VARIATION IN SUMMER DORMANCY AMONG COLLECTIONS OF *PHALARIS TUBEROSA* AT DAVIS, CALIFORNIA

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The summer-dormancy period among collections of *Phalaris tuberosa* L. from the eastern Mediterranean region when grown at Davis, California, ranged from 30 to 127 days. Plants from the more arid sites of origin tended to exhibit the longer dormancy. There were exceptions, however, and these, together with the diversity of behaviour in this material, suggest that genotypes with a potential for increased summer growth may be selected for use on rangelands.

INTRODUCTION

Perennial grasses in regions of prolonged hot and arid summers usually cease growth for periods of several months, then resume growth in the autumn when the environment moderates. These grasses are said to enter a period of summer dormancy (3). Growth cessation during the summer has an obvious value in that it increases the likelihood of summer survival. It also results in a period when no new forage is produced during the summer. The growth just prior to entering dormancy and that immediately after the dormant period is often of particular value on rangelands since many species may yield little at these times of the year.

It would seem that a highly desirable perennial grass for the arid summer regions would be one possessing the minimum period of summer dormancy needed to ensure plant survival, together with vigorous growth preceding and following the dormant period. Little effort has been directed toward surveying collections within a grass species to determine the variability in summer dormancy which may exist. Silsbury (5) has studied perennial ryegrasses collected from the Mediterranean area, and reports considerable differences in summer survival and in the occurrence of summer dormancy among them when grown in Australia. He suggests that this material will serve as a valuable source of new genotypes for Australia.

The present paper reports on the summer growth behaviour at Davis, California, of *Phalaris* accessions collected in 1965 by Professor R. M. Love in the Eastern Mediterranean region. The initial objective was to determine the extent of variation in summer-dormancy behaviour in this material.

PROCEDURE AND RESULTS

Mature heads were collected from stands of *Phalaris tuberosa* on six distinct ecological sites from the borders of Syria and Lebanon to the Negev desert. These sites ranged from 150 to 890 m in elevation and from 350 to 800 mm in annual precipitation. Soils varied from 40 to more than 300 cm in depth and included several types (Table 3). The soil on the Agronomy Farm at Davis is a non-calcic brown deep alluvial Yolo loam.

Seed from each head, identified as to origin, was sown in a glasshouse at Davis in February, 1966. In late March the young plants were transplanted to the field at 90 cm spacing and irrigated. Weather records were obtained from a weather station adjacent to the field.

During the second summer (1967), detailed records were kept of 1236 plants growing under

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TABLE 1. Weather data and plant development at Davis, California

Month	Daily mean temperature, °C Max.	Daily mean temperature, °C Min.	Rainfall (mm)	Average plant condition
Mar. 1967	16·15	4·44	95·25	Vegetative
Apr.	14·32	3·66	99·82	Heading (15–30 Apr.)
May	27·08	6·27	5·08	
June	28·75	11·77	24·13*	(15 June)
July	35·96	13·43	0·00	↑
Aug.	36·85	13·99	0·00	Summer dormancy
Sept.	34·52	13·15	1·02	↓
Oct.	27·08	8·82	6·60	(20 Oct.)
Nov.	20·42	6·05	27·94**	Vegetative
Dec.	13·15	0·78	24·38	
Jan. 1968	11·10	0·94	114·55	
Feb.	17·09	7·16	51·56	

*Rain on 1–3 June **Rain started 14 Nov.

natural conditions of temperature and rainfall. Weather data and plant-growth condition are given in Table 1. The summer was favourable for dormancy observations, being hot and without appreciable rain for 6 months from May onwards. The highest temperatures recorded in May, June, July, August and September were 38°, 39°, 39°, 41°, and 36°C, respectively. Following a mowing, 23 cm high, on 15 June, there was no shoot elongation above cutting height and all green basal shoots turned brown. This date was designated as the approximate beginning of the summer-dormancy period. Only 1·2% of the plants under study had completely browned before this date, and these were small plants from the 3 more arid collection sites. Breaking of dormancy which was marked by the resumption in growth of new shoots, took place between mid-July and early November, depending on the genotype. All but 11·2% of the plants has resumed growth by 1 Nov., and many of these produced new shoots before Nov. 14, when the autumn rains began. Growth resumption after summer dormancy and before effective rainfall has been reported by other investigators (2, 3, 6). The mechanism of this behaviour in many species is not completely understood, but a secondary root system is responsible for the resumption of autumn growth in *Ehrharta calycina* (6).

Once dormancy was broken, growth continued. Those plants which resumed growth early had produced most forage by autumn. Distinct differences in regrowth were apparent by 25 Sept., and on that date all plants were classified as follows:

Group A—those having over 50 green leaves per plant

Group B—those having 26 to 50 green leaves per plant

TABLE 2. Average growth of four summer-dormancy groups at Davis, California, for the 12 months beginning 1 Mar. 1967

Dormancy group	% of 1236 plants*	Regrowth height (cm) 18 days after cutting on 1 Mar. 1967	Date of heading	Field weight, kg/plant: Growth 1 Mar. to 15 June 1967	Field weight, kg/plant: Growth after dormancy to 1 Mar. 1968	Length of summer dormancy: Period in days after 15 June	Length of summer dormancy: Mean date of growth resumption
A	0·64	38·9	28 Apr.	3·81	1·36	30	14 July
B	1·86	37·6	24 Apr.	2·86	0·91	52	5 Aug.
C	12·50	37·6	25 Apr.	2·54	0·54	81	3 Sept.
D	84·80	30·9	16 Apr.	1·63	0·16	127	19 Oct.

*Except for this column, group A values are based on 8 plants; B, C, and D values are randomly selected 23-plant samples.

Group C—those having 1 to 25 green leaves per plant

Group D—those showing no regrowth by 25 Sept.

Table 2 presents a comparison of the growth characteristics of these groups to March, 1968. Group A broke dormancy the earliest, produced the most forage by height or weight on the sampling dates, and headed later than the others. The 'field weight' on June 15 was based on partially field-cured forage, while that in the following March was essentially a green weight. Although there were only 8 plants in group A and 23 in group B, these would seem the most promising for further development by the plant breeder for use on ranges. The great majority of the plants exhibited a prolonged dormancy and a reduced yield prior to and following that dormancy.

Twelve plants, 3 from each group, were used to established populations in the glasshouse for more intensive study. Each plant was propagated from a single shoot. Two months later, the average number of tillers per plant was 9·4, 7·8, 6·6 and 4·8 for plants of groups A, B, C, and D, respectively. Again, the most vigorous vegetative growth was associated with plants having the shorter dormancy period.

DISCUSSION

Further studies of attributes associated with dormancy behaviour remain to be completed. Probably soil temperatures play an important role in the responses. Ketellapper (2) reported that summer dormancy can be induced in *Phalaris* by high soil temperatures, even when adequate soil moisture is present. In our investigation the soil temperature at a depth of 10 cm for 5- and 10-day periods during the summer did not reveal any consistent temperature changes near the onset or breaking of dormancy.

The overall heat tolerance of the plant is likely to be related to dormancy behaviour. Established plants of the 12 clones brought to the glasshouse were subjected to 10 days of 16-hour photoperiod in a growth chamber with day temperatures of 36–38°C and night temperatures of 26°C. Each 150-mm pot received 150 ml of water daily. The number of living tillers per plant was recorded before this heat exposure, again at its termination, and at 30-day intervals thereafter. Except for one entry which tillered after 30 days, all D plants were killed after 8 days of exposure. In general, however, there was a progressive decline in tiller survival and subsequent new tiller initiation in groups A, B, C, and D, respectively.

Identification of the summer-dormancy behaviour with the site of seed collection reveals certain trends (Table 3). Sites M, BK, and F represent the more arid regions. These are classed as semi-arid Mediterranean by Emberger (1) while S, WG, and AV are designated as semi-humid Mediterranean. The majority of the plants exhibiting the longer summer dormancy came from the more arid regions and basaltic

TABLE 3. Percent distribution of summer-dormancy groups on the original collection sites

Collection site						Summer dormancy group (%)			
Designation	Mean annual rainfall (mm)	Altitude (m)	Number of plants	Soil types	Soil depth (cm)	A (30 days)	B (52 days)	C (81 days)	D (127 days)
S	800	890	218	Terra rossa red clay	50– 60	2·75	2·75	21·10	73·39
WG	600	150	112	Colluvial	250+	0·89	8·04	24·11	66·96
AV	650	700	64	Terra rossa gravelly red clay	150	0·0	6·25	15·63	78·13
M	450	240	246	Red-brown colluvial	100–150	0·41†	1·63††	14·63	83·33
BK	500	160	284	Balsaltic colluvium	100–150	0·00	0·00	5·63	94·37
F	350	200	312	Grumosolic brown	300+	0·00	0·00	6·41	93·59

†1 plant ††4 plants

soils which dry out rapidly. A notable exception, however, was found in the material from site M; one plant fell into the A group and 4 into the B group (Table 3). Although most plants from the semi-humid sites also possessed the D-group behaviour, more of them were found to fall into dormancy groups A, B, and C. Soil depth in site S is 50–60 cm, but the limestone parent material provides available moisture for most of the year (7).

The diversity of summer behaviour in these materials suggests that valuable genotypes may be identified in trials on range sites. Love and Begg (4) have shown the importance of soil-plant relations when predicting the successful establishment of annual range legumes in a Mediterranean-type environment. Our plan now is to subject these *Phalaris* clones to environments differing in soil and climate to help determine the extent of genetic control over summer dormancy.

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