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CLIMATIC ADAPTABILITY OF ANNUAL BLUEGRASS IN OHIO USING GROWING DEGREE-DAYS[1]

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ABSTRACT. Annual bluegrass (*Poa annua* L.) is a major turfgrass species in Ohio. Its reported poor heat tolerance makes it a difficult turfgrass species to maintain in areas where periods of high temperatures exist. The purpose of this study was to determine areas in Ohio based on growing degree-days where annual bluegrass is adapted. Thirty-year averages of minimum and maximum daily temperatures from 15 locations were used. A BASIC computer program was written to calculate and accumulate growing degree-days (GDD) and temperature stress degree-days (TSDD) using a sine curve as an approximation of the diurnal temperature curve. Based on TSDDs, annual bluegrass was best adapted to northern Ohio and least adapted to southern Ohio. In this study, TSDDs were useful in determining regions of annual bluegrass adaptation. Scientists involved in determining climatic regions of plant adaptation may want to consider using TSDDs as a method for quantifying temperature effects.

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INTRODUCTION

Annual bluegrass (*Poa annua* L.) is a cool season grass best adapted to the northern United States and Canada. It is found on golf courses throughout Ohio. Annual bluegrass forms a dense, uniform quality turf under irrigated, close cut cultural conditions (Beard 1973). The ability of annual bluegrass to adapt to low mowing heights makes it an excellent turfgrass species for golf course greens, tees, and fairways (Bogart and Beard 1973, Youngner 1959).

A major limitation of annual bluegrass as a turf is its poor tolerance to high temperature stress (Bogart 1972, Carroll 1943, Fischer 1967). This limitation makes annual bluegrass management difficult in the southern region of the northcentral United States. Additional difficulty in determining the tolerance of annual bluegrass is the variability in annual bluegrass biotypes (Beard et al. 1978). Poor stress tolerance is a critical factor in deciding whether annual bluegrass should be maintained as a desirable turfgrass species or eliminated and the site reseeded with a more heat tolerant turfgrass species. This decision should be based upon the adaptability of annual bluegrass to the various climatic regions in Ohio.

Temperature is a major classification scheme for defining climatic patterns (Ibrahim and Dennis 1982, Richardson et al. 1974). Although a climatic region is composed of a number of meteorological elements, the use of one element eliminates overlapping and transition zones (Fairbridge 1967).

Heat accumulation units or growing degree-days are used for studying plant-temperature relationships by computing accumulated daily mean temperatures above a threshold during a growing season (Wang 1960). Agricultural researchers have used growing degree-days to measure or predict temperature effects on biological processes (Arnold 1974, Danneberger and Vargas 1984, Eisensmith et al. 1980, Gilmore and Rogers 1958, Thornthwaite 1948). Baskerville and Emin (1969) have proposed a method by which the useful range of growing degree-days can be extended to allow for the introduction of an upper temperature threshold. This allows the researcher to incorporate high tem-

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perature effects on the accumulation of growing degree-days.

The purpose of this research is to identify areas of Ohio where annual bluegrass primarily the annual type (*Poa annua* var *annua*), based on temperature, is best adapted for golf course conditions.

METHODS AND MATERIALS

Minimum and maximum daily temperatures from 15 locations in Ohio were used. The minimum and maximum daily temperatures were 30-yr averages from 1941 to 1970 (Anon. 1974). A BASIC computer program written for an IBM personal computer was used to calculate growing degree-days according to the method described by Baskerville and Emin (1969), which assumes the sine curve as an approximation of the diurnal temperature curve. The equation used was:

$$\text{growing degree-days (GDD)} = [1/\pi] \cdot \left[w \int_{\theta}^{\pi_2} \sin t \, dt - \int_{\theta}^{\pi_2} (Kl - m)\, dt \right]$$

where w = maximum temperature (°C) − minimum temperature divided by 2; Kl = base temperature; m = maximum temperature + minimum temperature divided by 2; and t = a 24-hr period. The minimum temperature for growth or base temperature was 13°C (Bogart 1972).

The equation used to calculate temperature stress degree-days (TSDD) was:

$$\text{TSDD} = \text{GDD} - \text{GDD}'$$

where GDD′ was equal to growing degree-days with an upper temperature threshold. No growing degree-days are accumulated for the period when the temperature exceeds the upper threshold (*K2*). The growing degree-days with an upper threshold temperature were calculated using the same method as described previously except the equation used was:

$$\text{GDD}' = [1/\pi] \cdot \left[w \int_{\theta_1}^{\theta_2} \sin t \, dt - 1/2 \int_{\theta_1}^{\theta_2} (2Kl\text{-max-min})\, dt \right]$$

This computation is shown graphically by Baskerville and Emin (1969).

Two upper threshold temperatures (*K2*)—27 and 30°C—were evaluated. These two temperatures provide two levels at which detrimental effects occur to annual bluegrass. The first temperature reflects a reduction in normal plant function. Annual bluegrass roots turn a distinct brown once the temperature is at or above 27°C (Bogart 1972). The second, temperature (30°C or greater) causes annual bluegrass plants to mature and die rapidly (Carroll 1943).

RESULTS

The number of growing degree-days (GDD) for annual bluegrass increased from north to south in Ohio (fig. 1). The GDD ranged from 2229 in Cleveland to 3098 in Cincinnati.

Calculation of temperature stress degree-days (TSDD) using 27°C as the upper cutoff limit resulted in the same general trend as GDD (fig. 2). Cleveland had the fewest number of TSDD (0). Cincinnati had the most TSDD (>351). For Cincinnati, TSDD represented 24% of the total number of GDD.

Using the cutoff temperature of 30°C where annual bluegrass maturation and death occurs, southern Ohio had the greatest number of TSDD (fig. 3). Cincinnati again had the greatest number of TSDD (317).

DISCUSSION

Annual bluegrass adaptability as a golf course turfgrass species varied based on temperature. The northern portion of Ohio, based on TSDD, is favorable for annual bluegrass growth and development. No TSDDs were accumulated for either the 27 or 30°C upper temperature threshold along the northeastern part of Ohio. This could be due to the moderating effect that Lake Erie has on temperature and possible altitude and topography effects. Central Ohio is more high temperature stress prone than northern Ohio but it is still in the region where annual bluegrass can be maintained. This conclusion is based on the fact that no TSDDs were accumulated at the 30°C cutoff temperature where annual bluegrass death can occur. Southern Ohio, specifically the Cincinnati area, had the greatest number of TSDD at either 27 or 30°C. In this area, annual bluegrass management should be cautiously under-

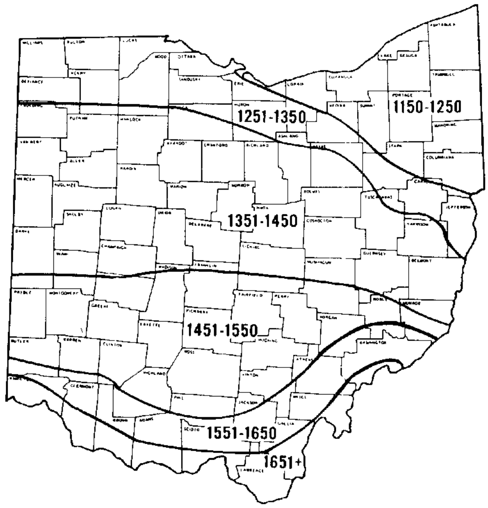

FIGURE 1. Growing degree-day accumulation for annual bluegrass in Ohio using 13°C as a base temperature.

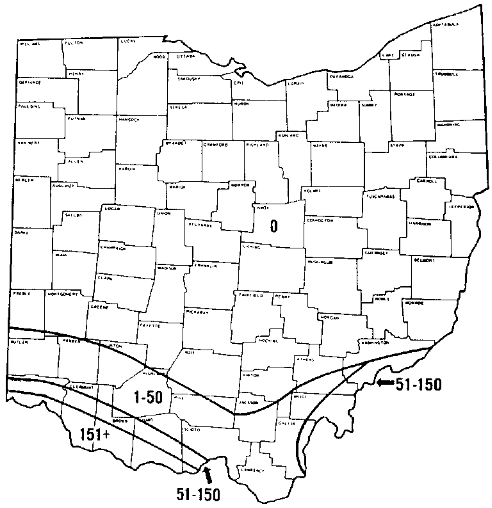

FIGURE 3. Temperature stress degree-day accumulation for annual bluegrass in Ohio using 30°C as the upper threshold. This temperature represents the threshold at which annual bluegrass death can occur.

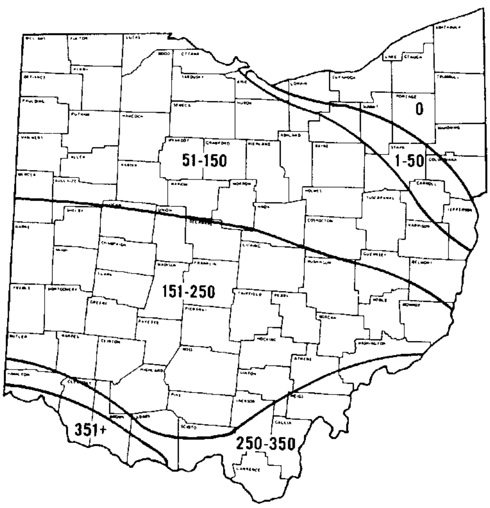

FIGURE 2. Temperature stress degree-day accumulation for annual bluegrass in Ohio using 27°C as the upper temperature threshold. This temperature threshold represents the temperature at which annual bluegrass roots begin to discolor.

taken given the number of TSDD accumulated. Serious consideration should be given for establishing a more heat-tolerant turfgrass species.

The range of annual bluegrass adaptability is not only influenced by temperature but by a number of other environmental factors. For example, the cooling effect transpiration has on the turf canopy is influenced by atmospheric vapor pressure, wind, water absorption rate and soil moisture tension. These factors need to be considered when determining adaptability of annual bluegrass for specific locations. However, for defining climatic regions the use of one climatic variable is most meaningful (Fairbridge 1967). In this study, the calculation of TSDDs was a useful method for determining regions of high temperature stress. The temperatures used in this study were 30-yr averages. Yearly temperature ranges may vary from this average resulting in longer or shorter periods of heat stress than otherwise expected. Turfgrass management practices such as disease and insect control, fertilization and proper irrigation practices will influence the survival of annual bluegrass at high temperatures (Beard et al. 1978, Danneberger et al. 1983). If these management practices are not properly followed, the additional heat stress load will render annual bluegrass unsuitable as a turfgrass. For example, inadequate irrigation, resulting in moisture stress will compound any stress due to heat.

This study attempts to show the areas in Ohio based on historical temperature data where annual bluegrass is adapted. Yearly conditions will vary, but historically, annual bluegrass is adapted as a fine turfgrass species to the northern two-thirds of Ohio if proper annual bluegrass management is practiced. In southern Ohio, annual bluegrass is not as adaptable, and its management will be very difficult.

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