Reproductive Growth and Development in Selected Kentucky Bluegrass Cultivars Under Different Environmental Conditions [1]

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ABSTRACT

Kentucky bluegrass (*Poa pratensis* L.) cultivars are known to differ quantitatively in their photothermal inductive requirements. The extent to which these requirements are met influences the potential for subsequent panicle exertion. A better understanding of the inductive requirements as they vary among cultivars would aid in the selection and management of cultivars for maximum seed yields. This study was designed to evaluate the response of three Kentucky bluegrass cultivars, Bristol, Victa, and Vantage, to differing photothermal inductive treatments in a controlled environment, a mild, wet field environment at Gervais, Oregon, and a cold, dry environment at Madras, Oregon.

Sod plugs pulled from breeder's nurseries were used as the source of plant material for this study. Plants of Bristol, Victa, and Vantage were exposed to ambient inductive conditions for periods ranging from 23 to 209 days. Quantitative measurements on the number of panicles produced and the rate of panicle exertion were made after transfer from inductive conditions to controlled environment chambers programmed to promote floral initiation.

A significant interaction was observed between cultivars and locations for the rate of panicle exertion. The environment at Gervais was more favorable for Bristol, relative to Victa and Vantage, than that of Madras in terms of the number of panicles exerted per plant and the rate of panicle exertion.

Controlled environment studies showed that Victa was highly dependent on early-emerging tillers for panicle production. In contrast, panicle production in Bristol and Vantage was equally distributed among tillers of all ages. The seed yields of cultivars such as Bristol and Vantage, which can exert panicles from late formed tillers may benefit by placement into production areas which promote fall and winter growth such as Gervais.

Additional key words: Kentucky bluegrass, *Poa pratensis* L., tiller, floral induction, initiation, juvenile stage.

INTRODUCTION

The seed yields of Kentucky bluegrass (*Poa pratensis* L.) cultivars vary among commercial production areas. The seed yield of Kentucky bluegrass is greatly dependent on the number of tillers which are transformed from a vegetative state to a potentially reproductive state (Langer and Lambert, 1959). This transformation requires exposure to both short days and cool temperatures (Peterson and Loomis, 1949) and is termed floral induction.

In many grass species, induction can occur only after completion of a juvenile state (Calder, 1967) during which the plant is insensitive to photoperiods which would otherwise be inductive. The juvenile stage varies greatly in duration among species, but little is known concerning the factors controlling its length (Bean, 1970; Gardner and Loomis, 1953; and, Calder, 1967). Working with tall fescue (*Festuca arundinacea* Schreb.) and meadow fescue (*Festuca elatior* L.), Bean (1970) observed that the younger the plant, the longer the inductive period required for subsequent floral differentiation. Gardner and Loomis (1953) concluded that in orchardgrass, each tiller has its own juvenile stage. Calder (1967), however, was not sure whether juvenility was a property of the individual tiller or the plant as a whole.

When tillers of meadow fescue, orchardgrass (Langer and Lambert, 1959) and *Lolium perenne* L. (Spiertz and Ellen, 1977) were labelled at intervals over time, the earliest formed tillers contributed the largest proportion of seed heads at harvest.

Both the photothermal inductive requirement and the subsequent response to lengthening photoperiods and warm temperatures which result in floral initiation are polygenically controlled in cool season grasses (Cooper, 1954). Lindsey and Peterson (1964) reported that in Kentucky bluegrass only early-emerging tillers are exposed to a sufficiently long cold period to assure subsequent reproductive development. Canode, Maun, and Teare (1972) observed differences in the inductive exposure duration requirements among four Kentucky bluegrass cultivars. Similar results have been reported in other grass species as well (Bean, 1970; Chilcote, 1961; and, Murray, Wilton, and Powell, 1973).

In this study, three Kentucky bluegrass cultivars were examined for differences in floral inductive requirements. Controlled environment chambers were used to determine the relative contribution of early and late formed tillers to panicle exertion. The extent to which the winter field conditions in two contrasting field environments fulfilled the induction requirements of the three cultivars was examined.

MATERIALS AND METHODS

On 1 September 1977, 10 cm diameter sod cores of 'Bristol', 'Victa', and 'Vantage' Kentucky bluegrass were

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removed from breeder's nurseries at Gervais, Oregon.[1] The sod cores were placed in 15 cm plastic pots filled with a sandy loam soil mix. All pots were watered twice weekly with tap water and left in the field at Gervais, Oregon, to facilitate vegetative growth. These sod cores were subsequently used for the field experiments at Gervais and Madras, Oregon, and the controlled environment experiment.

Twelve of the cores were divided into single primary tillers on 25 September and placed in flats in a greenhouse. On 5 October, tillers were selected for uniformity and transplanted into 10 cm diameter plastic pots. Twenty-one pots of each cultivar were transferred on 19 October from the greenhouse to a controlled environment chamber used to provide inductive conditions. The induction chamber was programmed for a 16/6 C day/night temperature regime, an 8-hour photoperiod, and a photosynthetic photon flux density (PPFD) of 280 μ E m^{-2} s^{-1} provided by a combination of fluorescent tubes and 40-watt incandescent bulbs. The primary tillers and tillers which had emerged from the soil between 25 September and 19 October were labelled with colored loops of wire. Tillers which emerged after this date, during the inductive period, were labelled on 14 November, 14 December and 14 January, thus designating four tiller age groups. A completely randomized design with three replications per treatment was used and the data were examined with analysis of variance techniques.

On each of seven dates, three pots of each cultivar were transferred from the inductive chamber to a controlled environment chamber programmed to stabilize the induced state (Murray et al., 1973). This chamber was set for a constant 10 C and a photoperiod of 11 hours. After one week, the pots were placed in a third controlled environment chamber programmed to promote floral initiation and were subsequently observed for the number of panicles exerted per tiller age group. Initiation conditions were 18/13 C day/night temperature with a 16-hour photoperiod. The PPFD for the stabilizaton period and the initiation period was 300 μ E $m^{-2}s^{-1}$ provided by a combination of florescent tubes and 40-watt incandescent bulbs. All chambers employed sub-irrigation systems (Stanwood, Phillips, and Chilcote, 1974) which watered the plants once daily. Each pot was fertilized on 19 October with 30 kg ha^{-1} each of N, P_2O_5 and K_2O. Each pot was additionally fertilized with 25 kg ha^{-1} N as it was transferred to the initiation controlled environment chamber.

On 1 October, four sod cores of each cultivar were buried to ground level in randomized complete block designs with four replications for each of the ten induction exposure duration treatments at both field locations, Madras and Gervais. Four pots of each cultivar were removed from the field inductive environments at both locations on each of ten dates and placed in the stabilization controlled environment chamber (Lindsey and Peterson, 1964). After one week in the stabilization chamber, the pots were transferred to the controlled environment chamber programmed to promote floral initiation and were observed for the total number of panicles exerted per pot and for the number of days required for exertion of the first panicle of each plant. Exertion date was recorded when a spikelet was visible beyond the subtending leaf sheath.

Plants exposed to the field inductive environments were fertilized with 40 kg ha^{-1} each of N, P_2O_5, and K_2O on 8 October, 7 November, and 18 December. Each pot was additionally fertilized with 37 kg ha^{-1}N when it was transferred to the initiation chamber.

RESULTS AND DISCUSSION

Gervais has a Mediterranean climate dominated by the moderating influence of the Pacific Ocean and receives over 100 cm of annual precipitation with a winter distribution. One hundred and sixty kilometers east of Gervais is Madras which has a continental climate and receives about 25 cm annual precipitation. Radiometry data obtained from the U.S. Weather Bureau at Portland, Oregon, and data obtained from the USDA Experiment Station at Redmond, Oregon, were used as estimates of the daily light energy received at Gervais and Redmond, respectively.

The light energy levels, mean daily minimum temperatures and mean diurnal temperature ranges differed significantly between Gervais and Madras from 1 October 1977 to 10 March 1978. The Madras location received a greater amount of sunlight over the course of the inductive season and also had lower minimum temperatures with a greater mean diurnal range than Gervais. The mean daily maximum temperatures were not significantly different between the two locations. The mean daily maximum and minimum temperaures recorded during the ten induction exposure duration treatments at Gervais and Madras is given in Table 1.

Table 1. Mean maximum and minimum temperatures recorded during induction treatments at Gervais and Madras.

Induction treatment Duration		Mean maximum temperature (C)		Mean minimum temperature (C)	
Begin	End	Gervais	Madras	Gervais	Madras
1 Oct.	23 Oct.	16.7	17.8	5.0	1.1
24 Oct.	6 Nov.	11.1	12.2	4.4	0.6
7 Nov.	20 Nov.	7.8	10.0	1.1	-3.3
21 Nov.	4 Dec.	8.9	8.9	4.4	-0.6
5 Dec.	18 Dec.	8.9	8.3	3.9	-1.1
19 Dec.	31 Dec.	5.6	-0.6	1.1	-5.6
1 Jan.	14 Jan.	5.6	2.2	1.7	-3.9
15 Jan.	3 Feb.	6.7	6.1	2.2	-1.7
4 Feb.	24 Feb.	8.9	7.8	2.8	-1.1
25 Feb.	10 Mar.	10.0	7.8	2.8	-7.8

At least 51 days of the fall-winter field environment exposure were required before panicles were exerted by any cultivar in either area (Table 2). Once this minimum or threshold level was achieved, Bristol, Victa and Vantage all produced more panicles per pot as the field exposure duration was lengthened, indicating the quantitative nature of induction. This supports results found by other workers (Canode et al., 1972).

[1] Breeder's nurseries were located at the O. M. Scott and Sons Company Research Station at Gervais, Oregon.

Table 2. Mean number of panicles exerted per pot of Bristol, Victa, and Vantage after different field inductive exposure durations at Madras and Gervais.

Inductive Exposure (Days)	23	37	51	65	79	92	106	126	147	161
3Madras										
Bristol	0	0	2.0	4.8	17.0	17.0	20.0	23.0	28.0	33.8
Victa	0	0	2.5	5.0	16.5	23.5	30.5	41.5	45.2	48.2
Vantage	0	0	0	1.2	5.0	10.2	8.5	16.2	17.5	19.2
Gervais										
Bristol	0	0	0	1.2	11.2	21.2	31.0	31.2	31.2	41.8
Victa	0	0	1.0	7.5	12.5	17.5	26.2	37.5	33.0	40.5
Vantage	0	0	0	1.0	6.0	10.2	10.8	15.0	15.5	8.0

$LSD_{.05}$ for differences among cultivars within columns is 5.76 for Madras and 6.23 for Gervais.

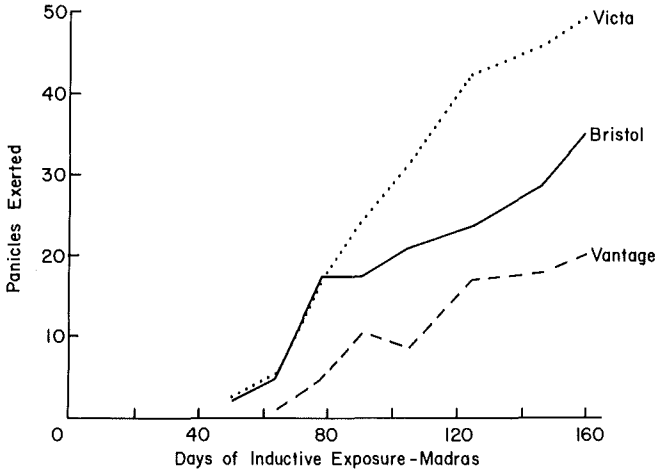


Fig. 1. Average number of panicles exerted by Bristol, Victa, and Vantage following ambient inductive exposure treatments of varying duration at Madras.

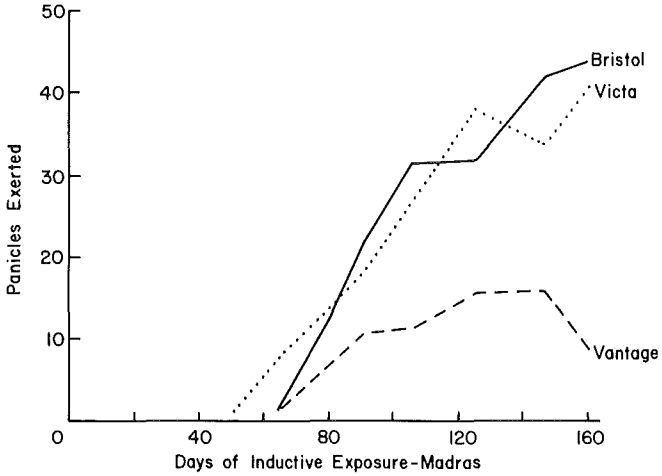


Fig. 2. Average number of panicles exerted by Bristol, Victa, and Vantage following ambient inductive exposure treatments of varying durations at Gervais.

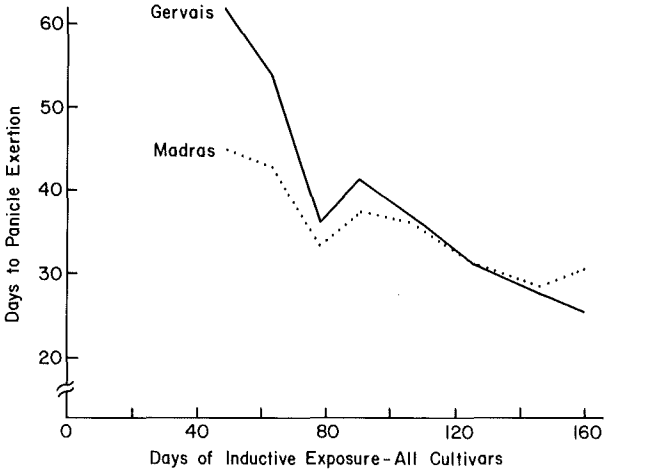


Fig. 3. Average number of days required for panicle exertion of three Kentucky bluegrass cultivars after transfer to initiation controlled environment chamber from ambient inductive exposure treatments of varying durations at Madras and Gervais.

Differences among cultivars in the number of panicles exerted per plant were observed after 79 days of inductive exposure in the Madras area (Figure 1). However, after 79 days, Vantage produced significantly fewer panicles than Victa or Bristol. Victa produced more panicles than Bristol or Vantage following induction exposures of 92 days or more.

Significant differences between cultivars in panicles exerted per pot were not observed at Gervais until after 92 days of inductive exposure (Figure 2). This was approximately two weeks later than at Madras. For inductive exposure treatments of 92 days or more at Gervais, Vantage produced fewer panicles than Bristol or Victa. Victa and Bristol, however, did not differ consistently from each other. Therefore, in terms of the number of panicles exerted, the environment at Gervais was as favorable for Bristol as it was for Victa. This is in contrast to the relative ranking of cultivars in the Madras area.

The number of days required for panicle exertion following transfer to the initiation chamber decreased as the length of the previous inductive treatment inceased (Figure 3). The rate of panicle exertion is another measure of the quantitative nature of induction, and is in support of results reported by other workers (Canode et al., 1972).

In the Madras area, the panicle exertion rate for Bristol was significantly slower than for Victa (Figure 4). However, at Gervais, Bristol and Victa did not differ (Figure 5). Therefore, the environment at Gervais was more favorable in promoting rapid panicle exertion for Bristol relative to Victa than was the Madras environment.

In the controlled environment induction study, differences in the number of panicles exerted among tiller age groups were significant only in Victa (Table 3). Victa exerted more panicles from tillers that developed prior to inductive conditioning than from those developed subsequently. Victa tillers apparently required a longer exposure to inductive conditions to attain the induced state. Panicle production in Bristol and Vantage was as dependent on the late formed tillers as on those formed early. Bristol and Vantage, therefore, would be more likely to benefit by

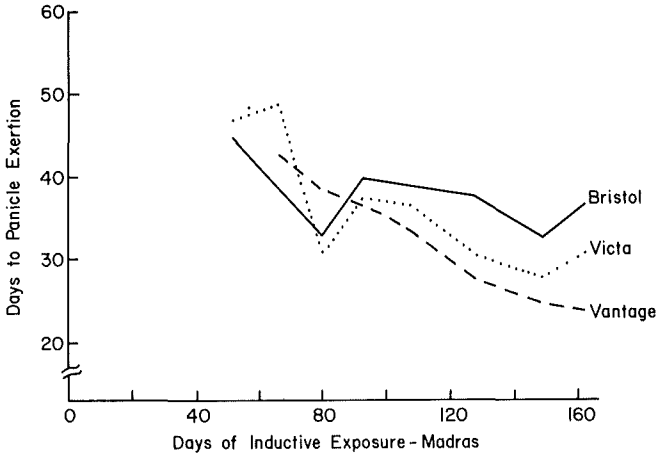


Fig. 4. Average number of days required for panicle exertion of Bristol, Victa, and Vantage Kentucky bluegrass after transfer to initiation controlled environment chamber from ambient inductive exposure treatments of varying durations at Madras.

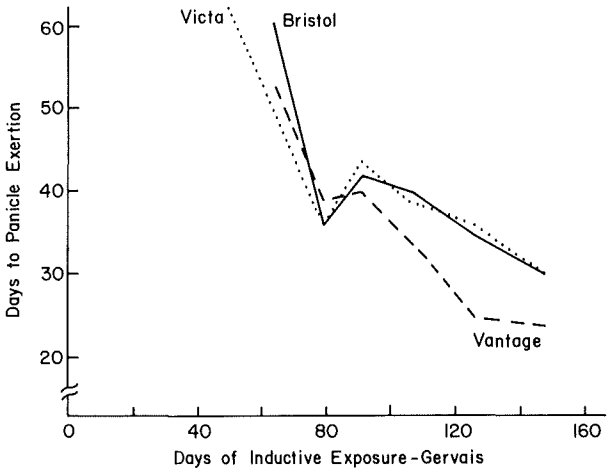


Fig. 5. Average number of days required for panicle exertion of Bristol, Victa, and Vantage Kentucky bluegrass after transfer to initiation controlled environment chamber from ambient inductive exposure treatments of varying durations at Gervais.

placement into production areas which promote fall and winter tillering.

There presently are dozens of Kentucky bluegrass cultivars being harvested for seed in the Pacific Northwest. It seems unlikely that all will respond similarly to the different climatic areas where they may be produced. Cultivars are known to differ in their inductive requirements. Victa, for instance, appears to benefit from the cold minimum temperatures and high light energy levels occurring in the Madras area. Bristol, on the other hand, seems well adapted to the more moderate temperatures and lower light levels recorded at the Gervais site. The degree to which the environment in a seed production area satisfies the inductive requirements of a cultivar, in relation to other cultivars, can be determined by examining factors such as panicle number per unit area and panicle exertion rate. An understanding of specific cultivar induction requirements will facilitate the selective placement of cultivars in areas that are best adapted for seed production. This will aid in optimizing yields.

Table 3. Mean number and percentage of tillers producing panicles per cultivar by tillers of four labelled age groups.

Tiller label Date	Victa	%	Bristol	%	Vantage	%
19 Oct.	3.33	77	1.50	34	0.33	33
14 Nov.	0.67	15	1.17	26	0.08	8
14 Dec.	0.17	4	0.50	11	0.42	42
14 Jan.	0.17	4	1.25	28	0.17	17
$LSD_{.05}$	0.93		0.93		0.93	

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