Study of Turf Management on Bluegrass Growth and Control

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The annual bluegrass *Poa annua* L. is a widespread weed of California turf and landscapes, especially home lawns, sports fields and golf greens. Thought to be of Mediterranean origin, this species is primarily a self-fertilizing inbred, with up to 15 percent outcrossing to different strains. Throughout the United States, researchers have sought effective control methods or means for adapting *P. annua* as a turfgrass. Perennial prostrate-growing strains, for example, have been suggested for use on golf greens. However, because of its lower resistance to drought and heat, a rapid deterioration of *P. annua* turf frequently occurs during dry, warm, summer months, creating serious problems for golf courses and other sports turf.

Breeding program attempts to select for heat resistance in *P. annua* indicated that that trait was not correlated with geographic distribution of *P. annua* populations grown in regions of high temperatures. The reason may be that plants complete their life cycle before the onset of heat stress, and heat resistance may be associated more with turf management practices than macroclimate differences. It is probable that regardless of improvements made to annual bluegrass through breeding and selection programs, the variability in annual bluegrass type will unfortunately ensure its continuance as a weedy grass problem. But this should not be a discouragement to future research in *P. annua*. Without knowledge of the interactions between the variable genetic characters and turf management practices, it is not possible to establish either an effective control or a breeding program for this species, and, therefore, it seems logical that future research should concentrate on identifying management practices that affect the genetic characters of this species.

Over the past four years, our research has used several approaches toward achieving an understanding of factors affecting *P. annua* growth, genetic differentiation and life history. Of various landscape situations, golf courses provide an ideal setting for study of *P. annua* populations, because different biotypes (groups of plants) can readily be identified in areas subjected to different turf management practices. The most distinct biotypes of *P. annua* are annual and perennial, with the annual often found in drier, less intensively managed areas, and the perennial commonly found in wetter, more highly managed areas. Additionally, in golf courses the two major management practices—irrigation and mowing—are performed with gradients of intensity.

We used *P. annua* populations from the Davis Municipal Golf Course as models to examine the effects of management practices and physical environmental conditions on the adaptation of this species. Our studies focused on: 1) seed dormancy and seed banks, 2) genetic differentiation and adaptation of life history traits, and 3) the effect of light conditions and growth regulators on growth of *P. annua* biotypes.

Seed Dormancy

We collected seeds of annual bluegrass from areas in the three golf course turf management categories: green, fairway, and rough. Management intensity decreases significantly from golf greens to fairways to roughs, while mowing height increases significantly from greens to roughs. We then conducted seed germination experiments to determine the effects of temperature on germination and correlation between field-collected seeds and greenhouse-produced seeds.

Seed germination was examined in 25°C and 12°C regimes, under 24-hour light in a growth chamber. After 20 days incubation, highly significant differences in germination rates appeared between the high and low temperature treatments and turf management categories. A positive, significant correlation in seed germination between the field-collected seed populations and their respective greenhouse-produced seed progenies was also observed. Under the 25°C regime, seed germination of the golf rough population was uniformly low, running less than 20 percent. Conversely, the germination of the golf green populations was high – greater than 80 percent. We found a wide range of seed germination among seed families of the fairway populations and highly significant statistical differences between turf management categories and between families within a management category. Under the 12°C regime, seed germination was uniformly high, and there was no distinguishable difference between the golf green and rough populations. These results indicate that the high-temperature-enforced seed dormancy differences among the golf course populations of *P. annua* are likely to be associated with the turf irrigation and mowing practices.

Variation in seed germinability in relation to temperature has been reported among populations of *P. annua*

Annual bluegrass plant from golf course rough area (left) is upright with few tillers and more flowering growth than the plant from the golf green (right) which is prostrate with profuse tiller branching.

collected from a wide range of geographical areas. The differences in seed germination behavior at the microecological level found among the golf course populations raises the important possibility that temperature acts as a signal that triggers seed germination and maximizes the chance of survival. *P. annua* in the golf course rough areas is not able to survive through the warm dry summer months of California's Central Valley. Seeds may occasionally receive water from runoff or drift, but if they germinate, the water supply will not be sufficient to support the plants throughout their life cycle. Since seasonal temperatures in the California Central Valley change in a regular and predictable pattern inversely correlated with precipitation, it is not surprising that the seed germination of the rough populations is controlled by temperature rather than by moisture.

P. annua populations on golf greens, however, receive frequent irrigation, and may germinate at any time of the year and be guaranteed to have favorable moisture conditions for their survival. Temperature-dependent seed germination would therefore be disadvantageous to the golf green populations.

The bimodal distribution of seed germination found in the fairway populations suggests that the fairway is a heterogenous habitat rather than an intermediate environment between the golf green and rough populations. Other researchers have reported evidence for this form of selection in *P. annua* growing on lawn bowling greens subject to clipping and in adjacent flower beds.

We can speculate that selection for temperature-enforced seed dormancy has been operating among the golf course annual bluegrass populations.

P. annua Life History Characters

Plants collected from two sites—a green and a rough—were grown in similar but different greenhouses to prevent cross-fertilization between biotypes by air currents. We allowed each biotype to produce seed, and after further inbreeding we grouped each into families. After germination, seedlings were grown in a growth chamber at 17°C days and 14°C nights with a 12-hour photoperiod. We harvested half of the plants in each family at flowering and the remainder at maturity, which we arbitrarily designated as 60 days after the first spike appeared. For both stages we recorded data on: flowering time (number of days from germination to flowering), number of tillers and inflorescences, number of nodes per flowering tiller, and dry weight partitioning (amount of dry weight allocated to different organs of the plant) of vegetative and reproductive tissues.

Green and rough populations of *P. annua* differed markedly for all traits except flowering time. The flowering and reproductive characters at maturity were greater in the rough population, while the number of vegetative tillers was greater in the green population. The reproductive output was greater in the rough population, and plants had more tillers, more nodes per tiller, more inflorescences and greater dry weight. Comparisons of life history characters within families show that genetic variation is usually much greater in the green population than in the rough population, while variations among families is much greater in the rough than in the green population. The total genetic variation is almost always greater in the rough than in the green population.

In *P. annua,* young shoots develop at the nodes of the crown (unelongated stem) and at the nodes of prostrate tiller shoots. Since the number of nodes per shoot is distributed from the base of the shoot to the tip, younger shoots have fewer nodes. The ability to develop shoots from crown nodes and tillers was found to be much greater in the rough population than in the green population. Flowering was also more abundant in the rough population.

Most of the life-history characters measured were highly heritable, indicating that a substantial portion of the variability observed between populations of *P. annua* is of genetic origin. The most probable explanation for the genetic differentiation recorded in the present study is selection generated by turf management practices.

P. annua from high adult mortality environments (rough) has a tendency towards an annual life-history strategy, whereas plants from high juvenile mortality environments (green) have a perennial life-history strategy. The golf green population could have been derived from the rough population on the golf course in this study, an evolution which must have been very fast as this golf course was not more than 25 years old. This may indicate that for *P. annua*, selection forces of turf management act through both physiological and developmental constraints, and these constraints can channel evolution of this species to very localized biotypes.

Effect of Light Conditions and a Growth Regulator on Growth and Dry Weight Partitioning

The chemical Paclobutrazol is used in landscape plant management to restrict plant growth. Because in many instances *P. annua* tends to thrive more in shade than in sun, we investigated effects of both the growth regulator and shade on *P. annua* growth. Plants of both green and rough biotypes were grown in the greenhouse under nine treatments which combined various light intensities and the growth regulator strengths. The first application of Paclobutrazol was at the beginning of the experiment, and the second application was six weeks later. We harvested plants at the end of 12 weeks growth, and examined dry weights of shoots, roots, and inflorescences.

Genetic differentiation in root mass production was found among annual bluegrass biotypes (botanical garden biotype is on the left and golf green biotype is on the right). Rooting differences may be important for annual bluegrass control.

Plants from golf greens produced greater total plant dry weight than rough biotypes under all light and growth regulator treatment combinations. Reducing light intensity from full to one-half-full sunlight increased total dry weight for both the green and the rough biotypes. Paclobutrazol treatment reduced dry weight for both the green and rough biotypes. With Paclobutrazol treatment, both biotypes produced more dry weight under low light than under high light intensities. Lower light intensity and growth regulator treatments increased inflorescence dry weight of the rough biotype, but had no significant effect on the green biotype. Root growth was reduced, but the dry weight ratio from root to shoot was increased. Overall, root growth was less affected by the growth regulator than shoot growth for both biotypes.

Both the golf green and rough biotypes were grown in 15-centimeter-diameter-by-16-centimeter-deep pots and in greenhouse soils. The plants were kept in the experimental garden and irrigated and fertilized regularly under favorable growth conditions. The golf green biotype produced greater root mass than the rough biotype. When the day length increased in May, nearly all the rough biotype tillers produced inflorescences and became senescent, but the golf green biotype remained vegetative.

Conclusions

A large component of genetic variation was found for various vegetative and reproductive traits of P. *annua*, and indicates that the perennial (golf green) populations are derived from the annual populations (rough). This evolutionary change has been very rapid, suggesting the reason why P. *annua* is a widespread weed in landscapes. Also it indicates that selection for better turfgrass characters in P. *annua* is possible.

Irrigation and mowing practices and temperature and rainfall act as selection forces which maintain a distinct genetic difference in seed germination among P. *annua* populations and biotypes at the microecological level. For sports turf management, knowledge of the seed germination characteristics is critical for establishing a pre-emergence herbicide weed control program.

Research on the effects of light conditions and growth regulator treatment on growth and dry weight partitioning indicate different responses between the annual and perennial biotypes. This information is of value for P. *annua* control and turf management.

The growth regulator Paclobutrazol can effectively inhibit P. *annua* growth. However, it should be used with extreme caution, because it may cause severe damage to existing turfgrass. More research is needed to discover differential response to this growth regulator among turfgrass species before it can be recommended for P. *annua* control in existing turf.

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