EFFECTS OF LIGHT INTENSITY ON VEGETATIVE GROWTH OF LINGONBERRIES[1]

PATRICIA S. HOLLOWAY[2], ROBERT M. VAN VELDHUIZEN[3], CECIL STUSHNOFF[4], and DAVID K. WILDUNG[5]

[2]*Department of Horticultural Science and Landscape Architecture, University of Minnesota, Saint Paul, Minn. 55108;* [3]*School of Agriculture and Land Resources Management, University of Alaska, Fairbanks, Alaska 99701;* [4]*Department of Horticulture Science, University of Saskatchewan, Saskatoon, Sask. S7N 0W0; and* [5]*North Central Experiment Station, University of Minnesota, Grand Rapids, Minn. 55744.* *Received 24 Feb. 1982, accepted 6 May 1982.*

HOLLOWAY, PATRICIA, S., VAN VELDHUIZEN, ROBERT, M., STUSHNOFF, CECIL AND WILDUNG, DAVID, K. 1982. Effects of light intensity on vegetative growth of lingonberries. Can. J. Plant Sci. **62**: 965–968.

Lingonberries were grown in Fairbanks, Alaska for up to three growing seasons in containers under four treatments: 0, 44, 56 and 73% shade provided by various thicknesses of polypropylene shade cloth. Following three growing seasons, plants grown without shade produced the greatest number of stems and dry weight per plant. Leaf size and number of leaves per stem did not differ among treatments. Leafy rhizome branches were longer under 73% shade than under higher light intensities. Rhizomes were longer without shade than under lower light intensities. The results indicate that for maximum growth and dry matter accumulation lingonberries should be grown in full sunlight.

Des plantes de Lingonne (*Vaccinium vitis-idaea* L.) ont été cultivés en conteneurs (hors sol) à Fairbanks (Alaska) pendant trois saisons de végétation, sous quatre traitements d'ombrage (0, 44, 56 et 73 %) réalisés au moyen de diverses épaisseurs de toile de polypropylène. Après trois saisons de végétation, c'est les plantes cultivées sans ombrage qui produisaient le plus de tiges et de matière sèche. Les traitements n'ont toutefois pas eu d'effet sur la taille des feuilles ou le nomre de feuilles par tige. Les rameaux aériens étaient plus longs sous ombrage de 73 % qu'aux intensités d'éclairement plus fortes. En revanche, les rhizomes étaient plus longs sans ombrage. Ces résultats montrent que le lingonne devrait de préférence être cultivé en plein soleil.

The lingonberry, *Vaccinium vitis-idaea* L., is a woody, evergreen shrub of circumpolar distribution whose fruit is harvested from native populations throughout most northern regions of the world. Recently, plans to domesticate the lingonberry have been implemented in Finland (Lehmushovi and Hiirsalmi 1973; Lehmushovi and Sako 1975; Lehmushovi 1977a,b), Sweden (Fernqvist 1977), Germany (Liebster 1975), and Alaska (Holloway 1982). The continued success of these efforts requires investigations which determine optimum growing conditions for maximum growth and plant establishment in cultivation.

Light intensity is one factor which greatly affects plant growth and development. Lingonberries grow in habitats with

[1]Paper number 12 072 of the Scientific Journal Series of the University of Minnesota Agricultural Experiment Station, Saint Paul, Minn. 55108.

[2]Present address School of Agriculture and Land Resources Management, University of Alaska, Fairbanks, Alaska 99701.

0008-4220/82/6204-0965 $2.00

light intensities measuring from 3.4% of photosynthetically active radiation to complete illumination (Krylova and Trembalya 1978). Oldemeyer and Seemel (1976) have found that the percentage cover of lingonberries in mature spruce-hardwood forests is negatively correlated with increasing cover of the tree canopy. In other plant communities, a positive correlation between percent canopy cover and lingonberry biomass was found. Smith (1962) noted that the greatest abundance of lingonberries occurred in moderate to heavy shade. In cultivated field experiments, Lehmushovi and Hiirsalmi (1973) found that shade increased both stem number and plant height. The purpose of this study was to clarify the relationship between light intensity and vegetative growth in lingonberries under controlled field conditions.

MATERIALS AND METHODS

A clone of lingonberry, *Vaccinium vitis-idaea* L. ssp. *minus* (Lodd.) Hult., was divided into plants consisting of a single rhizome measuring between 10 and 11 cm in length: a single, leafy, vegetative rhizome branch (the main stem), from 6 to 7 cm in length; and an undetermined amount of adventitious roots on the rhizome. Five plants were grown in a 15 × 15 × 15-cm plywood container lined with clear polyethylene that was perforated at the base to allow water drainage. The substrate was unsterilized, coarsely ground *Sphagnum* sp. peat from Fairbanks, Alaska. Containers were buried in the ground to within 2 cm of the top and mulched with additional peat. Polypropylene shade cloth of various thicknesses was stretched across wooden frames to cover the containers. Each frame measured 100 × 60 × 50 cm in length, width, and height, respectively. The shade cloth enclosed the top and all sides of the frame to within 10 cm of the ground to allow air movement and reduce air temperature differences among treatments. Light intensity was measured at plant level beneath the frames with a LI-COR Model LI-185 Quantum/Radiometer/Photometer. Treatments consisted of 0, 44, 56, and 73% shade. The control plots (0% shade) were not enclosed in frames or shade cloth.

Taylor minimum-maximum thermometers and irrometers were placed randomly within treatment groups, and daily air temperature and substrate moisture levels were recorded. Treatments were irrigated to maintain substrate moisture levels of less than 20 centibars.

The experiment was a randomized complete block design with five plants per treatment and five replicate blocks, each containing the four shade treatments. The experiment was repeated with plants being maintained under each treatment for one, two, or three growing seasons. In those experiments continuing for more than one season, the shade frames were removed at the time of the first snow fall in autumn and replaced upon snow melt in spring. All experiments were conducted during the 1978, 1979 and 1980 growing seasons near Fairbanks, Alaska.

Plants were harvested during the first week of September. Data included the number of leaves per stem and stem length of the main stem, lateral branches, and leafy rhizome branches. Counts also included the number of lateral branches, leafy rhizome branches, and new rhizomes per plant. Leaf length and width measurements were combined into a length-width ratio to give an estimate of leaf size for the main stem, lateral branches, and leafy rhizome branches.

All plant parts within each treatment were divided into four groups: vertical stems, leaves, rhizomes, and roots. Each group was dried separately in a forced-draft oven at 60°C for 24 h after which dry weight measurements were recorded. Data were analyzed by analyses of variance.

RESULTS

Plants grown for one season exhibited little vegetative growth under any of the treatments as revealed by the number of new plant components generated. The number of lateral branches per main stem and the number of leafy rhizome branches averaged less than one per plant for all treatments. The number of new rhizomes averaged 1.5–2.5 per plant, but differences among treatments were not significant. Leaf size, the number of leaves per stem, stem length, and plant dry weight also did not differ significantly among the treatments following one growing season.

Plants maintained for two growing seasons exhibited significant differences in production of leafy rhizome branches and new rhizomes (Table 1). In both instances, plants grown without shade had signifi-

Table 1. Average number of stems per plant of lingonberries grown under 0, 44, 56 and 73% shade for two and three growing seasons

Percent shade	Average number per plant		
	Lateral branches	Leafy rhizome branches	New rhizomes
	Two seasons		
0	2.2 NS	3.2 *a*	3.6 *a*
44	1.4	1.6 *b*	1.8 *b*
56	1.3	1.1 *b*	1.8 *b*
73	1.2	0.9 *b*	1.9 *b*
	Three seasons		
0	4.7 *a*	12.7 *a*	13.4 *a*
44	2.2 *b*	6.8 *b*	7.9 *b*
56	2.8 *b*	4.8 *b*	4.2 *b*
73	2.8 *b*	5.0 *b*	5.3 *b*

NS, nonsignificant at the 5% level.
a, *b* Mean separation by Duncan's new multiple range test, 5% level.

cantly greater numbers per plant when compared to plants grown in the 44, 56 and 73% shade treatments. Like plants maintained for one season, plants grown for two seasons did not differ in the number of leaves per stem, stem length, or leaf size. In addition, plant dry weight did not differ the among treatments.

Following three seasons of growth, plants differed significantly in the production of lateral branches, leafy rhizome branches, and new rhizomes (Table 1). Within all three groups, plants grown without shade had significantly greater numbers per plant than plants grown in any of the shade treatments. Similar numbers of leaves per stem were recorded for the main stem which averaged 16.4–19.1 leaves per stem, lateral branches which averaged 7.5–8.8 leaves per stem and leafy rhizome branches which averaged 4.3–6.6 leaves per stem.

The average length of the main stem and lateral branches did not differ among treatments. The main stem averaged 6.64–8.07 cm in length, while the lateral branches averaged 2.15–3.41 cm in length. Leafy rhizome branches were significantly longer in plants grown under 73% shade than in plants grown under greater light intensities (Table 2). In contrast, the length of new rhizomes was significantly greater in plants grown without shade than those grown under lower light intensities. Similar leaf size measurements were recorded for each stem type under all treatments. The length-width ratio was 1.64–1.75 for leaves on the main stem, 1.63–1.81 for leaves on lateral branches, and 1.27–1.56 for leaves on the leafy rhizome branches.

The dry weight of vertical stems, leaves, rhizomes and roots was significantly greater without shade when compared to the same plant part in the other three treatments (Table 2).

DISCUSSION

Total vegetative growth of lingonberries was greater in full sunlight than under 44, 56 or 73% shade. This is contrary to the observation by Smith (1962) that lingonberries predominate in natural environments with moderate to heavy shade. Perhaps shade is not as important in defining lingonberry habitat as other factors such as substrate, moisture and nutrient availability and plant competition. A lack of adequate moisture in full sunlight might ex-

Table 2. Average stem length and dry weight of lingonberries grown under 0, 44, 56 and 73% shade for three growing seasons

Percent shade	Average length (cm)		Dry weight (mg)			
	Leafy rhizome branches	New rhizomes	Vertical stems	Leaves	Rhizomes	Roots
0	3.94 *b*	11.25 *a*	191.5 *a*	474.3 *a*	309.6 *a*	53.4 *a*
44	3.61 *b*	6.06 *b*	92.8 *b*	223.2 *b*	142.7 *b*	21.1 *b*
56	3.18 *b*	7.55 *b*	103.0 *b*	241.8 *b*	170.5 *b*	16.4 *b*
73	5.84 *a*	7.93 *b*	108.8 *b*	266.6 *b*	165.4 *b*	17.1 *b*

a, *b* Mean separation by Duncan's new multiple range test, 5% level.

plain Smith's (1962) observations. This view seems possible considering the very wide range of light intensities under which lingonberries have been found to grow (Krylova and Trembalya 1978).

The results also do not agree with the cultivated field experiment of Lehmushovi and Hiirsalmi (1973) who found that shade increases vegetative growth. One possible explanation for this discrepancy might be ecotypic differences between Alaskan and Finnish populations of lingonberries. Based upon morphologic characteristics, four taxonomic subdivisions of the species *Vaccinium vitis-idaea* L. have been identified (Henriksson 1923; Hulten 1949, 1970), but the full extent of species variability is unknown. Considering the extensive range of the lingonberry from arctic to north-temperate regions throughout the Northern Hemisphere, and its habitat diversity, ecotypic variation, including variation in response to light intensity, seems possible.

Another possible explanation for the discrepancy between experiments is differences in water stress among treatments in the Finnish experiment. There may have been greater water stress in tissues of plants growing in full sunlight than those growing in shade, resulting in an increase in growth in shade. This condition is difficult to verify in the Finnish experiment since neither air temperature nor substrate moisture measurements were reported among shade treatments. In the present study, substrates were maintained under equal moisture conditions, and air temperatures did not differ by more than 2°C among treatments. The effects of water stress were considered minimal.

Both the present study and the one by Lehmushovi and Hiirsalmi (1973) indicate an increase in plant height with shade. We recorded an increase in stem length of the leafy rhizome branches only at the lowest light intensity after three growing seasons.

Results of this study have implications for site selection and modification for lingonberry cultivation. In modification of native populations to promote maximum vegetative growth, cover by shrubs and trees should be eliminated and weed growth minimized. Furthermore, it should be possible to grow lingonberries in full sunlight in cultivated fields without provisions for shading to enhance plant establishment.

FERNQVIST, I. 1977. Results of experiments with cowberries and blueberries in Sweden. Acta Hortic. **61**: 295–300.

HENRIKSSON, J. 1923. *Vaccinium vitis-idaea* L. var. *ovata*. Bot. Notiser **5–6**: 464.

HOLLOWAY, P. 1982. Studies on vegetative and reproductive growth of lingonberry, *Vaccinium vitis-idaea* L. Ph.D. Thesis. Univ. of Minnesota, Saint Paul, Minn.

HULTEN, E. 1949. On the races in the Scandinavian flora. Svensk. Bot. Tidskr. **43(2/3)**: 282–406.

HULTEN, E. 1970. Th circumpolar plants. II. Dicotyledons. Almqvist and Wiksell, Stockholm.

KRYLOVA, I. L. and TREMBALYA, YA. S. 1978. The yield of cowberry leaves in the central belt of the European part of the U.S.S.R. Rast. Resur. **14**: 184–191 (Abstr.).

LEHMUSHOVI, A. 1977a. Some aspects of the cowberry, *Vaccinium vitis-idaea*, trials in Finland. Ann. Agric. Fenn. **16**: 57–63.

LEHMUSHOVI, A. 1977b. Trials with the cowberry in Finland. Acta Hortic. **61**: 301–308.

LEHMUSHOVI, A. and HIIRSALMI, H. 1973. Cultivation experiment with the cowberry: Significance of substrate, liming, fertilization, and shade. Ann. Agric. Fenn. **12**: 95–101.

LEHMUSHOVI, A. and SAKO, J. 1975. Domestication of the cowberry (*Vaccinium vitis-idaea* L.) in Finland. Ann. Agric. Fenn. **14**: 227–230.

LIEBSTER, G. 1975. Growing red whortleberries (*Vaccinium vitis-idaea*) on cultivated land — a new objective of experimental research work in fruit growing. Erwerbsobstbau. **17**: 39–42, 58–61.

OLDEMEYER, J. L. and SEEMEL, R. K. 1976. Occurrence and nutritive quality of lowbush cranberry on the Kenai Peninsula, Alaska. Can. J. Bot. **54**: 966–970.

SMITH, D. W. 1962. Ecological study of *Vaccinium* species in Alberta. Can. J. Plant Sci. **42**: 82–90.