HARDINESS STUDIES OF SOME FRENCH AMERICAN HYBRID GRAPES

by

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INTRODUCTION

The grape was one of the first fruits brought under cultivation by man. Since ancient times the culture and vintage of grape has been recorded in the literature, drama, and songs of various civilizations. Perhaps no other fruit has meant so much to contentment, happiness, health, and prosperity of people all over the world as has the grape.

The Genus Vitis, of the Family Vitaceae or Ampelidaceae, has been well represented throughout the temperate and subtropical world. The numerous species have evolved under highly varied conditions, and they are not always adapted to new environment. Since the spread of grape culture north in the temperate zone, hardiness and winter injuries became the limiting factor in the grape industry. Several early attempts were made in many states of North America to grow the vinifera or European type grapes, but failed in the states east of the Rocky Mountains because of two reasons: First, vinifera species are not hardy enough for the American rigorous winters. They require the mild climate of hot, dry summers and cool wet winters. The range in both temperature and humidity east of the Rocky Mountains is greater than that of the grape-growing regions of Europe. The second reason is that vinifera grapes are highly susceptible to the root-aphid Phylloxera vitifolia, and the vine diseases, downy mildew, powdery mildew, blackrot, and anthracnose which are widely distributed in the trial area. It was only with the settlement of California that Vitis vinifera finally found a congenial home on this continent.

The high quality of vinifera as a wine, juice, and table grape compared to the American species, encouraged the American viticulturists to increase this species everywhere. Also the rapid spread of Phylloxera in the French vinifera vineyards during the second half of the nineteenth century caused great financial losses. This encouraged French viticulturists to protect their vines. After long and slow experiments and tests, the workers found that breeding was the solution. The breeders set up breeding programs to combine the insect and disease resistance as well as the hardiness of the Labrusca grapes with the higher fruit quality characters of vinifera grapes. The resulting hybrids have highly variable degrees of these combined characteristics.

The French hybrids vary in their resistance to cold. The investigations involved in this experiment are studies to determine the degree of hardiness of some French hybrids.

REVIEW OF LITERATURE

The response of grape vines to low temperatures is of interest not only because of its relation to winter killing, but also for the bearing it has on the adaptation of varieties to different regions. Many investigations have shown that failure of the vines to ripen the wood properly in the late summer and fall resulted in the death of canes even in ordinary winters. Following is a review of a partial list of papers dealing with hardiness of fruit plants:

Chandler (1913) found that the different tissues of a fruit tree vary in hardiness and also change at different seasons of the year. He has shown that when trees are in an activity growing condition, the cambium, young cortex, and sapwood cells are the most tender. When the tissues have matured, the pith in the twigs is the first to be killed by low temperature, followed by browning in the sapwood and the outer cells of the cortex. The cambium is most tender in the growing plant but relatively hardy when it is in winter condition.

Oskamp (1918) observed, in his winter injury on peaches and apples in Indiana, following the hard winter of 1917-1918, that one of the outstanding factors contributing to winter injury was the temperature as influenced by elevation. Also a short, cool, and wet season resulted in failure of trees to ripen their wood, increasing the degree of damage.

Harvey (1918) studied the relation of changes in the proteins to killing in cabbage plants. He found that upon hardening, the proteins change to forms which are less easily precipitated. During the formation of ice there is an increase in acidity sufficient to precipitate the proteins of non-hardy plants, but in hardy plants the proteins endure the degree of acidity without precipitation and resulting injury.

Chandler (1918) reported that the maturity of the wood of fruit trees results in increased cold resistance. During his observations following the severe winter of 1918-1918 in New York, he noticed that in every case where the leaves had been removed in the summer by insects or spray burning, there was killing of the wood. He indicated also, that the slow portion to mature was subjected to more winter injury.

During the severe winter of 1909-1910, at Fredonia, New York, almost half the fruit buds in Concord vineyard were killed, according to Gladwin (1919). The injury was traced to a lack of maturity of the tissues owing to a sudden termination of the growing period by unseasonably low temperatures. Hooker (1920) reported a high correlation between resistance to low temperatures and pentosan content. He found that plant tissues with high pentosan content lost less water and absorbed more water from the atmosphere than the tissues with low pentosan content. Angles (1922) observed that when early spring freeze kills the first shoots of grape vines, the second growth is likely to produce a partial crop. He noticed that the type of training has some influence on the number of shoots at the second growth and upon the yield.

Wellington (1930) reported that the proportion of vinifera "blood" in a given hybrid cannot safely make up more than 78-85 per cent of its constitution for areas having minimum winter temperatures of -15° F. or below. "Dilution" beyond this point is certain to result in lack of winter hardiness.

Anthony, et al. (1936) studied the effect of low temperature on orchards in Pennsylvania and adjoining states. They reported that the degree of maturity was the main cause of winter injury. Hardly any of the injury from the winter of 1935-36, was due to excessive cold weather alone. Some of the orchards injured have been subjected to temperatures 10° to 20° F. lower during the previous winters without much injury. In most of the northeastern states, fruit trees went into winter of 1935-36 poorly matured. The unseasonable freeze in early October injured the leaves and checked the normal maturity process. Some trees were injured because they were too vigorous and others because they were low in vigor. Excess fertilization, heavy pruning, late cultivation, and spray injury all resulted in more damage to trees.

Clark (1936) observed the effect of low temperature on grape buds of many varieties. He found that the primary buds of most of the varieties are more susceptible to injury by low temperature than were the secondary or tertiary buds. The wood of grape canes was generally more resistant to injury from low temperature than were the buds, based on the observation of woody tissues of canes which were being examined for bud injury. Knowlton (1936) studied the winter hardiness of some woody plants. He noticed that the rate of temperature drop could be more important than the minimum temperature. Wood maturity affected the degree of injury. He found also that the general vigor of the tree affected the amount of injury. With peaches, the older the tree the greater was the damage.

Yeager (1936) stated that grape varieties such as Concord, Worden, Delaware, and some other well known varieties of the Eastern United States would be listed as tender in the State of North Dakota.

Burkholder (1937) reported that fall pruning, if followed by low temperature, resulted in more serious injury to apple trees than that suffered by similar trees which were unpruned at the time of the freeze. He stated that observations of this type have been made on apple trees and suggested that winter killing of grape canes may occur if low temperatures follow early pruning. Gray (1942) studied the cold resistance of a few grape varieties after the freeze of November 1940. He found that the freeze was not as disastrous to grapes as to fruit trees because all of the vines that were severely damaged recovered and produced normal growth within a year or two.

Oberle (1943) reported that a number of the French-American hybrids have been under test at the New York State Agricultural Experiment Station for a number of years. The majority proved to be unsatisfactory for general cultivation in New York. Some seedlings have failed to survive and others have been killed to the ground by low winter temperatures. Two hybrids, Seibel 1000 and Seibel 6339, appeared to be hardy enough to survive the New York winters. Steuk (1946) tested some French-American hybrids, and reported that certain hybrids like Seibel 1000 have survived a severe winter and bore good crops the next year.

Campbell (1948) observed that more than 30 varieties of peach trees survived the severe winter of 1947 in Kansas. He reported that the temperature dropped from 40° F. to 8° F. during a period of 60 hours. Then temperatures fell rapidly to -32° F. After checking the trees at the Horticulture Farm, he noticed that many of the peach trees which survived that hard freeze showed minor damage to twigs. He stated, possibly the previous long, cold period or the slow temperature fall had given maximum hardiness to the peach wood. Brierley, et al. (1950) reported that the severe injury or complete killing of Harlson apple trees should be regarded as the combined effects of heavy crop, drought, depleted food reserve, and immaturity.

Carrier (1952) observed that segments of current season canes of Rosa between the basal and the terminal six inches, were significantly more frost resistant than the basal at the terminal positions.

Emmert and Howlett (1953) reported that the greatest hardiness differences among varieties occurred in the fall. As the season moved on, such differences disappeared. Also, they found that the maximum degree of cold resistance occurred between fall and mid-winter. By the end of the dormant season, a slight difference in hardiness was noticed. Chandler (1954) made a general review of the effect of cold on horticultural plants. He defined cold resistance as the ability of the plant cells to survive ice formation in the plant tissues. Some plants might die if held 48 hours or more at temperatures little above freezing, while seeds and pollen will grow even if they are exposed to very low temperatures. The reason is that the latter are too dry to have any ice crystals in their cells. He stated that if the temperature fall is slow, ice tends to form in hardy plants in the intercellular spaces, and water moves out of the cells. This movement of water increases the concentration of the cell sap. Also, it is fast enough to prevent ice formation in the cell. Both hardy and tender plants subject to abnormally rapid temperature fall, may be killed by the ice formation in the protoplasm. He stated that hardiness develops usually in Autumn and early winter. This development is due mostly to changes in the physical nature of the protoplasm rather than to increase in water holding substances in the cell sap.

Artificial freezing has offered a means of speeding up the process of testing, provided it gives results comparable to those observed in the field. Artificial freezing methods have been employed for some years in hardiness studies. Waring and Hilbron (1937) noted that the killing of parenchymor cells and the closing of vessels by wound gum in artificial freezing studies is the same as under natural conditions. Edgerton (1950) found such experiments were simulating a given set of conditions in the winter outdoors, and provide an entirely reliable guide to cold weather performance of the buds of fruit plants.

Such experiments have depended upon visual detection of damage to tissues or observation of subsequent growth to record the results of the experiments. It is easy to recognize a plant that has been completely killed. Frequently, however, the plant is not completely killed, and it becomes necessary to evaluate the degree of injury as well as to find out which areas of plants have been affected by the low temperatures. Therefore, it has been necessary to develop a technique for studying the nature and extent of the injury. The answer was the electrical conductivity test. This method was based upon the assumption that the release of the electrolytes by the cell, measured by electrical conductivity, produces a direct reading of the amount of injuries inflicted by a given treatment. The electrical method of testing the hardiness of plants has been used by several investigators. It was used on testing plant materials in 1897 by Stewart, Bugarsky, and Tangl, according to Miller (1938) Osterhout (1921) used this method largely to study the resistance of Laminaria to the passage of an electrical current after treatment with different concentrations. Although he did not work with temperature effect upon resistance, he proposed a theory explaining his data and suggested that temperature would produce like results. The electrical conductivity method was put to practice by Dexter, et al. (1930) in determining the degree of injury to frozen tissues of alfalfa and foliage plants. The work of these men marked the beginning of expanded use of the electrical method in hardiness studies, with the conductivity of exosmosed solutions being the measure of injury and later direct measurements on the tissues. Swingle (1932) used it on his studies on rootstocks. He did not accept it as applicable to all hardiness studies. He pointed out that the previous studies were with hard wood material. He checked his results by a visual method to insure accuracy. Stuart (1939) used the Swingle method, the controlled freezing test employing the electrolytes exosmosis conductivity technique, on more than 50 varieties of apple roots. His results checked quite well with ratings of relative hardiness as stated in many observations over a long period of years.

Filinger and Cardwell (1941) developed a method for direct measurement of electrical resistance. They used it in hardiness studies of raspberry canes. The drop in electrical resistance determined the amount of damage to plants. They recommended this method for hardiness studies because it is rapid. The apparatus is very handy to be carried out to the field to study the conditions of plants after adverse weather periods, and also the ability to test the plants without killing or destroying them.

Chaplin (1948) used artificial freezing tests on peach fruit buds. He found that fruit buds of peach were definitely more hardy than the bark while the leaves were still on the trees in early October, and there was a little gain in hardiness at the leaffall. His results supported the dependability of artificial freezing tests in hardiness studies.

Filinger and Zeiger (1951) used the same method of Filinger and Cardwell on hardiness studies of French crab apple rootstocks. They found that artificial freezing of plant materials gave similar results to the outdoor low temperatures. Their data demonstrated a decrease in relative electrical resistance with exposure of apple twigs to lower temperatures.

Emmert and Howlett (1953) used the electrolytic method for testing the resistance of apple varieties to low temperatures. The conductivity results showed that less electrolytes diffused from the hardy varieties, while more diffused from the tender varieties. Snyder (1953) tested the hardiness of the multiflora rose by means of artificial freezing. He then measured the soluble chemical materials leached from the segments of tissues by electrical means to determine the degree of injury. He reported that the electrolytic test is based on the fact that the greater the injury to the cell membranes, the greater the quantity of soluble chemicals will leach. He stated that the method of evaluating the degree of injury to plant tissues following exposure to low temperatures has proved to be satisfactory and rapid. He found also that canes of large diameter are less hardy than canes of small diameter, but roots are of equal hardiness regardless of the size.

MATERIALS AND METHODS

Description of the Varieties Used

The French hybrids, like other grapes, vary in color as well as in hardiness. Some have a highly-colored juice while others, although black, have a colorless juice. Size of clusters and berries vary greatly, as do flavor, some being neutral while others have a muscat flavor. Most of the varieties are high in acid and moderate to high in sugar content. Descriptions of the varieties used in these studies follow:

EXPLANATION OF PLATE I

Fig. 1. A general view of a commercial French American hybrid vineyard at Fredonia, Kansas.

Fig. 2. French American hybrids bearing fruit.

PLATE I

Fig. 1

Fig. 2

Seibel 1000 Wagner (1955). (Rup., Linc., vin.) Early. The best known hybrid in this country. Under favorable conditions it has vigor, hardiness, and ample disease resistance, bears heavy crops. Bunches and berries are of medium size. Berries are round, sweet, and neutral in flavor. Excellent wine grape. This variety should never be planted in locations of excessive humidity, it is subject to "conclure"-that is, failure to set full crop- and ripens unevenly. Average sugar content is 22% with low acidity. Plate II B.

Seibel 10096 Wagner (1955). (S. 5455 S. 5163) Midseason. Vine of moderate vigor, leaves very large, deep green, and sufficiently resistant to disease. Occasional blackrot of fruit. Berry below average in size, with a thin skin which sometimes cracks when wet weather coincides with humidity. This variety set generous half crop even after killing frost. Very heavy producer of fine vine. Average sugar content is 22-23%. The wine is alcoholic and, the pruning method is short. Black.

Bertille-Seyve 2862 Wagner (1955). Midseason. Stocky, vigorous clusters above average, well filled. It fails to ripen regularly in Finger Lakes region of New York. Long pruning method, resistant to disease. Good wine and table grape. Plate II A.

Baco No. 1 Wagner (1955). (Rip. Folle Blanche) Early. Vine of prodigious vigor, with huge leaves resembling those of its riparia parents. It is immune to the mildew and blackrot. Small berries are bornein long, loose clusters. The average sugar content is 20-21%, with acidity little above the average. This variety is widely spread throughout grape-growing regions, and is showing well adaptation to the cooler short-season regions. Red.

Seyve-Villard 14287 Wagner (1955). Early. Sufficient vigor. Good disease resistance. Very heavy producer, fairly compact bunches. Berries are round. Good wine, alcoholic. Short pruning method. Shoots are fertile after frost. The average sugar content of the fresh juice is 25%.

Seibel 15062 Schroeder (1949). Early. Vigorous and healthy. Very heavy producer of fine bunches of large berries, compact of good flavor. One of the best creations of M. Seibel.

EXPLANATION OF PLATE II

Fig. 1. Clusters of the French hybrid B.S. 2862 showing the relative size and shape of clusters and berries.

Fig. 2. Clusters of Seibel 1000.

PLATE II

Fig. 1

Fig. 2

Seibel 14117 Schroeder (1949). Early. Vigorous and resistance absolute. Heavy producer of above medium bunches, medium berries, very good flavor. Short pruning method and excellent wine grape. Black.

Seibel 5860 Schroeder (1949). Fairly early. Vigorous. Excellent table and wine grape. Excellent plant of good production. Very high disease resistance. Short pruning method.

Golden Muscat Barnett and Campbell (1949). Golden Muscat is a yellow hybrid grape which has many characteristics of the European type grape, including high quality fruit and lack of winter hardiness. The vine will kill to the ground in severe winters in Kansas. It has tendency to overproduce some years. This weakens the vine.

Concord Barnett and Campbell (1949). Concord is the variety which serves as a standard by which other American grapes are judged. It belongs in the group of black grapes, ripens in midseason, and is of good quality. The plant of Concord is hardy, vigorous, productive, and resistant to pests. It is in general the best variety for planting in Kansas, especially in commercial vineyards. It is used for jelly, dessert, and juice.

Experiments with One-Year-Old Grape Canes

On November 20, 1955, samples of one-year-old canes representing the French hybrids and Concord varieties, discussed above, were collected from the Kansas State Horticultural Farm. Each sample consisted of 100 cuttings, 10 inches long, varying in diameter, and representing three vines of the same age. These hybrid varieties were selected for tests because they have given promising results when grown in Kansas. Concord, an old variety, was selected for comparison.

The cuttings were tied in bundles and placed immediately in moist peat moss, and they were stored in the Horticultural cold storage at a temperature ranging from 35° to 38° F.

They were checked weekly until used. The lowest temperature to which these canes had been subjected outdoors prior to the collection was 20° F.

Two freezers were used in which the grape canes were artificially frozen. The first freezer was a household refrigerator. Its freezing compartment provided a temperature of -10° F. The second freezer was a converted war-surplus commercial freezer. The capacity of the freezing compartment was approximately 8 cubic feet. It was used to provide temperatures of -17°, -25°, and -40° F.

A Boyoucous Model C Moisture Bridge, manufactured by the Wood and Metal Products Company, was used to measure the electrical resistance of grape canes. This model employs a 1000 cycle alternating current, and a set of earphones is used to detect the null point (Plate III).

Contact on the canes was made by two pairs of electricians' pliers having parallel acting jaws and held apart six inches by a non-conducting fiber spacing bar. Extensions were fastened to the plier jaws to increase the capacity and it was through these extensions that portions of steel needles were inserted. This device was developed at Kansas State College by Filinger and Cardwell (1941); it is pictured in Plate IV.

A Bristol recording thermograph provided a record of temperatures. Accurate Fahrenheit and Centigrade thermometers served as a check on the thermograph. Canes were placed on the bottom of the cabinets to minimize chances of temperature

EXPLANATION OF PLATE III

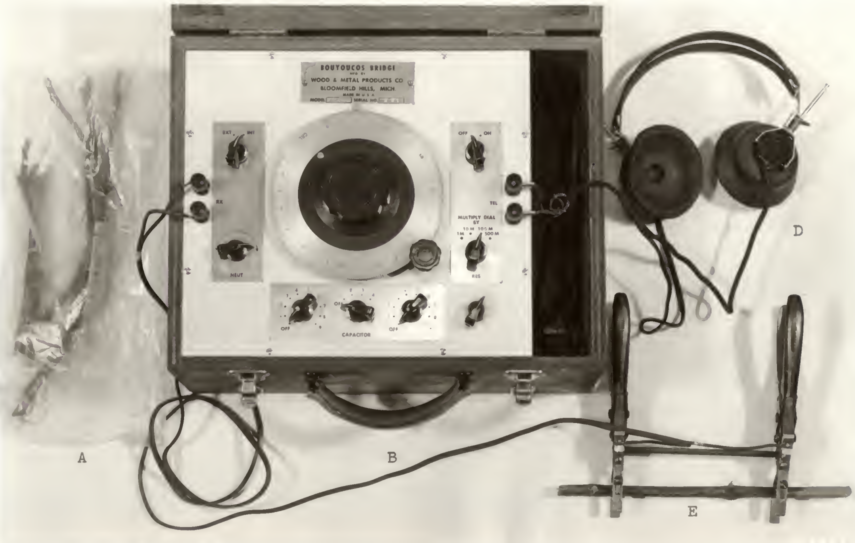
A. Polyethylene bag enclosing grape cuttings.

B. Boyoucous Model C Moisture Bridge.

C. Grape cutting in position for determining electric resistance.

D. Head phones for detecting the null point.

PLATE III


BOUYOUCOS BRIDGE
MFG BY
WOOD & METAL PRODUCTS CO
BLOOMFIELD HILLS, MICH.
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CAPACITOR
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A
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EXPLANATION OF PLATE IV

Fig. 1. A grape cutting is attached to electric resistance terminal by inserting needles through the cuttings.

Fig. 2. Side view of pliers showing the special extension and how the needle is attached to it.

PLATE IV

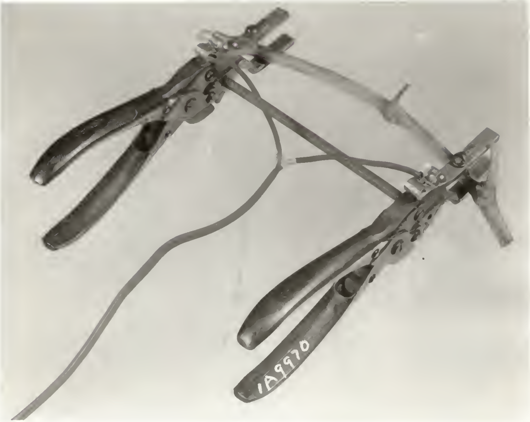


Fig. 1

Fig. 2

stratification influence. Polyethylene bags were used for keeping the cuttings when removed from the freezing cabinets.

An electrical resistance reading was recorded for each individual cutting before applying any treatment. The cuttings were returned to the moisture proof bags. They were then exposed to various temperatures for a period of 24 hours for all except treatments with liquid air and boiling water, in which it was two minutes. At the end of the 24 hour period, the cuttings were removed from the freezing cabinet and placed in polyethylene bags at room temperature. Three hours later the first reading of the electrical resistance was made.

The second check was taken 24 hours after the first reading. The third check was 24 hours after the second reading.

Few cuttings, representing each variety, were examined under a microscope to determine the degree of injury. This examination was made seven days after each treatment.

Six temperatures were read in this experiment: -10° F., -17° F., -25° F., -40° F., freezing in liquid air, and soaking in boiling water.

Experiments with One-Year-Old Potted Grape Plants

During the second half of February 1955, samples consisting of 40 cuttings of each variety were collected from the Horticultural Farm. Since they were collected in late winter, they were checked carefully to exclude those which might be damaged by cold weather. They were tied in bundles and placed in moist peat moss. They were stored in the cold storage at a temperature range of 35-38° F. These cuttings were prepared for propagation to be used as rooted plants later.

Early in March a bench in the propagating section of the Horticultural greenhouse was prepared, using a new material called Vermiculite as the rooting medium. The temperature ranged from 60° to 70° F. Special jet nozzles were used to provide high humidity.

The cuttings were taken out of the cold storage to the propagating house in mid-March. Each sample consisted of 25 cuttings. Fifteen cuttings from each variety were set in the Vermiculite with 1-2 buds left exposed and the other 10 cuttings from each variety were treated with a chemical Hormodin No. 2, to speed up the formation of roots. The treated cuttings were set in the propagating section apart from the others.

The treated cuttings started activity within eight days while the untreated cuttings pushed out their buds within 10-14 days. Treated cuttings of Seibel 2862, Seibel 5860, and Baco 1 started growth within three days. With the exception of the variety Seibel 15062, all made very good vegetative and root growth. Seventy per cent of the variety Seibel 15062 failed to grow (Plate V).

Between May 10 and 15 the plants were transplanted to six-inch clay pots. A mixture of two parts loam and one part of sand was used for potting. The plants were kept in the greenhouse ten days, then they were moved outside. A snow fence was placed over the bed as a means of protection during the hot summer. The plants were thus growing in partial shade.

EXPLANATION OF PLATE V

Figs. 1 and 2. Pots containing grape plants of the varieties used in the studies.

PLATE V

Fig. 1

Fig. 2

In early December the plants intended for study were moved to cold storage. Later on the plants were taken out of the pots because it was difficult to lower the temperature sufficiently while the plants were in the pots due to too much bulk. The first electrical resistance test was taken right after the removal of the plants from the pots (Plate VI). Then the roots were insulated with sawdust and dry moss, then wrapped with plastic sheets to prevent them from freezing during the treatment.

The temperatures used were -10° F., -17° F., and -25° F. Each treatment duration was 24 hours. Five plants of each variety were used.

DISCUSSION OF RESULTS

Experiments with One-Year-Old Grape Canes

Three electrical resistance readings for each cutting were taken after every treatment, as described under materials and methods. Readings taken after any possible recovery were compared with those taken before applying treatments. The per cent drop in resistance for each cutting was calculated. Also the total per cent drop in resistance for the cuttings under each variety was obtained. These data are presented in Table 1. This table shows that the per cent drop in resistance for each variety increased as the temperature to which it was exposed decreased. Results from higher temperature

Table 1. Per cent drop in electrical resistance of grape cuttings due to various temperature treatments.

Variety	Treatment temperatures: -10° F.	-17° F.	-25° F.	-40° F.	Liquid air	Boiling water
	25	45	59	70	67	78
	38	49	54	83	77	71
	27	52	58	63	77	70
	13	62	65	73	73	65
BS 2862	17	58	37	64	70	70
	22	46	58	70	72	77
	22	62	59	65	62	67
	10	50	38	76	53	66
	24	50	46	67	60	61
	15	59	56	58	60	69
Total	213	533	530	684	671	694
	19	64	58	75	66	65
	31	61	62	75	69	72
	30	71	64	69	72	66
	21	62	72	75	74	63
Baco No. 1	47	68	55	69	69	64
	13	37	62	73	69	63
	13	55	54	69	67	69
	18	38	60	53	73	68
	22	50	71	69	62	64
	15	39	57	57	74	72
Total	229	545	615	684	695	666
	16	50	69	72	75	60
	9	67	72	71	70	64
	14	55	66	73	69	67
	28	71	62	73	69	77
S. 15062	51	61	77	57	58	74
	54	29	69	71	80	71
	25	44	67	81	71	75
	26	37	71	80	71	78
	39	41	70	79	69	67
	35	38	70	80	68	63
Total	297	493	693	737	700	696

Table 1 (cont.).

Variety	-10° F.	-17° F.	-25° F.	-40° F.	Liquid air	Boiling water
	41	56	73	75	84	71
	37	63	77	81	81	82
	43	68	68	70	80	84
	20	61	79	81	86	82
S.V. 14287	25	50	76	84	83	73
	21	54	71	75	81	70
	36	64	76	82	85	67
	17	47	69	79	78	67
	34	65	73	60	81	73
	22	41	71	80	79	72
Total	296	569	733	767	818	741
	38	65	75	81	78	70
	20	51	75	81	68	77
	21	48	67	78	59	79
	39	66	63	80	78	79
S. 5860	37	65	68	78	68	78
	33	43	75	79	82	75
	42	47	79	79	82	78
	21	55	70	80	80	79
	22	55	72	82	82	75
	11	50	72	75	72	80
Total	284	545	716	793	749	770
	26	53	66	78	78	78
	19	50	75	75	82	80
	31	66	72	77	82	70
Concord	36	49	68	75	86	75
	29	52	75	74	80	78
	53	56	73	77	66	67
	41	62	64	79	77	76
	15	59	55	81	80	71
	16	50	66	74	82	72
	20	50	74	80	65	78
Total	286	547	688	770	778	745

Table 1 (cont.).

Variety	Treatment temperatures					
	-10° F.	-17° F.	-25° F.	-40° F.	Liquid air	Boiling water
	55	63	76	78	79	69
	53	69	78	76	83	77
	41	69	77	74	78	79
	43	64	74	76	79	72
S. 10096	17	53	65	74	79	76
	29	48	71	76	81	77
	29	54	71	74	79	78
	23	62	67	70	80	72
	22	58	71	72	78	70
	40	56	75	73	79	78
Total	352	596	725	743	795	748
	39	64	75	81	81	69
	58	62	76	78	80	82
	26	65	76	77	68	76
	26	62	76	76	71	75
S. 14117	43	53	72	81	72	84
	33	57	55	77	82	74
	32	55	79	73	84	73
	54	76	76	75	73	73
	32	48	77	80	75	78
	32	50	69	67	75	74
Total	375	592	731	760	761	758
	29	65	78	79	82	80
	31	52	70	85	66	79
	30	56	78	78	61	85
	64	52	80	85	71	70
S. 1000	50	52	78	87	64	83
	33	63	74	80	84	78
	48	78	77	79	79	84
	68	61	68	83	78	71
	44	67	75	79	77	83
	65	75	75	80	78	82
Total	451	621	753	815	740	795

Table 1 (concl.).

Variety	Treatment temperatures					
	-10° F.	-17° F.	-25° F.	-40° F.	Liquid air	Boiling water
Golden Muscat	45	71	78	84	85	85
	35	66	76	80	86	86
	67	66	73	85	87	83
	72	66	81	79	81	90
	63	62	78	80	81	86
	62	76	70	82	85	84
	62	64	76	81	86	82
	54	62	73	79	84	84
	60	65	72	77	73	75
	70	64	83	83	78	84
Total	590	662	760	810	826	834

treatments varied more than from the lower temperatures.

From the per cent drop in resistance of the individual cuttings shown in Table 1, an analysis of variance was computed and is presented in Table 2. The objective of this overall analysis is to determine whether or not there are: (a) Significant differences in mean per cent drop at the different temperature levels, when averaged over varieties; (b) Significant differences in mean per cent drop for the different varieties, when averaged over temperature levels; or (c) A significant interaction between temperatures and varieties.

The results show that the variation between varieties and treatments is highly significant. There is a highly significant interaction between treatments and varieties. This is shown by the fact that the response curves, particularly for B.S. 2862 and Golden Muscat, are not parallel (Fig. 1). There are marked differences among the varieties treated at -10° F., -17° F.,

EXPLANATION OF PLATE VI

The writer, taking resistance readings of grape plants during the studies.

PLATE VI

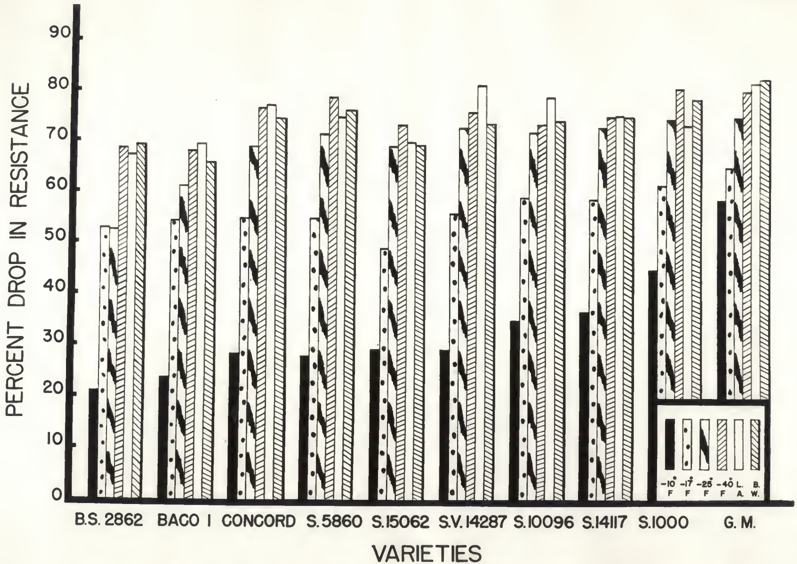


Fig. 1. Percent drop in electrical resistance of grape cuttings due to various treatment temperatures.

Table 2. Analysis of variance for the 10 grape cuttings for each of 10 varieties and 6 treatment temperatures.

Source of variation	Degrees of freedom	Mean square
Temperatures	5	27,388
Varieties	9	1,933
Interaction	45	164
Error	540	56
Total	599	29,541

-25° F., and -40° F. The varieties responded differently to the treatments. Figure 1 shows that the per cent drop in resistance is practically the same for treatments -40° F., liquid air, and boiling water. The statistical analysis confirms that there is no significant difference among these three temperature levels. This would seem to indicate that canes treated at -40° F. were dead as were those treated with liquid air or boiling water.

All of the grape canes were set into a propagating bench after treatment to determine if they would grow. Many cuttings of the varieties B.S. 2862, Baco 1, Concord, S. 5860, S. 15062, and S.V. 14287 grew after being treated at -10° F.; two cuttings of the following varieties: S. 10096, S. 14117, and S. 1000 grew when treated at -10° F., and only one cutting from each variety except Golden Muscat grew when treated at -17° F. and at -25° F. None of the cuttings treated at -40° F., liquid air, and boiling water grew.

The mean per cent drop in electrical resistance of the varieties treated is presented in Table 3. Figure 1, based on this table, shows that the range of the per cent drop is wide

Table 3. Mean per cent drop in electrical resistance of grape cuttings due to various temperature treatments.

Variety	Treatment temperatures					
	-10° F.	-17° F.	-25° F.	-40° F.	Liquid air	Boiling water
B.S. 2862	21.3	53.3	53.0	68.9	67.1	69.4
Baco 1	22.9	54.5	61.5	68.4	69.5	66.6
Concord	28.6	54.7	68.8	77.0	77.8	74.5
S. 5860	28.4	54.5	71.6	79.3	74.9	77.0
S. 15062	29.7	49.3	69.3	73.7	70.0	69.6
S.V. 14287	29.6	56.9	73.3	76.7	81.8	74.1
S. 10096	35.2	59.6	72.5	74.3	79.5	74.8
S. 14117	37.5	59.2	73.1	76.0	76.1	75.8
S. 1000	45.1	62.1	75.3	81.5	74.0	79.5
Golden Muscat	59.0	66.2	76.0	81.0	82.5	83.4

among varieties treated with -10° F. The mean per cent drop for the variety B.S. 2862 is 21.3, while in the case of S. 1000 it is 45, and 59 for Golden Muscat. As the treatment temperatures were lowered, the means per cent drop in resistance decreased with all the varieties, and the range among these means was narrowed. The variability in electrical resistance is high among the varieties which have been exposed 24 hours to -10° F. The varieties B.S. 2862 and Baco 1 have shown the lowest drop in per cent resistance at -10° F. as compared with the others. Under the conditions of these experiments, these two varieties seem to be the most hardy among the groups treated, while Golden Muscat, which has shown the highest drop in per cent resistance, seems to be the most tender.

Some workers have shown that injury due to low temperatures can be seen as variation in color of the damaged tissues when examined under a microscope. Chandler (1913) has shown that when fruit trees are in an activity growing condition, the cambium, young cortex, and sapwood cells are the tenderest. While when the tissues have matured and become dormant, the pith in the twigs is the first to be killed, followed by browning in the sapwood and outer cells of the cortex. Cambium is the most hardy among the tissues, and often recovers even if it appears dark.

Baco 1 was exposed to -17° F., -25° F., -40° F., liquid air, and boiling water. Tissues of this variety show some injury as illustrated in Plate VII. Figures B, C, D, E, and F show the degree of injury as a result of various treatment temperatures as compared to a healthy cross section A. The injury is shown by a dark colored ring through the epiderm, cork, cortex, and phloem of the bark. The dark ring is wider in sections C, E, and F which were treated with -40° F. liquid air and boiling water, respectively. Also, a brown color appears in the pith. The degree of browning increases with lower temperatures.

The plate shows that the more severe the injury, the wider the dark ring becomes and the more the browning of the pith shows up. Cross section A shows a healthy cutting used for comparison.

EXPLANATION OF PLATE VII

Cross sections of the variety Baco No. 1 showing the effect of various temperatures as compared to a healthy cross section.

A. Healthy (no treatment)

B. -17° F.

C. -40° F.

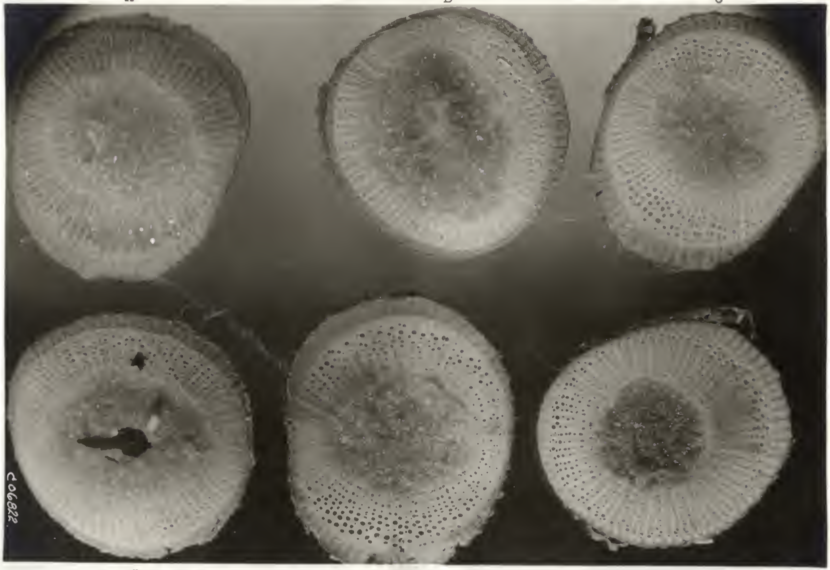
D. -25° F.

E. Liquid air

F. Boiling water

PLATE VII

A B C



D E F

Experiments with One-Year-Old Grape Plants

The per cent drop in electrical resistance for the individual plants is recorded in Table 4. Also the total per cent drop in resistance of all plants treated for each variety is shown. The table shows that the per cent drop in resistance increased with colder temperatures. Table 5 presents the mean per cent drop in resistance due to different treatments applied. The range drop in resistance among the varieties at -10° F. is 33.2 to 50.0 for the varieties B.S. 2862 and S. 14117, respectively. At -17° F. the range became narrower, but B.S. 2862 still shows the lowest drop in resistance. At -25° F. the range is wider and shows B.S. 2862 to be at the top of the hardy varieties, followed by Baco No. 1, S. 15062, and Concord (Fig. 2).

The variety Seibel 10096 was not included because of its unusual behavior. The mean per cent drop in resistance of this variety at -10° F. is the highest among the varieties, while its mean per cent drop at -17° F. and -25° F. is the lowest (Fig. 2). The unusual behavior of S. 10096 is in that its mean at -10° F. is higher than that when treated at -17° F. Table 4 shows a uniform drop in resistance among the individuals of the variety at each treatment. This strange behavior may be due, as stated under materials and methods, to injury of plants in late August by hot weather. As reported before, few plants which showed slight injury were used because of the limited number of plants. When these plants were treated at -10° F., they showed an unusual response to the treatment.

Table 4. Per cent drop in electrical resistance of grape plants due to various temperature treatments.

Variety	Treatment temperatures -10° F.	-17° F.	-25° F.
	46	69	71
	40	59	67
B.S. 2862	25	61	60
	18	44	60
	37	50	62
Total	166	283	320
	48	57	71
	39	53	58
S. 15062	31	64	58
	31	60	61
	30	53	65
Total	179	287	313
	29	62	69
	40	53	71
Baco No. 1	40	64	68
	36	50	65
	41	55	67
Total	186	284	340
	44	61	64
	29	50	68
Concord	45	64	64
	35	58	72
	46	55	68
Total	199	288	336
	42	65	74
	44	48	75
S.V. 14287	48	41	80
	46	71	75
	35	65	59
Total	215	290	363

Table 4 (concl.).

Variety	Treatment temperatures -10° F.	-17° F.	-25° F.
	43	50	63
	50	56	68
Golden Muscat	46	59	67
	47	62	79
	45	68	64
Total	231	295	341
	57	67	72
	58	70	71
S. 5860	49	50	68
	50	59	76
	22	59	75
Total	236	305	362
	51	61	76
	57	63	74
S. 1000	48	64	71
	29	68	75
	47	58	77
Total	232	314	373
	52	61	72
	52	60	62
S. 14117	53	62	70
	48	58	73
	44	60	73
Total	249	301	350
	62	67	60
	62	69	74
S. 10096	57	47	50
	54	50	47
	63	40	72
Total	298	273	303

Table 5. Mean per cent drop in electrical resistance of grape plants due to various temperature treatments.

Variety	Treatment temperatures -10° F.	-17° F.	-25° F.
B.S. 2862	33.2	56.6	64.0
S. 15062	36.0	57.4	62.6
Baco No. 1	37.2	56.8	68.0
Concord	40.0	57.6	67.2
S.V. 14287	43.0	58.0	72.6
Golden Muscat	46.2	59.0	68.2
S. 1000	46.4	62.8	74.4
S. 5860	47.2	61.0	72.4
S. 14117	50.0	60.2	70.0
S. 10096	59.6	54.6	60.6

From Table 4, a preliminary analysis of variance was computed and is shown in Table 6. The results of the analysis show that there is a significant interaction beyond the 1 per cent level, between varieties and treatments. The nature of this interaction may be examined more closely in Table 4. This table shows that the total per cent drop is increased with lower temperature treatments. Also, it shows that the variety Seibel 10096 has a total per cent drop at -10° F. higher than the total per cent drop when treated at -17° F.

Table 6. Analysis of variance of grape plants on Table 4.

Source of variation	Degrees of freedom	Mean square	F
Temperatures	2	7,423	
Varieties	9	186	
Interaction	18	125	2.27
Error	120	55	
Total	149	7,789	

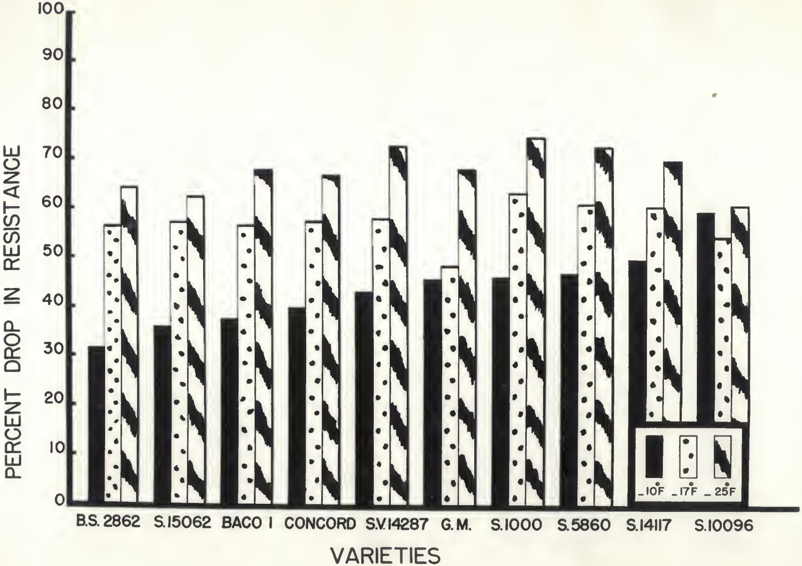


Fig. 2. Percent drop in electrical resistance of grape plants due to various treatment temperatures.

It was decided to compute the statistical analysis of variance excluding the variety S. 10096. The results are recorded in Table 7. The analysis shows that the mean square for interaction is no longer significantly different from the mean square of error. Upon computing the F test, a marked difference is noticed. Also, the variety mean shows a high significance beyond the 1 per cent level due to different responses of each variety to the treatments applied.

Table 7. Analysis of variance of grape plants on Table 4, excluding the variety Seibel 10096.

Source of variety	Degrees of freedom	Mean square	F
Temperature	2	8,237	168.10***
Varieties	8	205	4.18***
Interaction	16	33	0.67
Error	108	49	
Total	134	8,524	

*** Significant beyond the 1 per cent level.

A comparison of results obtained from grape canes and from rooted plants is interesting. The mean per cent drop in resistance of grape canes as a result of various treatments as shown in Table 3, differs from the drop in resistance of whole rooted plants exposed to the same temperatures as presented in Table 5. The variation is highly significant between canes and plants when treated at -10° F., while at lower temperature treatments, the variation is not as marked. Comparing the results of treatments at -17° F. and at -25° F. of canes and of plants, Figs. 1 and 2 do not show significant differences.

Rooted plants of Golden Muscat which made vigorous vegetative growth show a relatively lower drop in resistance than Golden Muscat canes. Seibel 10096 plants which made poor vegetative growth showed a greater drop in resistance when treated at -10° F. than other plants of the same variety which were more vigorous.

CONCLUSIONS

1. Electrical resistance of grape canes is decreased if the canes are exposed to low temperatures.

2. There is a high correlation between the per cent drop in electrical resistance of grape canes and the degree of injury caused by artificial freezing.

3. There is a wide variation in the response of some varieties treated at -10° F. and -17° F.

4. Treating at -40° F. for 24 hours produced the same effect on grape plants and canes as that produced by liquid air or by boiling water.

5. There is no significant difference between varieties treated at -40° F., liquid air, and boiling water, as apparently each treatment kills the tissues.

6. The varieties B.S. 2862, Baco 1, S. 5860, S. 15062, and SV. 14287 are considered as hardy under the conditions of the experiment as the American variety, Concord.

7. Golden Muscat apparently is the most tender variety

in the group. The rest of the varieties tested are considered semi-hardy since they did not show much drop in electrical resistance when treated at -10° F. for 24 hours.

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HARDINESS STUDIES OF SOME FRENCH AMERICAN HYBRID GRAPES

by

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AN ABSTRACT OF A THESIS

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Probably the most important factor that influences the distribution of the fruit industry is minimum temperature. It more or less marks the boundaries where certain fruit can be grown. This is important due to the fact that man tends to introduce economic fruits beyond the limits of their natural temperature zones.

Since grape culture has spread north of the temperate zone, winter injury has become one of the limiting factors in grape industry. The French hybrid grapes vary in their resistance to cold. The investigations involved in these experiments are studies to determine the degree of hardiness of the following hybrids: Seibel 1000, Seibel 14117, Seibel 10096, Seibel 5860, Seibel 15062, Seyve Villard 14287, Bertille Seyve 2862, Baco No. 1, the French American hybrid, and the Golden Muscat. The American variety Concord was added for comparison.

These experiments were started in February, 1955. Sixty cuttings of one-year-old grape canes and 15 one-year-old grape plants were used from each of the varieties mentioned above. Artificial methods of freezing were employed as a means of speeding up the process of testing. The degree of hardiness was measured by electrical conductivity tests. These tests were based upon the assumption that the release of electrolytes by cells, when measured by electrical conductivity, gives a direct reading of the amount of injury inflicted by a given treatment. The drop in electrical resistance indicates the amount of damage to plants.

Six treatments were applied for testing the cuttings: -10° F., -17° F., -25° F., -40° F., liquid air, and boiling water. The period of freezing was 24 hours with the first four treatments, two minutes with liquid air, and two minutes with boiling water. Three treatments were applied in testing the plants: -10° F., -17° F., and -25° F. for a 24-hour period.

An electrical resistance reading was recorded for each individual cutting or plant before applying any treatment. Three additional electrical resistance readings were obtained after treatment. The per cent drop in resistance was calculated for the individuals and the statistical analysis was computed.

The results of these analyses show that colder temperatures decrease electrical resistance. A high correlation between the per cent drop in electrical resistance and the degree of injury caused by artificial freezing was found. The analysis of the data shows a wide variation among varieties treated at -10° F. and -17° F. Cuttings treated at -40° F. for 24 hours showed about the same results as those which were killed by liquid air or boiling water. There was no significant difference between varieties treated at -40° F., liquid air, and boiling water.

The varieties B.S. 2862, Baco No. 1, S. 5860, S. 15062, and S.V. 14287 are considered as hardy under the conditions of the experiments as the American variety, Concord.

Golden Muscat seems to be the most tender variety. The rest of the varieties are considered semi-hardy as they showed only a slight decrease in resistance when treated at -10° F. for 24 hours.