SOME STUDIES ON THE HARDINESS OF CERTAIN SPECIES OF *VACCINIUM*[1]

W. G. BRIERLEY AND A. C. HILDRETH[2]

For the past twelve years the Minnesota Agricultural Experiment Station has been studying the possibilities of bringing the blueberry (*Vaccinium pennsylvanicum* Lam., *V. canadense* Kalm., and *V. corymbosum* L.) under field culture. The work has been hampered at times by winter injury to the plants. Such injury has occurred nearly every year with *V. corymbosum*, the common high bush blueberry of the east, and has been met with more or less frequently in the two native species. This recurring injury has led to a study of the hardiness of these species.

Observations in the field have shown that the most severe injury in the case of *V. corymbosum* has occurred in late fall. Under conditions prevailing at the Forest Experiment Station, Cloquet, where the field work is carried on, this species usually grows late, failing to mature its wood before the advent of severe freezing weather. Usually early snows have served to protect the lower portions of the new shoots, but the upper portions exposed to temperatures no lower than $-10°$ C. generally have been killed. Injury of this sort probably is due to lack of maturity and consequent lack of hardiness, rather than to inability to endure such temperatures in seasons which permit normal maturity and hardening off.

It appears likely that the lack of maturity in the shoots of *V. corymbosum* at Cloquet may be due in part to a short growing season. Blossoming and the beginning of shoot growth in this and the native species does not occur until late in May. Frosts in May or early June frequently are the cause of light crops through injury to the blossoms. Frosts at this time of year also are usually accompanied by low daily maximum temperatures under which shoot growth takes place slowly if at all. Light frosts frequently occur in late August and killing frosts are common in early September. Under such fall conditions shoots of *V. corymbosum* are frequently exposed to killing frosts before the formation of winter buds at the tips of the shoots has progressed very far, and before the normal maturing of the foliage has occurred. This is the condition of shoots described as poorly matured or showing a lack of maturity. Full maturity in the shoots of *V.*

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corymbosum as evidenced by well-developed buds at the tips and by maturity of foliage has occurred only once (1926) during the twelve seasons this species has been grown at Cloquet.

The native low bush species *V. pennsylvanicum* and *V. canadense* occur over a more northerly range than the *V. corymbosum*. It was thought, therefore, that they might be greatly superior in hardiness to the latter and could be used as a source of hardy parents in the production of hybrids with the *V. corymbosum,* which, because of its height and bush-form is a more desirable horticultural type. However, in the spring of 1924 extensive winter injury was noted in these native species, both in the cultivated plots and in the wild. In this season there was no snow cover until mid-January and sub-zero (F.) weather had been frequent. Again in the spring of 1925 similar injury was noted. This winter also was characterized by low temperatures in December with little snow. The question was raised therefore, whether the native species are materially hardier than *V. corymbosum* or whether they merely escape injury most years by reason of their low growth habit which enables them to be protected by a minimum snow cover.

Studies to determine the relative cold resistance of matured shoots of the three species were begun in the fall of 1925. Controlled temperatures under artificial refrigeration were employed, the freezing apparatus and methods being the same as used by HILDRETH (3) in determining the relative hardiness of apple varieties. Samples of new shoots and older wood were collected at Cloquet on October 22 after exposure in the field to a minimum temperature of $-10.5°$ C. At this time the new shoots of *V. corymbosum* were showing the characteristic injury resulting from freezing while immature. A few exceptionally vigorous shoots of *V. pennsylvanicum* also showed this type of injury although not to the same extent as *V. corymbosum*. Through a misunderstanding this material was subjected to a minimum temperature of $-12°$ C. in the freezing chamber, only 1.5° C. lower than the minimum to which they had previously been exposed in the field. After standing for some time with the butts in water in a cool greenhouse the samples showed no injury except as observed in the field.

Shoots of *V. pennsylvanicum* and *V. corymbosum* collected at Cloquet on January 26, 1926, were placed in a cool greenhouse with the butts in water. As the buds pushed into growth it was evident that there was only a little more injury at the tips than was found in the samples collected in October. It should be noted that although the air temperature had fallen as low as $-32°$ C. in December, the plants of *V. pennsylvanicum* were protected by snow and were probably not exposed to such a low temperature. The snow did not entirely cover the plants of *V. corymbosum,* but the exposed tips had already been killed in October as previously mentioned. Evidently the

snow had been sufficient to protect these plants against serious additional injury.

The value of snow protection for blueberries has been pointed out by COVILLE (**2**). He notes that in February, 1918, shoots of low bush hybrids were killed at Whitesbog, New Jersey, at a temperature of about – 12° F. while at Greenfield, New Hampshire, the parent stock, when protected by snow was uninjured although here the temperature dropped to – 30° F. The same season at Crotched Mountain, N. H., he found that tops of high bush blueberries, which projected above the snow, were killed back while the bases and sides of the same bushes which had been protected by snow bore the usual crop of berries.

Summarizing the results for the winter of 1925–1926, it appears that killing in the three species studied was due largely to a combination of immaturity plus early cold. The most severe injury occurred in October at temperatures no lower than – 10.5° C. *V. corymbosum,* which probably was not well matured, suffered most. Winter cold caused very little additional injury as the plants presumably were protected by snow.

In the fall of 1926 material was again taken for freezing tests, collection being made at Cloquet, October 21. Most of the new shoots were matured to the tip buds. Only a few of the very vigorous and immature shoots of *V. corymbosum* and *V. pennsylvanicum* showed slight freezing at the tips. Temperature records at Cloquet during the months of September and October showed a gradual decline, a minimum of – 6° C. having been experienced up to the time the material was collected.

Such fall weather conditions are generally considered to favor the development of hardiness. WINKLER (**5**) has shown that a gradually declining temperature increases the cold resistance in woody plants. REIN (**4**) and others have found that northern plants are able to accommodate themselves to cold, the plants becoming more resistant by exposure to temperatures that are relatively low but still above the lethal point. Under the conditions which prevailed at Cloquet this fall, it is assumed that full maturity was reached and that these species had attained about their maximum hardiness for the time of year.

After collection the samples were wrapped in damp moss and kept cool to hold them in condition till freezing tests could be made. On October 23 one lot of shoots from each species was exposed for three hours to a temperature of – 16° C. A second lot was similarly exposed on the following day to – 20° C. and a third lot on the 25th to – 24.5° C. All lots after freezing were stored in damp moss until October 26th when they were placed with the butts in water in a cool greenhouse. Three weeks later the shoots were examined and compared with control samples to determine the extent of

injury from the three treatments. The results obtained are shown in the accompanying table I.

TABLE I

THE EFFECTS OF LOW TEMPERATURES ON MATURE SHOOTS OF THREE SPECIES OF *Vaccinium* ALL LOTS EXPOSED FOR THREE HOURS IN A FREEZING CHAMBER

TEMPERATURE TREATMENT	*V. pennsylvanicum*	*V. canadense*	*V. corymbosum*
– 16° C.	Alive to tip buds All buds starting	Alive to tip buds Buds starting slowly	Alive to tips[1] Buds starting slowly Wood showing injury
– 20° C.	Alive to tip buds All buds starting	Buds not starting Wood color dull	Buds not starting Wood injury intensified
– 24.5° C.	Buds starting slowly Wood showing slight injury	Buds not starting Wood discolored	Buds not starting Wood discolored

[1] Except in the case of shoots killed at tips by freezing in the field.

It will be seen in this table that at – 16° C., *V. pennsylvanicum* was uninjured. In the other two species injury at this temperature was indicated by a slower pushing of buds. In *V. corymbosum* there was also a slight discoloration of the wood.

At – 20° C., *V. pennsylvanicum* still appeared uninjured with practically all buds starting to grow. *V. canadense* showed no buds starting and the normal greenish color of the wood was noticeably dulled. *V. corymbosum* was badly injured or killed with no buds starting and the wood had a water-soaked appearance.

At – 24.5° C., *V. pennsylvanicum* showed considerable injury with the buds starting slowly and the wood somewhat discolored. The other two species showed no sign of bud activity and the wood was darkened and had a water-soaked appearance. In *V. canadense* at this temperature the phloem was noticeably browned. Apparently this temperature was almost low enough to kill *V. pennsylvanicum* and did kill the other species.

As a further check on killing temperatures 15 to 20 shoots of *V. pennsylvanicum* and *V. canadense* were dug from beneath the snow at Cloquet on February 19, 1927, and frozen on February 28 for three hours at – 32° C. All of these shoots were killed except two shoots of *V. pennsylvanicum* which started a very few buds in a feeble manner after four weeks in the greenhouse.

These data show that the killing points of *V. corymbosum* and *V. canadense* at the end of October lie somewhere between – 16° and – 20° C., with *V. canadense* only slightly hardier than *V. corymbosum*. As *V. pennsylvanicum* was injured at – 24.5° in October and killed at – 32° in February,

it appears that the killing point of this species in October lies not far below −24.5° C. It is also evident that this species did not increase in hardiness to any appreciable extent after October.

In conclusion, it appears from the results of freezing tests that the killing points of all three species as grown in Minnesota lie fairly close together. This fact indicates that there is no great difference in the actual hardiness of the three species. Of still greater significance is the apparent inability of any of them to endure very low temperatures. Comparing the killing points of these *Vaccinium* species with those of orchard and forest trees which grow in northern climates (**1**, **2**, **5**) it is seen that the former develop relatively little cold resistance. Even the hardiest species, *V. pennsylvanicum,* apparently cannot endure exposure to such winter temperatures as commonly prevail in the regions to which it is native. As *V. pennsylvanicum* and *V. canadense* occur naturally over a more northerly and westerly range than *V. corymbosum,* in a region of low winter temperature but ordinarily with ample snow cover, it is safe to conclude that these two species are protected rather than inherently hardy. The adaptation of these species to cold climates appears to be largely an ecological one rather than any physiological adjustment of the tissues to extremely low temperatures. In the matter of avoiding cold injury in the fall, *V. pennsylvanicum* seems to have a slight advantage over the other two species, since it attains greater hardiness early in the fall when a few degrees of cold resistance may be sufficient to prevent killing back of the shoots. This fall hardiness, however, is probably only another result of the dwarf habit, the shorter terminal growths maturing earlier and becoming more hardened before severe freezing weather occurs.

With this relative lack of hardiness in all three species, it would seem futile to attempt to develop from this material tall hybrids which would be likely to grow late or to extend above the snow cover. If a truly cold resistant blueberry is to be developed apparently it will be necessary to search outside of these three species for hardy parent stocks.

MINNESOTA AGRICULTURAL EXPERIMENT STATION,
ST. PAUL, MINNESOTA.

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