and susceptible strains are identified, we will begin to examine physiological differences to explore ways in which to enhance *Poa annua*'s tolerance to ice coverage.

Heat Tolerance

On one of my collection trips along coastal Virginia, a superintendent remarked that "*Poa annua* is the greatest grass . . . for nine months of the year." Heat tolerance and *Poa annua* may seem like contradictory terms, but the superintendent who made that statement had greens consisting of 80% *Poa annua*. Many northern regions where *Poa annua* dominates also experience some measure of summer heat stress during July and August. Thus, any improvement that might be made towards enhancing the heat tolerance of greens-type *Poa annua* would benefit those superintendents and golfers who have *Poa annua* greens.

Generation after generation, Poa annua *has continuously evolved to gain a competitive edge and improved shoot density.*

Like the above two projects, screening for differences in heat tolerance among the collections is our starting point. Heat benches containing sand root zones and adjustable heating units serve as our coliseum where *Poa annua* is forced to wage battle against high temperatures (approximately 113°F). Will *Poa annua* with deeper roots win out, being able to transpire and thus cool off more effectively, or do some *Poas* have root/crown proteins that function slightly better at elevated temperatures? Only time will tell.

Other Complicating Factors

Greens-type *Poa annua* has many additional problems that ultimately need to be resolved: seed head production, disease and insect resistance, rooting potential, and determining best management practices. Each of these areas, as well as extreme temperature tolerances, are beginning to be addressed in our breeding program. By screening the increasing number of collected strains, and through the eventual screening of new genetic combinations resulting from our hybridization breeding program, we hope to develop large enough supplies to offer turfgrass science colleagues around the country a chance to test and evaluate the elite strains of greens-type *Poa annua*. The ultimate goal of developing commercially available sources of greens-type *Poa annua* is not to replace bentgrass as a preferred grass for putting surfaces, but rather to offer an additional tool for superintendents to have at their ready, especially in regions and climates where *Poa annua* is simply a better choice of grass for use as a putting surface. For many, there is no other choice than to commit to "For richer, for *Poa*."

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Dr. David Huff has collected thousands of Poa annua *samples throughout the United States. A pile of* Poa annua *this large will make any plant breeder smile.*

Donating *Poa annua*

If you or someone you know has greens-type *Poa annua* and would like to have its merits examined, the PSU *Poa annua* breeding program would like to receive your samples. Begin by collecting one or two aerification tine cores from each "patch" you wish to sample (no limit here), wrap in a moist paper towel, enclose in a zip-lock bag, and label each bag with your course name and hole location (example: Oakmont 18G). Send by overnight mail to:

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Poa annua *is a reality on most cool-season golf courses in America.* DR. DAVID HUFF, *assistant professor in turfgrass breeding and genetics at Pennsylvania State University, hopes to improve on what's available.*