Temperature Effects on Seed Production in Tall Fescue

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Abstract

Tall fescue (*Festuca arundinacea* Schreber) seed yields in the cooler climate of Oregon are generally greater than seed yields in the warmer climate of Missouri. Differences in yield between the two locations are probably due to both climatic and cultural factors. We were interested in determining if temperature alone affects seed production of tall fescue. Fifteen ramets from each of 8 randomly chosen genotypes were removed from a spaced-planted 'Kentucky-31' tall fescue nursery in early spring prior to development of reproductive culms. Five ramets of each genotype were placed into one of three growth chambers set to a day/night temperature regime of 27/22 ºC, 22/17 ºC, or 17/12 ºC, selected to represent growing conditions in Missouri, an intermediate temperature range, and the seed production area of Oregon, respectively. Plants grown at warmer temperatures had more internodes per panicle and wider flag leaves. Plants grown at the coolest temperatures, however, had longer panicles and flag leaves, more seeds per panicle, heavier seeds, and greater seed yields per panicle and per plant than those grown at the warmest temperatures. Temperature appears to be an important factor in determining the seed production potential of tall fescue with cooler temperatures promoting increased seed yields.

Introduction

Tall fescue (*Festuca arundinacea* Schreber) was first introduced in the U.S.A. in the late 1800s from Europe as a replacement for declining populations of meadow fescue, *Festuca pratensis* Hudson (Buckner et al. 1979, Terrell 1979). It is a highly adaptive, cool-season perennial bunchgrass with high nutritive content and good seed production. Since its introduction, it has become widely distributed across much of the eastern and central U.S.A., as well as some intensive production regions in the Pacific Northwest (Buckner et al. 1979), but its intolerance to extreme temperatures and drought restrict its wide use in extremely northern latitudes, at higher elevation, and in the desert Southwest. However, recent work suggests that tall fescue can grow quite well in certain Canadian provinces (previously thought to be beyond the northern edge of tall fescue's distribution), and that it's spread throughout Canada is more limited by summer drought than winter coldness (Fairey and Lefkovitch 1993, 1998). It is the most widely used cool-season perennial in the Midwest because of its ability to produce good forage growth during the cool spring months and then resume growth in the fall after a brief senescence during the hot, dry summer months (Matches 1979, Sleper and Buckner 1995). Frequent defoliation, either by manual mowing or grazing, often results in production of dense, turflike sods (Sleper and Buckner 1995).

'Kentucky-31' was one of the first tall fescue cultivars to be officially evaluated and released for forage production (Buckner et al. 1979). By the 1950s and 1960s, additional cultivars of tall fescue had become available, but KY-31 continued to dominate the majority of tall fescue pastures, especially in the region known as the "central transition zone" where much of the country's forage fescue is currently grown (Sleper and Buckner 1995). Seed production in this zone is simply a natural by-product of growing tall fescue for use as forage in extensive livestock growing regions of the Midwest. The majority of certified seed of forage and turf tall fescues is produced in the Pacific Northwest, primarily in Oregon (Youngberg and Wheaton 1979, Sleper and Buckner 1995). Prior to 1983, almost all production of tall fescue was of forage cultivars. However, the introduction of turf-type cultivars has led to a rapid shift in production (Young 1997). Tall fescue remains green during the dry summers in Oregon, which has a natural climatic advantage in that it provides mild, wet winter and spring months to promote grass growth and dry, low-humidity summer months, which favor harvesting clean, high-germination seed (Buckner et al. 1979, Youngberg and Wheaton 1979).

In the Midwest, tall fescue begins to produce reproductive panicles in mid to late spring that will eventually lead to formation of seed. Panicle development and seed development usually require about 2 months, with seed generally harvested no later than mid-June. By early July, tall fescue has dropped all of its seed and goes into a dormant stage until September and can be clipped or grazed for hay. Fall regrowth can be used for fall or winter grazing, but this management system results in much lower seed yields (Youngberg and Wheaton 1979).

It has generally been accepted that the peak seed production for tall fescue would be at a medium or lower temperature because decreases in temperature have previously been shown to increase flowering (Templeton et al. 1961b). Van Keuren and Canode (1963) suggested that tall fescue requires warm temperatures and long day lengths to produce sufficient vegetative material prior to flower induction, but flowering was only induced when day lengths were short and temperatures were 5 to 10 ºC. However, the majority of seed production still occurs in early summer in the central transition zone (Sleper and Buckner 1995, USDC 1994).

Tall fescue seed yields in commercial seed production fields in Oregon are generally greater than seed yields obtained from pastures harvested for seed in Missouri. Differences in seed yields could be due to differences in production practices

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and/or climate differences between the two locations. Our objective was to determine if temperature affects seed production of tall fescue. The temperatures were selected to represent Missouri, Oregon, and an intermediate range.

Materials and Methods

Fifteen ramets from each of 8 randomly chosen genotypes were removed from a spaced-planted Kentucky-31 tall fescue nursery at the University of Missouri Bradford Farm facility near Columbia, Missouri in early spring prior to development of reproductive culms. Each ramet was transplanted into separate pots. Five ramets of each genotype were placed in each of three growth chambers set to three day/night temperature ranges similar to temperatures that occur during periods of seed production in Missouri (27/22 °C), Oregon (17/12 °C), and an intermediate temperature (22/17 °C). Thus, there were 40 observations in each temperature treatment.

Plants remained in the growth chambers until panicles were produced and removed when the seeds were mature. Culms were harvested from each ramet, the number recorded, and air dried. The length of the panicle was measured from the peduncle internode to the tip of the panicle and the number of internodes per panicle counted. The panicles were separated from the culm at the peduncle internode and weighed with the seed. The length and width of the flag leaf were measured. The flag leaf area was estimated by multiplying the length times the width at the midpoint by 0.905 (Kemp, 1960).

Seeds were hand threshed from each panicle and the total seed weight determined. The weight of 100 seed was measured and the number of seed per panicle was calculated by dividing the seed weight per panicle by the 100-seed weight and multiplying by 100. The seed yield per plant was calculated by multiplying the seed weight per panicle by the number of panicles per plant.

The data were analyzed using the Statistical Analysis System (SAS) (SAS Institute, 1985) to perform ANOVA (SAS, Proc. GLM). The experiment was analyzed as a randomized complete block design with a split-plot arrangement. The main plot was temperature and the sub-plots were genotype and temperature x genotype. There were no differences among genotypes so data were pooled within temperature treatments. Fisher's Least Significant Difference (LSD) tests were performed to test for differences between temperature treatments, $P \leq 0.05$.

Results

At the coolest temperatures, which were selected to represent Oregon, the panicles were longer and heavier than panicles produced at the warmest temperatures, which were selected to represent Missouri (Table 1). Panicles from the coolest temperature treatment were over twice as heavy as panicles from the warmest temperature treatment (0.41 g and 0.19 g,

Table 1. Panicle and flag leaf measurements of tall fescue genotypes grown in growth chambers under three temperature treatments.

	Temperature ° C (day/night)		
	27/22	22/17	17/12
Panicle length (cm)	16.6b†	19.5a	18.9a
Panicle weight (g)	0.19b	0.37a	0.41a
Internodes per panicle (no.)	3.69a	3.68a	3.52b
Flag leaf length (cm)	6.77b	6.38b	7.45a
Flag leaf width (cm)	0.22a	0.19a	0.16b
Flag leaf area (cm^2)	1.52a	1.23a	1.15a

† Means within a row followed by the same letter are not significantly different at the 0.05 level.

Table 2. Seed yield components of tall fescue genotypes grown in growth chambers under three temperature treatments.

	Temperature ° C (day/night)		
	27/22	22/17	17/12
Panicles per plant (no.)	4.7a†	4.9a	4.4a
Seeds per panicle (no.)	46b	111a	119a
100-seed weight (g)	0.20b	0.23a	0.25a
Seed weight per panicle (g)	0.10b	0.26a	0.30a
Seed yield per plant (g)	0.47b	1.27a	1.32a

† Means within a row followed by the same letter are not significantly different at the 0.05 level.

respectively). Panicles produced at intermediate temperatures were similar to those at cooler temperatures but did not differ at the warmer temperatures. In contrast, there were fewer internodes per panicle produced at the cooler temperatures than at either the warmer or intermediate temperatures.

Flag leaves developed at the cooler temperatures were longer but narrower than those developed at the warmest and intermediate temperatures (Table 1). Although the estimated flag leaf area was numerically greater at the warmer temperature, the areas were not significantly different among temperature treatments.

There were no significant differences among the three temperature treatments for number of panicles (Table 2). All other seed yield components were significantly different between the warmest and coolest temperatures. Seed yield components produced at the intermediate temperatures were similar to those at the cooler temperatures but differed from the warmer temperatures. Seed weight per panicle was three times greater at the coolest temperatures as compared to the warmest temperatures (0.30 g and 0.10 g, respectively) (Table 2). The increased yield was caused by more and heavier seed produced at the cooler temperatures. Panicles produced at the coolest temperatures had 2.5 times more seed than panicles at the warmest temperatures (119 and 46, respectively). One-hundred seed weights averaged 0.25 g at the coolest temperatures and 0.20 g at the warmest temperatures. Except for panicle number, all seed yield components measured were greater at the cooler temperatures compared to the warmest temperature. Thus, the total seed yield per plant was 2.8 times greater at the coolest temperature compared to the warmest temperature (1.32 g and 0.47 g, respectively).

Discussion

Tall fescue seed yields produced in the cooler climate of Oregon are generally greater than seed yields produced in the warmer climate of Missouri. Production methods also vary greatly between the two locations. In Oregon, plants are grown in rows and managed specifically for seed production. Tall fescue seed production in Missouri comes mainly from pastures that are also used to raise livestock. Differences in yield between the two locations are probably due to many factors both climatic and cultural. We were interested in determining if temperature alone affects seed production of tall fescue.

When plants were placed in a growth chamber set at day/night temperatures selected to represent Oregon, the panicles weighed over twice as much as panicles produced at the warmest temperatures, which were selected to represent Missouri (Table 1). Most of this increase in weight was due to increased seed yields (Table 2). If seed weights are subtracted, panicles produced at the cooler temperatures averaged only 0.02 g heavier than panicles at the warmest temperatures. Flag leaves developed at the coolest temperatures were longer but narrower than those at the warmest temperatures. Although flag leaf areas tended to increase as temperatures increased, the effect was not significantly different among treatments.

Seed production at the coolest temperatures was 2.8 times greater than for plants grown at the warmest temperatures (Table 2). This difference in seed production was not due to the development of more panicles. The number of panicles per plant were similar among the three day/night temperature treatments tested. The number of panicles may have been set before the plants were dug from the field and placed in the chambers.

All seed yield components, except panicles per plant, were greater at the coolest temperatures compared to the warmest temperatures. Panicles that developed in the cooler temperatures representing Oregon had 2.5 times more seeds and the seed were 25% larger than panicles that developed at temperatures representing Missouri. The larger seeds may have more energy for germination and be of better quality than smaller seeds developed at warmer temperatures. Greater seed number and larger seed at the cooler temperatures resulted in panicles with 3 times more seed.

Plants placed in growth chambers set at day/night temperatures selected to represent the seed production area of Oregon produced more seed and larger seed than plants at temperatures representing Missouri. We believe that temperature plays a significant role in the differences observed in fall fescue seed yields between Oregon and Missouri.

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In Brief

Newsletter on Organic Seeds and Plant Breeding

ECO-PB (The European Consortium for Organic Plant Breeding) are producing a monthly newsletter on organic seeds and plant breeding. This newsletter can be viewed at www.eco-pb.org and is also a good strating point for information on the current issues associated with organic seed production of forage species as well as other plant species, and issues related to plant breeding in an organically acceptable manner. Good links to many seed specific sites can also be found here.

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2003 Conference

5TH INTERNATIONAL HERBAGE SEED CONFERENCE

The 5th International Herbage Seed Conference will be held on the Gatton Campus of the University of Queensland. This is in the heart of the Lockyer Valley, an intensive farming region a little over an hour's drive from Brisbane International Airport. Gatton is the main centre for the University's seed technology courses, and is strategically located close to most of the subtropical seed houses in Australia.
The Conference will start with registration and welcoming activities on Sunday 23 November 2003. Because this is during the University summer vacation, on-Campus accommodation will be available to house Conference delegates, either in single rooms in one of the halls of residence or in a limited number of motel-style units.

The morning program over the next three days (24-26 November) will be given to the presentation of delegates' papers either in oral or in poster form. During the afternoon sessions, short trips will be made to a range of field sites through south-east Queensland.

In response to the many requests from North American and European members, the post-Conference tour (27-28 November) highlights the temperate seed production areas in central and northern Victoria. Because Australia is a big country, this will involve travelling by air to Melborne to begin the tour. Over the next two days, delegates will be able to see a number of seed herbage seed crops. Visits will also be made to commercial premises and seed cleaning plants.

On 30 November, delegates can continue their travels from Melbourne to various destinations depending on their preference.

A provisional programme and preliminary registration details can be found on pages 9 and 10.