

Winter Killing of the Roots of the Beta Grape¹

By W. G. BRIERLEY and ERNEST ANGELO, *University of Minnesota, St. Paul, Minn.*

THE most important grape grown in Minnesota is the variety Beta which probably is a seedling derived directly from *Vitis vulpina*. Although experience has demonstrated that the Beta is hardier than varieties derived from *Vitis labrusca*, growers have frequently reported injury to the canes or weak growth following severe winter cold, particularly in young vines. Such injury usually has occurred during the absence of snow cover and particularly in light soils. In one 3-year-old vineyard growing in sandy soil shoot growth on many vines in 1931 was found to be only 6 to 8 inches in August and the entire vines were dwarfed. When some of these vines were dug most of the old roots were found to be dead and the vines were barely kept alive by weak new roots. The callus at the base of the original cuttings generally was uninjured and in many cases apparently had enlarged since the vines were planted. Vines set deep in the soil with 2 or 3 whorls of roots arising from the nodes of the original cuttings showed the greatest amount of killing in the roots at the first node below the soil surface. Injury to the roots was not as severe at successively lower nodes. In addition to these observations, experience at the University of Minnesota Fruit Breeding Farm with single-eye cuttings taken from the Beta and seedlings of that variety has been of a similar nature. Root killing has been frequent both in yearling vines left over winter in the nursery row and in two year old vines during their first winter in the vineyard.

Carrick (1) has shown that roots of the Clinton during the winter months are injured at temperatures below -14 degrees and killed at -18 degrees C. Although the Clinton is at least partly derived from the species *Vitis vulpina* and might be used to indicate the probable behavior towards low temperatures of other varieties derived from the same species it appeared desirable to determine for the Beta variety the usual killing point of the roots, the effect of depth of roots in the soil upon the extent of injury, and the behavior of single-eye cuttings relative to root killing.

Studies along the above lines were begun in 1932 and continued until the spring of 1934. In one phase of the work, normal well matured canes were made up into 1-, 2-, and 3-eye cuttings in the early spring. These cuttings, selected for apparent uniformity, were planted in long narrow boxes which were plunged outdoors so that the soil level in the boxes was the same as outside. In the fall the boxes were lifted when growth was fully matured and stored in a moist cellar at 1 to 5 degrees C. On January 30 they were placed in a low-temperature laboratory room at 0 degrees C. Due to irregular growth of the cuttings, the numbers of each type of vine per box were not uniform, but the boxes were divided into two lots containing approximately the same number of each type. On February 1, one lot was placed in a

cold room at -12 degrees C and exposed to that temperature for 72 hours. Exposure for that length of time was deemed necessary to insure a uniform temperature in the soil. The second lot was placed in the cold room on February 4, and exposed to a temperature of -18 degrees for 68 hours. Failure of the temperature controls prevented completion of the 72-hour period. In each case, after the cold treatment, the boxes were returned to the storage cellar to thaw. Thirteen days were required for the soil to thaw completely. The boxes were then placed in a cool greenhouse to observe growth response. After 5 weeks a majority of the buds in the lot exposed to -12 degrees C were starting to grow, but only a few buds were pushing in the lot exposed to -18 degrees. In the lot exposed to -12 degrees the canes were uninjured. The roots were all killed back to the original cuttings but new callus and new roots were developing on about half the vines. In the lot exposed to -18 degrees, although the canes apparently were uninjured, the roots and other parts below ground were dead.

This phase of the study was repeated in 1933, with minor changes. All the cuttings were grown in nursery rows, the single-eye type being started in the greenhouse and transplanted after danger of frost was past. When fully matured in late October the vines were dug, selected for uniformity, and five vines of each type were planted in each box. The canes were cut back to three or four buds to facilitate handling. They were then watered and left outdoors in the shade. At the onset of cold weather the boxes were placed in the cellar used the previous year. Later they were moved to the cold room at 0 degrees C except for one box which was held in the cellar as a check. Beginning on December 30, three lots were exposed in sequence in the low temperature laboratory for 72 hours at -6 , -9 , and -12 degrees C, respectively. After this treatment the boxes were returned to the cellar to thaw gradually. On February 13, they were placed in a cool greenhouse and 2 weeks later buds were pushing in all three lots. On March 13, the shoot growth in the check and the lot exposed to -6 degrees C was normal except for the single-eye cuttings which were weak. Growth in the lot exposed to -9 degrees C was slightly less vigorous and in the lot exposed to -12 degrees the shoots were dying. On April 16, the vines were examined to note the extent of injury. In the check lot the vines from the 2- and 3-eye cuttings were uninjured and growth was vigorous and normal. The vines from single-eye cuttings were all dead, although they had not been exposed to freezing temperatures. In the lot exposed to -6 degrees, growth in the plants from 2- and 3-eye cuttings was normal and no injury was found in either roots or callus. The tops of the vines from single-eye cuttings were all dead or dying, and the old roots were nearly all dead. Most of them had developed weak new roots but these apparently were insufficient for recovery. In the lot exposed to -9 degrees, no injury was found in the roots or callus of the plants from 2- and 3-eye cuttings. The vines from the single-eye cuttings were nearly all alive but very weak. The old roots were dead but new roots were developing. In the lot exposed to -12 degrees, all the old roots were killed but the callus was uninjured. All of the 10 vines from the 2- and 3-eye, and 8 of the 10

¹Paper No. 1305 of the Journal Series of the Minnesota Agricultural Experiment Station.

from the single-eye cuttings were alive but shoot growth in all cases was very weak. The wood and pith of the original cuttings were slightly browned but no injury was detected in the year-old canes. New roots had developed in the 2- and 3-eye cuttings from the nodes and near the callus. In the single-eye cuttings new roots had developed near the callus and from the basal region of the year-old canes.

In another phase of the study, 50 cuttings of each of the three types, and also of a lot 18 inches long with four to seven nodes, were planted in the spring of 1932 in a frame and grown throughout the season with ordinary nursery care. The first node below ground was set approximately 3 inches below the surface except in the case of the single-eye cuttings. Since not all the cuttings developed roots at the first node, the depth of the first whorl of roots varied from 3 to 6 inches with those from the single-eye cuttings less than 3 inches below the surface. Due to an extremely dry growing season the stand was poor, but at the end of the season there were 17 vines from the single-eye cuttings, 28 from the 2-eye, 14 from the 3-eye, and 28 from the long cuttings. The vines were allowed to mature normally and the frame was then covered to exclude snow. With the advent of sub-zero weather in mid-December, the covering was removed to expose the roots to low temperatures. Thermometers recorded the temperatures at depths of 3 and 6 inches. With continued cold weather between the 12th and 16th of December, the temperature at the 3-inch level fell slowly from -7.5 to -15 degrees C and at the 6-inch level from -3 to -12 degrees C. After 24 hours at the lowest temperatures the frame was covered until spring. On June 14, when new shoot growth was well developed, the plants were dug and examined.

New growth from the single-eye cuttings was very weak, except for one vine. The roots were all injured, most of them so severely that no new rootlets were developing from them. There was no apparent injury to the callus and many new roots were developing at the node of the original cutting.

New shoot growth from the 2-eye cuttings was vigorous. The roots showed in general only slight injury although in some vines severe injury was noted and in one vine there was none. This difference in the amount of injury probably was due to variations in the depth at which the roots developed in the soil. The wood of the original cuttings generally was uninjured, but in a few cases there was more or less browning. Some degree of browning was found in the pith in slightly over half the vines but the remainder were uninjured. Although the old roots were alive and had developed new rootlets, many new roots were developing from the original cutting near the callus.

New shoot growth from the 3-eye cuttings was normal and vigorous. Most of the roots at the first node were severely injured although in two vines no injury was noted. Injury to wood and pith was similar to that in the 2-eye cuttings with more than half the plants uninjured. In nearly every case new roots had developed in abundance at the first node. The roots at the second node, and the original callus, were uninjured.

New shoot growth from the long cuttings was normal and vigorous

except in a few plants that had developed whorls of roots within 3 inches of the soil surface. These roots were severely injured and the shoot growth was reduced in vigor. In the majority of plants the roots at the first node were only slightly injured and a few plants showed no injury. Except for a few plants there was no apparent injury to the wood or pith. The roots at the second and lower nodes, and the callus, were uninjured.

In the repetition of this study in 1933, minor changes were made to obtain a uniform number of plants and to regulate the depth of the roots from the first node. Cuttings of the three types were grown in the nursery. When fully matured in late October they were dug and 50 uniform plants of each type planted in a frame with the first whorl of roots set as nearly as possible at a depth of 3 inches. The plants were then watered thoroughly and later covered to exclude snow. With the advent of sub-zero weather, towards the end of December, the covering was removed to expose the plants to low temperatures. At the 3-inch level the soil cooled gradually from -4 to -14.5 degrees C and at the 6-inch level from -1 to -11 degrees C. After about 24 hours at the low temperatures the frame was covered until spring. As normal growth in the spring was affected by the unusual drouth the plants were watered at intervals to avoid adding drouth injury to that caused by low temperature. On June 20, when new shoot growth was fairly well developed the plants were dug and examined.

In the single-eye plants practically all old roots were killed back nearly to the original cutting. The callus in two plants was uninjured; in 25 there was severe injury and in the remainder it had been killed. Two plants were completely killed. In 41 plants new roots had formed at the old node, and 7 had developed roots at the base of the year-old canes. In all cases new shoot growth was very weak.

Of the plants from the 2-eye cuttings, 30 were making normal shoot growth. The remainder apparently had been injured by drouth so that the tops did not grow, but the roots were alive. None of the old roots escaped injury, but in only 17 plants was the injury severe enough to kill back nearly to the original cutting. New roots had developed in abundance from the uninjured portion of the old ones and from the base of the cutting. In five plants the callus had been killed but in the remainder it was normal or only slightly injured. Injury to the wood was limited to nine plants, in which light to medium browning was found.

Of the plants from the 3-eye cuttings, 17 apparently had been affected by the spring drouth. The tops were dead, but there was no discoloration in the wood or pith as would probably be the case in canes killed by cold. The rest of the vines were making normal shoot growth. Most of the roots at the first node had been killed back nearly to the cutting. At the second node injury was general and in 37 plants severe enough to kill half way to the cutting. The callus, wood and pith were normal except for a slight browning in the pith of the 17 plants with dead tops.

From these studies it is apparent that roots of young vines of the

Beta variety are severely injured or killed at about -12 degrees C. whether grown outdoors or frozen in soil in the laboratory. The most severe injury outdoors was at the 3-inch depth, with less severe injury or none at all occurring at greater depths at which the temperature was slightly higher. The wood and callus of the original cutting apparently withstand cold that kills or severely injures the roots. These parts apparently behave in the same way as cuttings after the year old roots have been killed, and develop new roots in about the same manner as a new cutting. Recovery in some cases was rapid and fairly vigorous growth followed, but in many cases the new growth was reduced. This behavior duplicated that of vines previously observed in vineyards. The loss of the year old roots obviously prevented the intake of water and nutrients so that new growth was reduced in vigor. The work of Schrader (2) with the Concord variety presents an additional explanation for the greatly reduced vigor of the injured vines. He found that in young vines the greater proportion of the stored foods was in the roots. If this is the case in the Beta variety also, the loss of the stored foods would contribute materially to the reduction in vigor. Vines produced from single-eye cuttings usually lack vigor and as the roots generally are nearer the surface than in longer cuttings, injury from cold is more likely to occur. These results and previous field observations suggest that deeper planting and protection by means of cover crops should be included in vineyard practices in Minnesota in order to lessen injury to the roots.

The authors are indebted to R. H. Landon for careful regulation of temperatures and other assistance in the low temperature laboratory studies.

LITERATURE CITED

1. CARRICK, D. B. Resistance of the roots of some fruit species to low temperature. Cornell Univ. Agr. Exp. Sta. Memoir 36. 1920.
2. SCHRADER, A. L. Seasonal changes in the chemical composition of the Concord grape vine. Proc. Am. Soc. Hort. Sci. 21: 39-44. 1924.