Development of Roundup Ready Bentgrass for the Control of *Poa annua*

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새포아풀 방제를 위한 Roundup Ready Bentgrass의 개발

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ABSTRACT

Annual bluegrass(*Poa annua* L.) is a problem weed that is very difficult to control on golf courses. There are some reasons that make *Poa annua* such a difficult weed to be controled. One of these reasons is this plant's ability to reproduce its seed even under stressful conditions. Another reason is its adaptation to low mowing heights. Above all things, the greatest competitive advantage of *Poa annua* is its genetic diversity. Generally, *Poa annua* is a bunch type and annual type cool-season grass, but some types act as weak perennials and have stolons. There has been much research on controlling annual bluegrass in golf course turf with chemical and cultural techniques. This research has been conducted for more than 85 years. There has been some progress in controlling some types of *Poa annua*, but these methods have not been successful on every biotype. Among all of the techniques, Roundup ready creeping bentgrass has the most promise of controlling the diverse types of *Poa annua*. Roundup ready bentgrass is capable of tolerating the effects of Roundup(glyphosate) while it kills other plants including *Poa annua*. By using this new technology, we can make *Poa annua* free greens, tees, and fairways.

Key words : annual bluegrass, golf course green, herbicide, *Poa annua*, Roundup ready bentgrass, weed

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Nearly everywhere that the game of golf is played, Annual bluegrass(*Poa annua* L.) is a problem. Throughout the world in both cool-season and warm-season regions it invades well-maintained golf courses and is often cited by golf course superintendents to be one of their biggest problems. *Poa annua* is a weed that is very difficult to control. Both chemical and cultural techniques generally prove to be ineffective and this plant generally has a way of beating almost everything that we have thrown at it.

Annual bluegrass life cycle and physiology

Poa annua is a cool-season grass that can be identified by its boat-shaped leaf tip, folded vernation, and prominent membranous ligule(Christians, 2004). It is usually recognized as a bunch grass and as a winter annual. This is a highly variable species, however, and many of the things that have been written about it do not prove to be true of all *Poa annua*. A true winter annual should germinate from seed in the late summer to early fall, live through the winter as a mature species, produce a seed crop in the spring and then die. It is true that some types of *Poa annua* are capable of acting in this way. There are types, though, that are commonly observed to germinate almost any time during the season and are more perennial than they are annual. Some types also produce stolons and can not be described as bunch grasses.

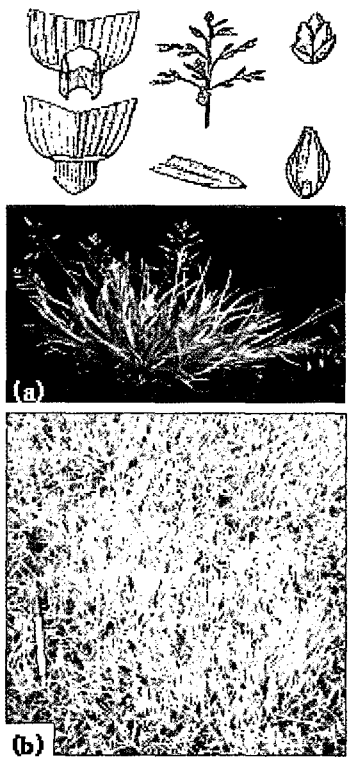

Fig. 1 (a)Morphology of *Poa annua*, (b)*Poa annua* patch on Kentucky bluegrass turf.

One of the things that make *Poa annua* such a difficult weed to control is its ability to produce seed. The ability to produce seed throughout the season, at even the lowest mowing heights, gives it competitive advantage over grasses like creeping bentgrass(*Agrostis stolonifera*). The seed can live for years in the soil and will geminate when it is exposed by a ball mark or divot. Another major competitive advantage of *Poa annua* is its adaptation to low mowing heights. Very few grasses can tolerate the extremely low mowing

heights that this grass can tolerate. It can even produce seed at mowing heights as low as 0.254 cm (0.1 inch). This gives it a big advantage over Kentucky bluegrass(*Poa pratensis*) that is poorly adapted to mowing heights below 4 cm. The fact that it is a cool-season grass also gives it an advantage over warm-season grasses, like Zoysiagrass and Bermudagrass during cooler times of year when these species are dormant.

The greatest competitive advantage of *Poa annua*, however, is its genetic diversity. There are hundreds of biotypes of this grass that we know as *Poa annua*, each with their own specific characteristics that separate it in some way from the others. There are annual bluegrasses termed *Poa annua* var. *annua* L. Timm.(Beard et al., 1978) that are bunch grasses that act as true winter annuals. There are also types know as *Poa annua* var. *reptans*(Hauskn) Timm.(Timm, 1965). The *reptans* types act as weak perennials and may have stolons. There are many biotypes between these two extremes, some closer to the *annua* types and some closer to the *reptans*. It is common to find distinct biotypes on older golf courses that are adapted to fairways, others that are best suited to greens, and yet others that predominate on tees(Lush, 1989). Likewise, it is not unusual to find a mixture of several biotypes in the greens, tees, and fairways of these courses(Cline, 2001; Wu, 1991). Observations of older greens with heavy infestations of *Poa annua* will generally reveal variations in color, texture, and time of seedhead production. Researchers who work in the area of *Poa annua* control with herbicides often observe variations in herbicide response among these biotypes.

A historical perspective of annual bluegrass control

In 1996, I spent several weeks studying more than 85 years of research on attempts to control annual bluegrass in golf course turf. The results were published in a Golf Course Management article titled 'A historical perspective of annual bluegrass control'(Christians, 1996). I have also worked for more than 25 years with a wide variety of materials with the potential of controlling this species. While some of these materials looked promising in small research plots, they generally failed when they were tested under varying field conditions. This again was due to the tremendous genetic diversity found in this species throughout the U.S. and the world(Fig 2).

There are products that have worked on a regional basis to selectively remove *Poa*

annua from some species in some environments. One of these is Ethofumesate(Prograss) that has been effective at removing *Poa annua* from perennial ryegrass fairways and tees in the Midwestern United States. When used in other species and other locations, however, its use has been less successful. Fenarimol(Rubigan), a systemic fungicide, has been used as a postemergence control of the annual types of *Poa annua* along the Gulf Coast in the Southern US. It has not been equally successful on the perennial types, however. Flurprimidol (Cutless) and Paclybutrazol(TGR and Trimmit), both plant growth regulators, have shown success in some environments and on some biotypes. These variations may be partly due to variations in environmental conditions, but most of the inconsistency is due to the genetic diversity of the *Poa annua*.

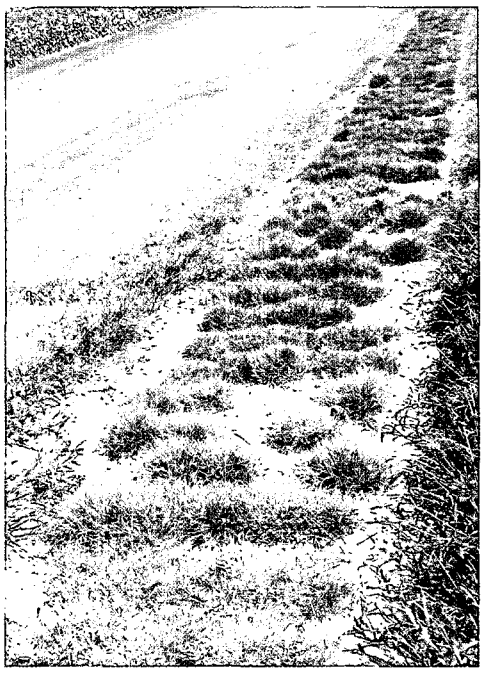

Fig. 2. Test plots of *Poa annua* biotype diversity.

The 10 years since the Golf Course Management article was published have brought a few new materials, but the results with these products have generally been the same, highly variable. Rimsulfuron(TranXit GTA) is showing some promise as a control of *Poa annua* in Bermudagrass(*Cynodon* spp) turf in the Southern US(Walker et al., 2003). Bispyribac-sodium(Velocity), a new product introduced in 2005, has also met with some success as a selective control of *Poa annua* in creeping bentgrass fairways. These new materials will likely meet with limited success on certain biotypes of *Poa annua*.

Roundup ready bentgrasses

It is my opinion, that there will never be a single 'magic bullet' herbicide that will be the final solution to the *Poa annua* problem. There is some new technology on the horizon, however, that may result in some major changes in the industry. This new technology is the developing science of genetic transformation. Of particular interest

is the recent development of Roundup ready creeping bentgrasses.

The nonselective herbicide Roundup(glyphosate) is very effective on most of the major cool-season and warm-season grasses and is often used in the renovation process where all existing vegetation is to be killed before reestablishment. There isa gene that allows some plants to tolerate the effects of this herbicide. Scientists have been able to isolate this gene and place it in plants, like soybean, that normally would be susceptible to Roundup.

Scientists at the O.M. Scotts Co. of Marysville, Ohio, in conjunction with scientists from the Monsanto Co. of St. Louis, Missouri have found a way to insert the roundup ready gene into creeping bentgrass. This Roundup ready bentgrass is still experimental and has not been approved for sale as of the spring of 2006. This technology has the potential to provide one of the first truly effective means of removing *Poa annua*, which is susceptible to Roundup, from creeping bentgrass turf. Roundup should also control most of the other weeds that compete with creeping bentgrass on the golf course.

Like any new technology, there will be problems that arise with Roundup ready creeping bentgrass. The gene that protects plants from Roundup does exits in nature and it is possible that over the years, resistant *Poa annua* could eventually develop. Even if that were to happen, Roundup ready bentgrasses has the potential to provide many years of *Poa annua* free greens, tees, and fairways.

Conclusions

Work has been conducted at Iowa State University to determine the best procedure for converting existing turf to Roundup ready bentgrasses. Specifically, we are working on the proper timing of Roundup application following seeding. The objective is to develop methods that will allow the golf course superintendent to convert existing turf to Roundup ready bentgrasses with a minimal amount of down-time for the course. In addition to converting creeping bentgrass greens and fairways, we are also working on the conversion of Kentucky bluegrass and perennial ryegrass fairways. Seeding directly into existing turf, combined with Roundup applications to kill the existing turf before it competes with the new Roundup ready bentgrass appears to be the most effective method of conversion.

국문요약

애뉴얼 블루그래스는 골프장에서 방제하기가 대단히 어려운 잡초이다. 방제가 어려운 이유로는 애뉴얼 블루그래스의 경우 불량환경에서도 왕성하게 종자생산을 할 수 있는 특성과 또한 낮은 예초환경에서도 적응력이 있기 때문이다. 하지만 무엇보다도 유전적으로 다양성이 있기 때문에 골프장의 잔디에 비해 우점할 수 있는 것이다. 일반적으로 애뉴얼 블루그래스는 일년생 한지형 잔디로, 생육형은 주형이다. 하지만 포복경이 있어 다년생의 특성을 갖는 생태형이 다른 애뉴얼 블루그래스도 있다. 골프장에서 애뉴얼 블루그래스 방제를 위해 화학적 방법과 재배적 방법에 관한 수많은 연구가 지난 85년간 진행되었다. 연구결과 일부 종류의 애뉴얼 블루그래스 방제에 성공적인 결과도 있지만, 모든 종류의 애뉴얼 블루그래스 방제에 성공적인 방법은 아직 없는 실정이다. 이 모든 방제 방법들 중에 Roundup ready creeping bentgrass의 사용은 다양한 종류의 새포아풀을 방제 할 수 있다. Roundup readgy bentgrass는 Roundup에 내성이 있어 약해 피해 없이 생존이 가능하다. 따라서 골프장에서 이 새로운 기술을 활용하면 새포아풀이 없는 그린, 티, 훼어웨이를 유지할 수 있다.

주요어 : 그린, 라운드업 내성 벤트그래스, 새포아풀, 애뉴얼 블루그래스, 잡초, 제초제

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