

Poa annua Management on Golf Course Putting Greens

Management is possible; eradication is unlikely.

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In early spring perhaps no other grass is as much the subject of an inquiry as the subject of this sketch. At this time of the year it is conspicuous in lawns and on putting greens as well as in shady places where most other grasses do not thrive. On putting greens it commonly appears in autumn, and indeed in the latitude of Washington, D.C., and often blooms before winter. In the early spring it grows rapidly and blooms before any other turfgrass. When once established it volunteers year after year, increasing in abundance. In spring it is often the most abundant grass in some putting greens and in shady lawns. It vanishes completely by midsummer, at least as far north as Washington, D.C., but in Philadelphia and northward some plants may be found at any time during the summer.

Poa annua, the scientific name being quite as familiar as its common name, is easily distinguishable by its small tufts, fibrous roots, bright green not at all bluish color, soft texture, and the cross crumpling of the leaves near the base. The grass is native to Europe, but it now occurs practically everywhere in the United States.

C. V. Piper and R. A. Oakley
“Annual Bluegrass (*Poa annua*)”
USGA Green Section Record, March 1921

Here we are 94 years later in 2015. What kind of progress have we made and what have we learned? We have learned a lot. In terms of progress, well, that is up for debate. To be sure, we have made progress, but the problem of *Poa annua* in putting greens still persists. Or is it a problem at all? The answer to this question is simple. It depends on whom you ask. If you are in northern California with pure *Poa annua* greens, you might not think *Poa annua* is much of a problem — stem gall nematode (*Anguina pacifica*) aside. If you are in Dallas, Texas; Washington D.C.; Raleigh, N.C.; Scottsdale, Ariz.; etc., where greens are often composed 50 percent bentgrass and 50 percent *Poa annua*, it is a huge problem.

Let's try to simplify the problem. If you are in a climate where you can successfully grow *Poa annua* year round (does not get too cold or too hot), then *Poa annua* is the species to grow, correct? Not necessarily. Take Paris, France, for instance. *Poa annua* thrives in that climate because it does not get very cold in winter or very hot

in summer (usually). In fall and winter, the temperatures generally fall between 32 and 50 degrees Fahrenheit (0 to 10 degrees Celsius) and cloud cover is

very common during that time of year. Microdochium patch (pink snow mold, Figure 1) thrives in these conditions and is a major obstacle to successfully



Figure 1 — Microdochium patch on Poa annua in Paris, France.



Figure 2 — Typical growth habit of *Poa annua* with an annual life cycle.

Figure 3 — Typical growth habit of *Poa annua* with a perennial life cycle.

managing *Poa annua* greens. Add to the equation that there is very limited fungicide availability in France and many other areas in Europe, and *Poa annua* is not a good choice despite the ideal conditions for growth.

In the golf course industry, it is safe to say that *Poa annua* is the plant that we love to hate. However, many successful U.S. Opens have been played on *Poa annua* greens. In mild climates where *Poa annua* thrives, it can be a very good putting surface, but the problems with heat tolerance, cold tolerance, disease, and uneven growth (just to name a few), can make it a difficult species to grow at certain times of the year. In these areas of the world, if you were to ask golf course superintendents if they had a choice between *Poa annua* or creeping bentgrass, most would choose bentgrass. In climates in the transition zone, it is a

little more straightforward: *Poa annua* is considered a weed.

What do we do with this desirable plant/weed (weed being defined as an unwanted plant)? As previously stated, *Poa annua* has been the subject of inquiry for at least 100 years. To this day, it is a hot topic of discussion and a target of a great deal of research. A search of the Turfgrass Information Files maintained at Michigan State University revealed that there were 68 articles written in 2014 alone. That is a lot.

POA ANNUA, THE PLANT

As with any pest, it is important to understand *Poa annua* biology and ecology if the plant is to be successfully managed. It is a cool-season plant that is typically an annual (Figure 2), but it can become a perennial (Figure 3) under certain growing and environ-

mental conditions and intensive management. When *Poa annua* takes on a perennial life cycle, it often produces short stolons that result in more of a creeping growth habit. Perennial biotypes typically survive the summer and grow for many years, and, of course, they are the types found on putting greens that are maintained as *Poa annua* greens.

Compared to creeping bentgrass, *Poa annua* is adapted to different ideal growing conditions (Beard, 2002, *Turfgrass Management for Golf Courses*). Consider Table 1:

Poa annua can be successfully grown as a desirable turfgrass species in cooler climates, but it is limited worldwide by its heat tolerance. For instance, in Florida, *Poa annua* is prevalent in winter and spring but dies as temperatures rise in late spring and early summer. In this type of climate, *Poa annua* exists as a typical winter annual weed that cannot survive summer conditions. There are also areas of the world where cold temperatures cause winter kill of *Poa annua*. In the U.S., such areas include the upper Midwest, the Rocky Mountains, areas of New England, and areas of the high plains.

In a mild climate, *Poa annua* thrives almost year round. Sometimes, in late summer, high temperatures and high humidity can stress *Poa annua* and make the plant susceptible to certain

TABLE 1
Comparison Between Creeping Bentgrass and *Poa annua*

	Creeping Bentgrass	<i>Poa annua</i>
Heat Resistance	Fair	Poor
Cold Hardiness	Excellent	Moderate
Drought Resistance	Fair	Poor
Shade Tolerance	Fair	Excellent
Salinity Tolerance	Good	Very poor
Wear Tolerance	Poor	Moderate

diseases such as anthracnose (*Colletotrichum graminicola*). However, in general, the climate in the Pacific Northwest is probably as conducive to managing *Poa annua* as anywhere in the world. In this type of climate, *Poa annua* acts as a true perennial and can be grown as a desirable turfgrass. This is because of the mild summers and winters that prevent death from extreme high and low temperatures, respectively.

As previously mentioned, when *Poa annua* adapts to a perennial life cycle, it develops a more lateral growth habit. However, when grown as a desirable turfgrass species on greens, *Poa annua* still retains some of its natural characteristics, such as prolific seed-head production. But, more important, because of its genetic diversity as well as other factors, *Poa annua* populations on putting greens tend to have varying growth characteristics. Such variance often produces an uneven putting surface. This uneven growth is the main issue with *Poa annua*, both as a contaminant in creeping bentgrass putting greens or even *Poa annua* greens. For this reason, when comparing monostands of *Poa annua* versus bentgrass on putting greens, bentgrass is considered by most to be the more desirable species. Plant growth regulators can help reduce the adverse effects of varying growth rates, but the question remains — why do *Poa annua* populations tend to grow at different rates? More on this later.

Following the establishment of creeping bentgrass greens, *Poa annua* will gradually invade the stand if there is no intervention. The rate of invasion is highly dependent on environmental factors (primarily climate) and various cultural factors. Dr. Shawn Askew at Virginia Tech has surveyed *Poa annua* infestations on golf courses versus age of greens. Figure 4 demonstrates this effect of age. The correlation of *Poa annua* to age is very linear. As the graph illustrates, the first five years show infestations at or below about 15 percent. However, by year 15, *Poa annua* has increased to about 35 percent. It should be noted that these data are from Virginia, which is in the transition zone.

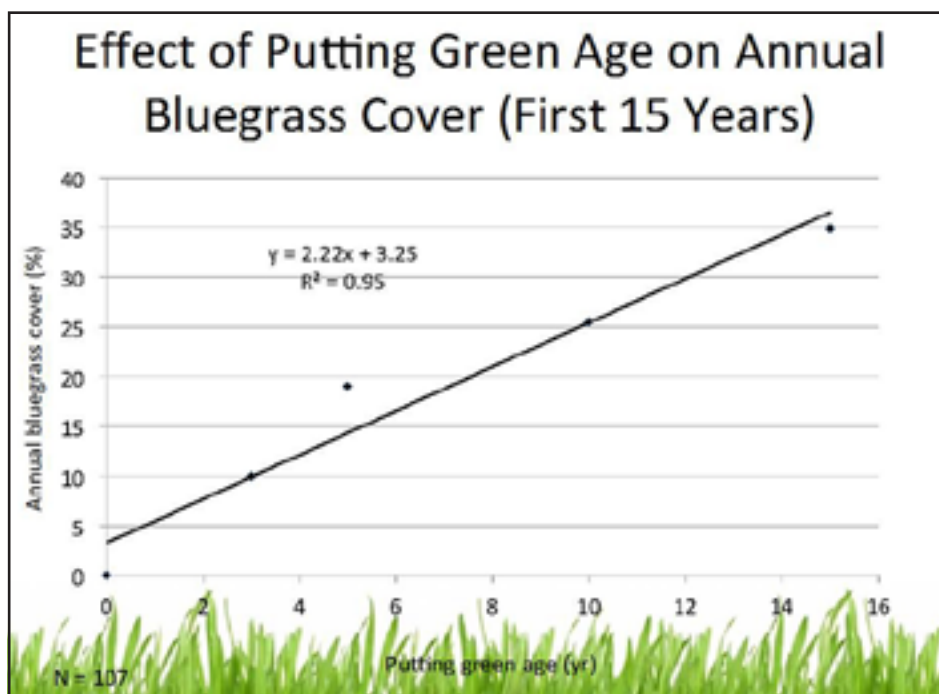


Figure 4 — As bentgrass greens age, the percentage of *Poa annua* often increases steadily.

But what effects do cultural practices have on *Poa annua* infestations? Specifically, do modern putting green cultural practices influence *Poa annua* infestations? One key cultural practice, namely the decrease in putting green mowing heights, appears to influence the amount of perennial *Poa annua* in

putting greens. Dr. Askew correlated the effects of mowing height on the percentage of *Poa annua* that exhibits a perennial life cycle. Figure 5 shows that as mowing height decreases, the percentage of perennial biotypes of *Poa annua* increases. Specifically, mowing heights from 0.100 inch up

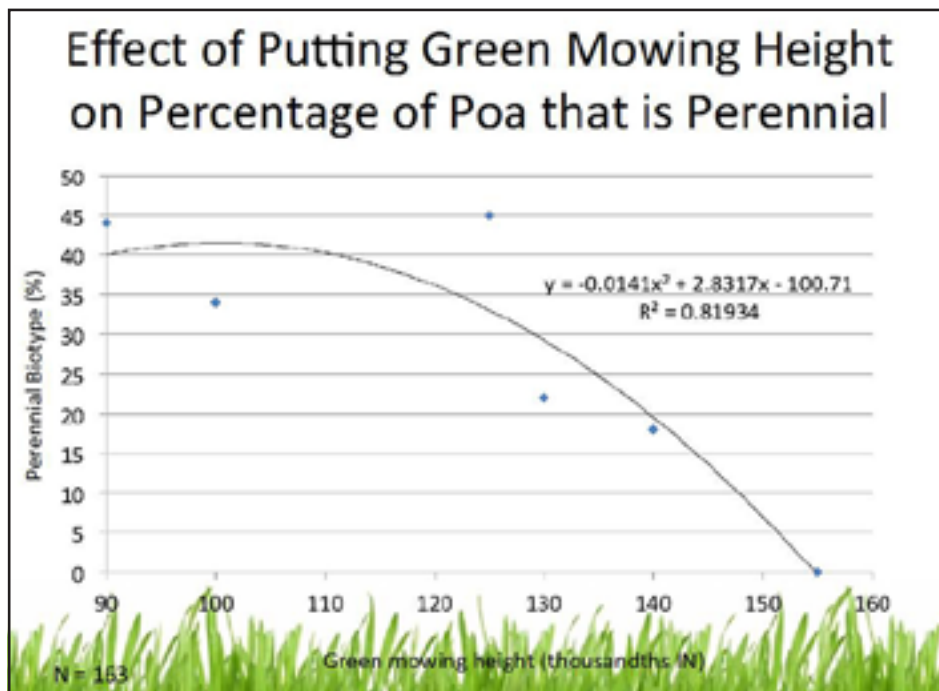


Figure 5 — Dr. Shawn Askew of Virginia Tech demonstrated that as mowing height decreases, the percentage of perennial biotypes of *Poa annua* increases.



Figure 6 — Biotypes of *Poa annua* often react differently to chemicals such as herbicides and growth regulators.

to 0.125 inch had significantly more perennial biotypes of *Poa annua* than mowing heights at 0.140 to 0.150 inch. This supports the notion that a gradual decrease in mowing heights has contributed to an increased incidence in perennial *Poa annua* in putting greens. The implication here is that lower mowing heights tend to shift the competitive edge to *Poa annua* and away from creeping bentgrass.

As previously mentioned, *Poa annua* as a species is very genetically diverse. *Poa annua* has often been called a collection of different plants. Dr. Scott McElroy, Turf Scientist at Auburn University, described the genetics of *Poa annua* very well in a 2013 article in *Golfdom* magazine. *Poa annua* is a tetraploid — meaning it has four sets of chromosomes, two sets from *Poa infirma* and two sets from *Poa supina*,

which are its ancestral parents. (Humans, by the way, are diploids; we have only two sets of chromosomes.) Therefore, when you look at a putting green with a great deal of *Poa annua*, you see all kinds of different-looking plants. They look different because they are different. Technically, these are referred to as biotypes. This wide range of genetic diversity in *Poa annua* is a big deal since this is one of the main reasons why *Poa annua* is so difficult to manage and control. This is also one of the reasons *Poa annua* is conducive to the development of resistance to herbicides (more on this later also).

This genetic diversity can be routinely seen with the use of paclobutrazol (Trimmit, etc.). Figure 6 is an image from a research trial that illustrates that some biotypes of *Poa annua* are more

susceptible to paclobutrazol than others. Some are severely injured and some are almost unaffected, along with everything in-between. This is also very likely to be the main reason some golf course superintendents have different levels of success with various control strategies. The *Poa annua* your neighbor or colleague has on another course may not be the same biotypes of *Poa annua* as on your course. This genetic diversity (in the view of this author) is one of the main reasons why, 94 years after Piper and Oakley wrote in the *Green Section Record*, researchers and practitioners are still trying to figure this weed out. We can summarize *Poa annua* as a complex species. Because of this complexity, we think there is a reasonable possibility someone will be writing about *Poa annua* in the *Green Section*

Record 94 years from now! No way, you say. What about Roundup-ready creeping bentgrass? Or what about methiozolin? They are supposed to solve all of our *Poa annua* problems, correct? Unfortunately, this is incorrect. For those who think there is a silver bullet just around the corner that will solve this problem, consider this: We should all agree that the issue with *Poa annua* is a complex issue. Now consider this great paraphrased quote from H. L. Mencken in 1917:

“For every complex problem, there is an answer that is clear, simple, and wrong.”

I do not think Mr. Mencken was talking about *Poa annua*, but he could have been. It certainly applies. So let's talk about control.

CONTROL OF POA ANNUA

First of all, methiozolin (when registered) or even some type of glyphosate-tolerant bentgrass would be significant management tools in the war on *Poa annua* in creeping bentgrass putting greens. But they should be regarded as tools, as are paclobutrazol, fluprimsidol, etc. Difficulties arise when we start to think that they will unequivocally solve the problem.

So why wouldn't Roundup-ready bentgrass or methiozolin unilaterally solve the problem? The answer is herbicide resistance. Herbicide resistance in global agriculture is probably the number-one production issue in food and fiber crops. We are certainly not immune to herbicide resistance in turfgrasses. To understand the issue of herbicide resistance, we need to provide a very brief background. First, let's define herbicide resistance.

HERBICIDE RESISTANCE

Herbicide resistance can be defined as the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide that would normally be lethal.

The key phrase here is “dose of herbicide that would normally be lethal.” This implies that the herbicide once killed the plant but certain biotypes of the plant have developed the ability to survive the herbicide in question. In fact, this is evolution in

TABLE 2
Herbicide-Resistant Annual Bluegrass (*Poa annua*) Globally

Country	Active Ingredients	Site of Action
France, Belgium, USA, Japan, Czech Republic, United Kingdom, Netherlands, Norway	atrazine, simazine, diuron, cyanazine	Photosystem II
USA (Oregon)	ethofumesate	Lipid inhibitors
USA (North Carolina, Tennessee)	pendimethalin, prodiamine, dithopyr	Microtubule inhibitors
USA (California)	glyphosate	EPSP synthase inhibitors
Belgium	paraquat	PSI electron diverter

Ian Heap, International Survey of Herbicide Resistant Weeds, January, 2015. Weed Science Society of America.

action. It is the natural selection that Charles Darwin talked about in *The Origin of the Species*. The herbicide is the selection pressure and the weed in question has biotypes that can “adapt” to this selection pressure. When these biotypes subsequently reproduce, it can eventually lead to a population that is resistant.

It is important to distinguish between “herbicide resistance” and “herbicide tolerance.” Herbicide tolerance implies that the plant was never susceptible to the herbicide in question. For instance, Kentucky bluegrass is not affected by fenoxaprop (Acclaim Extra) and bermudagrass is not affected by trifloxy-sulfuron (Monument). Therefore, Kentucky bluegrass and bermudagrass are not resistant; rather, they exhibit herbicide tolerance. In summary, herbicide resistance implies the plant in question was once controlled, but by repeated herbicide use and selection pressure by the herbicide the population is now resistant.

Consider the history of herbicidal control of *Poa annua*. There have been many herbicides labeled that are excellent (as good as, or even better than glyphosate or methiozolin) for the control of *Poa annua*. Most have been registered for use in warm-season grasses for several years and have been widely used. However, in many cases, *Poa annua* has developed resistance to these products. Why? It is because *Poa annua* is a highly diverse species. This genetic diversity

is very important as we think about management practices, specifically herbicide use, that are utilized to reduce *Poa annua* populations.

According to the Weed Science Society of America (which catalogs cases of documented resistance), there are 27 cases of herbicide resistance in *Poa annua*. They include, but are not limited to, those listed in Table 2.

Poa annua has evolved resistance to every effective mode of action that has been widely used to control this weed. This speaks further to the genetic diversity of this species. In summary, we should expect nothing different to new modes of action in the future. It would be unwise to assume we will not get resistance to methiozolin. We should plan on it and initiate management programs that discourage the development of resistance if and when this product gets registered. The easiest way to prevent the development of herbicide resistance is to rotate products that have differing modes of action.

RESEARCH ON THE REDUCTION OF POA ANNUA

There has been much research on reducing *Poa annua* infestations in bentgrass putting greens. The ideal product, or management strategy, would be to have products that slowly remove *Poa annua* so the bentgrass could fill in the voids. The result would be a smooth transition from one species to the other. Therefore, we



Figure 7 — This golf course used methiozolin from tee to green and significantly reduced *Poa annua* on creeping bentgrass tees, fairways, and greens.

need a product that is highly effective in control of *Poa annua*, totally safe on creeping bentgrass, slow acting, and one that we can follow with bentgrass seeding with minimal restriction. We would need to accomplish this with a weed (*Poa annua*) that is a highly genetically diverse species.

Is it any wonder we have difficulty? Meeting all of these criteria is next to impossible. The biggest barrier is finding a product that provides control and does not harm bentgrass. Remember, removing a cool-season grass from within a stand of cool-season grasses is inherently difficult. Let's look at where we are in 2015.

Methiozolin — Let's start here since there is so much interest in this product. But remember, it is not currently registered in the U.S. and may never achieve such status. It is registered in South Korea and Japan, and many of us have seen its use on golf courses in those countries. Figure 7 is a photo taken at The Club at Nine Bridges in the JeJu Islands in South Korea. This golf course used methiozolin from tee to green and significantly reduced *Poa annua* on creeping bentgrass tees, fairways, and greens.

There is little doubt that methiozolin is very effective in controlling *Poa*

annua. The research community recognizes it as potentially the single most effective product we have investigated. Askew (2014) conducted a multi-year trial at three golf course putting greens in Virginia and effectively reduced perennial *Poa annua*

populations, significantly reduced *Poa annua* seedheads, and increased creeping bentgrass in research conducted from March 2009 to March 2011 (Figure 8). Spring and fall applications of methiozolin at 750 g/ha reduced *Poa annua* populations to 15 percent in treated plots, compared to 59 percent in untreated plots. At one of the sites, Gypsy Hill Golf Course, he reduced seedheads on *Poa annua* by 87 percent. In his research, methiozolin proved to be effective in reducing the *Poa annua* population and seedheads (Askew and McNulty, 2014).

Research (Yelverton et al, 2012) conducted at three golf courses and one research station in North Carolina in 2012 showed that as quickly as 12 weeks after the initial treatment of methiozolin, *Poa annua* populations were suppressed by 59 to 94 percent. On these sites, the *Poa annua* population was primarily annual biotypes, with some perennial biotypes present. These were also fall applications of methiozolin at 1.1 kg ai/ha. These data would indicate that, similar to other products used for *Poa annua* control, the annual biotypes are more easily controlled than perennial biotypes.

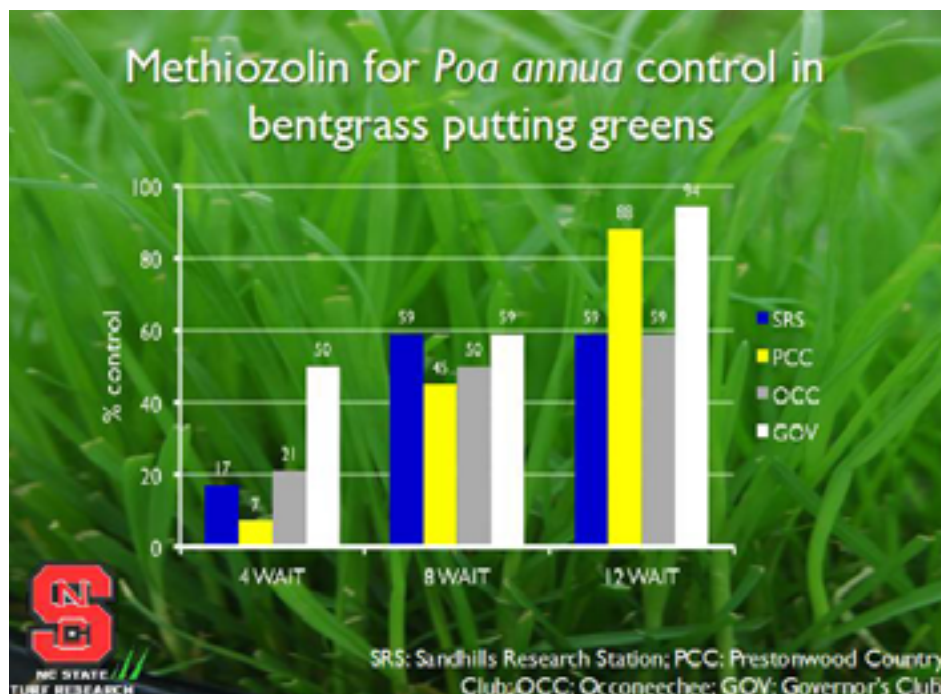


Figure 8 — Askew (2014) conducted a multi-year trial at three golf course putting greens and effectively reduced perennial *Poa annua* populations, significantly reduced *Poa annua* seedheads, and increased creeping bentgrass.

While the results from Virginia and North Carolina are very promising, as you can tell, *Poa annua* was not completely eliminated. While most in the industry are hoping methiozolin will be registered for use, it should be remembered that it is only another tool in the overall management of *Poa annua*.

Xonerate (amicarbazone) — Amicarbazone is a Photosystem II inhibitor that received considerable research interest from about 2007 to 2012. Creeping bentgrass maintained at putting green height has intermediate tolerance, and *Poa annua* activity was fair to good but was inconsistent. Also inconsistent was creeping bentgrass

tolerance. While some success was obtained with this product, control of *Poa annua* (where it occurred) was very fast. As a result of its inconsistency for *Poa annua* control and inconsistent creeping bentgrass tolerance, many researchers are concerned that this product may not be a viable option for *Poa annua* control in creeping bentgrass.

Paclobutrazol (Trimmit, etc.) — Paclobutrazol is a plant growth regulator that works by temporarily inhibiting gibberellin biosynthesis in plants. Gibberellins are responsible for, among other things, cell elongation in plants. By inhibiting gibberellin biosynthesis, the affected plant has a more compact growth habit and growth is slowed, resulting in a reduction in mowing needs. Paclobutrazol is effective in reducing *Poa annua* populations because it reduces *Poa annua* growth more so than creeping bentgrass growth. Hence, repeated use over time shifts the competitive edge away from *Poa annua* and to creeping bentgrass. This effect has been demonstrated in research trials by Isgrigg and Yelverton (1999). Figure 9 shows that 0.25 lbs. ai/a of paclobutrazol reduced *Poa annua* growth more than creeping bentgrass growth. At three weeks after application of paclobutrazol, *Poa annua* was producing only 40 percent of the biomass relative to the untreated check, whereas creeping bentgrass was producing about 65 percent relative to the untreated check.

Currently, paclobutrazol is the most widely used product for the reduction of *Poa annua* in creeping bentgrass putting greens. Golf course superintendents generally acknowledge this product is effective in reducing *Poa annua*, but success depends on a regimented program over multiple years. In addition, seldom does paclobutrazol reduce *Poa annua* populations below five percent, even after multiple years of use at regular intervals.

Visually, where paclobutrazol is used, you can note that *Poa annua* is affected more than creeping bentgrass. Figure 10 shows *Poa annua* and bentgrass in a putting green on which paclobutrazol was applied. Note that

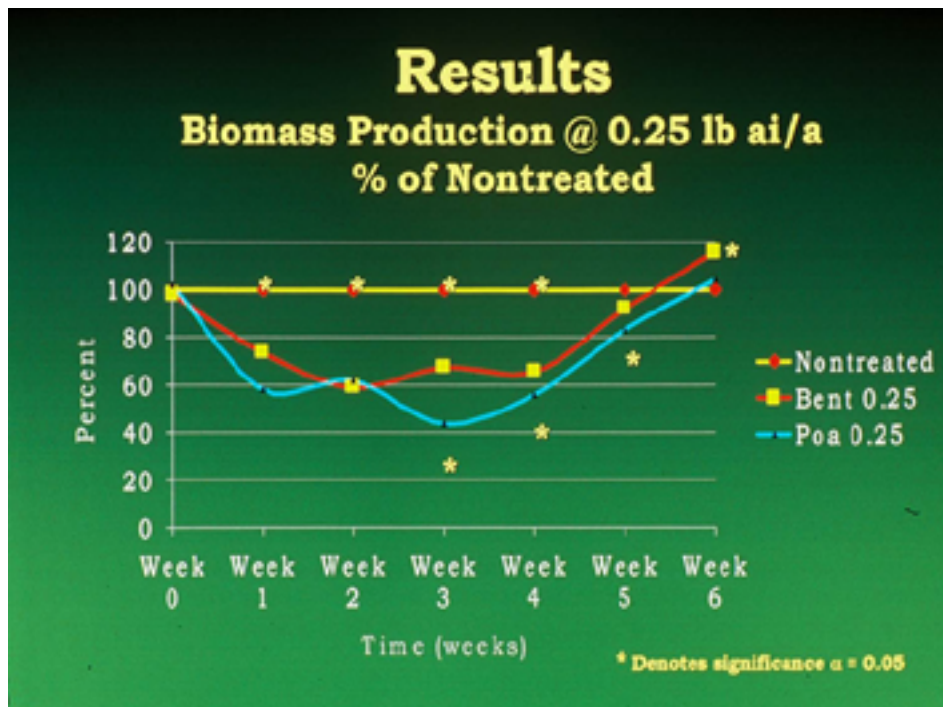


Figure 9 — 0.25 lbs ai/a of paclobutrazol reduced *Poa annua* growth more than creeping bentgrass growth.



Figure 10 — Paclobutrazol applied to a putting green severely stunted the *Poa annua* while having little impact on the bentgrass.

the *Poa annua* is severely stunted while the creeping bentgrass appears to be less affected. Repeated use over time results in the patch of *Poa annua* becoming progressively smaller while the creeping bentgrass grows into the voids.

Field research results indicate that paclobutrazol is effective. Bruneau et al (1999) documented the effectiveness of paclobutrazol on reducing perennial biotypes of *Poa annua*. Note that three fall plus three spring applications of paclobutrazol reduced *Poa annua* populations by 31 percent (Table 3). This is a significant reduction in only one year.

In these same trials, Bruneau also estimated seedhead reduction by each treatment. Paclobutrazol and flurprimidol were effective in reducing *Poa annua* spp. Reptans seedheads (Table 4). However, paclobutrazol was more effective than flurprimidol.

Figure 11 shows the effectiveness of paclobutrazol in reducing *Poa annua* and *Poa annua* seedheads in a separate research trail. This population was predominately annual biotypes of *Poa annua*. Note that the area to the left of the photo is untreated and the

TABLE 3
Percent Reduction in *Poa annua* spp. reptans from September 1995 to May 1996 Following 6 Applications of Plant Growth Regulators

Treatment	Rate (kg ai/ha)	Percent Reduction in <i>Poa annua</i> spp. reptans
Untreated	n/a	n/a
Trinexapac ethyl	0.11	0 a
Paclobutrazol	0.42	31 b
Flurprimidol	0.28	3 a

Bruneau et al. All plots had in excess of 80% Poa annua at trial initiation. Means followed by the same letter are not significantly different at P = 0.05.

TABLE 4
Percent Seedhead Reduction in *Poa annua* spp. reptans from September 1995 to May 1996 Following 6 Applications of Plant Growth Regulators

Treatment	Rate (kg ai/ha)	Percent Seedhead Reduction in <i>Poa annua</i> spp. reptans
Untreated	n/a	n/a
Trinexapac ethyl	0.11	18 c
Paclobutrazol	0.42	80 a
Flurprimidol	0.28	48 b

Bruneau et al. All plots had in excess of 80% Poa annua at trial initiation. Means followed by the same letter are not significantly different at P = 0.05.



*Figure 11 — Paclobutrazol was effective in reducing *Poa annua* and *Poa annua* seedheads in this research trial. This population was predominately annual biotypes of *Poa annua*. Note that the area to the left of the photo is untreated and the area to the right was treated.*

area to the right was treated with six applications of paclobutrazol (three fall and three spring).

Paclobutrazol is effective in reducing *Poa annua* in putting greens and is generally safe to creeping bentgrass. While some results can be seen within a year, often multiple years of applications are needed to get the desired results. Also, strict application intervals need to be utilized to get the desired effect.

Velocity (bispyribac-sodium) — Velocity was the subject of significant research from about 2005 through 2012. Velocity is an acetolactase synthase (ALS) inhibitor much like the sulfonyleurea herbicides. However, Velocity does not belong in the sulfonyleurea family of herbicides, even though it has a similar site of action. McCullough and Hart at Rutgers showed that Velocity can be highly effective in reducing *Poa annua* in creeping bentgrass, but the control of *Poa annua* with Velocity was highly temperature-dependent. The warmer the temperature, the more effective the product was in reducing *Poa annua*. It was also noted that under cooler temperatures, increased chlorosis on creeping bentgrass occurred.

Through much experimentation by researchers and golf course superintendents, the main issue with Velocity is that it frequently causes some discoloration in creeping bentgrass. Although the discoloration was usually temporary, it eventually resulted in less Velocity use on bentgrass putting greens.

SEEDHEAD REDUCTION OF POA ANNUA

Poa annua is a prolific seedhead producer. These seedheads reduce surface uniformity and adversely impact ball roll, thus impacting playing quality. In climates where *Poa annua*

thrives agronomically, the ability to control seedheads would make the plant much better suited to putting greens. Ethephon is a plant growth regulator labeled for use in putting greens. It works by altering ethylene production in plants. Haguwood et al (2013) investigated the use of several plant growth regulators on creeping bentgrass/*Poa annua* putting greens for *Poa annua* seedhead reduction. Treatments containing ethephon reduced visible seedheads of *Poa annua* by 95 percent. Adding trinexapac-ethyl to the mix had little effect on *Poa annua* seedhead production but did enhance creeping bentgrass turf quality up to 6 percent compared to ethephon alone. Adding trinexapac-ethyl to ethephon is now a frequent recommendation for reducing seedheads on *Poa annua*.

These same researchers investigated mefluidide for seedhead suppression of *Poa annua*. While effective, the authors reported unacceptable injury to creeping bentgrass. This has also been observed in practice, particularly when applications are made in warmer temperatures.

SUMMARY

Annual bluegrass, often referred to by its Latin name, *Poa annua*, has been problematic on golf courses for 100 years or more. This plant species is difficult to manage because it is cosmopolitan in nature and exhibits great genetic diversity. These factors, coupled with the production of abundant seed, allow this species to evolve and adapt to selection pressure from herbicides and cultural practices imposed by management on putting greens.

In our view, *Poa annua* is a species that can be managed in putting greens. If golf course superintendents and the

golfing public embrace a management strategy that is multi-faceted, success can be obtained. However, if the goal is to eradicate this weed from a given property, then history and science tell us that success is very unlikely.

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