Excerpt from the literature review of "Genetics and Physiology of Flowering in *Poa annua* L."



## INTRODUCTION

*Poa annua* L. (annual bluegrass) is an incredibly diverse species in morphology and adaptability Because of its association with humans, the species has extended its range of growth throughout the world to all the continents except Antarctica (Fenner, 1985). Hence, it has been described by many authors and has many synonyms: annual meadowgrass, wintergrass, Junegrass, Suffolkgrass, speargrass, and walkgrass (Gibeault, 1971).

*Poa annua* can be found growing in many different environments, but it has the greatest economic impact in high maintenance turfgrass areas, especially golf course greens, fairways, and tees. Although it is very rarely intentionally planted, it is has been considered the best putting surface for golf greens because of its upright habit and fine texture. It tolerates very close mowing, shade, and compacted soils, all of which are common on golf course sites. Some *Poa annua* genotypes exhibit an annual or winter annual life cycle in a turfgrass stand meant to be perennial, but die out from heat and drought stress. Unfortunately, this often occurs during the busiest period of the golfing season. *Poa annua* also flowers under close mowing, even at the low heights of cut on a golf green (3-6 mm), creating an irregular putting surface.

Because of these detrimental characteristics, a considerable amount of research and money has been spent on the control of *Poa annua* as a weed. Efforts have often failed or have not been as successful as desired. *Poa annua* is persistent in spite of eradication efforts because of the extensive seed bank in the soil and the wide variation and adaptability in the species. Seed is always present and ready to germinate when conditions are favorable (Fenner, 1985; Lush, 1988).

Sometimes *Poa annua* is the only species that survives as it outcompetes the intentionally planted turfgrasses, particularly in cool coastal climates and cool temperate climates. In those situations, there is a great desire to culture it. In fact, many golf course superintendents have made distinguished careers on being able to successfully grow and maintain fine *Poa annua* turf. Since the species is so competitive, adaptable, and has many desirable characteristics, it has much to offer an plant improvement program. We can also learn from its survival and adaptation strategies and apply that knowledge to plant improvement or turf management. This information may help us to protect and beautify the sometimes unnatural world we have created in our urban living environment.

The variation and adaptability in the species may be traced to the diverse life-history patterns among the populations and individual genotypes that range from true annuals to long-lived perennials (Gibeault, 1971). These life-history characteristics differ among and within *Poa annua* populations. Part of this variation involves flowering habits or patterns, since flowering can occur continuously throughout a growing season or be restricted to very specific periods after winter, and flowering characteristics are genetically controlled (Law et al., 1977; Lush, 1989; Till-Bottraud et al., 1990).. Flowering patterns are important because the flowering processes influence nearly all aspects of the plant, significantly altering many vegetative traits important to perennial turfgrass communities and many reproductive traits important for seed production of improved varieties.

## DESCRIPTION OF THE SPECIES

### Origin

The morphological and reproductive variation in the species *Poa annua* may trace to diverse environmental adaptations of its putative parents, *Poa supina* Schrad. and *P. infirma* H.B.K., both

2n=2x=14 (Nannefeldt, 1937; Tutin, 1957). *Poa supina* is native to the cool climates of north and central Europe, while *Poa infirma* is native to the Mediterranean and warm regions (Tutin, 1957). *Poa annua* seems to have encompassed adaptations of both in one species. The most common form, the allotetraploid (2n=4x=28), is intermediate between *P. supina* and *P. infirma* in many morphological characteristics (Nannefeldt, 1937), and crosses between these two species yielded plants quite similar to *Poa annua* (Tutin, 1957). However some doubt remains on these putative parents, since evidence from chromosome pairing indicates that either *P. supina* or *P. infirma* and some as yet unidentified species are the parents of *Poa annua* (Koshy, 1968) The vegetative vigor inherent to alloploids (Fehr, 1987) may have greatly contributed to the evolutionary success of *Poa annua*,.

Diploid forms (2n=2x=14) of *Poa annua* also exist (Hovin, 1957; Ellis, 1970; Litardiere, 1938), and are frequently found on golf course greens (Cline et al., 1993; Johnson et al., 1993; Velguth & White, 1993), but the origin, adaptive ability, and evolutionary history of these individuals is not yet known. Litardiere (1938) concluded that this diploid race (named subsp. *exilis*) was the most primitive, and the tetraploid race descended from it. However, one diploid plant originated from the cross of two tetraploid parents (Johnson et al., 1993). The diploid forms can be readily identified as very diminutive plants that make a dense fine turf, forming colonies that persist in golf greens for many years (Cline et al., 1993; Velguth & White, 1993). These plants appear to be sterile, and without pollen (Johnson et al., 1993), although earlier citations of diploids report fertile flowers (Litardiere, 1938; Hovin, 1957).

## Morphology

*Poa annua* genotypes exhibit wide variation in morphological characteristics (Hitchcock, 1950,; Gibeault, 1971; Hutchinson & Seymour, 1982; Ruemmele, 1989). General stature ranges from upright to spreading, with a height from 1-20 cm, and leaf blades 1-5 mm wide. Color varies from light to dark green (Gibeault, 1971). Panicles range from large and open, spreading types, 30 cm long, to small, compact forms, 2.5 cm long (Hitchcock, 1950); and spreading forms usually have stolons that root at nodes (Ruemmele, 1989). The cultural environment also has a significant impact on many morphological characteristics (Johnson, 1991).

Many subspecies or botanical varieties have been named (Gibeault, 1971). However the species is typically classified into two to three botanical varieties. Variety *annua* is the typical annual type, which has a mostly upright, bunch-type growth habit, and prolific seed production. This is sometimes called var. *erecta* (Timm, 1965; Adams & Bryan, 1980). Variety *reptans* is a stoloniferous perennial, characterized by a spreading habit, darker green color, and numerous secondary tillers on prostrate or semi-prostrate culms. Variety *reptans* is sometimes divided into variety *typica*, which exhibits the most vegetative tillers and least number of flowers, and variety *pauciflora* which has narrower leaves and a less vigorous habit (Timm, 1965; Adams & Bryan, 1980). The *annua* and *reptans* varieties classify the species into the most distinct types, but a continuum of types appears to exist. Individuals combining various aspects of these annual and strongly perennial forms emcompass the variation in between, including winter annuals, biennials, and weakly perennial forms (Ruemmele, 1989; Johnson et al., 1993; White & Kaerwer, personal communication).

For the remainder of this literature review, the species will be referred to as *Poa annua*, and the two varieties *annua* and *reptans*. However, in later chapters, the var. *annua* type will be referred to as *Poa annua* and the var. *reptans* types as *Poa reptans*. Hopefully this will help prevent some of the confusion that arises when the contradictory terminology "perennial *Poa annua*" is used. The types are quite distinct morphologically and are worthy of defining as two separate species.

## Annual growth cycle

*Annua* and *reptans* type plants differ in their life-history patterns, so they also differ in their annual growth cycles. Seeds of both typically germinate in fall when temperatures and moisture conditions are most favorable to these cool-season grasses. The early-flowering annuals begin to flower during the fall before cold temperatures slow or stop active growth. Floral induction and floral initiation then occur during fall and winter, in those types that are sensitive to the cold temperatures. Once temperatures are again favorable in the spring, floral development begins, and the reproductive phase is underway.

The early flowering *annua* individuals flower throughout the summer growing season, but they normally die when heat and drought stress the plants. These annuals produce an abundance of seed which typically lies dormant and germinates in fall, to begin the cycle again. *Reptans* types exhibit a more limited flowering pattern by flowering in the spring, but then less the remainder of the year (Johnson et al., 1993), and they partition carbohydrate to maintain vegetative plant structures in addition to producing seed. This generally reduces the number of flowers, and consequently seed production, but the vegetative structures are more tolerant of stressful summer periods (Grime, 1979).

## Life-history variation

Two ecological investigations of *Poa annua* populations associate life-history and flowering patterns with specific growing environments. Law et al. (1977) examined populations of *Poa annua* in a garden and found them to be "opportunistic". They germinated, flowered quickly, then died, taking advantage of the bare soil and completing their life-cycle quickly. Populations in a closely grazed pasture had less disturbance than the garden, and individual plants lived for a significantly longer time, but they experienced constant abrasion, leaf removal, and compaction. Vegetative reproduction was more important in this environment, and perennials dominated. Lush (1989) observed *Poa annua* populations on a golf course in Australia, particularly in the rough, fairway and green areas. Opportunistic types, or annuals, were found most often in the rough areas, while those like the pasture types were found in golf green locations. Although these two reports described quite different locations, the selection pressures and habitats are remarkably similar. Environmental factors other than climate appear to place selection pressure on *Poa annua* populations. Some variation between populations has been attributed to phenotypic plasticity (Ellis, 1971), but this concept cannot explain all the variation and adaptation observed in the species (Till-Bottraud et al., 1990).

But these reports of annual and perennial forms of *Poa annua* are an exception in the literature because most authors describe *Poa annua* as being truly annual, flowering soon after germination (40 days according to Gibeault, 1971), and continuing to flower profusely until death (Sprague & Burton, 1937; Beard, 1973; Hutchinson & Seymour, 1982). *Poa annua* is unique, because individuals range from true annuals to long-lived perennials, with substantial variation in between. The balance or partitioning between vegetative and reproductive structures may be important for this continuum and may involve flowering requirements or the environmental triggers that induce flowering (Wallace et al., 1993).

Table 1. Comparisons of flowering characteristics in *Poa annua* populations as observed by Law et al. (1977) and Lush (1989), each in two environments.

| | Populations | |
|---|---|---|
| | Opportunist[†]/ Rough[‡] | Pasture[†]/ Green[‡] |
| Life-history | annual | perennial |
| Pre-reproductive period | short | longer |
| Growth Habit | erect | prostrate |
| Population regulation[†] | density-independent | density-dependent |

[†] Terms used by Law et al., 1977

[‡] Terms used by Lush, 1989

**REFERENCES**


Adams, W.A.. and P.J. Bryan, 1980. Variations in the growth and development of annual bluegrass populations selected from seven different sports turf areas. p. 109-115. *In* Proceedings of the Third International Turfgrass Research Conference.

Beard, J.B. 1973. Turfgrass: Science and culture. Prentice-Hall Inc., Englewood Cliffs, NJ.

Cline, V.W., D.B. White, and H. Kaerwer, 1993. Observations of population dynamics on selected annual bluegrass-creeping bluegrass golf-greens in MN. p. 839-844. *In* Proceedings of the Seventh International Turfgrass Research Conference.

De Litardiere, M.R., 1938. Recherches sur les *Poa annua* subsp. exilis et subsp. typica Relations taxonomiques, chorologiques et caryologiques. Revue de Cytologie et de Cytophysiologie Vegetales 3:2-4:134-141.

Ellis, W.M., B.T.O. Lee, and D.M. Calder, 1971. A biometric analysis of populations of *Poa annua* L. Evolution 25:29-37.

Fehr, W.R., 1987. Polyploidy p. 59-65 *In* Principles of cultivar development Vol. 1. Theory and Technique. McGraw-Hill, Inc. New York.

Fenner, M., 1985. Seed ecology. Chapman and Hall, New York, NY.

Gibeault, V., 1971. Perenniality in *Poa annua* L.; Ph.D. diss. Oregon State Univeristy, Corvallis.

Grime, J.P., 1979. Plant strategies and vegetation processes. John Wiley & Sons, New York, NY.

Hitchcock, A.S., 1950. Manual of grasses of the United States. United States Government Printing Office. p. 106. Washington, DC.

Hovin, A.W. 1957. Cytogenetic studies on reproduction in *Poa annua* L. Ph.D. diss. University of California at Los Angeles.

Hutchinson, C.S. and G.B. Seymour, 1982. Biological flora of the British Isles. J. of Ecol. 70:887-901.

Johnson, P.G. 1991. Factors affecting seed set in *Poa annua* L., using an excised stem technique. M.S. diss. University of Minnesota, St. Paul.

Johnson, P.G., B.A Ruemmele, P. Velguth, D.B. White, P.D. Ascher, 1993. An overview of the reproductive biology of *Poa annua.* p. 798-804. *In* Proceedings of the Seventh International Turfgrass Research Conference.

Koshy, T.K. 1968. Evolutionary origin of *Poa* annua L. in the light of karyotypic studies. Canadian Journal of Genetics and Cytology 10:112-118.

Law, R., A.D. Bradshaw, and P.D. Putwain, 1977. Life history variation in *Poa annua.* Evolution 31:233-246.

Lush, W.M. 1988. Biology of *Poa annua* in a temperate zone golf putting green (Agrostis stolonifera/*Poa annua*) II. The seed bank. Journal of Applied Ecology 25:989-997.

Lush, W.M., 1989. Adaptation and differentation of golf course populations of annual bluegrass (*Poa annua*). Weed Sci.ence 37:54-59.

Nannfeldt, J.A. 1937. The chromosome numbers of *Poa* sect. Ochlopoa A. & Gr. and their taxonomical significance. Botaniska Notiser 1937. 238-254.

Ruemmele, B.A., 1989. The reproductive biology of *Poa annua* L. Ph.D diss. University of Minnesota. St. Paul.

Sprague, N.B. G.W. Burton, 1937. Annual bluegrass (*Poa annua*) and its requirements for growth. New Jersey Agricultural Experimental Station Bulletin 630.

Till-Bottraud, I., L. Wu, and J. Harding, 1990. Rapid evolution of life history traits in populations of *Poa annua* L.. Journal of Evolutionary Biology 3:205-224.

Tutin, T.G. 1957. A contribution to the experimental taxonomy of *Poa annua* L. Watsonia 4:1-10.

Velguth, P.H. and D.B. White, 1993. The relative frequency of diploid and tetraploid *Poa annua* L. on selected golf courses in Minnesota. p. 165. In Agronomy Abstracts. ASA, Madison, WI.

Wallace, D.H., K.S. Yourstone, P.N. Masaya, and R.W. Zobel, 1993. Photoperiod gene control over partitioning between reproductive and vegetative growth. Theoretical and Applied Genetics 86:6-16.

White, D.B., and H. Kaewer, personal communication. D.B. White professor, H. Kaewer, adjunct professor, University of Minnesota, Dept. of Horticulture, 305 Alderman Hall, 1970 Folwell Ave. St. Paul, Minnesota 55108.