HEAT STRESS, NOT ANTHRACNOSE IS SCOURGE OF POA ANNUA

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The distribution of annual bluegrass is worldwide. A native of Europe, it is also found in North Africa, Northern Asia, Australia, North America, South America, and within the Arctic Circle. On the North American continent, it is found from Newfoundland and Labrador west to Alaska — and south to California and Florida. In the areas mentioned, it is a fact of life in both professionally managed and homeowner maintained stands of turf and lawn grasses. In these situations, its degree of acceptance ranges all the way from (i) it is a weed to be controlled, to (ii) it is a valuable, if not necessary, component of the existing turf, and, therefore, a species to be nurtured in such a manner that its tenure in the area will be a long one.

Those who consider annual bluegrass to be a weed point to its lack of persistence during periods of high air temperatures. The general approach to its culture from this school of thought is to "get rid of it before it dies and leaves the area in which it was growing a beautiful display of dirt."

In the past few years, there has been a significant effort put forth to support the view that annual bluegrass is an important component of the existing turfs in the temperate zones of North America. Furthermore, it is advocated that through certain management practices, its pattern of growth can be stabilized to the extent that it can be just as reliable, if not more so, than the commonly cultivated temperate zone turfgrasses. The major thrust of this thinking has been directed toward the control of anthracnose — the theory being that this particular disease is the primary cause of death of annual bluegrass during the summer months. Consequently, if anthracnose is controlled, and a prescribed fertilization and watering program is followed, annual bluegrass can be grown successfully during this time period (8, 9).

The purpose of this paper is to (i)) review the present state of knowledge of the patterns of growth of annual bluegrass under various management stresses and those from the physical environment, (ii) outline our present understanding of the nature of anthracnose as it occurs on annual bluegrass, and then, from this background, determine if we can unequivocally state whether or not the major contributing factor to the commonly occurring death of plants of this species during the warm summer months is heat, anthracnose, or varying combinations of these and other stress factors.

The Nature of Annual Bluegrass

Annual bluegrass is a hybrid between *Poa supina*, a creeping perennial that is commonly found in the mountainous regions of Central and Northern Europe, and *Poa infirma*, an upright growing annual that inhabits warm, low-lying areas

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of much of the Mediterranean region. Its growth pattern as a winter annual was recognized when it was given the botanical name *Poa annua* by the Swedish biologist Carl Linnaeus in 1743. It is usually self pollinated, but does cross pollinate. The hybrid nature of annual bluegrass, and its capacity to cross pollinate within the species, has given rise to a large number of subspecies (ssp.) that differ in their appearance, growth habit, and capacities to respond to various environmental stresses. To date, 48 district subspecies of annual bluegrass have been described, and it is highly possible that there are many more left to be described (4).

Two commonly occurring subspecies of annual bluegrass are *Poa annua* ssp. *annua* and *Poa annua* ssp. *reptans*. The variant *Poa annua* ssp. *annua* has a tufted, bunch type of growth habit. Its root system is not as fibrous as that of *reptans* and it has fewer adventitious roots. Also, in comparison with *reptans*, it has fewer leaf and node numbers and less secondary tillers. The subspecies *annua*, however, is a higher producer of seed than is *reptans* (7).

Poa annua ssp. *reptans* is the variant most commonly found in close clipped, irrigated, high managed areas such as putting greens. Its growth habit is creeping. Rooting occurs at the nodes of prostrate tillers. The subspecies *reptans* is not shallow rooted. Rather, its root system is highly fibrous and its depth of rooting compares favorably with Kentucky bluegrass and bentgrass. Also, this particular variant compares favorably with other temperate zone grasses in its ability to root in compacted soils. Furthermore, under close cut, irrigated turfgrass cultural conditions, it is capable of forming a dense, uniform quality of turf. If its ability to survive during the stress periods of either summer or winter seasons could be enhanced, it would add much to the stability of turf quality in many sections of North America.

The response of annual bluegrass to management and environmental stresses has been studied, and comparisons made with other temperate zone grass species growing under the same set of conditions. The specific factors that have been considered are: low temperature hardiness, response to high air temperatures, response to high and low soil temperatures, wilting tendency, submersion tolerance, response to soil moisture stress, tolerance to smog, shade adaptation, and wear and compaction tolerance.

In comparison with the other temperate zone grasses, the low temperature hardiness of annual bluegrass is intermediate. It is equal to that of creeping red fescue and tall fescue, and is more winter hardy than perennial ryegrass. However, it is more prone to low temperature kill than Kentucky bluegrass, creeping bentgrass, or colonial bentgrass (1). It has been found that the specific killing temperature varies between the seasons. In late fall, annual bluegrass will be killed from a 5-hour exposure to a soil temperature of -5°F, while in early spring, it is killed after a 5-hour exposure At + 5°F. Also when annual bluegrass is growing on poorly drained soil, it is much more prone to low temperature kill (2).

The basic growth pattern of annual bluegrass is directly related to soil temperature. At cool soil temperatures, the tillers grow horizontally, while at high soil temperatures, they grow more upright. Also, at high soil temperatures the amount of tillering is significantly reduced (5). The capacity of annual bluegrass to form a dense turf, then, decreases proportionately with corresponding increases in soil temperature.

The hybrid nature of annual bluegrass, and its capacity to cross pollinate within the species, has given rise to a large number of subspecies with different appearance, growth habits, and stress responses.

Another effect of increasing soil temperatures is a progressive reduction in the growth rate of the root system of annual bluegrass. When the soil temperatures reach 75°F, the root systems become thinner and change in color from white to light brown. When the temperature reaches 85°F, they become even thinner and take on a darker brown color. The root growth of creeping bentgrass, on the other hand, continues at the same rate throughout the soil temperature range of 60°-80°F. In comparison tests, it has been shown that Penncross roots grow faster in the 55°-85°F soil temperature range than do those of annual bluegrass (5). This means that at the higher soil temperatures, all other conditions being equal, the creeping bentgrasses have a distinct, competitive advantage over annual bluegrass.

At higher soil temperatures (75 to 85° F) creeping bentgrass has a distinct competitive advantage over annual bluegrass.

Variability exists both among and within the various subspecies of annual bluegrass in their capacity to withstand the stress of high air temperatures. In a study on the effect of a series of 95°F days and 65°F nights on the growth reduction of 'Baron' and 'Fylking' Kentucky bluegrass, 'Jamestown' red fescue, 8 selections of *Poa annua* ssp. *reptans*, and 1 selection of *Poa annua* ssp. *annua*, Duff (3) found that they could be grouped as follows: (i) 5 of the selections of *Poa annua* ssp. *reptans* ranked with the 2 varieties of Kentucky bluegrass as the most heat tolerant, (ii) the remaining 3 *reptans* selections ranked second in their resistance to high temperature stress, (iii) the selection of *Poa annua* ssp. *annua* tested ranked third in heat tolerance, but only slightly above (iv) the red fescue, which was fourth, and, therefore, the entry that showed the greatest degree of growth reduction due to high temperature stress.

Variability in susceptibility to high air temperature stress is also known to exist among certain varieties within the various species of temperate zone turfgrasses. However, when the total amplitude of the individual varietal responses within a species is taken into consideration, it has been found that it is valid to characterize individual species on the basis of their "collective" response. When annual bluegrass as a species, then, is ranked with the various temperate zone turfgrass species with respect to the collective capacity of its individual variants to withstand the stress of high air temperatures, it falls in the poorest grouping. Basically, its heat tolerance is equal to that of creeping red fescue and perennial ryegrass, and it is significantly inferior to tall fescue, the bentgrasses and Kentucky bluegrass (1).

In our laboratory, we have observed that high air temperature stress produces two types of leaf symptoms in annual bluegrass. Continued exposure of the plants to a daytime temperature of 95°F and a night temperature of 75°F produces a chronic symptom pattern. This is seen as a leaf tip dieback that begins as a light yellow color which gradually changes to brown and then becomes light tan to strawcolored. When the plants are given a short term exposure to higher temperatures, an acute symptom pattern develops. In these instances, the entire leaf first becomes dark green to purple, and then withers and fades to a light tan.

Annual bluegrass grown under high nitrogen fertilization is more prone to injury from high air temperature than when it is grown at low nitrogen (5, 6). Also, when annual bluegrass is under high nitrogen fertilization, it produces significantly fewer seed heads than plants under normal or low nitrogen nutrition (6). Nitrogen fertilization levels, then, are important factors in the capacity of annual bluegrass to survive high air temperature stresses within a given growing season, and to perpetuate itself from one season to the next.

Annual bluegrass does not compare favorably with other temperate zone grasses with respect to its tolerance to either excess or deficient soil moisture. Its submersion tolerance is better than that of red fescue and equal to perennial ryegrass. However, its capacity to survive extended periods of exposure to excess soil and free surface water is less than that of Kentucky bluegrass, tall fescue or creeping bentgrass. The wilting tendency of annual bluegrass is higher than red fescue, Kentucky bluegrass, creeping bentgrass, or perennial ryegrass (1). Also, the capacity of annual bluegrass to withstand periods of drought is less than any of the other temperate zone grasses (1, 11).

Annual bluegrass grown under high nitrogen fertilization is more prone to injury from high air temperature.

In comparison with Kentucky bluegrass, creeping bentgrass, and perennial ryegrass, annual bluegrass has the poorest tolerance to smog. Also, in its capacity to withstand the direct effects of traffic on the destruction of the vegetation (i.e., crushing and shearing off of leaves and stems and crushing of crowns), annual bluegrass is the poorest of the temperate zone grasses (1).

The relative shade adaptation of annual bluegrass is very good. In this capacity, it ranks only below red fescue and is equal to creeping bentgrass and tall fescue. Its tolerance to soil compaction is also good. The capacity of annual bluegrass for root development in compacted soils is equal to that of perennial ryegrass and better than red fescue, Kentucky bluegrass or creeping bentgrass (1).

By assigning a numerical value to each of the descriptive adjectives used above to compare relative responses to specific environmental stresses (i.e., excellent = 4, good = 3, fair = 2, poor = 1), and then calculating the sums of these values for each species, it is possible to rank annual bluegrass with other temperate zone grasses on the basis of its capacity to respond to the integrated stress effects of shade, smog, wilting, low soil water, excessive soil water, wear, high and low air and soil temperatures, and soil compaction. This potential for response to integrated environmental stress effects is known as the Relative Mortality Potential. Simply stated, the Relative Mortality Potential is a comparison with other grasses of the ability of a given species to survive environmental stresses. A species with a high Relative Mortality Potential, for example, is more likely to thin out, if not completely die out, due to integrated environmental stresses than is one with a low Relative Mortality Potential. These comparative rankings for annual bluegrass and 5 other temperate zone grass species are given in Table 1. On the basis of this comparison, annual bluegrass is the species that is least likely to survive the pressure of integrated environmental stress.

Table 1. Relative Mortality Potential of Certain Temperate Zone Grasses.

HIGH	1. Annual Bluegrass
	2. Perennial Ryegrass
	3. Creeping Bentgrass
	4. Kentucky Bluegrass
	5. Creeping Red Fescue
LOW	6. Tall Fescue

The Nature of Anthracnose

Anthracnose is an important and widespread disease of maize, sorghum, wheat, oats, barley, and rye. The nature of the disease on these crops has been researched rather thoroughly. The pathogen has been identified as the fungus *Colletotrichum graminicola*, and the means by which it parasitizes these particular plant species and the factors that contribute to the outbreaks of epidemics are fairly well defined.

The nature of anthracnose on turfgrasses, on the other hand, is not well understood. To date, the pathogenic potential of *Colletotrichum graminicola* on turfgrasses has only been subjected to one comprehensive study. In the report of the results of this research, the author stated that while several varieties of seedling bentgrass were susceptible to infection by *Colletotrichum graminicola*, mature grasses, inoculated in a variety of ways, never developed symptoms of the disease. Furthermore, she pointed out that while ". . . the fungus has been conspicuous in dead or injured turf, which harbored other fungi known to be pathogenic . . . the author has never found a clear-cut case of turf disease that could be attributed to *C. graminicolum* alone." As a result of this research, she concluded that "*Colletotrichum graminicolum* is a saprophyte, growing in soil and on dead and diseased grass tissues. It is not pathogenic on mature turf" (10).

The research described above was limited to testing the pathogenic potential of *Colletotrichum graminicola* on bentgrass, Kentucky bluegrass, and tall fescue. It did not include annual bluegrass. To date, no research has been reported in which inoculation experiments were carried out to test whether or not this particular fungus can actually infect annual bluegrass. All reports purporting

Continues on page 54

Poa Annua

from page 50

pathogenicity have been based on observations from the field of the association of Colletotrichum graminicola with dead and dying annual bluegrass. In other words, the pathogenicity of *Colletotrichum graminicola* on annual bluegrass has yet to be shown by the widely accepted laboratory procedure of isolation of the fungus, inoculation of plants,, observation of symptoms, and then re-isolation of the fungus. All of what we feel that we know about anthracnose on turfgrass in general, and on annual bluegrass in particular, then, has been gained through apocryphal statements, field observations, and interpolations from research conducted on the disease as it occurs in cereal crops. Furthermore, a systematic field study has never been conducted to determine the exact distribution of *Colletotrichum graminicola* within the annual bluegrass growing region of the North American continent. This means that not only are we lacking in substantive knowledge of the pathogenicity of anthracnose and its potential for killing out stands of annual bluegrass, but, also, we do not know whether the fungus *Colletotrichum graminicola* actually exists in a high percentage of the areas in which the summer dying-out of annual bluegrass occurs.

> Annual bluegrass is least likely to survive the pressure of intergrated environmental stress

Is it Anthracnose or is it Wilt?

We now come to the bottom line. The question is, when annual bluegrass dies during warm, humid weather, is the cause of this death anthracnose, wilt, or a number of interacting factors? Furthermore, if these stress factors are lethal, are they necessarily the same from one area to the next, or from one warm season the next?

The lethal effects of high temperatures on annual bluegrass are well documented. When compared with the more commonly grown temperate zone grasses, its heat hardiness ranks among the poorest. Depending on the range and duration of the day-night air temperature patterns, the progress of the deterioration of the plant may be either rapid or slow. In the final analysis, however, the fact remains that even with the more heat tolerant strains, heat stress alone is capable of either killing annual bluegrass outright or significantly reducing its capacity to compete successfully for the same growing space with the other temperate zone grasses. Furthermore, while it is more tolerant than certain other temperate zone grasses to some of the other environmental stresses, when compared to them with respect to its capacity to survive the collective and continuing pressures of these various stresses, annual bluegrass has the poorest potential for survival.

Our working knowledge of the nature of anthracnose on annual bluegrass, on the other hand, is very limited. In addition to the lack of information on its pathology, we do not know whether the disease actually occurs in all of the areas of the North American continent characterized by the summer dying-out of annual bluegrass. If this were actually to be the case, it would indeed be a very unique circumstance, for it would be the only disease of turfgrasses that is of major importance uniformly throughout this total area.

The capacity of annual bluegrass to withstand periods of drought is less than any of the other temperate zone grasses.

Also, it would be the only turfgrass disease that is both epidemic and severe in its outbreak each year. The likelihood of this being the case for anthracnose is extremely remote.

Based on what we know about both the nature of annual bluegrass and the various disease and environmental stress factors that attend its growth, it is both simplistic and highly unrealistic to try to designate any one of these as the universal and continuing cause of its death during warm weather. However, as we look to these various factors, certain of them can be ranked as more significant in their impact on the longevity of annual bluegrass than others. In reviewing the research information we now have, there is not sufficient data to establish anthracnose as a major factor, contributing in its own right either the widespread or local dying-out of stands of annual bluegrass. On the other hand, with the knowledge we have of the relative susceptibility of annual bluegrass to heat stress, it would seem reasonable to assume that of all the stress factors, on a year-to-year basis, high temperature is probably the most frequent, if not the most important, single cause of the death of annual bluegrass during the summer season.

Not only are we lacking in substantive knowledge of the pathogenicity of anthrachose to annual bluegrass, we do not know if it exists in significant numbers in areas where dying-out occurs.

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