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Chilling and Budbreak in Lingonberries, *Vaccinium vitis-idaea* L.[1]

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Abstract. **Three seedling populations of lingonberries from Fairbanks, Alaska, Oulu, Finland, and the Pasvik River Valley, Norway were exposed to 0, 170, 344, 513, 681, 843, 1013, and 1185 hours of continuous chilling temperatures (4 ± 1°C) to determine chilling requirements necessary to satisfy rest. Both the Finnish and Alaskan populations required at least 681 hours of chilling to obtain maximum terminal vegetative budbreak. Continuous chilling for 1185 hours was insufficient to obtain maximum budbreak in the Norwegian population. In the Finnish and Alaskan populations neither the percentage of stems exhibiting lateral budbreak nor the number of lateral branches per stem differed among chilling treatments. Plants from Norway showed significantly greater lateral budbreak in the 513- and 681-hour treatments than in all other treatments. At least 681 hours of chilling were necessary to achieve normal flowering in the Finnish population.**

Dormancy is a period where active growth in terminal and lateral meristems is suspended temporarily (2). The cessation of active growth may be due to unfavorable environmental conditions or to an internally controlled rest period where growth does not occur even though external growing conditions appear favorable. Rest often is satisfied by exposing plants to a period of chilling temperatures (1–10°C) varying in duration from 250 to more than 1000 hours (3, 4). Investigations into rest and chilling requirements have not been reported previously in the lingonberry, *Vaccinium vitis-idaea* L. The purpose of this study was to determine the chilling requirements of 3 populations of lingonberries by continuous chilling in a controlled environment. By imposing artificial chilling regimes, we hope to develop a research tool by which more than 1 growth cycle in lingonberries can be obtained annually.

Materials and Methods

Forty plants of uniform size were selected from each of 3 seedling populations of *Vaccinium vitis-idaea*. The seeds were collected from Fairbanks, Alaska (64° 51′N), the Pasvik River Valley, Norway (69° 41′N), and Oulu, Finland (65° 00′N). Plants from Alaska and Finland were identified as the arctic-montane subspecies *minus* (Lodd.) Hult., while plants from Norway were of the lowland subspecies *vitis-idaea* (1). At the beginning of this experiment, plants from the Alaskan and Norwegian populations were 2 years old, and no flower buds were evident. Finnish plants were 7 years old and contained numerous flower buds.

The plants were grown outdoors in 4-liter containers at the Horticultural Research Center, Excelsior, Minn. The substrate was milled *Sphagnum* sp. peat. On Aug. 15, 1980, all plants were transferred to a greenhouse with natural daylength conditions and with a minimum air temperature of 16°C. On Oct. 1, five plants, selected at random from each population, were transferred to another greenhouse with 18° minimum air temperatures. Daylength was extended to 20 hr with Sylvania Directlite incandescent bulbs. The remaining plants were placed in a refrigerated storage room in continuous darkness at 4 ± 1°. Five plants, selected at random from each population, were removed from the cold room at approximate weekly intervals and placed under the lights in the greenhouse. Plants from each population received 0, 170, 344, 513, 681, 843, 1013, or 1185 hr of continuous chilling.

The experiment was a randomized complete block design with subsampling. All experimental units contained 5 vegetative stems per plant selected at random with 1 plant per replicate. Observations on terminal vegetative budbreak were made at 3-day intervals for 60 days following the chilling treatment. After 60 days, the number of lateral buds to break and the percentage of stems exhibiting lateral and terminal budbreak were recorded.

In the Finnish population, 5 reproductive stems per plant were selected at random. The number of florets per raceme, the percentage of stems with normal flowers, and the number of days to full bloom were determined for each treatment. Full bloom was identified as the date at which 75% of the corollas were open.

Results and Discussion

In the Alaskan population of lingonberries, 25% terminal vegetative budbreak was achieved after 170 hr of chilling (Table 1). The number of days to 25% budbreak was reduced significantly by treatments of 513 or more hours. Although 75% budbreak was found in plants treated with 513 hr, the number of days to 75% budbreak was reduced by more than half with an additional week, or 681 hr, of chilling temperatures. More than 10 days elapsed between 25 and 75% budbreak in plants treated with 513 hr. Plants in the 681-hr treatment achieved both 25 and 75% budbreak after 15 days in the greenhouse. These results indicate a more rapid rate of budbreak in the 681-hr treatment. The maximum percentage of terminal budbreak was greater in

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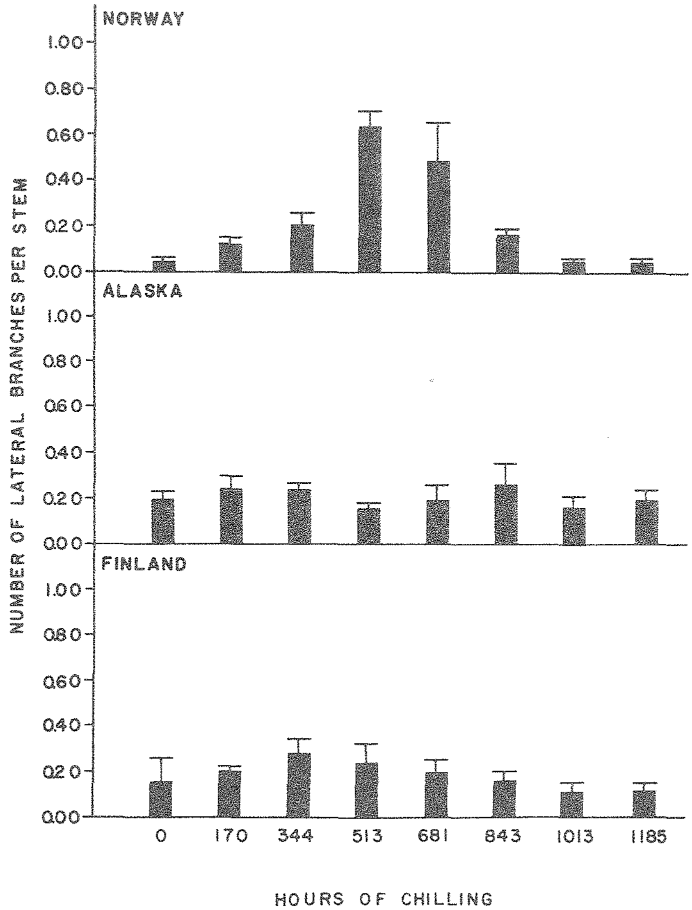

Fig. 1. Development of lateral branches of 3 lingonberry populations in response to different durations of chilling temperatures.

plants treated with 513 or more hours than in the 0-, 170-, or 344-hr treatments. Neither the percentage of stems exhibiting lateral budbreak (Table 1) nor the number of lateral branches per stem (Fig. 1) differed among chilling treatments.

The Norwegian population of lingonberries required at least 681 hr of chilling temperatures to achieve 25% terminal vegetative budbreak (Table 2). We observed 75% budbreak only on plants treated with 1185 hr after 49 days in the greenhouse. A treatment of 681 or more hours was necessary to achieve the highest level of budbreak amounting to 60–80% of the vegetative stems. Based upon observations of growth under field conditions where nearly 100% terminal vegetative bud break has been found, the maximum level of vegetative growth probably was not observed in this experiment for the Norwegian population. Of the 40 total plants in this experiment, only 4 reached 100% budbreak after 60 days of observation. More than 1185 hr of chilling probably will be necessary to satisfy rest in this population.

Norwegian plants treated with 513 and 681 hr of chilling temperatures had greater percentages of lateral budbreak than plants treated with fewer or greater numbers of chilling hours (Table 2). In addition, more lateral branches per stem were produced on plants treated with 513 and 681 hr of chilling than plants in the other treatments (Fig. 1).

Plants from Finland exhibited 25% terminal vegetative budbreak after 170 hr of chilling temperatures (Table 3). The number of days to 25% budbreak was reduced significantly by 681 or more hours of chilling temperatures. Plants treated with 0, 170, 344, or 513 hr did not reach 75% budbreak after 60 days of observation. The number of days to 75% budbreak did not differ among treatments of 681 or more hours. Terminal budbreak greater than 90% was observed for chilling treatments of 681 or more hours. Neither the percentage of stems exhibiting lateral budbreak (Table 3) nor the number of lateral branches per stem (Fig. 1) differed among chilling treatments.

Normal flowers were produced on at least 80% of the reproductive stems receiving 513 or more hours of chilling temperatures (Table 3). Plants treated with 0, 170, or 344 hr had a greater incidence of abnormal racemes which included flower buds that expanded but failed to elongate, complete flower abortion, and normal development of one or more proximal florets with abortion of the more immature distal florets. Racemes on plants treated with 170 and 344 hr of chilling temperatures commonly included 1 to 3 florets that developed normally. Plants treated with 513 or more hours averaged between 8.2 and 12.3 normal florets per raceme. Flower buds on control plants did not develop. The number of days to full bloom was reduced significantly by chilling treatments of 681 or more hours.

The response of lingonberries to chilling treatments was similar for the Alaskan and Finnish populations. Both populations required at least 681 hr of chilling temperatures to achieve maximum terminal vegetative budbreak in the shortest period of time.

Table 1. Response of vegetative buds of an Alaskan population of lingonberries to chilling regimes.

Amount of chilling (hr)	Time to terminal vegetative budbreak (days)		Budbreak after 60 days (%)	
	25%	75%	Terminal	Lateral
0	---[z]	---	16.0b	16.0a
170	36.5a[y]	---	36.0b	20.0a
344	27.3ab	---	52.0b	24.0a
513	21.6bc	32.8a	84.0a	16.0a
681	15.0bc	15.0b	80.0a	12.0a
843	11.0c	11.0b	100.0a	20.0a
1013	11.0c	11.0b	96.0a	8.0a
1185	10.6c	11.0b	100.0a	8.0a

[z]The designated percentage budbreak was not achieved after 60 days in the greenhouse.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 2. Response of vegetative buds of a Norwegian population of lingonberries to chilling regimes.

Amount of chilling (hr)	Time to terminal vegetative budbreak (days)		Budbreak after 60 days (%)	
	25%	75%	Terminal	Lateral
0	---[z]	---	4.0b	4.0b
170	---	---	0.0b	8.0b
344	---	---	0.0b	20.0b
513	---	---	8.0b	52.0a
681	60.0a[y]	---	60.0a	44.0a
843	55.0ab	---	60.0a	16.0b
1013	47.5b	---	63.0a	4.0b
1185	45.6b	49.0	80.0a	4.0b

[z]The designated percentage budbreak was not achieved after 60 days in the greenhouse.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 3. Response of vegetative and reproductive buds of a Finnish population of lingonberries to chilling regimes.

Amount of chilling (hr)	Time to terminal vegetative budbreak (days)		Budbreak after 60 days (%)		Stems with normal flowers (%)	No. of florets per raceme	Time to full bloom (days)
	25%	75%	Terminal	Lateral			
0	---[z]	---	20.0b	16.0a	0.0a	0.0b	---
170	39.7a[y]	---	28.0b	20.0a	4.0a	1.0b	49a
344	32.7a	---	44.0b	32.0a	28.0a	2.3b	42a
513	28.3a	---	64.0b	16.0a	80.0b	11.0a	40ab
681	18.8b	22.6a	92.0a	16.0a	86.0b	10.6a	33b
843	16.3b	20.0a	100.0a	8.0a	100.0b	8.2a	36b
1013	17.0b	18.0a	96.0a	12.0a	100.0b	10.0a	33b
1185	14.2b	16.8a	100.0a	12.0a	90.0b	12.3a	30b

[z]The designated percentage budbreak was not achieved after 60 days in the greenhouse.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

The response of these populations differed from the Norwegian population which probably will require more than 1185 hr of chilling to complete rest. The Norwegian population also differed from the others in the response of lateral buds to chilling temperatures. These results are evidence of differences between the subspecies *vitis-idaea* and *minus*. Previously, only morphologic characteristics distinguished the 2 subspecies (1). Further comparative studies using more populations from both subspecies will be necessary to verify this viewpoint.

At least 681 hr of continuous chilling will be necessary to satisfy rest and evoke a normal vegetative growth response in lingonberries. However, considerable variation among populations can be expected. Vegetative and reproductive growth appear to require similar chilling regimes to complete rest.

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