Ecotypic Variation in the Reproductive Response of *Poa alpina*

by

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Introduction

In 1983 the Alberta Environmental Centre (AEC) at Vegreville began a program to develop licensed, commercially available seed varieties suitable for use in the reclamation of rangeland and man-made disturbances in the alpine and subalpine regions of the East Slopes of the Rocky Mountains. *Poa alpina* L., one of the species potentially suitable for use in alpine reclamation was selected on the basis of its hardiness, its ability to withstand and even flourish under extreme stress conditions and its ability to colonize disturbances in alpine environments (Watson et al. 1980). In conjunction with the breeding program an experiment was set up:

1. To compare the reproductive response of four populations of *P. alpina* grown under different temperature conditions.
2. To determine the best growth chamber temperature conditions for the *P. alpina* life cycle.

Materials and Methods

In 1984 four whole plants of *P. alpina* were collected from each of four populations in the alpine and subalpine ecoregions of the province. These ecoregions have been defined by Strong and Leggat (1981) on the basis of the regional climate as expressed by vegetation. Data from Strong and Leggat is included in the collection site descriptions.

The alpine ecoregion is characterized as the zone above tree level (approx. 2200 m at Lake Louise). The major ecological factors limiting plant growth are strong winds, summer coolness and frequent freezing temperatures during the warmest months. The mean May to September temperature is 6.5°C and that of July averages 10°C or lower. The January mean is -15°C. It is estimated that the region accumulates less than 500 growing degree days (above 5°C) annually. The occurrence of summer freezing temperatures is spatially variable and depends upon aspect and topographic location. Free-draining south-facing slopes have frost free periods of about 25 days, while in depressions and protected areas frost may occur almost nightly. The precipitation of 730 mm falls mostly during the summer months. Site 78 in the Cassiope-Dryads Subregion comprises scattered micro-habitats among the boulders of an alpine fell field. The major species were _Cassiope tetragona_ in the wetter locations and _Dryas hookeriana_ in the drier places as well as scattered plants of _Poa arctica_, _P. alpina_ and _Trisetum spicatum_. Site 84 is in the dry grass-kobresia subregion on a level saddle area which does not trap cold air. The site has a coarse well-drained mineral soil and is surrounded by a stunted timberline forest of _Larix lyallii_ and _Abies lasiocarpa_. The major species are _Kobresia_ sp., _Koeleria cristata_, _P. alpina_, _T. spicatum_ and _Festuca saximontana_. The subalpine ecoregion of the Alberta Rocky Mountains is an altitudinal vegetation zone bounded above by the Alpine and below by the montane and aspen parkland ecoregions. It has a cordillerean climate characterized by snowy, cold winters and showery, cool summers with a mean annual precipitation of 720 mm. The mean May to September temperature is

9.5°C, below freezing temperatures are common in all months but are particularly common in valley bottoms which nightly collect the cold air draining down the mountainside. The number of growing degree days above 5°C ranges from 710 to 930. Site 88 is located in the spruce-fir subregion characterized by mixed stands of Abies lasiocarpa and Picea engelmannii. P. alpina is rarely found in this subregion except in disturbed sites. The pine subregion in which Site 24 is located comprises stands of Pinus contorta on very xeric sites. Site 24 is in an abandoned campsite above the Oldman River. P. alpina is an invader on the trampled and disturbed sandy soil. Understory vegetation is very sparse, the major associated species being Populus tremuloides, Arnica cordifolia, Fragaria vesca and Rosa spp.

The collected plants were placed in plastic bags and stored on ice for three days while being transported to AEC. They were transplanted into 15 X 24 cm flats and placed into a growth chamber set to cycles of 22/15°C day/night temperatures with 16-hr/photoperiods for 76 days. Each plant was then divided into three approximately equal parts repotted and placed under the same conditions for an additional 14 days to become re-established. The chamber was then adjusted to give a vernalization period of 30 days at 3°C in continuous darkness. Following vernalization the experiment was begun by placing one clone of each plant into each of 3 growth chambers under conditions of 8/1°C, 15/8°C and 22/15°C day/night temperatures with a 16-hr/photoperiod. The light intensity of each chamber was measured at 2000 lux. The experiment was run for 243 days. The design was a randomized complete block with the four plants from each population forming the replicates. Phenological stages of each plant were noted and seed heads were harvested as they became mature. The production of normal, abnormal and viviparous heads was noted. Normal heads were considered those whose culm had elongated and whose development showed a normal pyramidical shape without compaction. Abnormal heads were considered to be those whose culm had not elongated past the sheath, had little rachis elongation and small, extremely compact heads. Viviparous heads were those showing a vegetative proliferation of the spikelets above the first glumes to form a leafy shoot or bulbil (Nielsen 1941).

Results and Discussion

The data presented in Tables 2 and 3 indicates that following vernalization the duration of both the vegetative and reproductive stages of the life cycle is a function of the temperature under which the plants are grown. In the 25/15°C chamber only plants from Site 24 produced flowering heads, the plants from the other sites remained vegetative for the duration of the experiment. In the 15/8°C temperature chamber both the vegetative and flowering phases were significantly longer for plants from the alpine ecoregion (sites 78 & 84) than for those from the subalpine ecoregion (sites 24 & 88). The population from Site 78 (the most severe environmental conditions) failed entirely to produce normal seed heads under the 15/8°C temperature regime. In the 8/1°C chamber there was no difference among the populations in the timing of floral initiation or in the duration of the reproductive stage.

The flowering head production did not vary with population in the 8/1°C chamber (Table 4) while, in the 15/8°C chamber one population (site 88) produced significantly more heads per plant than those from other sites. However, under the warm chamber conditions only the population from site 24 produced any flowering heads. Overall there was a significant drop in the mean number of flowering heads produced with each increase in temperature.

The number of seeds produced per head is very much a function of population and the temperature of the growth chambers (Table 5). In the cold chamber those populations originating from the more unfavorable environments produced a greater number of seeds then those originating from the milder locations. Conversely the 15/8°C chamber populations originating in milder environments produced a greater number of seeds than those originating from the harsher environments. Again, in the warm chamber only the plants from site 24 produced seeds.

The significant differences among populations found in the response data indicates that under any one temperature condition the flowering response of each population is very much related to the site of origin. The differences among the populations were especially noticeable in the duration of the vegetative and flowering stages, the number of seeds produced per head and in the percentage of heads produced which were considered normal. The reproductive responses are very much related to the putative climatic conditions at the collection sites. For example the number of seeds produced per head in the cold chamber was highest in plants from the most extreme (coldest) sites and lowest in plants originating in the warmest sites. Under the warmer temperature condition this relationship was reversed suggesting that the reproductive response of populations of east slope P. alpina is very much related to the type of environment from which the populations originate.

In the 15/8°C chamber viviparous heads were present on all plants, except two from site 78. The same plants were observed to simultaneously bear viviparous and seminiferous heads. There was no significant difference in the percentage of viviparous heads among populations. However, there were significant differences in the percentage of normal heads produced by each population (Table 6). The populations from the alpine areas producing fewer normal heads than those from the subalpine environments. No abnormal heads were produced in the cold chamber.

Vivipary is an additional method of propagation for many grass species and is often found in those species that do not have a marked capacity for vegetative spread by creeping rhizomes or stolons (Wycherley 1953a). Reports of propagation of P. alpina by viviparous means are rare in North America. Hulten (1968) mentions the existance of viviparous populations in Alaska, while Boivin (1967, cited by Scoggan 1978) refers to some in Greenland. Moss (1983), Scoggan (1978), Looman and Best (1979), and Boivin (1981) deal specifically with the western Canadian flora but do not mention this phenomona as occurring in Canadian populations. In Europe both seminiferous and viviparous modes of reproduction exist (Muntzing 1980, Wycherley 1953b, Skalinska 1951).

In many populations vivipary occurs as a response to environmental stress (Lee and Harmer 1980). Schwarzenbach (1956) induced vivipary in nonviviparous Greenland populations of P. alpina through the manipulation of light and temperature conditions. Foreman (1971) found that some Colorado clones of P. alpina became viviparous after being transferred from growth chambers at 8-hr/photoperiods and 8°C to greenhouses at 21°C and 24 hr/photoperiods.

The results of the temperature experiment indicate that the Alberta Rocky Mountain populations of P. alpina are able to reproduce by viviparous methods under certain conditions. This ability appears to be general as it was found equally in test populations originating from quite diverse environments. It is suggested that the temperature stress induced by the 15/8°C conditions induced the formation of viviparous heads. The presence of a stressful situation in this chamber is indicated by the significant reduction in the number of flowering heads per plant and in the reduced number of seeds per head over those formed in the low temperature chamber.

Conclusions

The results of this experiment suggest that considerable variability in flowering response to temperature exists among populations of Alberta Rocky Mountain P. alpina. This response is a function of both the temperature under which the plants are grown and the environmental conditions from which the plants originated. Uniformity in the lengths of the vegetative and reproductive stages among various populations can be achieved by growing them at a lower temperature (8/1°C). The flowering response is very much related to the environment of origin. The populations from populations in colder environments performed best when grown in the cold chamber, while the populations from milder environments were able to perform better in the medium temperature chamber. No P. alpina populations performed well in the warmer temperature chamber (22/15°C).

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TABLE 1. Site number of origin of the tested populations.

Site #	Elev. (m)	Ecoregion	Subregion	Location
78	2700	Alpine	Cassiope-Dryads	Lake Louise
84	2375	Alpine	Grass-Kobresia	Lake Louise
88	2000	Subalpine	Spruce-Fir	Lake Louise
24	1450	Subalpine	Pine	Oldman River

TABLE 2. Comparison of the duration (in days) of the vegetative stage of four populations of *P. alpina* when grown under three temperature regimes.

	Temperature Ranges		
Site #	8/1°C	15/8°C	22/15°C
78	77a	97a	243+a
84	80a	96a	243+a
88	74a	63 b	243+a
24	97a	36 c	27 b
		LSD = 25.6	

1 day/night temperatures
16-hr/photoperiod

TABLE 3. Comparison of the duration (in days) of the reproductive stages of four populations of *P. alpina* when grown under three temperature regimes.

	Temperature Ranges		
Site #	8/1°C[1]	15/8°C	22/8°C
78	76a	[2]a	[3]a
84	79a	118 b	[3]a
88	74a	56 c	[3]a
24	92a	34 c	28 b
		LSD = 35.8	

[1]Day/night temperatures
[2]No normal heads formed
[3]No heads formed

TABLE 4. Comparisons among four populations of *P. alpina* of the number of flowering heads produced per plant under three temperature regimes.

	Temperatures Ranges		
Site #	8/1°C[1]	15/8°C	22/15°C
78	117.5a	23.3 b	0 b
84	130.0a	18.5 b	0 b
88	102.5a	58.5a	0 b
24	90.3a	25.0 b	6.7a
Mean	110.1a	30.3 b	1.3 c

[1]Day/night temperatures

TABLE 5. Comparisons of the number of seeds produced per head among four populations of *P. alpina* under three temperature regimes.

Site #	Temperature Ranges		
	8/1°C[1]	15/8°C	22/15°C
78	190.9a	0 c	0 b
84	143.9ab	35 c	0 b
88	89.5 bc	103 b	0 b
24	43.7 c	293a	30a
	LSD = 95	LSD = 48	LSD = 17

[1]Day/night temperatures

TABLE 6. Percentage of normal, abnormal and viviparous flowering heads found in four populations of *P. alpina* in the 15/8°C temperature treatment.

Site #	Heads per Plant	Normal	Abnormal	
			Non-viviparous	Viviparous
78	23.3 b	0.0 c	86.0a	14.0a
84	18.5 b	1.5 c	62.0a	36.5a
88	58.5a	16.2 b	52.6 b	31.2a
24	25.0 b	61.3a	9.3 c	29.4a

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Overlander Lodge, Hinton

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For more information on the Alberta Chapter of the Canadian Land Reclamation Association please write to CLRA, Box 682, Guelph, Ontario, Canada N1H 6L3.

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