AN ABSTRACT OF THE THESIS OF

J. Kevin Turner for the degree of Master of Science

in Crop Science presented on May 7, 1980

Title: Growth and Reproductive Development in Selected Cultivars of Kentucky Bluegrass Given Different Durations of Exposure to Floral Inductive Conditions

Abstract Approved: Redacted for privacy

D. O. Chilcote

Kentucky bluegrass (Poa pratensis L.) cultivars are known to differ quantitatively in their photothermal floral inductive requirements. The extent to which these requirements are met influences the potential for subsequent panicle exsertion. 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 to differing floral inductive exposure durations in controlled environment chambers and in two contrasting climatic areas.

Plants of three Kentucky bluegrass cultivars 'Bristol', 'Victa', and 'Vantage' were exposed to inductive conditions in a controlled environment chamber for periods ranging from 25 to 209 days. Tillers of these plants were labelled to record their emergence dates at monthly intervals during the inductive period. Plants of each cultivar were also exposed to the field inductive conditions in two climatic areas for periods ranging from 23 to 161 days. The quantitative nature of induction at each area was examined by observing the plants for the

number of panicles produced and for the rate of panicle exsertion after transfer from the field to controlled environment chambers programmed to promote floral initiation. Changes in leaf area (LA), leaf number per tiller and specific leaf weight (SLW) were also evaluated.

The two areas, Madras and Gervais, differed climatically during the fall and winter inductive season. Night temperatures were lower and light energy levels were higher at Madras than at Gervais. Leaf area measurements demonstrated that more growth occurred for the plants grown at Gervais. The Gervais plants had fewer leaves per tiller than the Madras plants.

A significant interaction between cultivars and locations was observed for the rate of panicle exsertion. 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 exserted per plant and the rate of panicle exsertion.

Controlled environment studies showed that Victa was most dependent on tillers which had emerged early for subsequent panicle production. In contrast, panicle production in Bristol and Vantage was equally distributed among tillers of each emergence date. The seed yields of varieties such as Bristol and Vantage, which can exsert panicles from late formed tillers may benefit by placement into production areas which promote fall and winter growth.

GROWTH AND REPRODUCTIVE DEVELOPMENT IN SELECTED CULTIVARS OF KENTUCKY BLUEGRASS GIVEN DIFFERENT DURATIONS OF EXPOSURE TO FLORAL INDUCTIVE CONDITIONS

by

J. Kevin Turner

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1981

APPROVED:

Redacted for privacy

Professor of Crop Science in charge of major

Redacted for privacy

Head of Department of Crop Science

Redacted for privacy

Dean of Graduate School

Date thesis is presented May 7, 1980

Typed by Lynn O'Hare for J. Kevin Turner

ACKNOWLEDGEMENTS

The author would like to express his thanks to his major professor, Dr. D. O. Chilcote, for his guidance and support during the course of this study. Thanks are also expressed to Drs. R. V. Frakes and William Chilcote for their interest as advisors on the graduate committee. For valued suggestions and encouragement, the author is indebted to Dr. Eugene Dade.

The author would also like to thank Becky Johnstone and Doris Aponte for their help throughout the program.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX FIGURES

Appendix Figures | Page

LIST OF APPENDIX TABLES

Growth and Reproductive Development in Selected Cultivars of Kentucky Bluegrass Given Different Durations of Exposure to Floral Inductive Conditions

Literature Review

The seed yields of Kentucky bluegrass (Poa pratensis L.) cultivars vary greatly between areas of commercial production. In the Pacific Northwest there are several areas with substantially different climates where extensive acreages of Kentucky bluegrass are harvested each year. The extent to which an area promotes growth and fulfills the induction requirements of a cultivar will influence the seed yield of that cultivar.

Potential seed yield in Kentucky bluegrass is greatly dependent on the number of tillers which are transformed from a vegetative state to one which is potentially reproductive (7). This transformation is a photothermal process which requires an exposure to both short days and cool temperatures (10) and is termed floral induction.

In many grass species, induction can occur only after completion of the juvenile stage (2). During the juvenile stage the plant is insensitive to conditions which would otherwise be inductive. The juvenile stage varies greatly in duration among species but little is known concerning the factors controlling its length. Working with tall fescue (Festuca arundinacea Schreb.) and meadow fescue (Festuca elatior L.), Bean (1) observed that the younger the plant, the longer the period of induction required for subsequent floral differentiation. Gardner and Loomis (6) concluded that in orchardgrass, each tiller has a juvenile stage. Calder (2), however, reported that it is unknown whether juvenility is a property of the individual tiller or of the plant as a whole.

Langer and Lambert (7) labelled tillers of meadow fescue and orchardgrass at intervals over time and recorded their subsequent reproductive performance. They found the earliest formed tillers contributed the largest proportion of seed heads present at harvest. Spiertz and Ellen (11) observed that tillers of Lolium perenne L. which formed late had a lesser chance of becoming fertile.

Lindsey and Peterson (8) reported that in Kentucky bluegrass only tillers emerging early are exposed to a sufficiently long cold period to assure subsequent reproductive development. However, both the photothermal inductive requirement and the subsequent response to lengthening photoperiods and warm temperatures resulting in floral initiation are polygenically controlled in cool season grasses (5). Canode, Maun and Teare (3) observed differences in the inductive exposure duration requirements among four Kentucky bluegrass cultivars. Similar results have been reported in other grass species as well (1, 4, and 9).

In this study, the extent to which the contrasting winter field conditions in two production areas fulfill the induction requirements of three Kentucky bluegrass cultivars was examined. The number of panicles produced per unit area and the rate of panicle exsertion were measured to determine the quantitative nature of induction. Differences in growth characteristics during the induction period were also observed. The relative contribution of early and late formed tillers to potential seed yield of the three cultivars was evaluated in a controlled environment chamber study.

Materials and Methods

On 1 September, 1977, 10 cm diameter sod cores of Bristol, Victa and Vantage were removed from breeders 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 biweekly with tap water and left in the field at Gervais to facilitate vegetative growth. These were subsequently used for the field and controlled environment experiments.

Some of the sods 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 variety were transferred on 19 October from the greenhouse to a controlled environment chamber used to provide inductive conditions. 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 with color coded wire loops, 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 variety were transferred from the inductive chamber to a controlled environment chamber programmed to stabilize the induced state (9). After one week, the pots were placed in a controlled environment chamber programmed to promote floral

---

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

initiation and were subsequently observed for the total number of panicles exserted per pot and the number of panicles exserted per tiller age group. Each pot was fertilized on 19 October with approximately 30 kg/ha of N, P_2O_5 and K_2O. Each pot was additionally fertilized with approximately 25 kg/ha N as it was transferred to the initiation controlled environment chamber.

On 1 October, 40 sod cores of each cultivar were buried to ground level in randomized block designs with four replications for each of the ten treatments at both field locations, Madras and Gervais. Four pots of each variety were removed from the field inductive environments at both locations on each of ten dates and placed in the stabilization controlled environment chamber (8). 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 exserted per pot and for the number of days required for exsertion of the first panicle of each plant. Exsertion date was recorded when a spikelet was visible beyond the subtending leaf sheath.

On 1 October, 18 additional pots of each cultivar were buried to ground level in a randomized block design with three replications for each of seven treatments at both field locations. On each of six dates, three pots of each variety were removed from the plots. Leaf weights, leaf number per tiller and leaf area were recorded for each plant and specific leaf weights were computed.

Plants exposed to the field inductive environments were fertilized repeatedly with approximately 40 kg/ha of N, P_2O_5 and K_2O. These applications were made on 8 October, 7 November and 18 December. Each pot was additionally fertilized with approximately 37 kg/ha N as it was transferred to the initiation chamber.

The controlled environment chamber used for stabilization of the induced state was a cabinet type programmed for a constant 10°C and a photoperiod of 11 hours. The photosynthetic photon flux density (PPFD) was approximately 300 microeinsteins per square meter per second ($\mu E \cdot m^{-2} \cdot s^{-1}$) provided by a combination of fluorescent tubes and 40 watt incandescent bulbs.

The controlled environment chambers used to provide initiation conditions were programmed for 18/13°C day/night temperature with a 16-hour photoperiod. The PPFD was approximately 300 $\mu E \cdot m^{-2} \cdot s^{-1}$ provided by a combination of fluorescent tubes and 40-watt incandescent bulbs.

The inductive controlled environment chamber was programmed for a 16/6°C day/night temperature regime, a 8-hour photoperiod, and a PPFD of 280 $\mu E \cdot m^{-2} \cdot s^{-1}$ provided by a combination of fluorescent tubes and 40-watt incandescent bulbs. All chambers employed sub-irrigation systems (12) which watered the plants once daily.

The climate at Gervais is dominated by the moderating influence of the Pacific Ocean and annually receives over 100 cm of precipitation. One hundred and sixty kilometers east of Gervais is the Madras site. Madras has a continental-type climate and annually receives about 25 cm of precipitation. Radiometry data, obtained from the U.S. Weather Bureau at Portland, Oregon, was used as an estimate of the daily light energy received at Gervais. Radiometry data, obtained from the USDA Experiment Station at Redmond, Oregon, was used as an estimate of the daily light energy received at the Madras site. Daily minimum and maximum temperatures were recorded for each site during the term of the induction season. Paired t tests were used to determine differences between locations in light energy means, minimum and maximum temperatures and mean diurnal temperature range.

Results and Discussion

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 (Table 1). The light energy load in both areas decreased until mid-winter and then increased during late winter and early spring. The Madras location, however, received a greater amount of sunlight over the course of the inductive season (Figure 1). Madras was observed to have lower minimum temperatures and a greater mean diurnal range than Gervais. The mean daily maximum temperatures were not significantly different between the two locations.

The total leaf area for the plants grown at Gervais was greater than for those at Madras (Figure 2). In both areas, however, there was a general increase in the leaf area per plant throughout the inductive season. The Madras plants had more leaves per tiller, but the Gervais plants had more leaf area per leaf (Table 2). Therefore, the respective increases in total leaf area per plant appear to be the result of more leaf expansion at Gervais and more leaf differentiation at Madras.

Kentucky bluegrass will remain insensitive to conditions which would otherwise promote floral induction until after the juvenility requirements are satisfied. Changes in leaf area and leaf number per tiller may indicate the degree to which juvenile growth has been completed and may, therefore, influence the sensitivity of the plant to inductive conditions.

Table 1. Average maximum and minimum temperatures, average diurnal temperature range and average daily light energy received at Madras and Gervais.

TD#	Induction Begin	Treatment End	Duration (Days)	Avg. Max. Temp. Madras °C	Avg. Max. Temp. Gervais °C	Avg. Min. Temp. Madras °C	Avg. Min. Temp. Gervais °C	Avg. Diurnal Temp. Range Madras °C	Avg. Diurnal Temp. Range Gervais °C	Avg. Daily Insolation Madras Langleys	Avg. Daily Insolation Gervais Langleys
* 1	Oct. 1	Oct. 23	23	17.8	16.7	1.1	5.0	17.1	11.6	224	216
* 2	Oct. 24	Nov. 6	37	12.2	11.1	0.6	4.4	11.7	7.2	156	97
3	Nov. 7	Nov. 20	51	10.0	7.8	-3.3	1.1	13.7	7.1	156	102
* 4	Nov. 21	Dec. 4	65	8.9	8.9	-0.6	4.4	9.7	4.4	104	58
5	Dec. 5	Dec. 18	79	8.3	8.9	-1.1	3.9	7.8	5.2	88	49
* 6	Dec. 19	Dec. 31	92	-0.6	5.6	-5.6	1.1	5.9	4.8	67	74
7	Jan. 1	Jan. 14	106	2.2	5.6	-3.9	1.7	6.1	3.9	75	49
* 8	Jan. 15	Feb. 3	126	6.1	6.7	-1.7	2.2	7.6	4.2	110	69
9	Feb. 4	Feb. 24	147	7.8	8.9	-1.1	2.8	8.6	5.8	146	119
*10	Feb. 25	Mar. 10	161	7.8	10.0	-7.8	2.8	10.1	7.6	176	182

*Leaf area, leaf number tiller and specific leaf weight measurements were made on these plants.

FIGURE 1. AVERAGE LIGHT ENERGY RECEIVED (LANGLEYS) AT MADRAS AND GERVAIS FROM OCTOBER 1, 1977 TO MARCH 10, 1978.

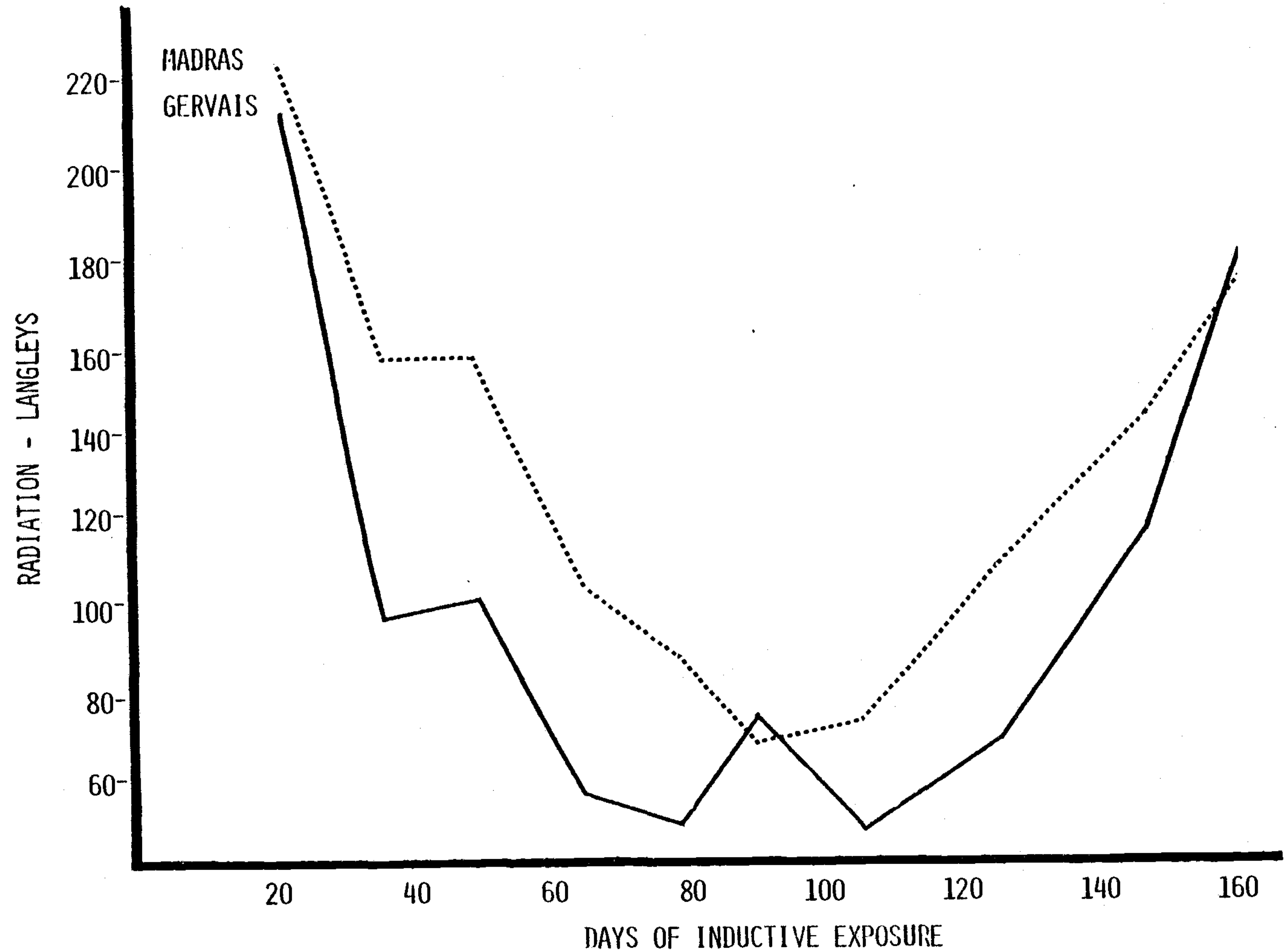


FIGURE 2. AVERAGE TOTAL LEAF AREA OF THREE KENTUCKY BLUEGRASS CULTIVARS AFTER DIFFERENT INDUCTIVE EXPOSURE DURATIONS AT MADRAS AND GERVAIS.

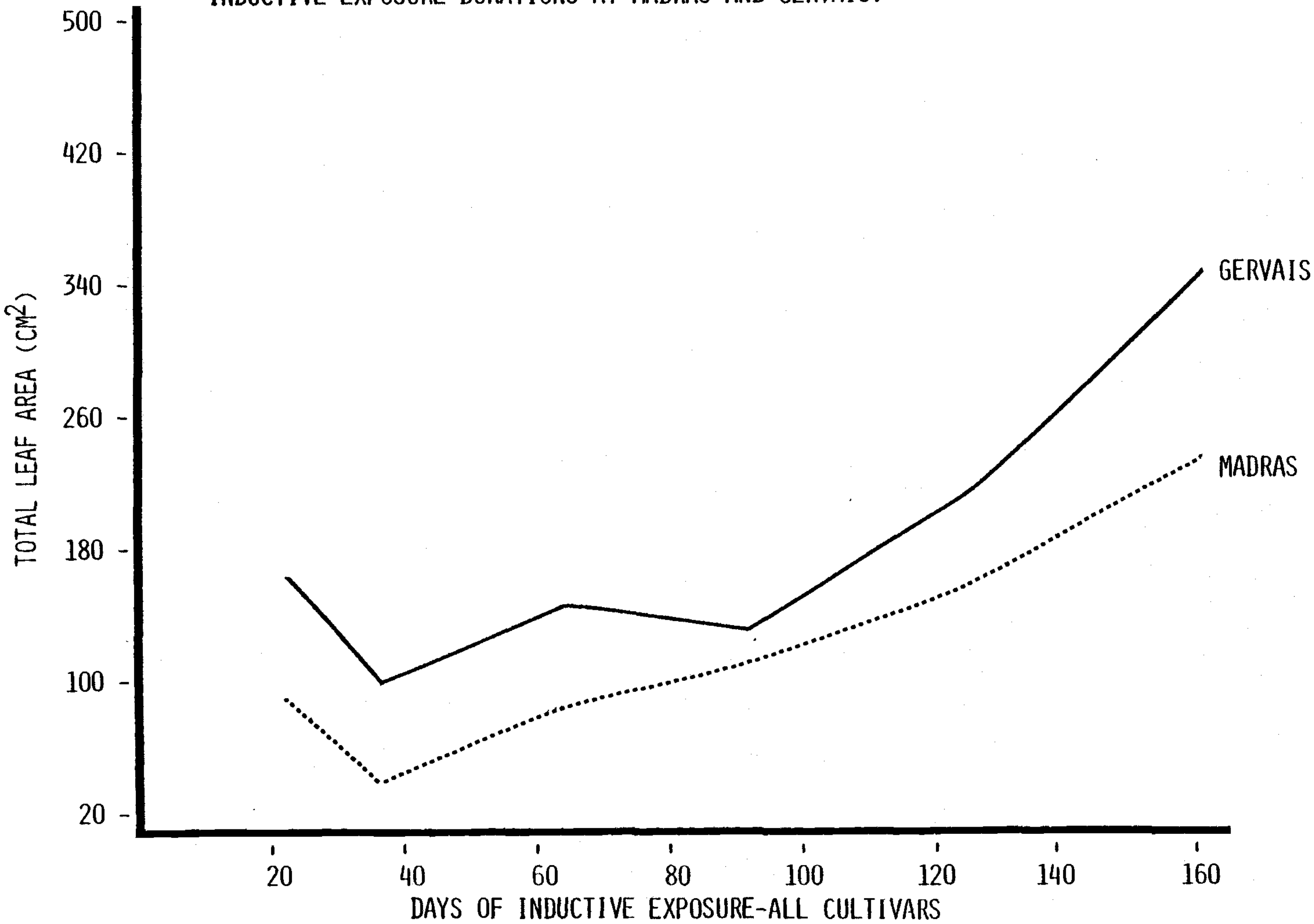


Table 2. Mean leaf area per leaf (LA/L) and mean leaf number per tiller (LN/T) of three Kentucky bluegrass cultivars after inductive exposure treatments at Madras and Gervais.

	LA/L (cm^2)	LN/T
Madras	0.43	3.40
Gervais	0.70	2.98
$LSD_{.05}$	0.05	0.22

Specific leaf weight (SLW) can be considered a function of available light energy and temperature levels. The differences in specific leaf weight between the two areas decreased as the light energy load for both areas decreased (Figure 3). In the spring, as the light energy levels began to increase, specific leaf weights of plants in both areas remained low, possibly due to self shading from accumulated leaf material.

No panicles were exserted by any cultivar in either area until after a previous exposure to 51 days of the fall-winter field environment (Table 3). 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 (3).

No differences among cultivars in the number of panicles exserted per plant were observed prior to 79 days of inductive exposure in the Madras area (Table 3). However, after 79 days, Vantage produced significantly fewer panicles than Victa or Bristol. Victa produced more panicles than did Bristol and Bristol produced more panicles than did Vantage following induction exposure treatments of 92 days or more. The environment at Madras, therefore, was more favorable for Victa than for Bristol or Vantage in terms of the number of panicles produced per pot.

Significant differences between cultivars in panicles exserted per pot were not observed at Gervais until after a previous exposure to 92 days of inductive exposure. 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 did Bristol or Victa.

FIGURE 3. AVERAGE SPECIFIC LEAF WEIGHT OF THREE KENTUCKY BLUEGRASS CULTIVARS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.

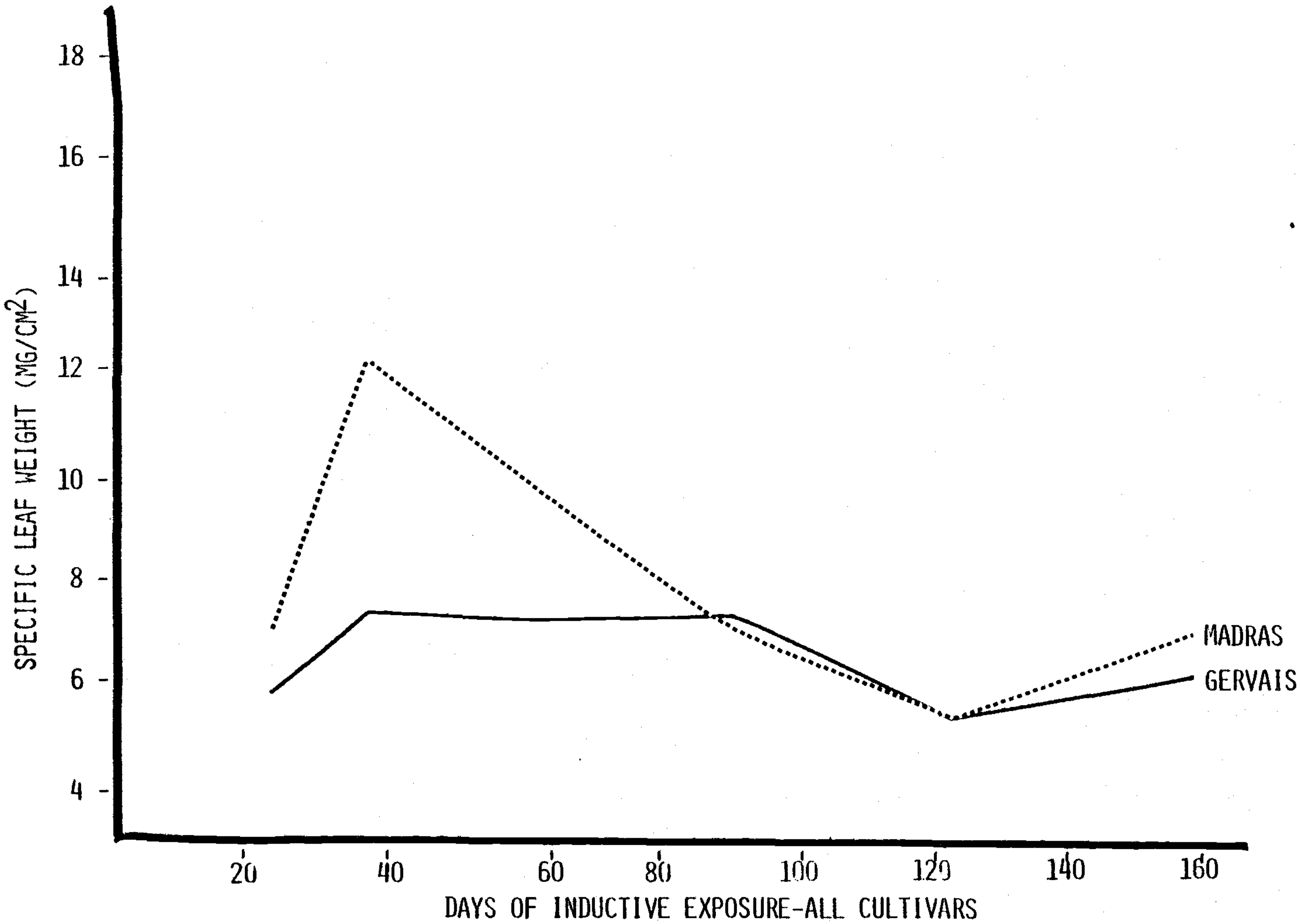


Table 3. Mean number of panicles exserted per pot of Bristol, Victa and Vantage after different field inductive exposure durations at Madras and Gervais.

TD	1	2	3	4	5	6	7	8	9	10
Inductive Exposure (Days)	23	37	51	65	79	92	106	126	147	161
Madras										
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 varieties within columns is 5.76 for Madras and 6.23 for Gervais.

This is in contrast to the relative ranking of cultivars in the Madras area.

The number of days required for panicle exsertion decreased as the length of the previous inductive treatment increased (Table 4). The rate of panicle exsertion is another measure of the quantitative nature of induction, and results of this study support results reported by other workers (3).

In each area, Vantage had the fastest rate of panicle exsertion when averaged over the field inductive exposure duration treatments. The fact that Vantage produced fewer panicles per pot and, therefore, had fewer competing sinks may help explain these results.

In the Madras area the panicle exsertion rate for Bristol was significantly slower than for Victa. However, at Gervais, Bristol and Victa did not differ. In promoting rapid panicle exsertion, therefore, the environment at Gervais was more favorable for Bristol relative to Victa than was the Madras environment.

In the controlled environment study, differences in the number of panicles exserted among tiller age groups were significant (Table 5) only in Victa. Victa exserted more panicles from tillers labelled 19 October than from those subsequently labelled. Victa tillers apparently required a longer inductive exposure to attain the induced state under the conditions in the controlled environment chamber. Panicle production in Bristol and Vantage was as dependent on the late formed tillers as on those formed early.

The first three controlled environment inductive duration treatments, TD 1, 2 and 3 exposed plants to 25, 54 and 82 days of inductive conditions respectively (Table 6). Plants produced panicles, however,

Table 4. Mean number of days for panicle exsertion of Bristol, Victa and Vantage after different field inductive exposure durations at Gervais and Madras.

TD	Days of Inductive Exposure	Madras			Gervais		
		Bristol	Victa	Vantage	Bristol	Victa	Vantage
1	23	--	--	--	--	--	--
2	37	--	--	--	--	--	--
3	51	44	46	--	--	65	--
4	65	38	48	43	60	49	52
5	79	32	30	33	35	35	38
6	92	39	37	37	41	43	39
7	106	38	36	36	39	38	33
8	126	37	36	31	34	38	24
9	147	32	27	28	29	29	23
10	161	36	30	30	36	29	19

Table 5. Mean number of panicles produced per cultivar by tillers of four labelled age groups.

Tiller Label Date	Mean Panicles Per Cultivar		
	Victa	Bristol	Vantage
October 19	3.33	1.50	0.33
November 14	0.67	1.17	0.08
December 14	0.17	0.50	0.42
January 14	0.17	1.25	0.17
$LSD_{.05}$	0.93	0.93	0.93

Table 6. Number of days to which the entire plant and the different tiller age groups were exposed to inductive treatments before transfer to initiation conditions*.

TD	Treatment termination date	Entire plant	19 Oct.	14 Nov.	14 Dec.	14 Jan.
1	11-13-77	25	25	--	--	--
2	12-12-77	54	54	28	--	--
3	01-09-78	82	82	56	26	--
4	03-22-78	154	154	128	98	67
5	04-05-78	168	168	142	112	81
6	04-18-78	181	181	155	125	94
7	05-16-78	209	209	183	153	122

*All plants of TD 1, 2, and 3 remained vegetative.

only after exposure to 154 days (TD 4) of the inductive environment. All plants in TD 1 to TD 3 remained vegetative. Therefore, the minimum exposure resulting in at least a threshold inductive level was between 82 and 154 days (TD 3 and TD 4) under the conditions of this study. If the interval between TD 3 and TD 4 had been less the threshold inductive requirement could be more accurately assessed.

The number of panicles produced did not differ among the inductive duration treatments ranging from 154 days to 209 days (TD 4 to TD 7) of exposure (data not shown). It should be noted that the plants used in this study were made up of tillers which emerged at various times throughout the inductive period and were labelled at intervals into tiller age groups. Many panicles were produced from axillary tillers which were apparently exposed to as few as 67 days of the inductive treatment (Table 6). Possible explanations offered are: (a) once the minimum threshold inductive level was attained by the primary tiller, then the induced state may be translocated within the integrated tiller system making up the plant, (b) a reduced inductive requirement exists for secondary and tertiary tillers, (c) a reduction in the juvenility period for tillers associated with older, dominant tillers occurs, or (d) some combination of these possibilities.

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. By examining factors such as panicle number per unit area and panicle exsertion rate, the degree to which each area satisfies the inductive requirements of a cultivar, in relation to the other cultivars, can be determined. The selective placement of a cultivar into the areas in which it is best adapted for seed production will aid in optimizing yields.

Bibliography

1. Bean, E. W. 1970. Short day and low temperature control of floral induction in Festuca. Annals of Botany 34:57-66.

2. Calder, L. T. 1967. Inflorescence induction and initiation in the Gramineae. In: The growth of cereals and grasses. ed. by F. L. Milthorpe and J. D. Ivins. Proceedings of the 12th Easter School in Agricultural Science, Nottingham, University of Nottingham, 1965. London, Butterworths, p. 59-73.

3. Canode, C. L., M. Anwar Maun and I. D. Teare. 1972. Initiation of inflorescences in cool-season perennial grasses. Crop Sci. 12: 19-22.

4. Chilcote, D. O. Environmental control of flowering in selected genotypes of orchardgrass (Dactylis glomerata). Ph.D. Thesis. Lafayette, Purdue University, 1961.

5. Cooper, J. P. 1954. Studies on growth and development in Lolium. IV. Genetic control of heading responses in local populations. J. of Ecology 42: 521-556.

6. Gardner, F. P. and W. E. Loomis. 1953. Floral induction and development in orchardgrass. Plant Physiol. 28:201-217.

7. Langer, R. H. M. and D. A. Lambert. 1959. Ear bearing capacity of tillers arising at different times in herbage grasses grown for seed. J. of British Grassland Soc. 14:137-140.

8. Lindsey, K. and M. L. Peterson. 1964. Floral induction and development in Poa pratensis L. Crop Sci. 4:540-544.

9. Murray, J. J., A. C. Wilton and J. B. Powell. 1973. Floral induction and development in Festuca rubra L. Differential clonal response to environmental conditions. Crop Sci. 13 (6):645-648.

10. Peterson, M. L. and W. E. Loomis. 1949. Effects of photoperiod and temperature on growth and flowering of Kentucky bluegrass. Plant Physiol. Jan. 1949:31-43.

11. Spiertz, J. H. J. and J. Ellen. 1977. The effect of light intensity on some morphological and physiological aspects of the crop perennial ryegrass (Lolium perenne var. Coopper) and its effect on seed production. Neth. J. Agric. Sci. 20:232-246.

12. Stanwood, P. C., J. C. Phillips and D. O. Chilcote. 1974. Fully automatic subirrigation system for glasshouse and growth chamber use. Crop Sci. 14:773-774.

APPENDIX

General Literature Review

Some components of seed yield in cool season perennial grasses are the number of fertile tillers per unit area, the number of florets per tiller, seed set percentage and seed weight. Seed yield is initially determined by the number of tillers which are transformed from a vegetative state to one which is potentially reproductive. This change requires chemical modifications of the apex and is termed induction. Induction requires the exposure of the plant to a combination of short days and/or cool temperatures.

In many grasses, including Kentucky bluegrass (*Poa pratensis* L.), induction can occur only following the completion of the juvenile state (3). The factors controlling the length of juvenility remain unclear. During the juvenile stage, the plant is insensitive to conditions which would otherwise be inductive. Gardner and Loomis (9) report that juvenility is a property of the individual tillers. However, very little is known about juvenility in grasses.

Following the juvenile stage, induction enables the apical meristem to perceive increasing day lengths and warmer temperatures. Under such conditions, the previously induced tiller undergoes a series of morphological changes, collectively termed initiation. The elongation of the apex and formation of the double ridge stage are the first morphological indications of initiation. L. T. Evans (8) demonstrated certain chemical changes in the shoot apex of *Lolium temulentum* during initiation. The RNA phosphorus content, the DNA phosphorus content and the ratio of RNA phosphorus to DNA phosphorus in the apex all increased dramatically over the first six days following an initiation treatment.

Many environmental factors affect the genetically determined tillering potential of a grass plant. Seed yield is, in part, dependent on how many tillers are ultimately induced (12).

Peterson and Loomis (18) found both short days and cool temperatures essential for Kentucky bluegrass to be induced. Differences in exposure duration requirements were observed among four cultivars of Kentucky bluegrass by Canode et. al. (4). 'Merion' and 'Cougar' required longer exposures to cold, short days for induction than did 'Newport' which, in turn, had a longer requirement than 'Delta'.

Stobbe (21) found the induction requirements of orchardgrass (*Dactylis glomerata* L.) include both cool temperatures and short photoperiods for attainment of maximum panicle numbers. Some cultivars, however, produced some panicles after only short day induction treatments. Chilcote (5) observed alternating temperatures to be more favorable for induction than were constant temperatures. Von Amsberg (23) obtained data on orchardgrass to suggest that alternating temperatures would fulfill the temperature requirements for floral induction so long as a critical maximum temperature is not surpassed. Stobbe (21), Von Amsberg (23), and Chilcote (5) all found the induction requirements for photoperiod and temperature of orchardgrass to vary with genotype.

Bean (2) found induction requirements to vary among the species and cultivars of *Festuca*. A Tunisian ecotype of tall fescue flowered in response to exposure to short days and warm temperatures. 'S.170' tall fescue (*Festuca arundinacea*, Schreb.) and 'S.215' meadow fescue (*Festuca elatior* L.), on the other hand, required short days and cool temperatures to complete induction. Templeton et.al. (22) observed that while some cultivars of tall fescue had no cold requirement for floral induction, a period of growth at low temperatures greatly increased the flowering response. When exposed to winter temperatures, some plants were able to flower without previous short day treatments.

Evans (7) observed Lolium perenne to be fully induced after exposure to short days at four degrees centigrade for 17 weeks. Further investigation resulted in induction after exposure to temperatures up to 10°C under continuous light.

Peterson et. al. (19) found that Lolium temulentum will head without a previous cold treatment but that certain lines respond to cold by earlier heading. Cold treatments given concurrently with continuous light were at least as effective as those given under eight hour photoperiods. Without cold, various lines exhibited leaf numbers ranging from five to twenty before heading, but when eight or twelve weeks of cold were given these differences were removed.

The common demoninator of all induction treatments is the establishment of a state in which the plant is able to respond to photoperiods which stimulate inflorescence development.

Both the cold requirement and response to photoperiod are polygenically controlled in cool season grass (6). Consequently, there is continuous variation in these two components of flowering. Murray et. al. (15), working with Festuca rubra, observed that the different clones they tested varied in the length of exposure to winter conditions required before panicles would subsequently be produced. Some clones required up to 30 days longer exposure to the field environment than did others. Assuming that this variation is due to genetic causes, the authors suggest that it may be possible to select for longer or shorter induction requirements.

Bean (2) suggests the flowering response represents an adaptation to an ecotypes area of origin. Habjorg (11), working with latitudinal and altitudinal ecotypes of Kentucky bluegrass, found the induction requirements differed between ecotypes. The more northern the ecotype, the more rapidly floral induction took place. The southern and low elevational ecotypes were found to require a longer cold and short day treatment than did the northern and high elevational ones.

Langer and Lambert (12) labelled tillers of 'S.215' meadow fescue and 'S.37' orchardgrass at intervals over time and recorded their subsequent performance at harvest. They found the earliest formed tillers contributed the largest proportion of the ears present at harvest. Spiertz and Ellen (20), in agreement with Langer and Lambert (12) found tillers of Lolium perenne which formed late had a lesser chance of being fertile.

Lindsey and Peterson (14) report that only those tillers emerging early are exposed to a sufficiently long cold period to assure reproduction. However, requirements for induction are found to vary even among cultivars within species (4, 15, 23). It seems likely, therefore, that varieties may require differing lengths of exposure for induction.

Gardner and Loomis (9), working with orchardgrass, proposed that the apex of each tiller must be induced independently. Calder (3) in agreement with Gardner and Loomis also observed there was no translocation of the vernalized state in Gramineae. Stobbe (21), on the other hand, obtained data to suggest the induced state was transmitted from primary to secondary and tertiary tillers in orchardgrass. Tillers that had emerged during the initiation stage were observed to flower under high light conditions.

Nyahosa, Marshall and Sagar (16) traced the flow of labelled carbon between tillers and rhizomes in Kentucky bluegrass. They found that once established, primary tillers and rhizomes become independent of the parent shoot for carbohydrates. If, however, all but one of the tillers were defoliated, the defoliated primary tillers and rhizome-tillers were once again supplied with carbohydrates from the remaining shoot. The entire tiller-rhizome system is, therefore, physiologically integrated.

Peterson and Loomis (18) observed that the cool temperatures and short photoperiods of fall and early winter were duplicated in the spring and they postulated that further induction may take place during this second period. Habjorg (11) found that the northern and high elevational ecotypes required long photoperiods for floral differentiation than southern and low elevational ones. This suggests that spring induction may be more pronounced and effective for the northern and high elevational types.

Habjorg (10) observed northern and high elevational ecotypes had a longer critical day length for vegetative growth than the southern and low elevational ones. In both groups, photoperiods shorter than the critical day length for leaf growth led to an increasing number of tillers. The northern and high elevational ecotypes were observed to continue tillering at considerably longer photoperiods and would, therefore, continue to increase their tiller populations later in the spring than the southern and low elevational types. Since the northern and high elevational types are more rapidly induced, spring tillering may result in increased panicle numbers over their southern and low elevational counterparts.

Spiertz and Ellen (20) found that supplemental light in the fall increased the number of tillers/dm^2 of Lolium perenne. By spring, however, the number of tiller/dm^2 was not different from plants receiving normal intensity light. When the supplemental light was given in the early spring an increase in tiller number was directly related to the increase in light intensity. The formation of fertile tillers increased with additional spring light, and decreased by shading.

Audra et.al. (1) found tillering in orchardgrass to be associated with light energy rather than photoperiod. As light energy increased from 25% of normal to normal sunlight, tillering in orchardgrass increased. Tillering also increased when photoperiod lengthened but not if the increase in photoperiod was at reduced light levels. Stubble water soluble carbohydrates increased at higher light intensities and was assumed to be due to the effect of increased light intensity on photosynthesis. At temperatures of 10 to 16 degrees C, as opposed to 21 to 27 degrees C, tillering rate was low although carbohydrates were high. Tillering was considered a function of growth rate and carbohydrate depletion.

Pauldi and DeVay (17) observed that at vernalization temperatures a specific rRNA is synthesized in the shoot tip of winter wheat seedlings. At devernalization temperatures (25°C) two rRNA's of a different molecular weight were observed in the shoot tip. These rRNA's are found only at devernalization temperatures and only in the shoot tip following an incomplete vernalization treatment.

Lindsey and Peterson (13) observed a reversal of induction in Poa pratensis by exposure to high temperatures. However, with increasing exposure to cool, short days, long periods of high temperature were required for de-induction.

There is evidence to suggest that the quantitative nature of induction exerts an influence on the subsequent critical photoperiod for initiation. Peterson et.al. (19), working with Lolium temulentum, obtained data to suggest that the flower initiation threshold photoperiod is dependent on the previous exposure to cold.

Under 14 hour photoperiods, plants which were previously exposed to 2°C for two or four weeks were observed to flower. Only those plants receiving six weeks of cold temperatures exserted panicles under 14 hour photoperiods.

Chilcote (5) working with orchardgrass found the longer the exposure to short photoperiods and cool temperatures, the faster also was the subsequent rate of inflorescence exsertion. For certain cultivars of Kentucky bluegrass, where the rate of inflorescence was used as an index, induction intensity was increasing up to March 15.

Appendix Table 1. Number of panicles exserted per pot following transfer from field inductive exposure treatments of varying durations.

Transfer Date		Gervais										Madras									
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Variety	Rep																				
Bristol	1	0	0	0	2	17	19	29	29	51	45	0	0	1	1	21	13	9	18	36	34
	2	0	0	0	0	17	23	23	26	34	52	0	0	2	6	9	18	22	23	31	31
	3	0	0	0	3	4	20	39	37	33	26	0	0	0	7	20	18	25	27	24	29
	4	0	0	0	0	7	23	33	33	49	50	0	0	5	5	19	19	25	24	21	41
	Σ	0	0	0	5	45	85	124	125	167	173	0	0	8	19	69	68	81	92	112	135
Victa	1	0	0	0	13	14	13	20	33	29	38	0	0	6	8	21	22	25	39	44	39
	2	0	0	1	2	14	22	24	25	37	37	0	0	0	5	12	31	36	49	53	46
	3	0	0	0	9	10	15	38	44	32	45	0	0	4	5	22	25	29	39	41	52
	4	0	0	3	6	12	20	23	48	34	42	0	0	0	1	11	16	32	39	43	56
	Σ	0	0	4	30	50	70	105	150	132	162	0	0	10	19	66	94	122	166	181	193
Vantage	1	0	0	0	2	4	14	10	25	22	8	0	0	0	1	2	10	14	17	18	23
	2	0	0	0	2	9	8	12	4	13	6	0	0	0	0	5	9	9	18	20	20
	3	0	0	0	0	3	11	11	14	10	10	0	0	0	4	7	13	7	12	19	11
	4	0	0	0	0	8	8	10	17	17	8	0	0	0	0	6	9	4	18	13	23
	Σ	0	0	0	4	24	41	43	60	62	32	0	0	0	5	20	41	34	65	70	77

Appendix Table 2. Days required after transfer from field inductive exposure treatments of varying durations to initiation controlled environment chamber until at least one panicle was exserted.

		Gervais								Madras							
Transfer Date		3	4	5	6	7	8	9	10	3	4	5	6	7	8	9	10
Variety	Rep																
Bristol	1	-	62	43	43	39	35	30	24	54	46	32	43	39	38	33	37
	2	-	-	32	38	39	35	30	24	39	33	32	38	37	35	30	31
	3	-	57	32	43	42	35	30	28	-	41	32	43	39	35	33	37
	4	-	-	32	38	37	81	24	28	39	33	32	33	37	38	30	37
			119	139	162	157	136	114	104	132	153	128	157	152	146	126	142
			60	35	41	39	34	29	26	44	38	32	39	38	37	32	36
Victa	1	-	46	32	43	39	35	33	31	46	37	32	38	37	28	24	31
	2	75	57	32	43	37	35	30	28	-	41	27	38	31	31	24	31
	3	-	46	43	48	39	35	30	28	46	57	32	38	37	31	30	28
	4	54	46	32	38	37	35	24	28	-	57	27	33	37	31	30	28
		129	195	139	172	152	140	117	115	92	192	118	147	142	121	108	118
		65	49	35	43	38	35	29	29	46	48	30	37	36	30	27	30
Vantage	1	-	57	43	38	31	24	24	20	-	46	48	38	33	28	24	24
	2	-	46	32	38	31	24	21	16	-	-	43	33	31	24	24	24
	3	-	-	43	38	37	24	21	20	-	37	32	38	37	28	24	28
	4	-	-	32	43	33	24	24	20	-	-	27	33	31	28	24	16
			103	150	157	132	96	90	76		83	150	142	132	108	96	92
			52	38	39	33	24	23	19		42	38	36	37	27	24	23

Appendix Table 3. Percent total water soluble carbohydrates in stem bases following field inductive exposure treatments of varying durations.

Date removed from induction		Gervais						Madras					
		10/23	11/6	12/4	12/31	2/3	3/10	10/23	11/6	12/4	12/31	2/3	3/10
Transfer Date (TD)		1	2	4	6	8	10	1	2	4	6	8	10
Variety	Rep												
Bristol	1	1.02	1.36	0.78	0.86	0.76	2.31	1.64	1.64	1.10	0.76	0.22	0.27
	2	0.96	1.35	0.78	0.84	0.12	1.20	2.75	1.83	1.26	1.06	0.27	0.14
	3	3.08	1.63	0.83	1.02	1.15	1.58	1.46	2.02	0.94	0.98	0.24	0.15
Victa	1	1.18	1.19	0.35	1.05	0.41	1.31	2.36	1.89	0.73	0.52	0.31	0.13
	2	2.00	1.23	0.67	0.23	0.54	0.66	2.16	1.89	0.45	0.51	0.58	0.16
	3	0.88	1.17	0.69	0.58	0.41	0.96	2.24	1.56	0.91	1.59	0.21	0.13
Vantage	1	1.92	1.87	0.86	1.31	0.25	2.36	3.14	1.79	1.80	0.56	0.39	1.02
	2	2.80	1.87	1.13	1.36	0.16	3.11	3.24	1.40	1.07	0.44	0.39	1.08
	3	2.44	2.05	0.89	1.10	0.23	2.61	3.57	2.49	1.20	0.50	0.32	1.14

Appendix Table 4. Specific leaf weight (G x $10^{-3}/cm^2$) following field inductive exposure treatments of varying durations.

		Gervais						Madras					
Date removed from induction		10/23	11/6	12/4	12/31	2/3	3/10	10/23	11/6	12/4	12/31	2/3	3/10
Transfer Date (TD)		1	2	4	6	8	10	1	2	4	6	8	10
Variety	Rep												
Bristol	1	5.8	11.8	8.4	8.1	8.8	7.5	7.8	7.9	9.5	8.7	6.6	7.9
	2	5.3	8.7	9.0	6.1	8.5	6.6	8.2	11.4	10.4	4.7	5.3	7.7
	3	7.3	9.0	8.3	11.6	8.1	6.5	7.0	13.7	9.3	11.1	6.4	6.9
Victa	1	5.2	8.8	6.4	8.4	3.5	6.7	7.2	11.6	8.8	7.9	6.4	7.5
	2	5.1	6.1	6.5	7.0	2.6	5.7	9.2	10.0	10.4	5.5	6.3	8.3
	3	6.5	7.5	7.5	5.7	3.3	6.5	5.5	17.0	8.9	10.7	5.2	6.4
Vantage	1	6.2	8.5	9.7	9.8	7.3	7.7	9.9	15.2	9.6	9.7	7.4	7.1
	2	8.9	4.1	7.5	10.3	7.5	7.6	9.4	17.6	13.8	4.2	7.4	11.3
	3	7.3	9.9	8.8	6.7	5.0	7.0	5.8	16.7	13.9	7.7	4.1	7.8

Appendix Table 5. Leaf area (cm^2) of plants following field inductive exposure treatments of varying durations.

Date removed from induction		Gervais						Madras					
		10/23	11/6	12/4	12/31	2/3	3/10	10/23	11/6	12/4	12/31	2/3	3/10
Transfer Date (TD)		1	2	4	6	8	10	1	2	4	6	8	10
Variety	Rep												
Bristol	1	145.1	84.5	123.9	172.6	230.1	377.2	69.9	42.8	68.0	98.32	126.6	182.1
	2	195.6	82.6	113.8	215.7	226.6	449.0	106.8	32.2	68.8	130.1	123.4	177.9
	3	168.8	95.6	89.0	104.7	213.3	410.2	39.4	26.6	60.5	56.5	139.1	206.8
Victa	1	148.9	82.1	108.2	121.3	179.8	326.6	92.3	31.0	94.5	66.8	101.1	230.7
	2	189.9	82.0	168.7	54.8	224.8	277.1	81.1	49.0	75.0	115.8	144.7	207.5
	3	105.5	69.5	134.0	71.4	237.1	295.0	114.8	31.4	94.8	88.4	156.3	303.4
Vantage	1	154.8	89.2	145.8	148.4	210.8	375.5	101.2	34.0	91.2	118.5	236.3	279.0
	2	157.6	169.5	179.2	123.6	191.9	279.64	82.8	34.4	62.9	179.3	166.7	225.8
	3	156.2	95.0	193.8	125.9	186.6	277.03	97.2	32.2	93.0	91.6	194.4	253.0

Appendix Table 6. Leaf area (cm^2) per leaf of plants following field inductive exposure treatments of varying durations.

Date removed from induction		Gervais						Madras					
		10/23	11/6	12/4	12/31	2/3	3/10	10/23	11/6	12/4	12/31	2/3	3/10
Transfer Date (TD)		1	2	4	6	8	10	1	2	4	6	8	10
Variety	Rep												
Bristol	1	1.01	0.41	0.51	0.43	0.34	0.69	0.47	0.21	0.49	0.48	0.36	0.35
	2	0.98	0.61	0.49	0.61	0.40	0.70	0.43	0.34	0.36	0.66	0.43	0.27
	3	0.85	0.49	0.58	0.62	0.43	0.68	0.52	0.20	0.27	0.39	0.30	0.29
Victa	1	0.69	0.43	0.58	0.52	0.80	0.90	0.73	0.32	0.55	0.43	0.30	0.34
	2	0.93	0.66	0.42	0.34	0.77	0.85	0.52	0.28	0.48	0.32	0.30	0.29
	3	0.99	0.48	0.53	0.52	1.23	0.68	1.13	0.28	0.41	0.38	0.43	0.42
Vantage	1	1.14	0.59	0.54	0.54	0.75	1.21	0.61	0.35	0.46	0.48	0.52	0.46
	2	0.95	0.79	0.62	0.35	0.82	1.10	0.57	0.36	0.41	0.46	0.40	0.39
	3	1.15	0.53	0.66	0.76	1.27	0.98	0.73	0.27	0.46	0.62	0.69	0.43

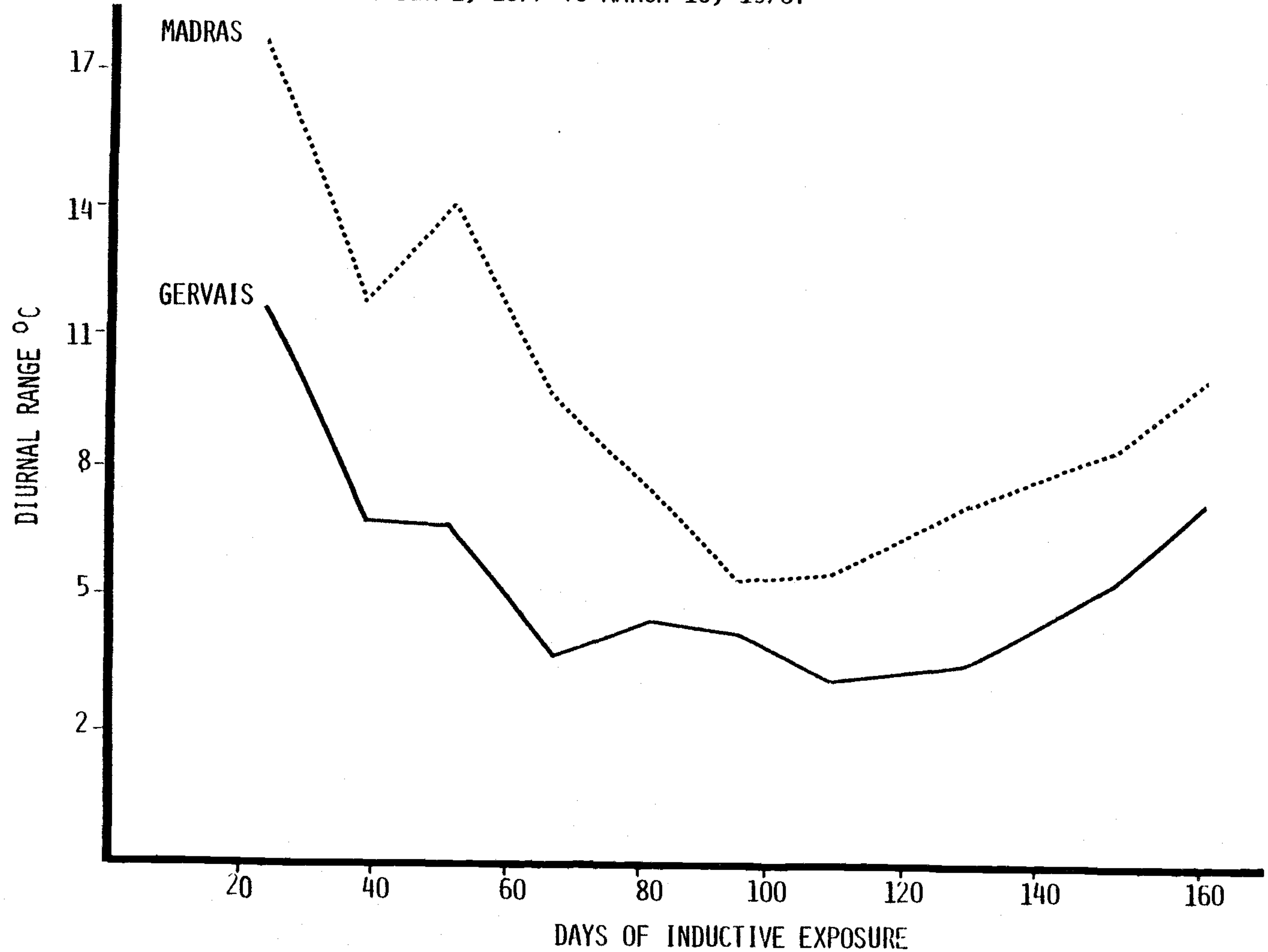
Appendix Table 7. Number of leaves per tiller of plants following field inductive exposure treatments of varying durations.

Date removed from induction		Gervais						Madras					
		10/23	11/6	12/4	12/31	2/3	3/10	10/23	11/6	12/4	12/31	2/3	3/10
Transfer Date (TD)		1	2	4	6	8	10	1	2	4	6	8	10
Variety	Rep												
Bristol	1	3.3	2.8	2.9	3.4	3.4	3.6	3.7	3.8	2.6	2.7	4.5	4.0
	2	3.5	2.9	2.9	2.5	3.6	3.1	5.1	2.6	2.8	2.8	4.5	3.4
	3	3.8	3.0	2.6	3.8	2.5	3.1	3.1	2.6	2.9	3.0	4.4	3.2
Victa	1	4.0	3.0	2.0	3.0	2.5	3.1	4.1	2.7	2.7	3.4	2.9	3.7
	2	4.1	2.7	3.1	1.7	3.2	2.9	4.5	3.6	3.0	2.8	2.7	3.6
	3	2.9	2.3	2.9	1.7	2.0	2.5	3.2	2.5	3.3	4.3	2.2	3.2
Vantage	1	4.5	3.1	4.1	3.4	1.8	2.2	4.1	3.6	3.1	3.6	5.0	3.9
	2	3.5	2.9	3.7	3.2	2.6	2.3	4.5	2.6	3.5	4.1	3.6	2.3
	3	3.8	4.4	3.3	2.0	1.8	2.4	3.9	3.6	3.7	2.5	2.4	3.6

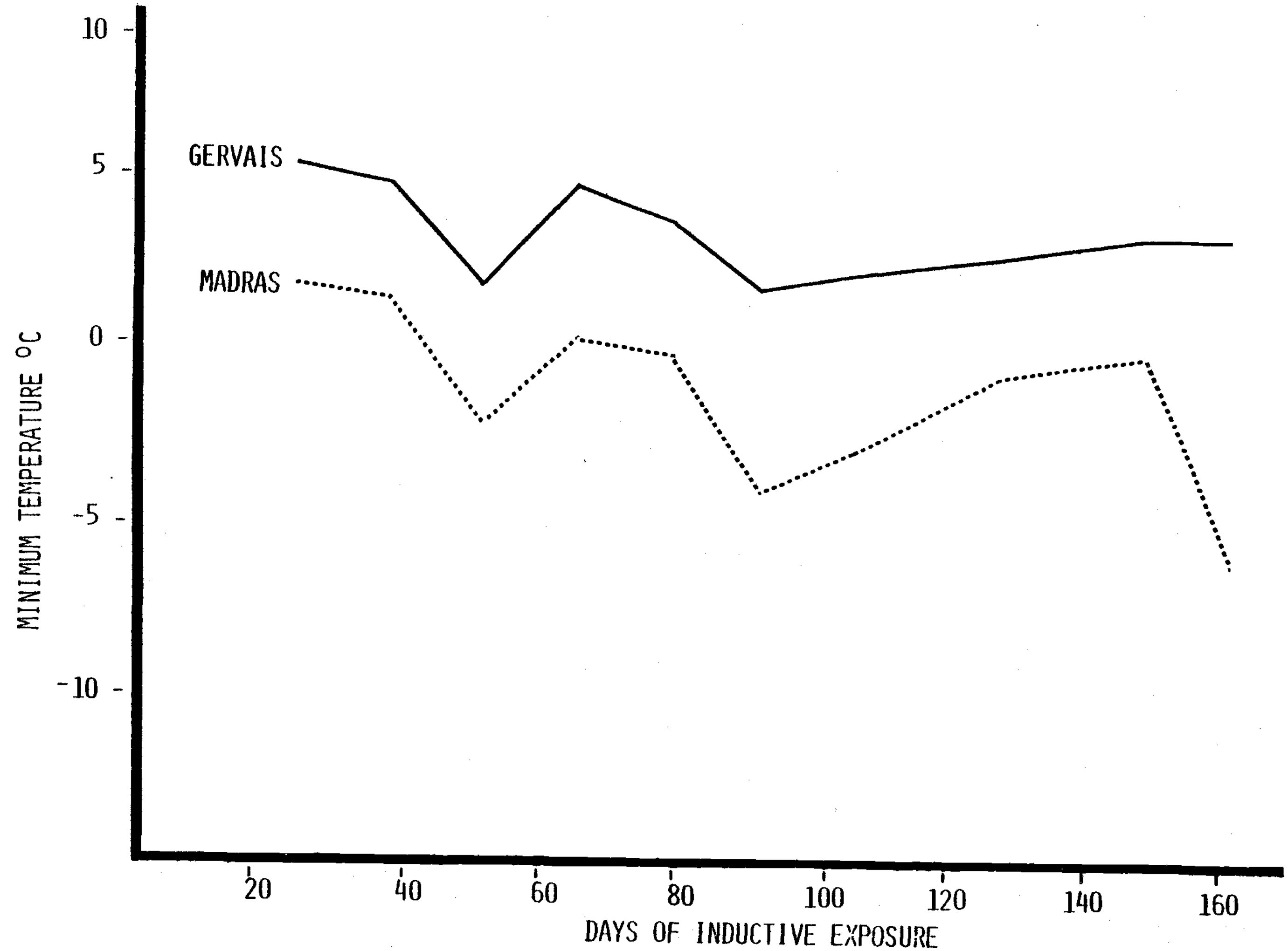
Appendix Table 8. Specific leaf weight (SLW), leaf area (LA) per pot, leaf weight per pot (LW) and percent total water soluble carbohydrates (TWC) in stem bases of Bristol, Victa and Vantage plants removed from controlled environment inductive conditions on April 5 and May 16.

Date removed from induction	Variety	Replication	SLW ($g/cm^2 \times 10^{-2}$)	LA (cm^2)	LW (g)	TWC (%)
April	Bristol	1	1.3	234.8	3.1	4.1
		2	1.8	211.9	3.9	3.4
	Victa	1	1.8	200.2	3.5	3.9
		2	1.8	235.2	4.2	4.0
	Vantage	1	1.7	264.1	4.6	3.7
		2	1.6	228.4	3.6	2.3
May 16	Bristol	1	1.3	271.1	3.4	2.8
		2	1.1	238.3	2.5	2.2
	Victa	1	1.2	311.0	3.6	2.9
		2	1.2	302.2	3.5	2.3
	Vantage	1	1.3	327.6	4.4	2.1
		2	1.2	263.9	3.2	2.7

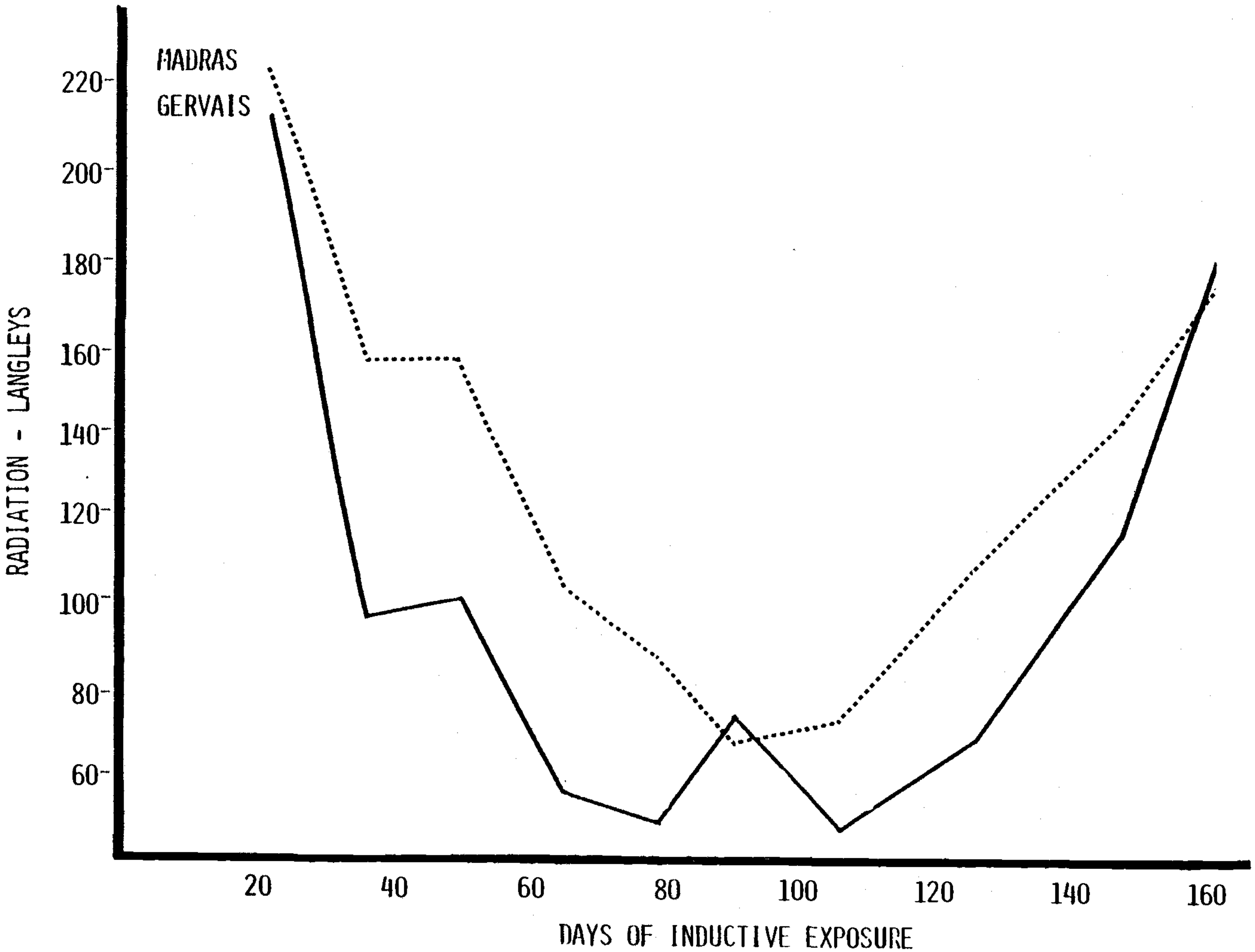
APPENDIX FIGURE 1. AVERAGE DIURNAL TEMPERATURE RANGE (°C) AT MADRAS AND GERVAIS FROM OCTOBER 1, 1977 TO MARCH 10, 1978.



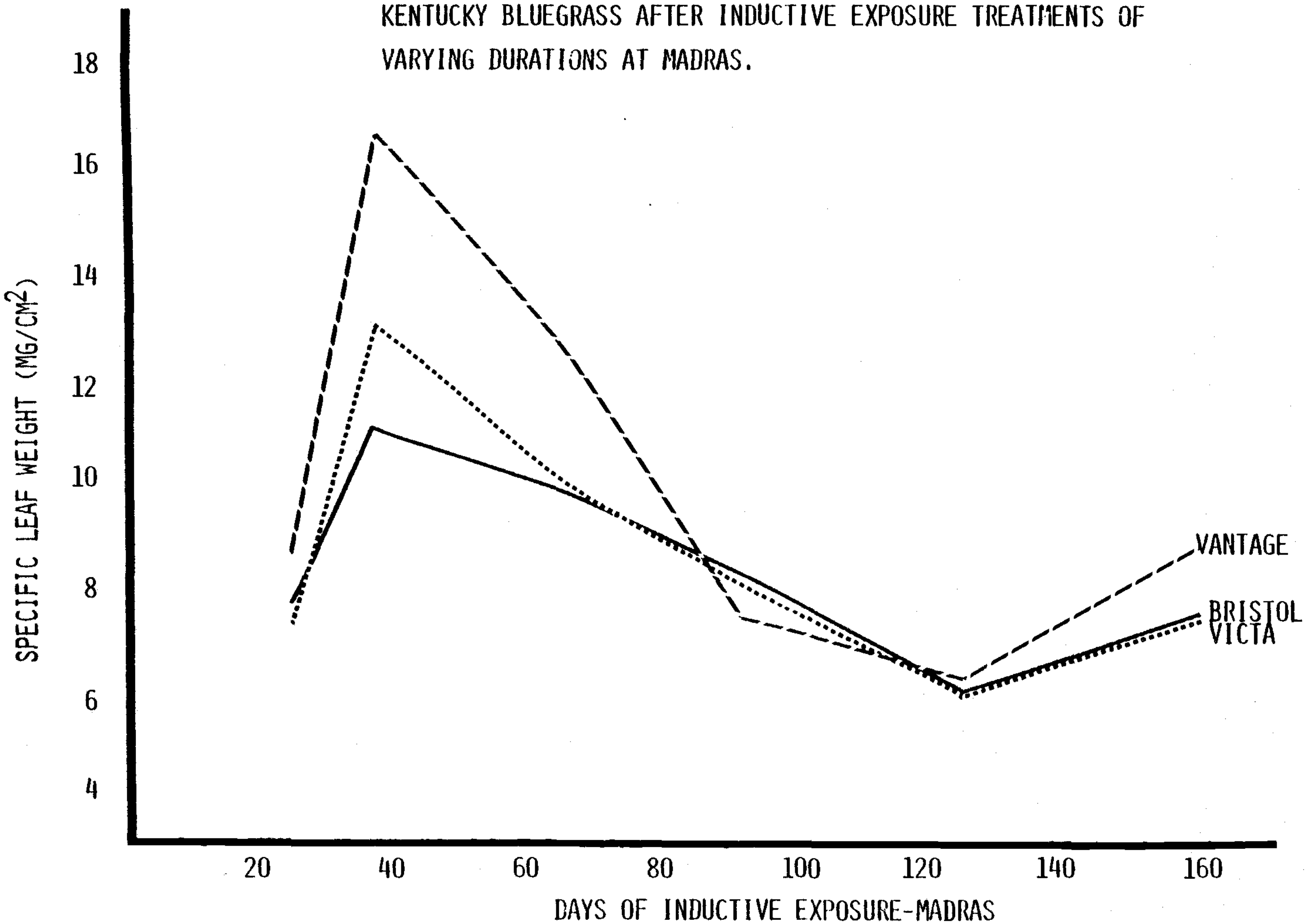
APPENDIX FIGURE 2. AVERAGE MINIMUM TEMPERATURE (°C) AT MADRAS AND GERVAIS FROM OCTOBER 1, 1977 TO MARCH 10, 1978.



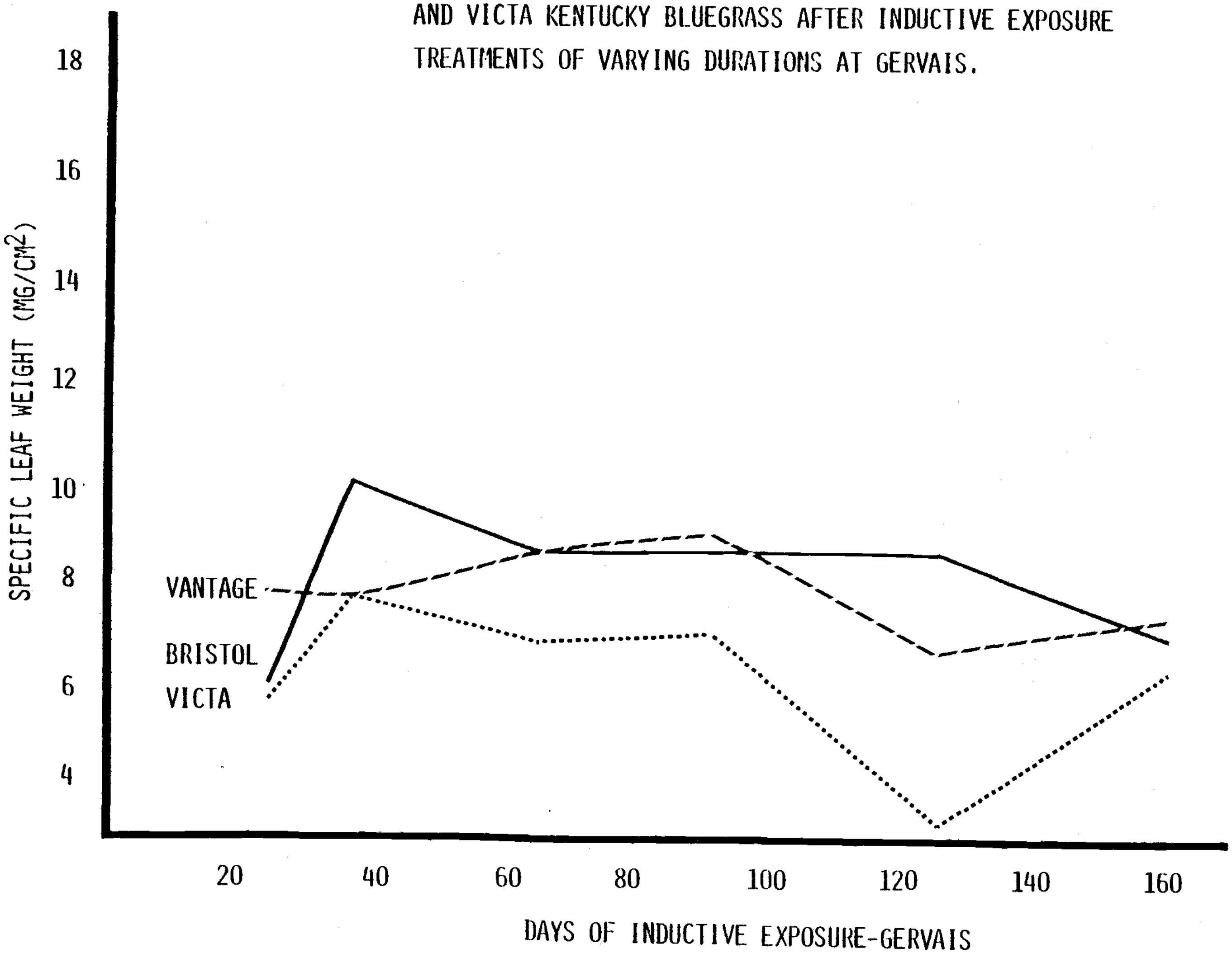
APPENDIX FIGURE 3. AVERAGE LIGHT ENERGY RECEIVED (LANGLEYS) AT MADRAS AND GERVAIS FROM OCTOBER 1, 1977 TO MARCH 10, 1978.



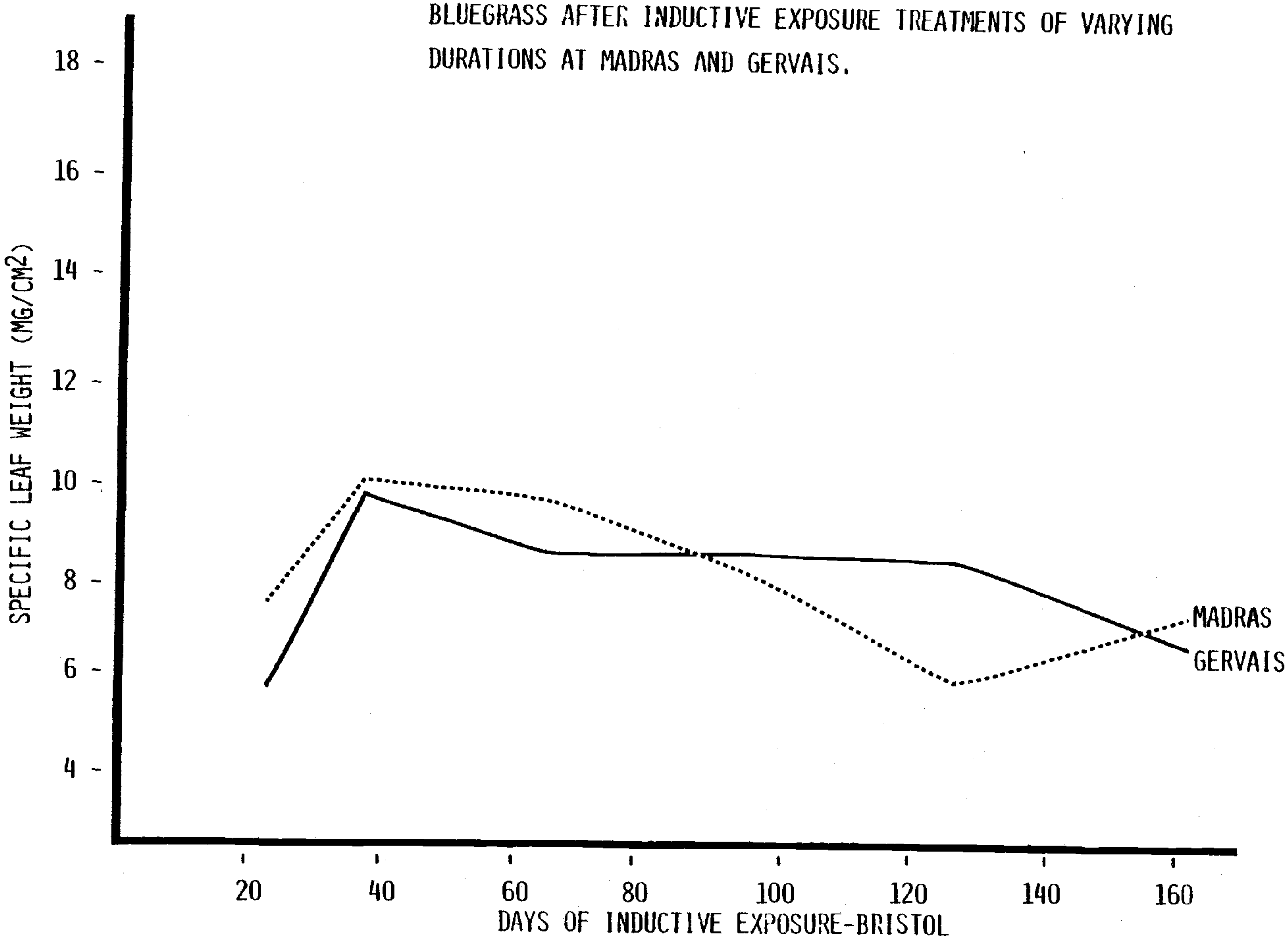
APPENDIX FIGURE 4. AVERAGE SPECIFIC LEAF WEIGHT OF VANTAGE, BRISTOL AND VICTA KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS.



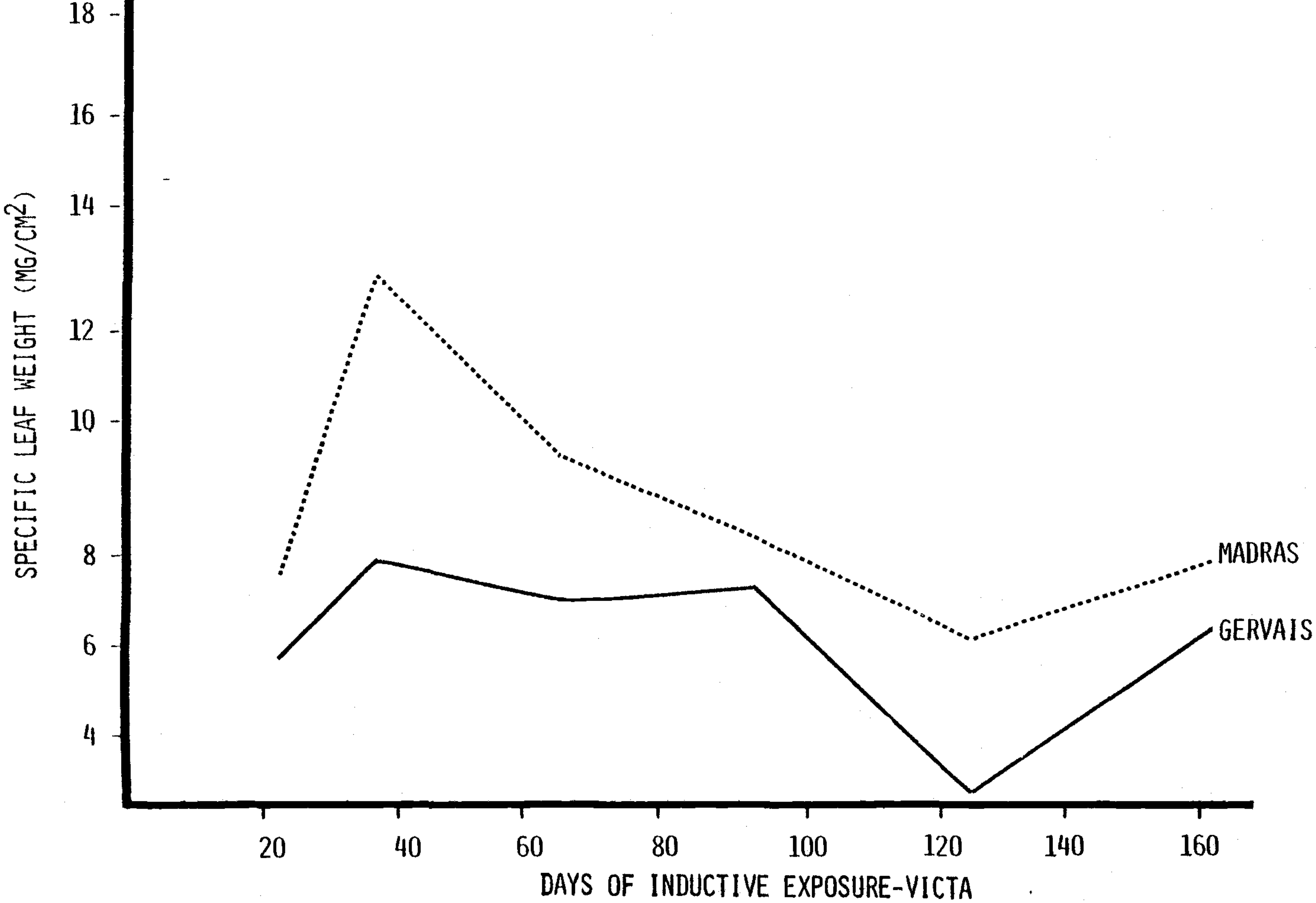
APPENDIX FIGURE 5. AVERAGE SPECIFIC LEAF WEIGHT (MG/CM^2) OF VANTAGE, BRISTOL AND VICTA KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT GERVAIS.



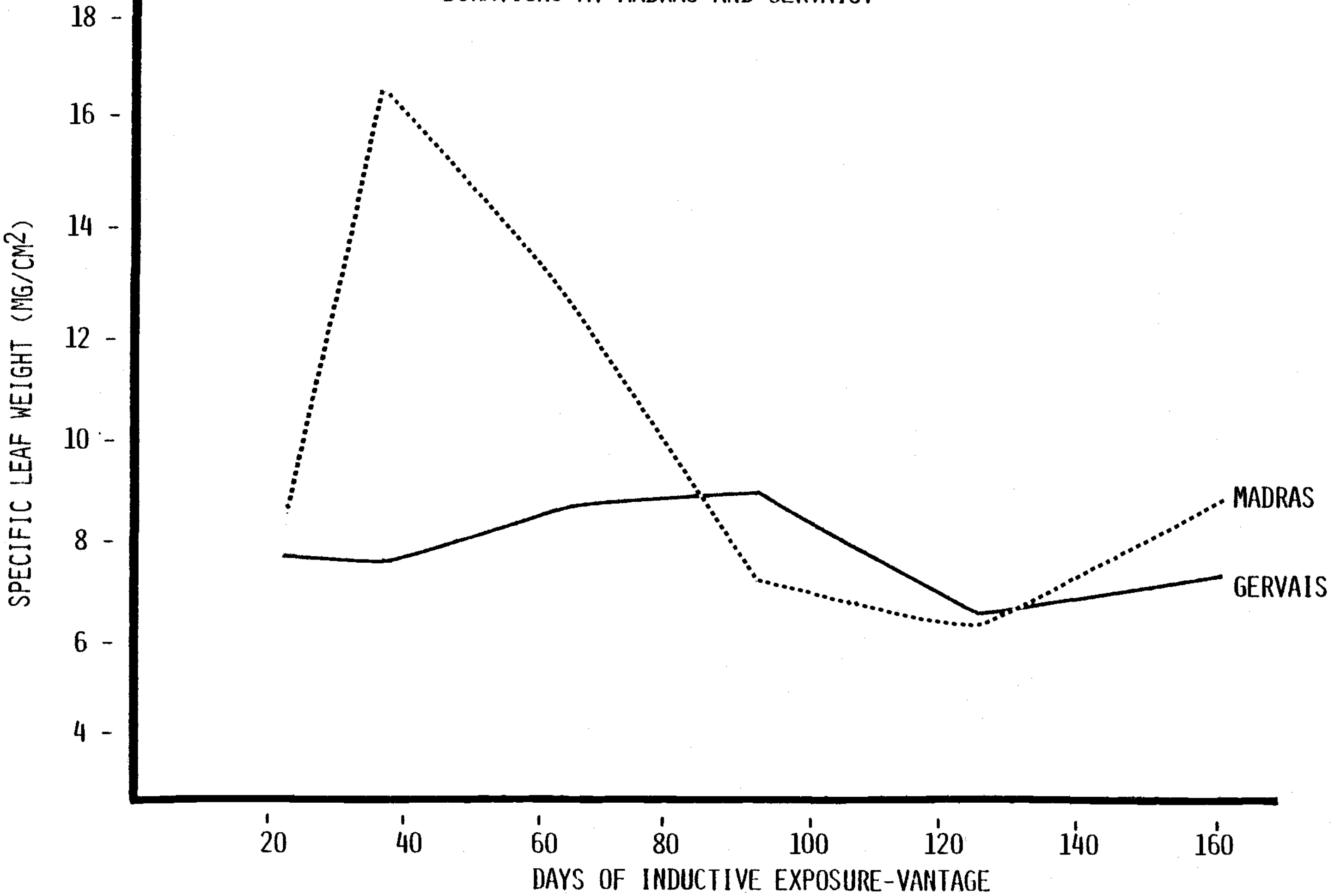
APPENDIX FIGURE 6. AVERAGE SPECIFIC LEAF WEIGHT (MG/CM^2) OF BRISTOL KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



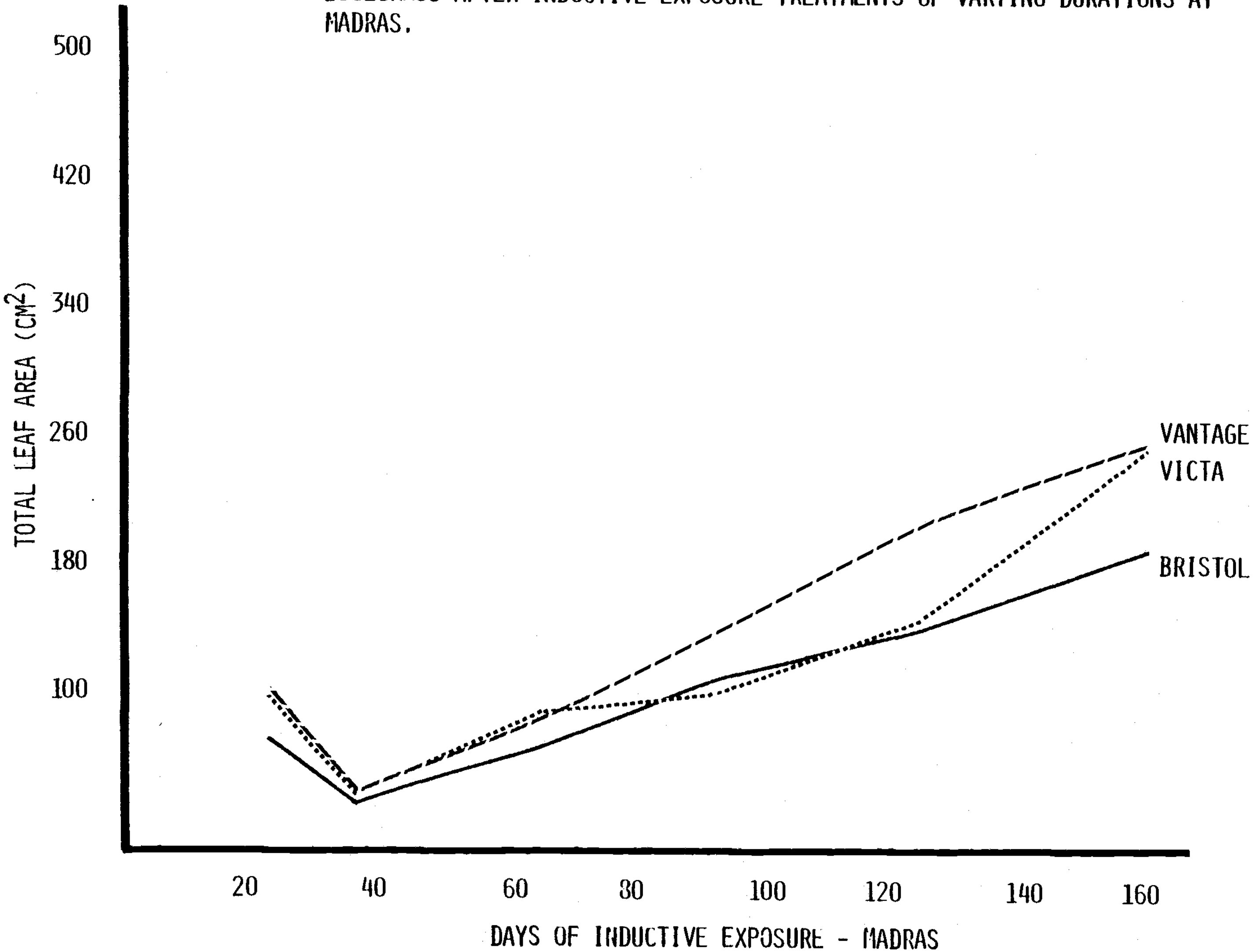
APPENDIX FIGURE 7. AVERAGE SPECIFIC LEAF WEIGHT (MG/CM^2) OF VICTA KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



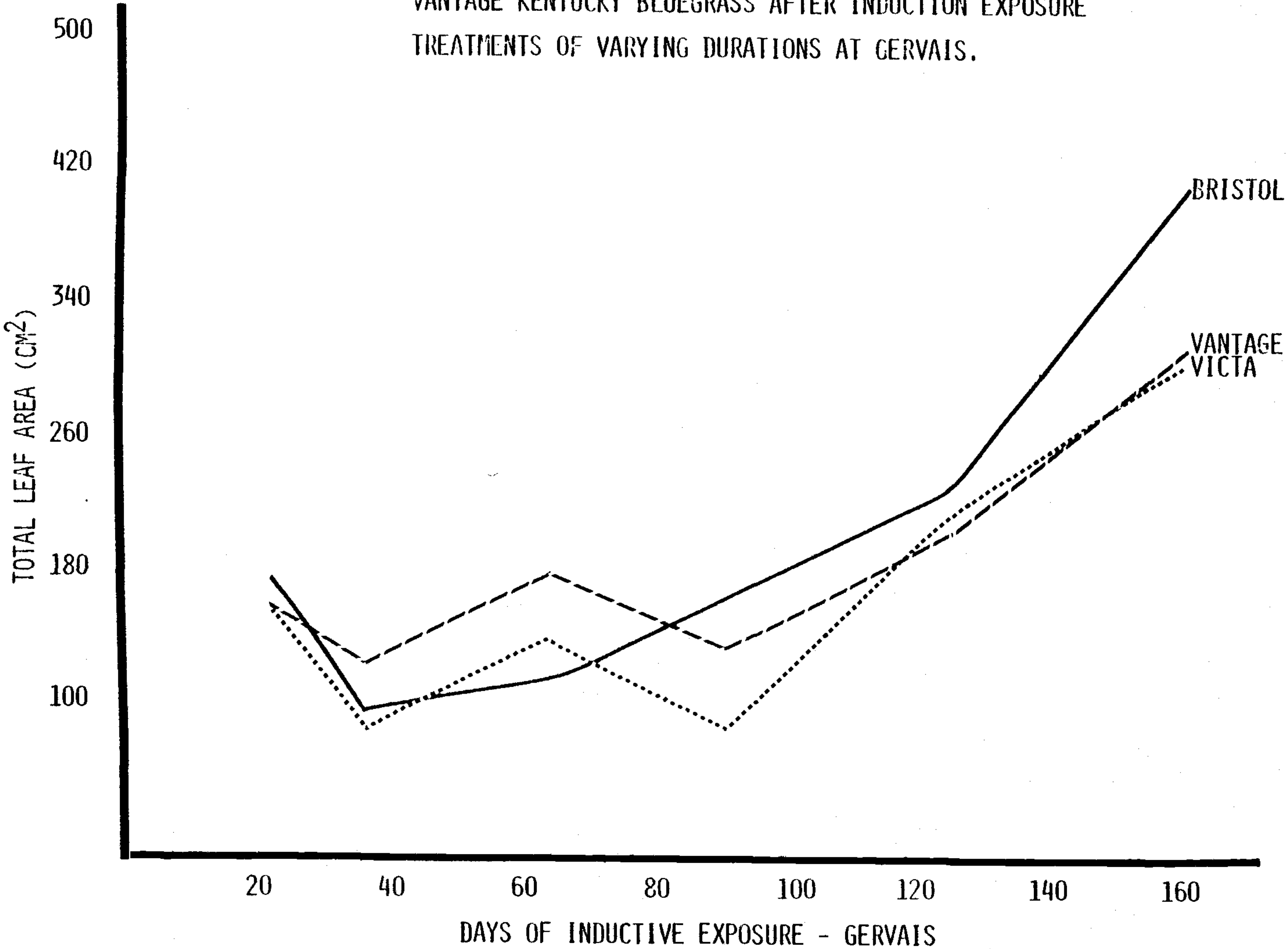
APPENDIX FIGURE 8. AVERAGE SPECIFIC LEAF WEIGHT (MG/CM^2) OF VANTAGE KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



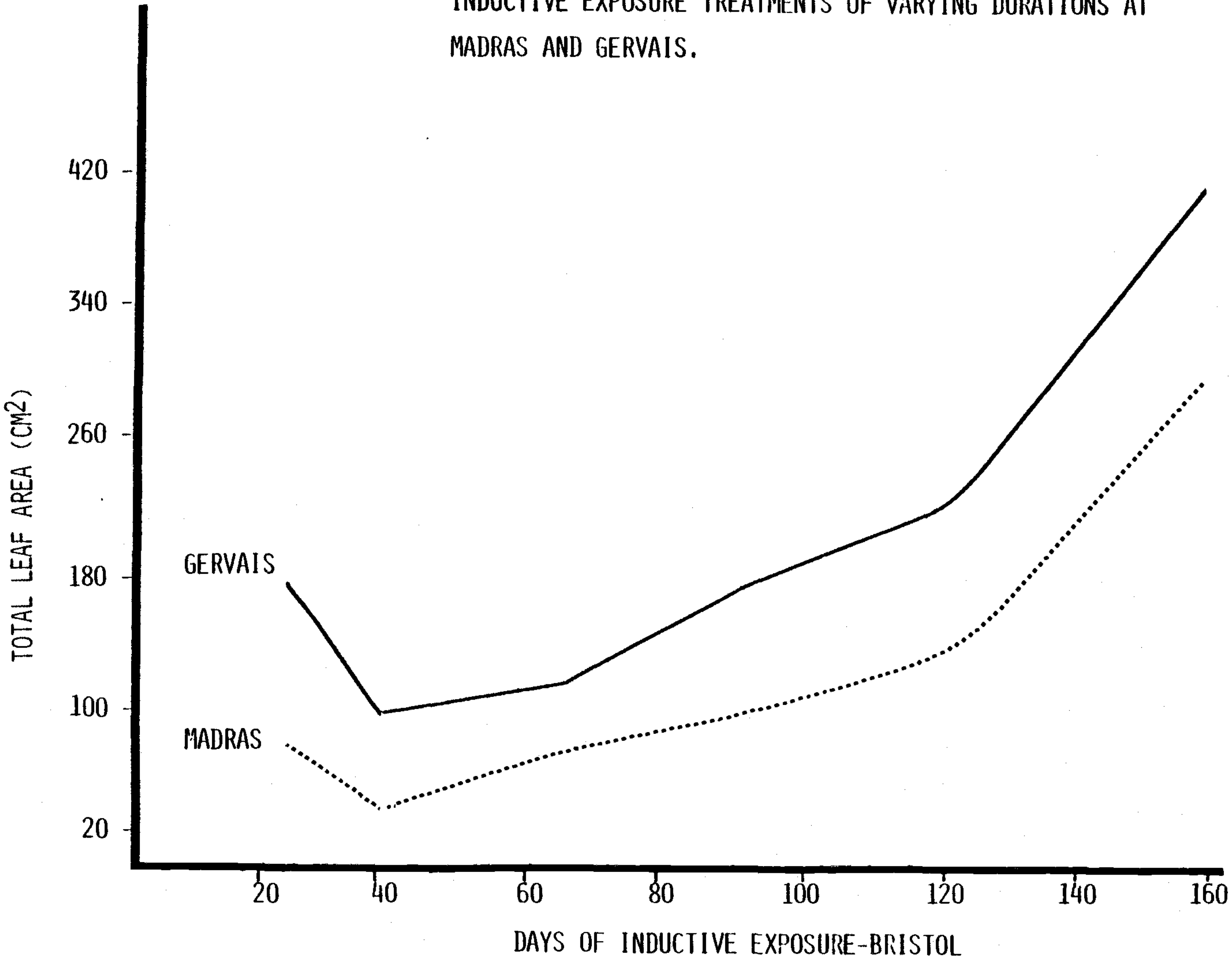
APPENDIX FIGURE 9. AVERAGE TOTAL LEAF AREA (CM^2) OF BRISTOL, VICTA, AND VANTAGE KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS.



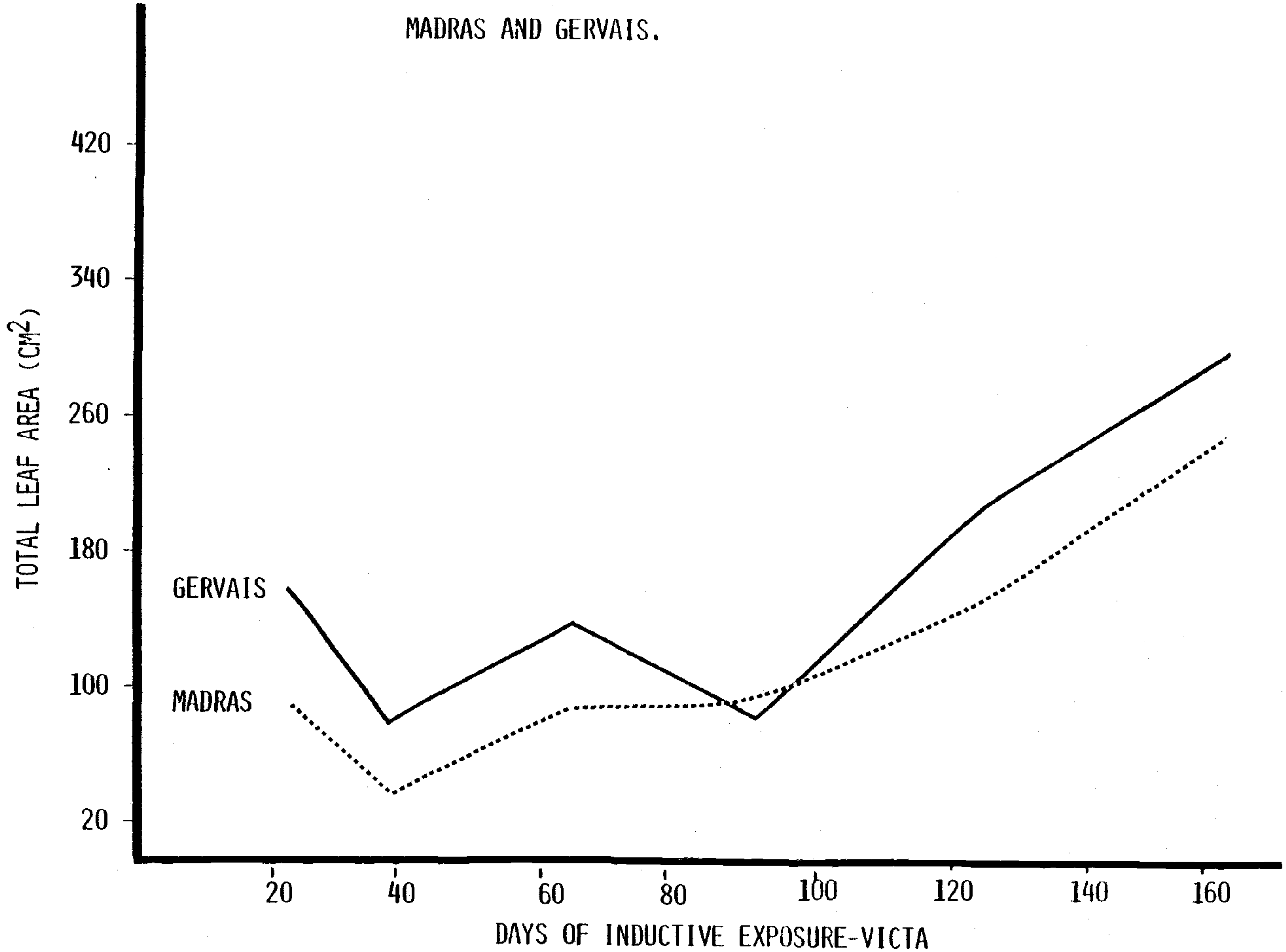
APPENDIX FIGURE 10. AVERAGE TOTAL LEAF AREA (CM^2) OF BRISTOL, VICTA AND VANTAGE KENTUCKY BLUEGRASS AFTER INDUCTION EXPOSURE TREATMENTS OF VARYING DURATIONS AT GERVAIS.



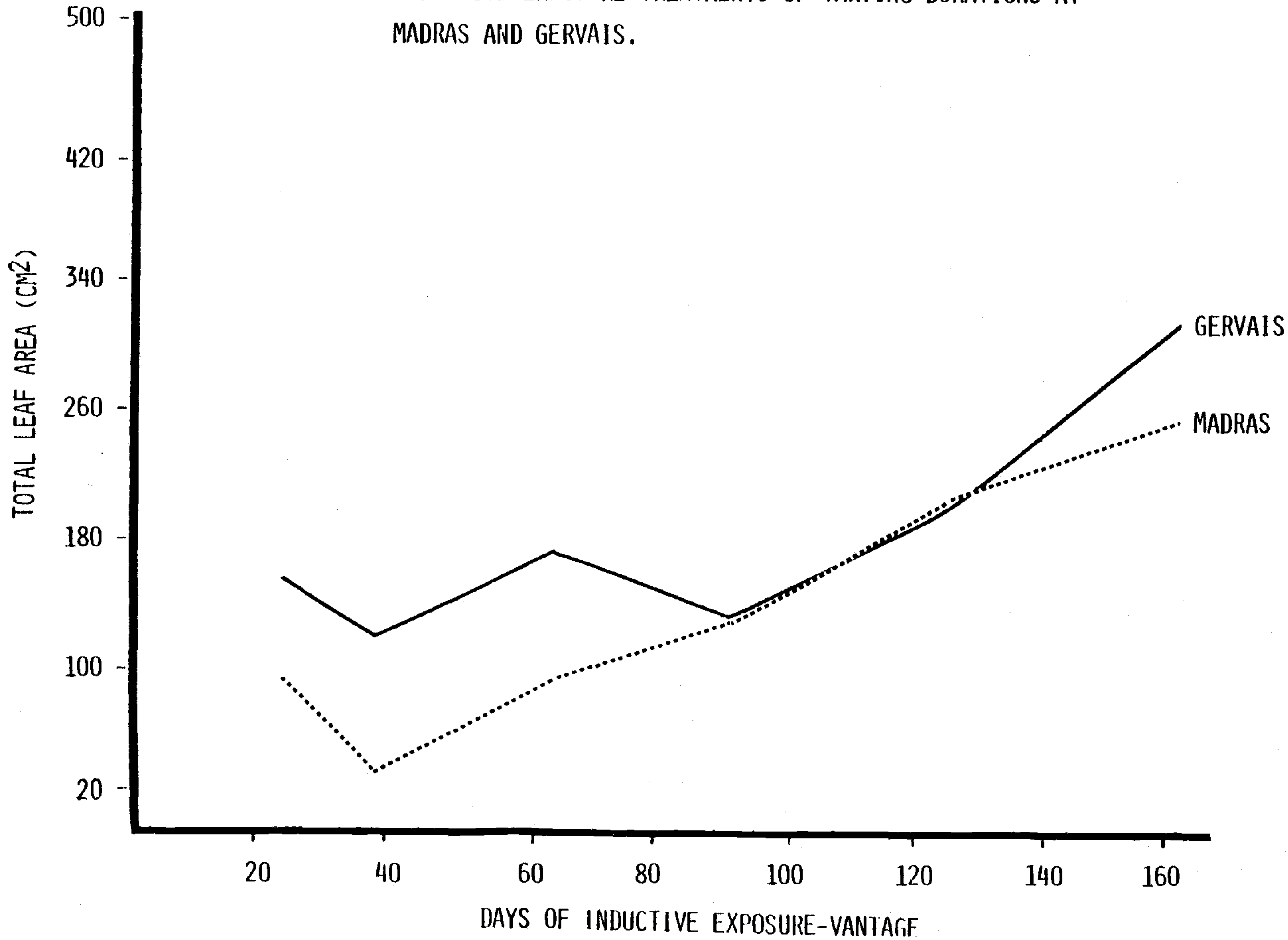
APPENDIX FIGURE 11. TOTAL LEAF AREA (CM^2) OF BRISTOL KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



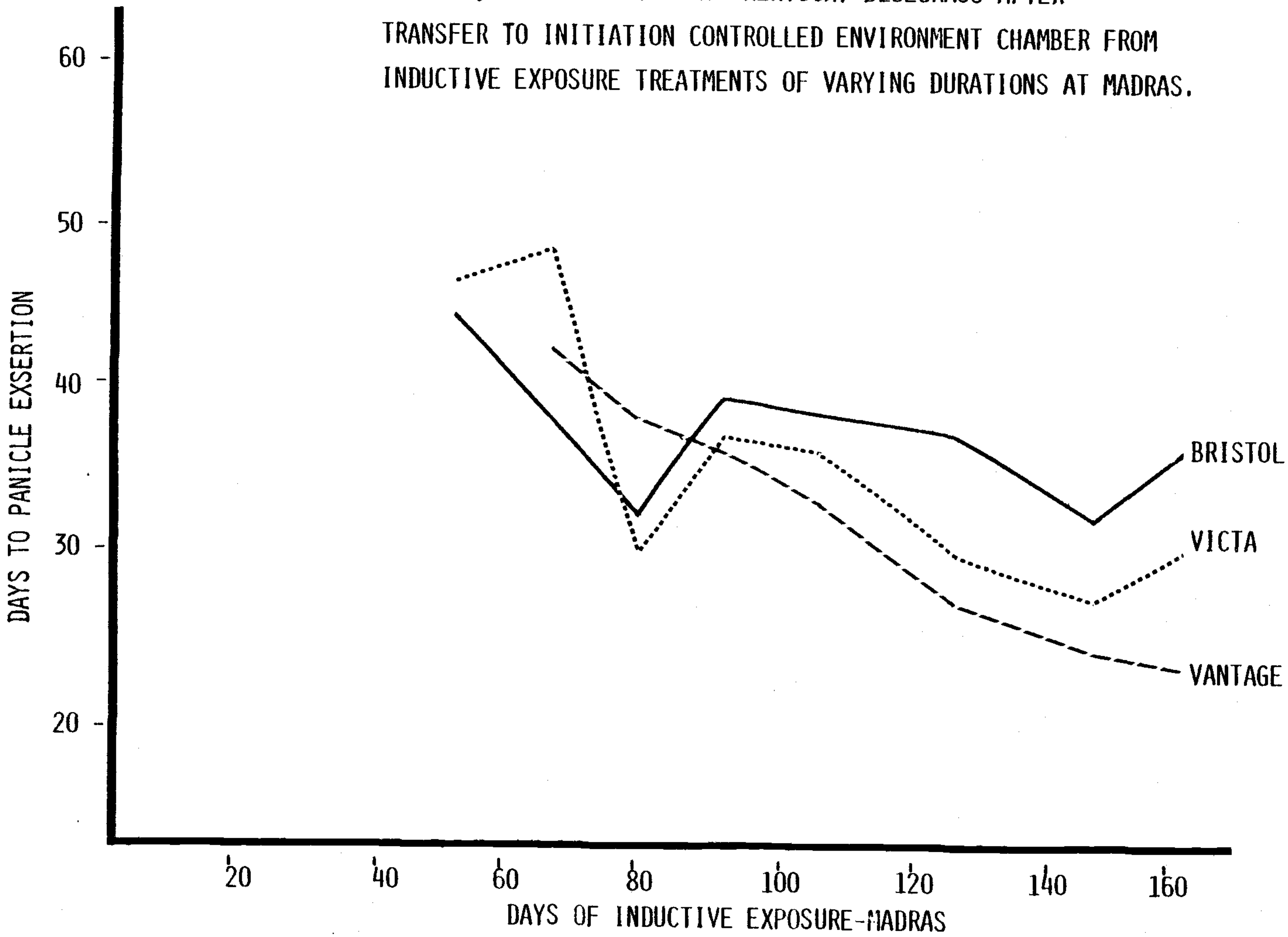
APPENDIX FIGURE 12. TOTAL LEAF AREA (CM^2) OF VICTA KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



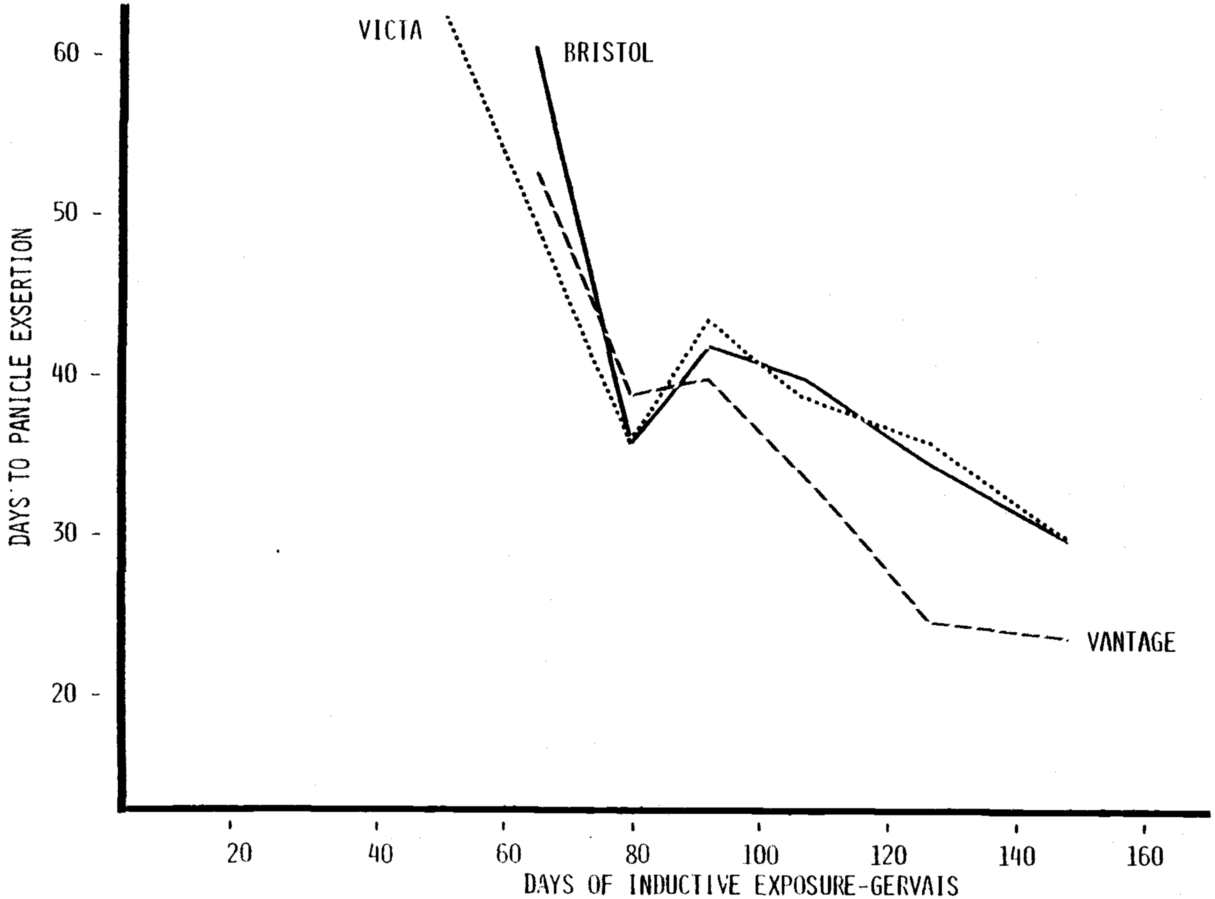
APPENDIX FIGURE 13. TOTAL LEAF AREA (CM^2) OF VANTAGE KENTUCKY BLUEGRASS AFTER INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



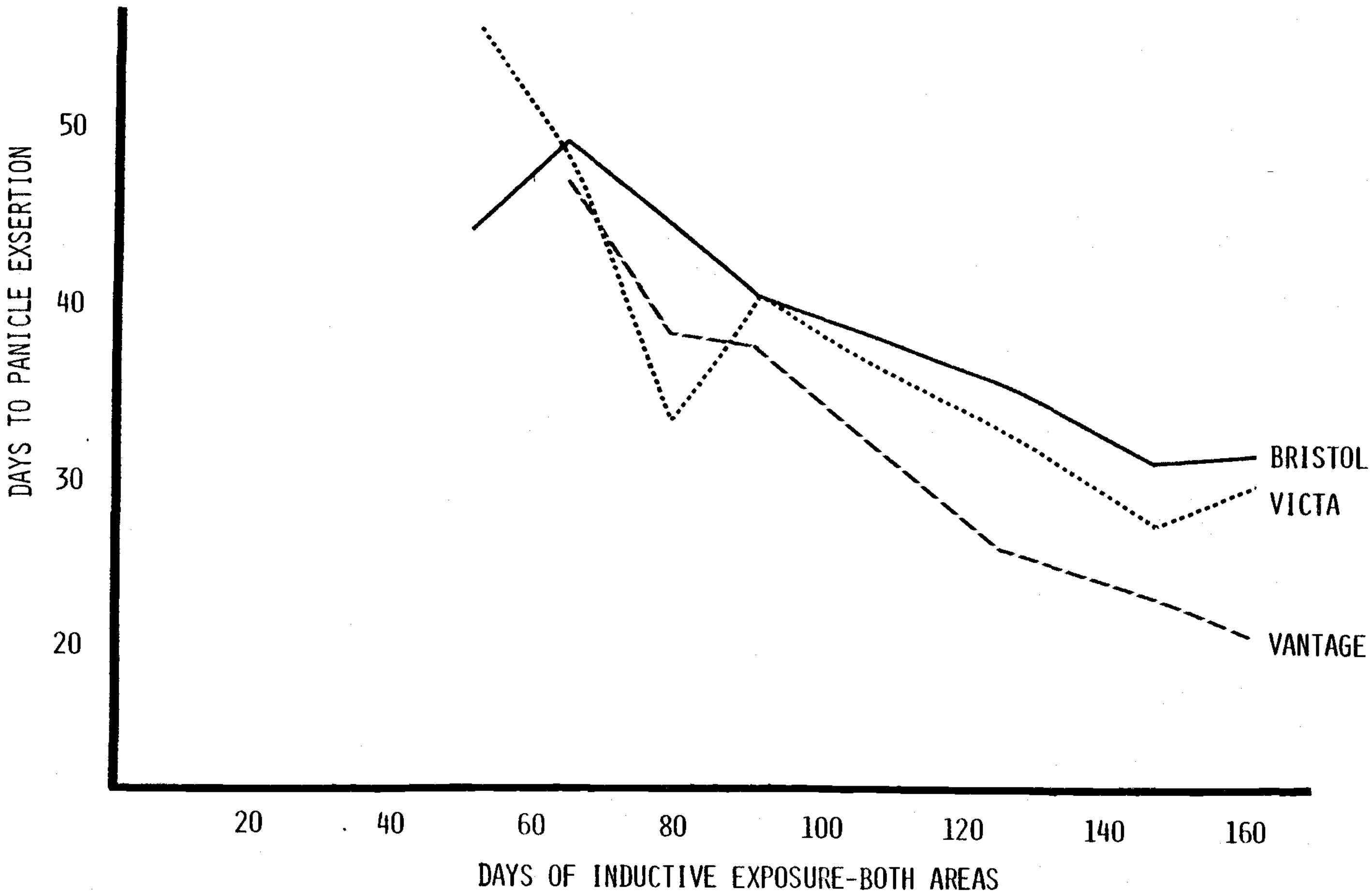
APPENDIX FIGURE 14. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF BRISTOL, VICTA AND VANTAGE KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS.



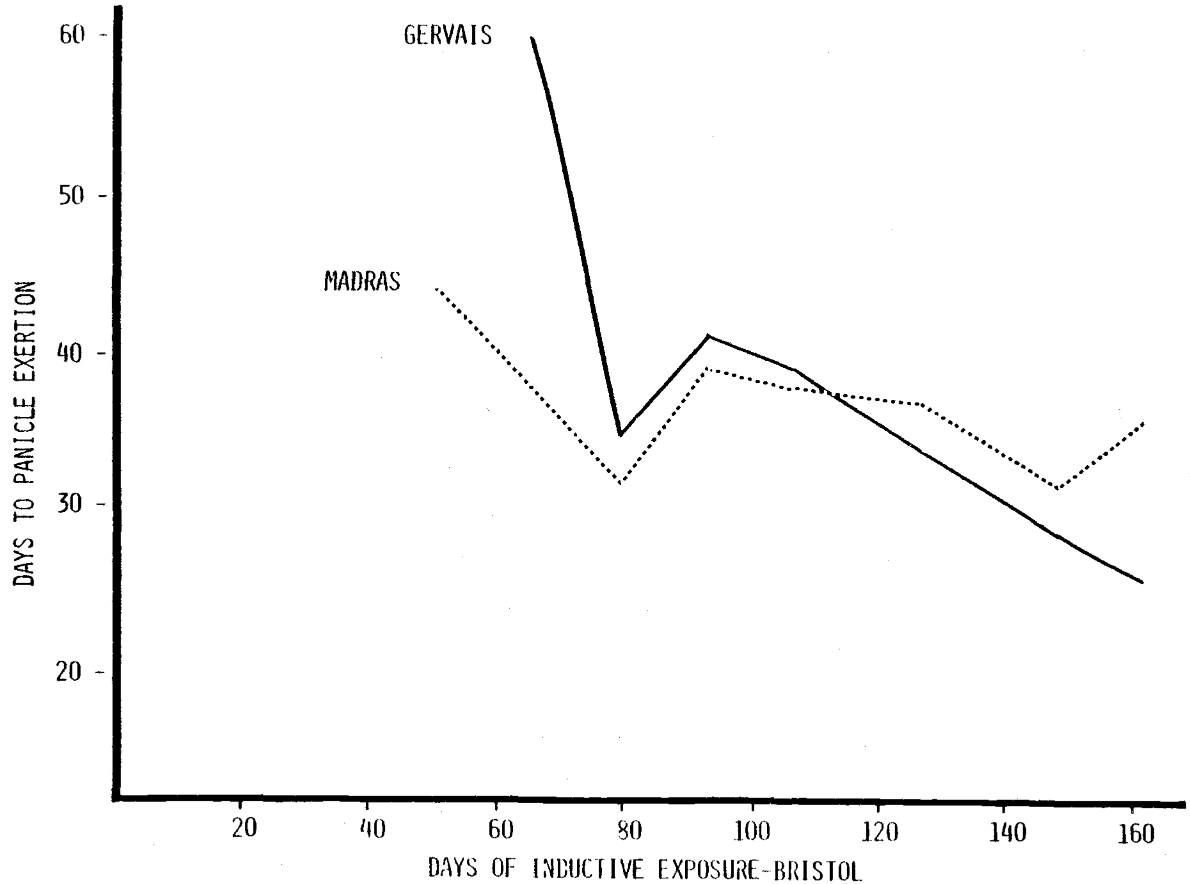
APPENDIX FIGURE 15. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF BRISTOL, VICTA, AND VANTAGE KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT GERVAIS.



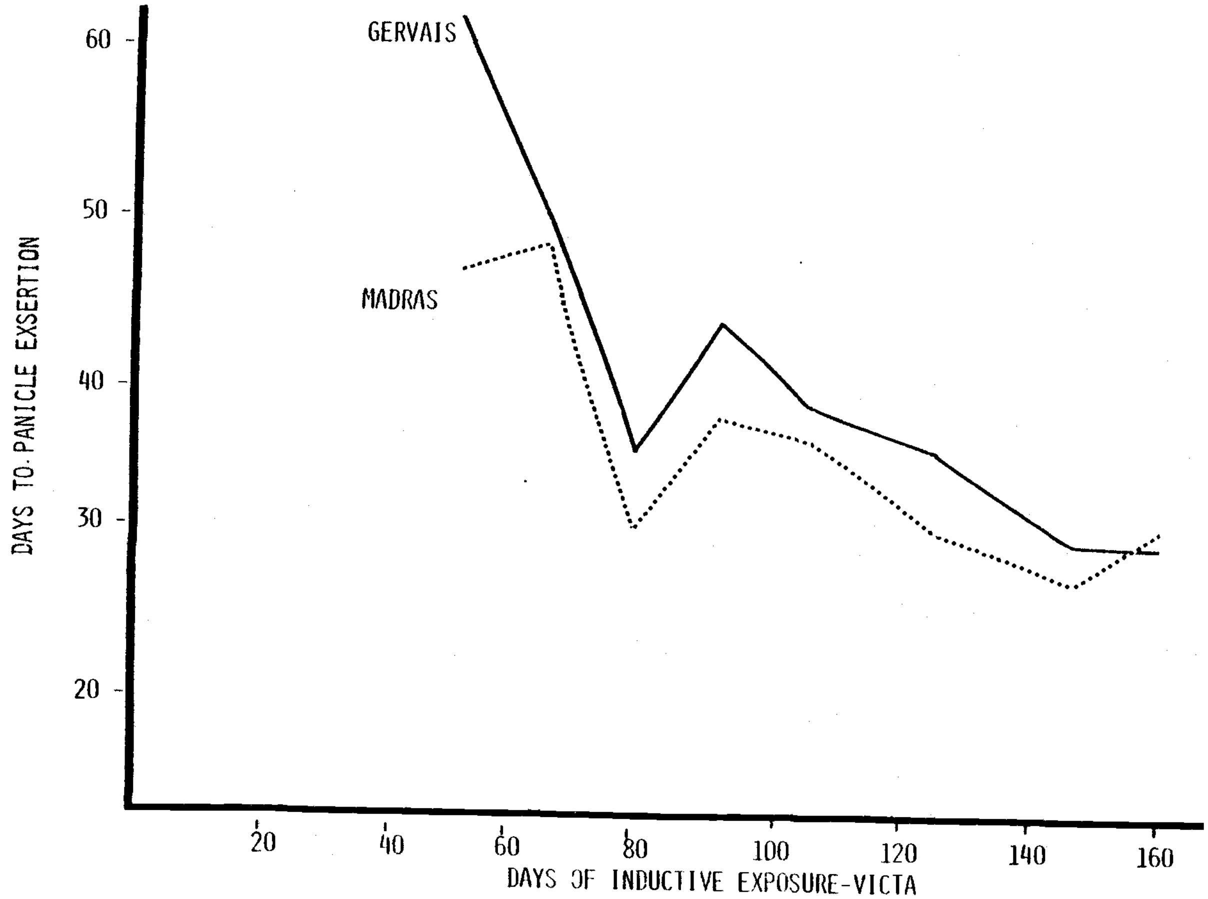
APPENDIX FIGURE 16. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF BRISTOL, VICTA AND VANTAGE KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



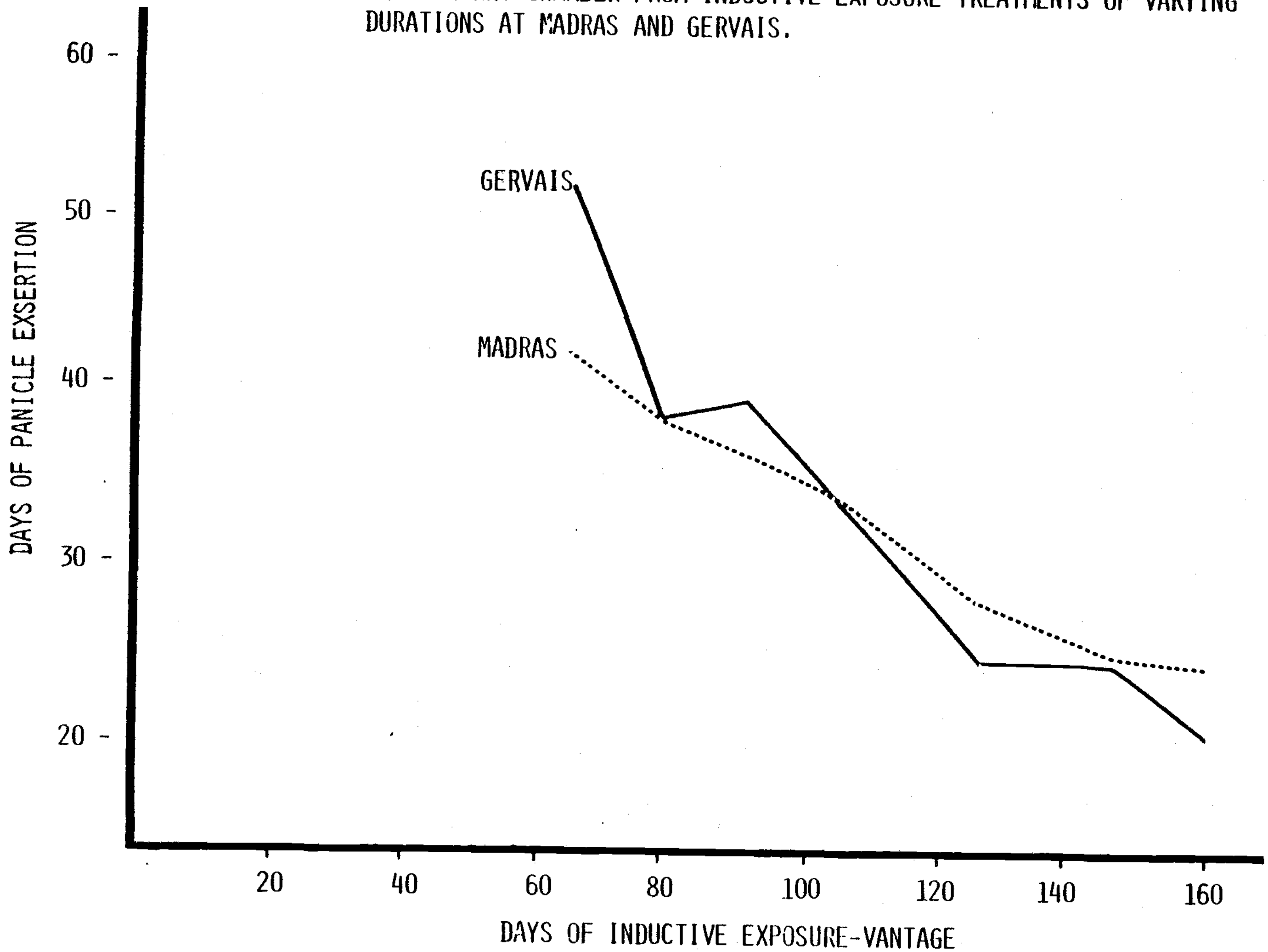
APPENDIX FIGURE 17. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF BRISTOL KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



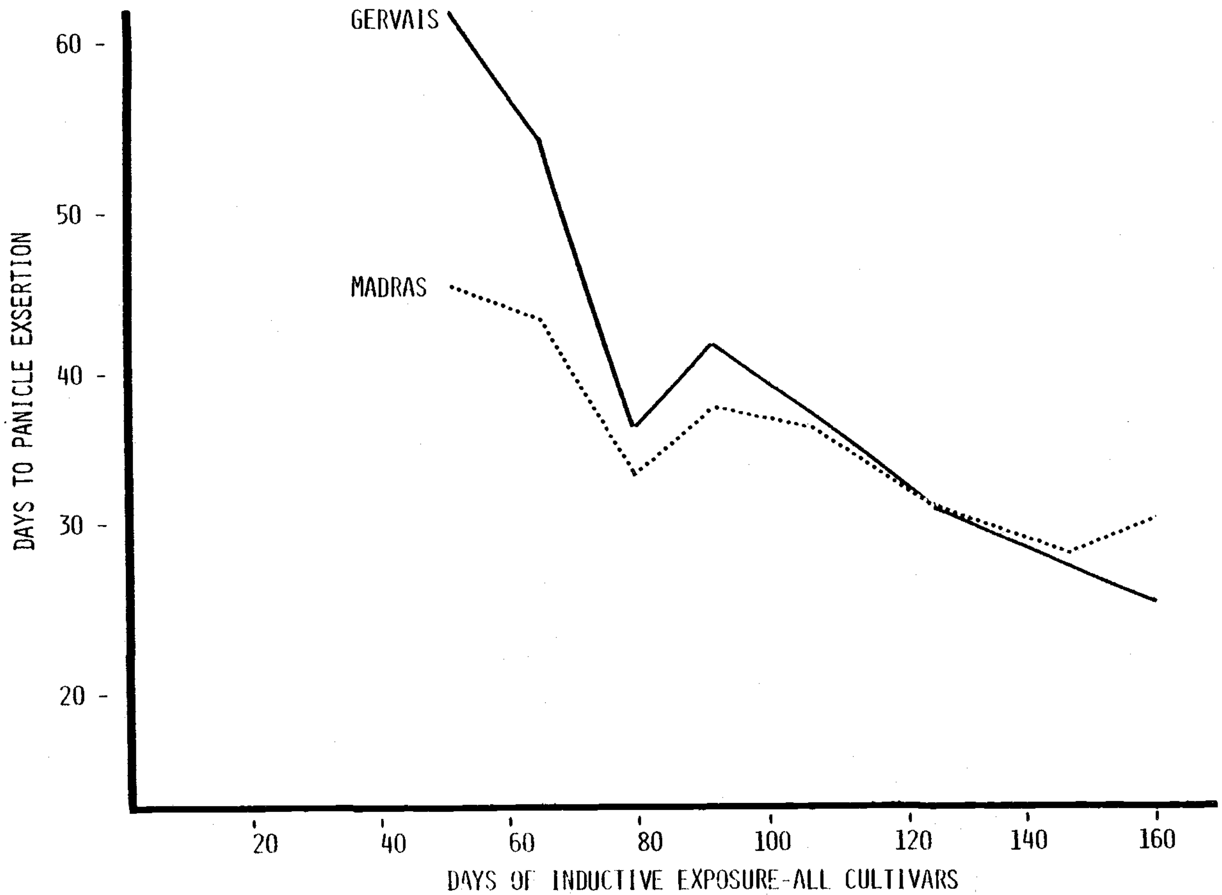
APPENDIX FIGURE 18. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF VICTA KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



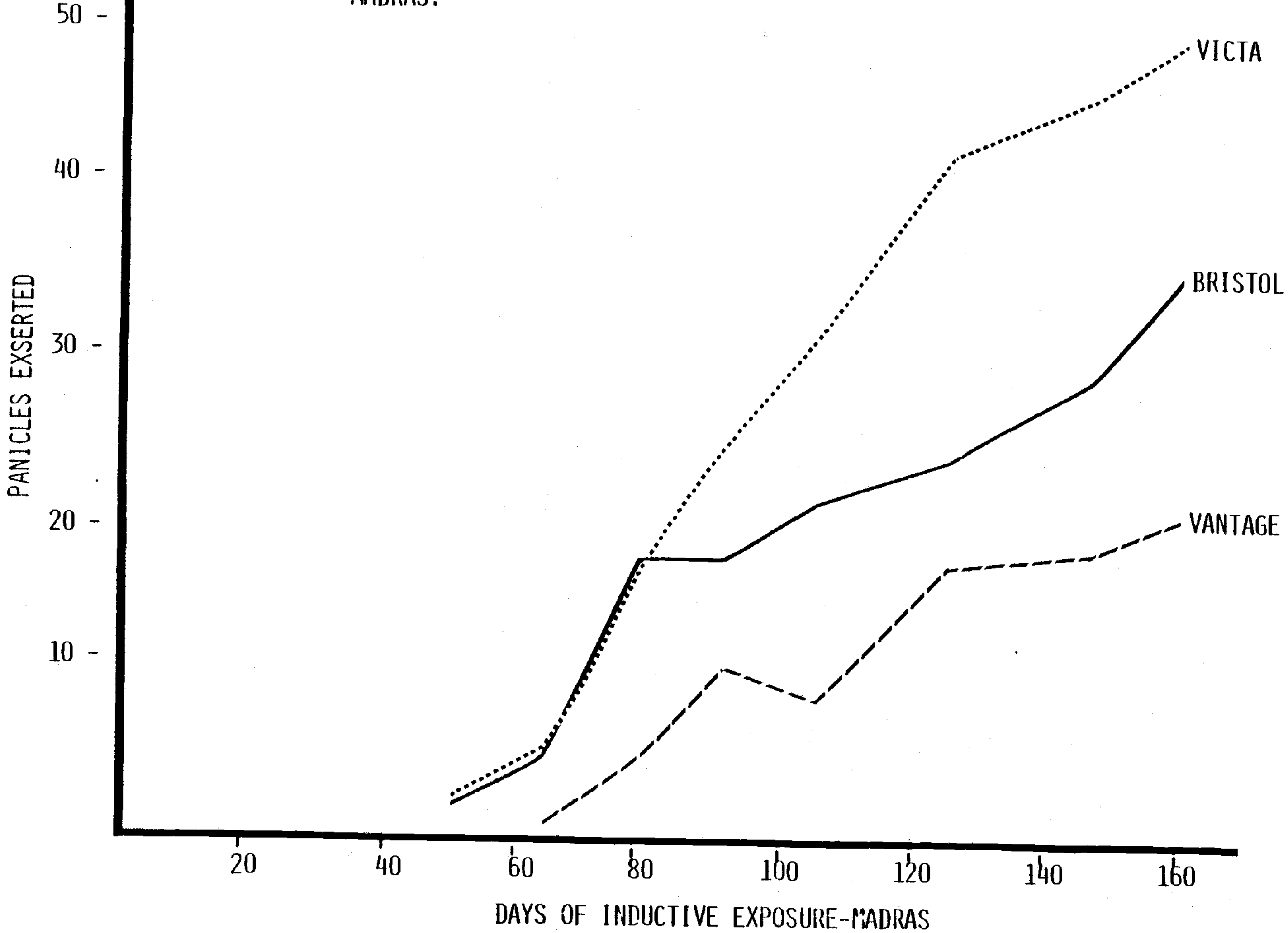
APPENDIX FIGURE 19. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF VANTAGE KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



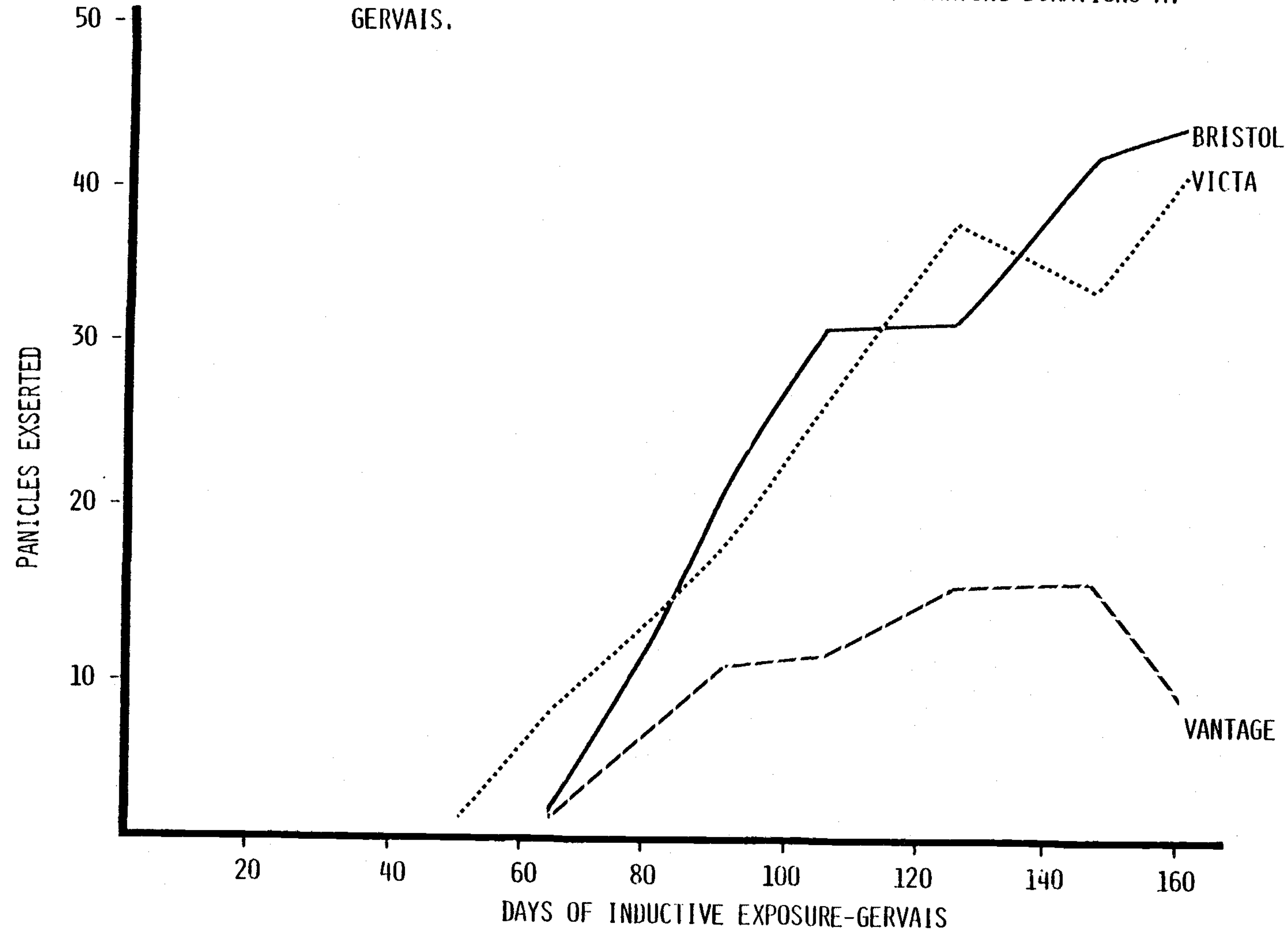
APPENDIX FIGURE 20. AVERAGE NUMBER OF DAYS REQUIRED FOR PANICLE EXSERTION OF THREE KENTUCKY BLUEGRASS AFTER TRANSFER TO INITIATION CONTROLLED ENVIRONMENT CHAMBER FROM INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



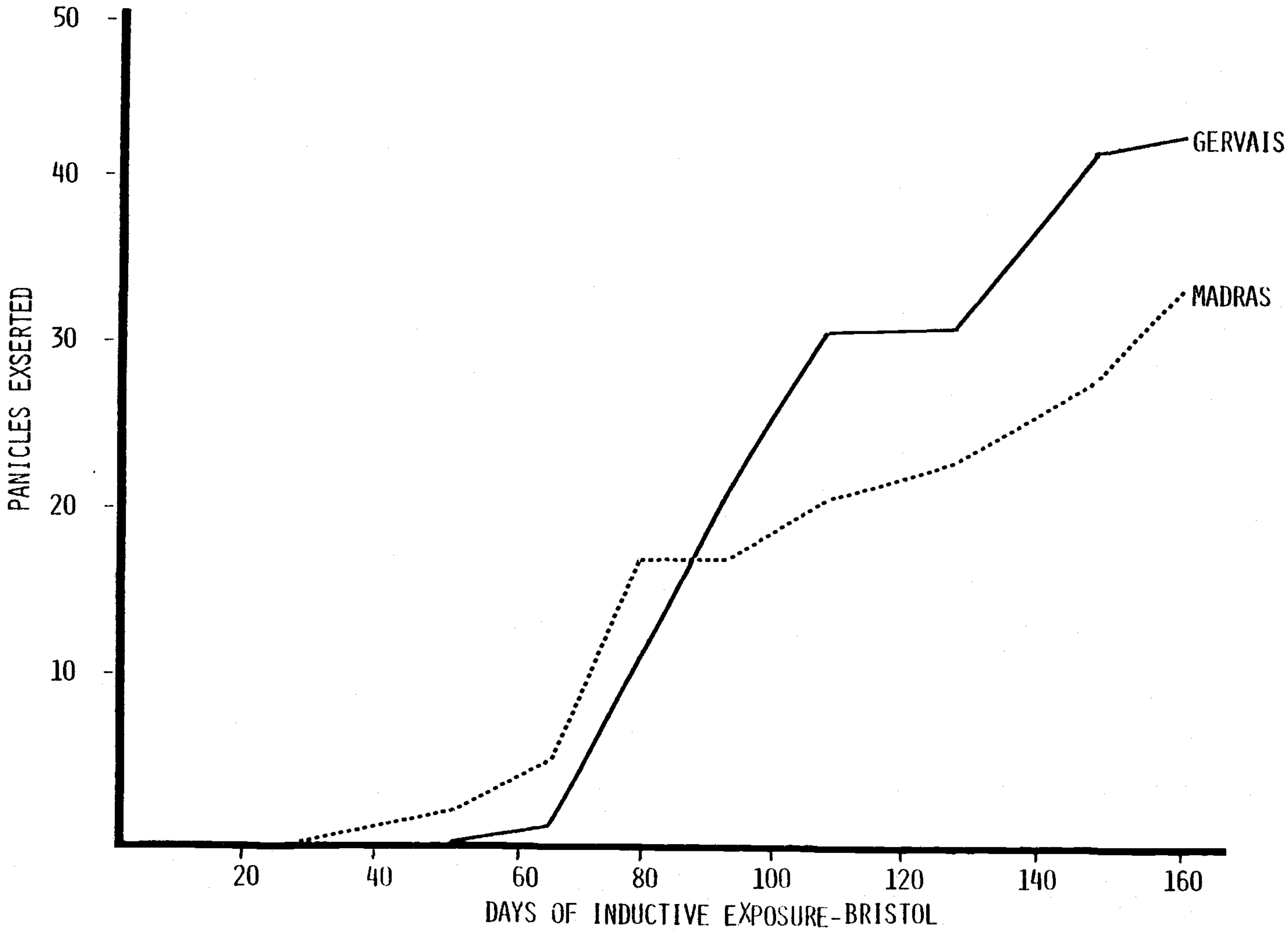
APPENDIX FIGURE 21. AVERAGE NUMBER OF PANICLES EXSERTED BY BRISTOL, VICTA, AND VANTAGE FOLLOWING INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS.



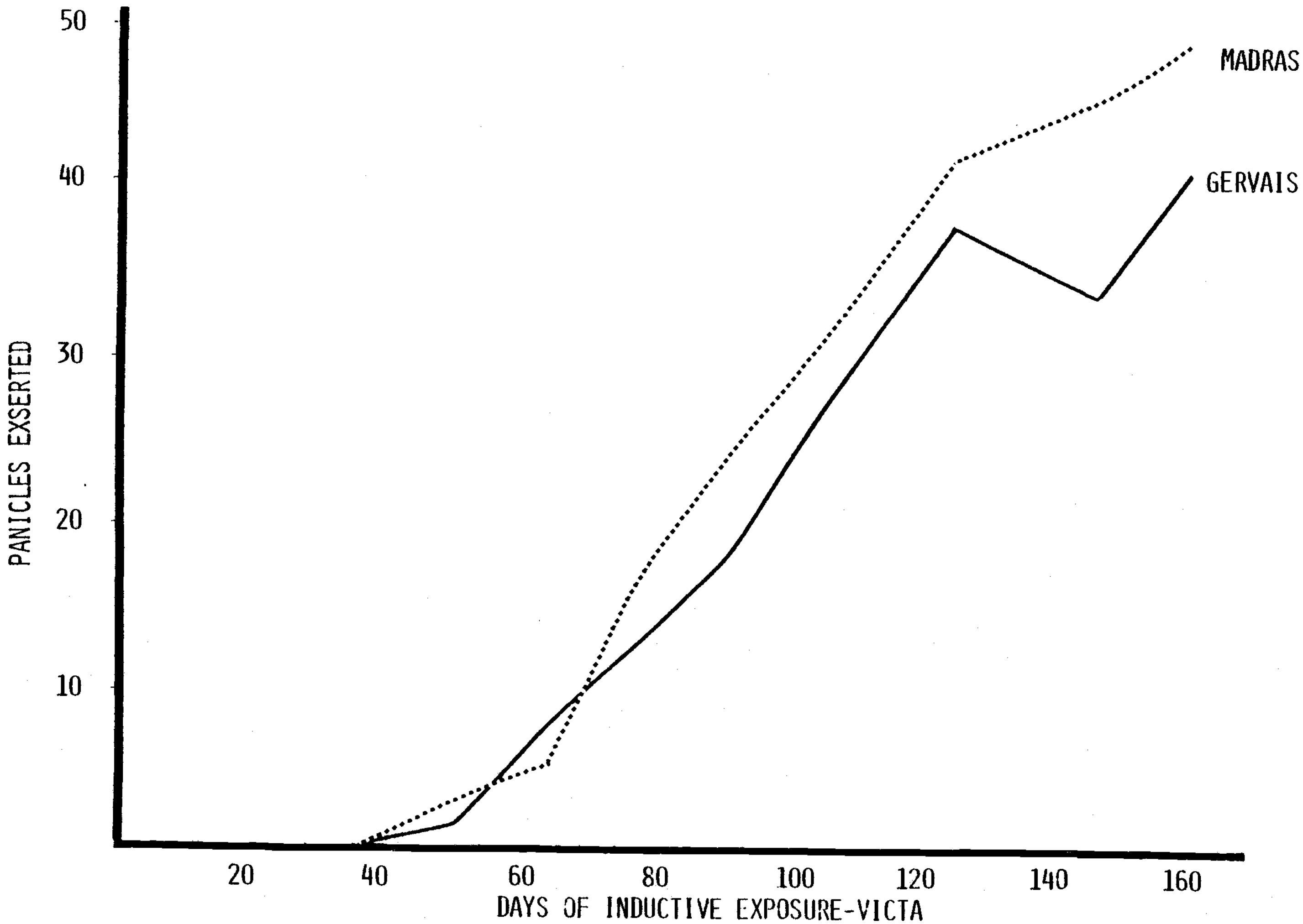
APPENDIX FIGURE 22. AVERAGE NUMBER OF PANICLES EXSERTED BY BRISTOL, VICTA, AND VANTAGE FOLLOWING INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT GERVAIS.



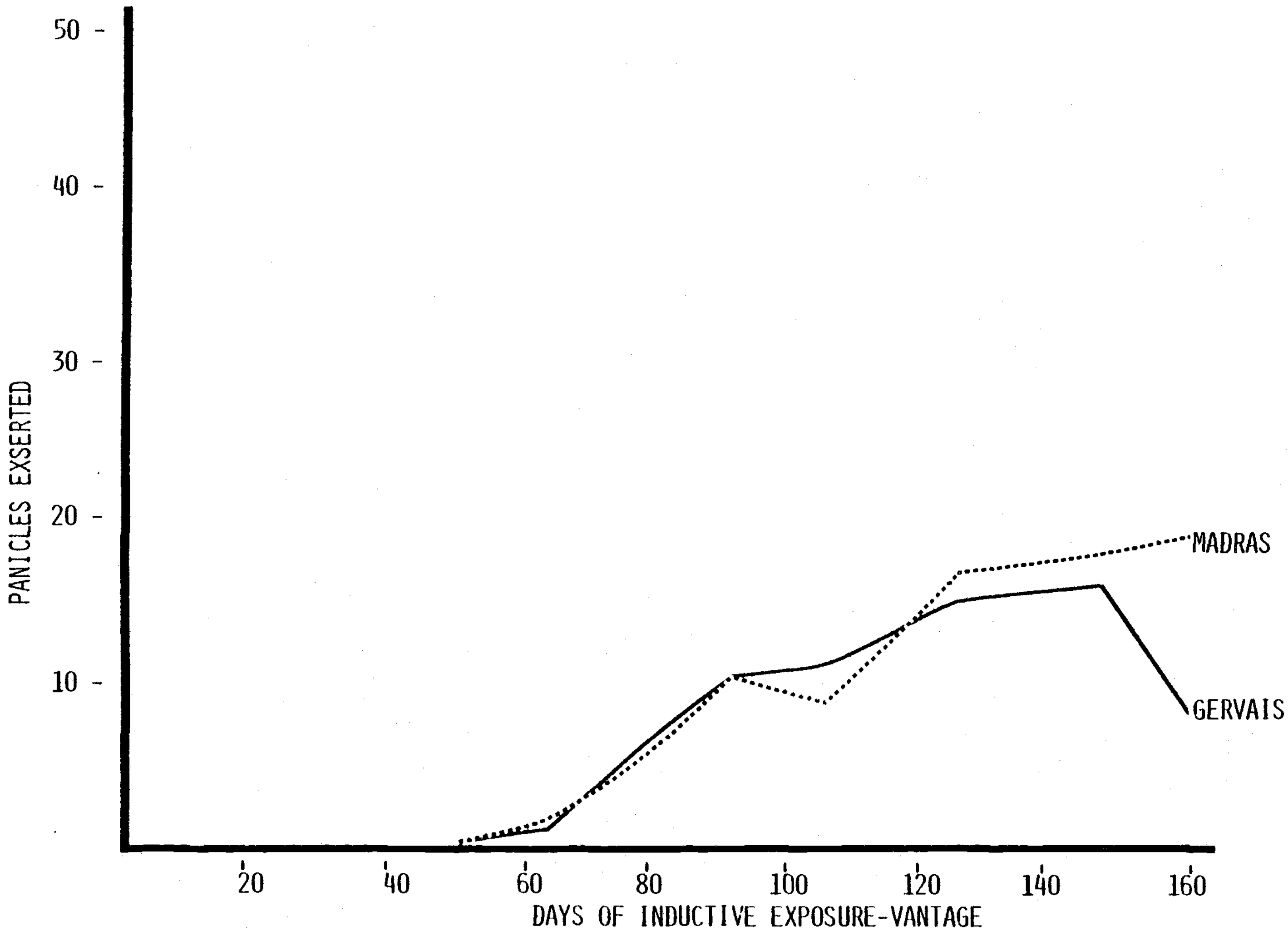
APPENDIX FIGURE 23. AVERAGE NUMBER OF PANICLES EXSERTED BY BRISTOL FOLLOWING INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



APPENDIX FIGURE 24. AVERAGE NUMBER OF PANICLES EXSERTED BY VICTA FOLLOWING INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



APPENDIX FIGURE 25. AVERAGE NUMBER OF PANICLES EXSERTED BY VANTAGE FOLLOWING INDUCTIVE EXPOSURE TREATMENTS OF VARYING DURATIONS AT MADRAS AND GERVAIS.



Bibliography

1. Auda, Hamid, R. E. Blaser, and R. H. Brown. 1966. Tillering and carbohydrate contents of orchardgrass as influenced by environmental factors. Crop Sci. 6:139-143.

2. Bean, E. W. 1970. Short-day and low temperature control of floral induction in Festuca. Annals of Botany 34:57-66.

3. Calder, D. M. 1966. Inflorescence induction and initiation in the Gramineae. In: The growth of cereals and grasses. Ed. by F. L. Milthorpe and J. D. Ivins. Proceedings of the 12th Easter School in Agricultural Science, Nottingham, University of Nottingham, 1965. London, Buttersworth, p. 59-73.

4. Canode, C. L., M. Anwar, and I. D. Teare. 1972. Initiation of inflorescences in cool-season perennial grasses. Crop Sci. 12:19-22.

5. Chilcote, D. O. 1961. Environmental control of flowering in selected genotypes of orchardgrass (Dactylis glomerata). Ph.D. Thesis. Lafayette, Purdue University.

6. Cooper, J. P. 1954. Studies on growth and development in Lolium. IV. Genetic control of heading responses in local populations. J. of Ecology 42:521-556.

7. Evans, L. T. 1960. The influence of temperature on flowering in species of Lolium and in Poa pratensis. J. of Agric. Sci. 54:410-416.

8. Evans, L. T. 1967. Inflorescence initiation in Lolium temulentum L. IX. Some chemical changes in the shoot apex at induction. Aust. J. Biol. Sci. 20:1-72.

9. Gardner, F. P. and W. E. Loomis. 1953. Floral induction and development in orchardgrass. Pl. Phy. 28:201-217.

10. Habjorg, Atle. 1976. Effects of photoperiod and temperature on vegetative growth on different Norwegian ecotypes of Poa pratensis. Scientific Reports of the Agricultural University of Norway. Vol. 55. Report #61, 1976.

11. Habjorg, Atle. 1978. Climatic control of floral differentiation and development in selected latitudinal and altitudinal ecotypes of Poa pratensis L. Scientific Reports of the Agricultural University of Norway. Vol. 57. Report #57, 1978.

12. Langer, R. H. M. and D. A. Lambert. 1959. Ear bearing capacity of tillers arising at different times in herbage grasses grown for seed. J. of British Grassland Soc. 14:137-140.

13. Lindsey, K. E. and M. L. Peterson. 1962. High temperature suppression of flowering in Poa pratensis L. Crop Sci. 2:71-74.

14. Lindsey, K. E. and M. L. Peterson. 1964. Floral induction and development in Poa pratensis L. Crop Sci. 5:540-544.

15. Murray, J. J., A. C. Wilton, and J. B. Powell. 1973. Floral induction and development in Festuca rubra L. differential clonal response to environmental conditions. Crop Sci. 6:645-648.

16. Nyahos, Felix, C. Marshall and G. R. Sagar. 1973. The interrelationship between tillers and rhizomes of Poa pratensis L. An autoradugraphic study. Weed Res. 13:304-309.

17. Pauldi, E. and M. DeVay. 1977. Ribosomal RNA synthesis in spring and winter wheat varieties at temperatures active for vernalization and at neutral and devernalization temperatures. Biochem. Physiol. Pflanzen 171:249-259.

18. Peterson, M. L. and W. E. Loomis. 1949. Effects of photoperiod and temperature on growth and flowering of Kentucky bluegrass. Plant Phy. Jan. 1949:31-43.

19. Peterson, M. L., J. P. Cooper and Leo E. Bendixen. 1961. Thermal and photoperiodic induction of flowering in Darnel (Lolium temulentum). Crop Sci. Vol. 1, No. 1:17-20.

20. Spiertz, J. H. J. and J. Ellen. 1977. The effect of light intensity on some morphological and physiological aspects of the crop perennial ryegrass (Lolium perenne var. Cropper) and its effect on seed production. Neth. J. Agric. Sci. 20:232-246.

21. Stobbe, E. H. 1969. Tiller development in Dactylis glomerata L. as influenced by nutrient supply and panicle removal. Ph.D. Thesis. Oregon State University. June, 1969.

22. Templeton, W. C., Jr., G. O. Mott, and R. J. Bula. 1961. Some effects of temperature and light on growth and flowering of tall fescue (Festuca arundinacea, Schreb.) II. Floral Development. Crop Sci. 1:283-286.

23. Von Amsberg, Hans Joachim. Floral and vegetative development in Dactylis glomerata as influenced by different temperature levels and durations. Ph.D. Thesis. Oregon State University, 1965.