Effects of Fluctuating Winter Temperature Stress on Growth and Productivity of Grape (*Vitis*) Species

C. A. MULLINS, K. PETREY, D. E. DEYTON, AND D. L. COFFEY*

The grape, like many fruit crops, is quite sensitive to low temperatures. The U. S. grape crop is reduced an estimated 10% annually by late spring freezes alone (10). Climatic conditions greatly limit the geographic distribution of grape species and cultivars. In the eastern U. S., *Vitis labrusca* cultivars predominate with the Concord cultivar accounting for over 80% of the production (2). *V. vinifera* grapes that are rather winter tender are increasing in acreage (1, 5, 7). French hybrids which have labrusca, vinifera, and other species in their parentage are intermediate in hardiness and are also rather widely planted in this region.

The hardiest cultivars of all three types have been identified (1, 2, 4, 5, 6, 9, 11). Most of the selections were tested in the extremely low winter temperature conditions of northern states. Being in a zone of climatic transition, the mid-south region is subject to a different type of hardiness problem which is associated with fluctuating spring, fall, and winter temperatures. These wide fluctuations in temperature cause severe stress to grapes and other perennial fruit plants (3, 8).

PROCEDURE

A planting of several American and French hybrid type cultivars shown to be hardy in eastern U. S. trials was initiated at the University of Tennessee Plateau Experiment Station near Crossville, Tennessee in 1973. The test site experiences rather severely fluctuating temperature conditions and few grape cultivars have survived in two previous tests (8). Vines were grown with standard cultural practices. Most vines were trained to the 4 arm Kniffin system but a few were head trained and spur pruned. Canes were usually pruned to 10 to 12 buds. The experimental design was a randomized complete block with 4 replications. Each plot consisted of 3 plants.

Early production was good but after 2 to 4 years cultivars exhibited a decline in vine vigor and productivity. Cluster size was smaller than expected. A low temperature of −16° F. occurred in January of 1977 and resulted in considerable vine injury. Analysis of the temperature patterns showed severe temperature fluctuations occurred during the test period. Fluctuations of as much as 55-58° F. repeatedly occurred between subsequent 24 hour reading periods in December. In most years, the autumn was mild and rapid mid-December freezes severely injured the not then fully dormant vines.

In 1979 and 1980 measurements of summer growth and development of primary canes were taken. The number of buds remaining after pruning, percent bud break, and length of shoot growth from these buds were determined in mid-June for each of the 4 canes per vine. Yield per vine and soluble solids content and acidity were also determined for each cultivar.

RESULTS

The American type cultivars averaged 40.9 buds per plant left on the primary canes after pruning (Table 1). Six of the 10 cultivars tested averaged over 40 buds per plant. However, bud

*Associate Professor (Crossville), Former Graduate Student (Knoxville), Assistant Professor (Knoxville), and Professor (Knoxville), Department of Plant and Soil Science, respectively.

break averaged only 81% with a range of 76 to 86%. Concord, Moored, Moores Early, Catawba, and Niagara averaged 82 to 86% bud break. The length of shoot growth from buds on the primary canes of all cultivars averaged 17 m per plant in mid-June. Cane growth from Concord was much more vigorous than that from any other cultivar. Canes from Moored, Moores Early, Fredonia and Catawba had acceptable vigor. All cultivars but Alwood, Catawba, Yates, and Niagara had 100% plant survival.

The French hybrid type cultivars averaged 36.3 buds per plant on pri-

Table 1. Buds left per vine, % bud break, shoot growth per vine, and % vine survival of American type cultivars, 1979-80.

Cultivar	Buds left per vine	Bud break	Shoot growth	Vine survival
		%	m/vine	%
Concord	39.0 bcd[z]	86 a	27.6 a	100 a
Alwood	45.6 a	80 bcd	11.7 d	92 ab
Moored	38.9 bcd	84 ab	17.7 bc	100 a
Moores Early	43.1 ab	82 abc	20.4 b	100 a
Bath	35.1 d	77 cd	12.5 d	100 a
Fredonia	40.1 abcd	76 d	20.4 b	100 a
Catawba	46.2 a	83 ab	17.8 bcd	83 ab
VanBuren	41.9 abc	78 cd	13.9 d	100 a
Yates	43.1 ab	80 bcd	11.7 d	50 c
Niagara	35.8 cd	86 a	15.2 cd	75 b
Mean	40.9	81	17	93

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 2. Buds left per vine, % bud break, shoot growth per vine, and % vine survival of French hybrid type cultivars, 1979-80.

Cultivar	Buds left per vine	Bud break	Shoot growth	Vine survival
		%	m/vine	%
Rougeon	43.4 a[z]	68 bc	15.1 a	100 a
Rosette	38.0 a	79 a	12.7 ab	100 a
Vidal 256	42.4 a	58 de	9.7 bc	92 a
Seyval	37.5 a	63 cd	6.0 c	92 a
Cascade	37.2 a	70 bc	6.2 c	75 ab
Aurore	30.5 a	76 ab	8.6 c	75 ab
GW 7	39.2 a	68 bc	9.3 c	75 ab
Baco noir	41.5 a	74 ab	10.1 bc	42 bc
Villard Blanc	40.8 a	53 c	9.0 c	42 bc
Foch	34.5 a	72 ab	8.0 c	50 bc
DeChaunac	14.6 b	71 abc	5.2 c	17 c
Mean	36.3	68	9.0	69

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 3. Yields, fruit soluble solids content, and acidity of American type cultivars, 1979-80.

Cultivar	Yield	Soluble solids	Titratable acidity
	mt/ha	%	%
Concord	13 a[z]	14.3 c	0.9 c
Alwood	11 ab	13.4 d	0.7 e
Moored	11 ab	15.5 b	0.7 de
Moores Early	7 c	12.7 d	1.3 a
Bath	8 bc	14.5 c	0.8 d
Fredonia	9 bc	12.7 d	1.1 b
Catawba	9 bc	16.9 a	1.2 ab
VanBuren	4 d	13.3 d	1.0 c
Yates	3 d	17.6 a	0.4 g
Niagara	9 bc	15.1 bc	0.6 f
Mean	8.4	15	0.9

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Yields, fruit soluble solids content, and acidity of French hybrid type cultivars, 1979-80.

Cultivar	Yield	Soluble solids	Titratable acidity
	mt/ha	%	%
Rougeon	10 a[z]	17.2 de	0.8 bc
Rosette	9 a	17.9 cd	0.8 bc
Vidal 256	7 b	19.6 ab	0.9 b
Seyval	5 c	19.5 ab	0.7 cd
Cascade	4 cd	18.5 bcd	0.5 f
Aurore	3 d	17.1 de	0.8 bc
GW 7	3 d	17.9 cd	0.5 f
Baco noir	3 d	19.0 abc	1.2 a
Villard Blanc	3 d	17.7 cde	0.8 cd
Foch	3 d	20.2 a	0.7 e
DeChaunac	1 e	16.3 e	0.7 e
Mean	4.5	18	0.8

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

mary canes after pruning (Table 2). DeChaunac vines averaged only 14.6 buds per plant, indicating very poor vigor. Bud break for the 11 French hybrid type cultivars averaged 68% resulting in only 25 viable buds per vine on the primary canes. These cultivars averaged only 9 m of growth per vine from buds on the primary canes in mid-June. Rougeon vines had more growth than all cultivars but Rosette. Rougeon and Rosette vines had 100% plant survival. Vidal 256 and Seyval vines had 92% plant survival while all other cultivars had 75% or less. DeChaunac vines had only 17% survival.

Yield of the American type cultivars averaged 8.4 mt/ha with Concord, Alwood, and Moored among the highest yielding cultivars (Table 3). These yields were much lower than those reported from most other tests in the eastern U. S. (1, 2, 4, 5, 6, 9). Soluble solids levels averaged 15% from all cultivars with Catawba and Yates having the highest levels of 17 and 18%, respectively. Titratable acidity levels averaged 0.9%.

The French hybrid type cultivars averaged 4.5 mt/ha (Table 4). Fruit soluble solids averaged 18.3%. Vidal 256, Seyval, Baco noir, and Foch cultivars had highest fruit soluble solids. Fruit acidity averaged 0.8%. Baco noir fruit had highest acidity and GW 7 fruit had the lowest acidity.

Highly significant correlations were found between buds left per vine and yield ($R = .89$), percentage bud break and yield ($R = .93$), and live buds per vine and yield ($R = .94$). Live buds were calculated by multiplying buds left by percentage bud break. The correlation between June shoot growth length and yield was also highly significant ($R = .94$). Data from both grape types were pooled for these correlations. These results indicate that fruit yields at this site were highly associated with shoot growth, number of buds left after pruning, and percentage bud break. Shoot growth in June appeared to be an excellent indicator of vine condition and yield potential.

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Winter Bud Injury of Grapevines 1981-1982

MARILYN BRUSKY-ODNEAL[1]

Abstract

Mature dessert and wine grape cultivars and numbered selections at the State Fruit Experiment Station of Southwest Missouri State University were classified according to the percentage of primary, secondary, and tertiary buds alive after minimum temperatures of −27°C and −25°C were reached in mid-January 1982. Concord Seedless, GR-7, Ives, and Steuben were the most hardy of the 81 cultivars and selections whereas Lakemont, S-14117, and Suffolk Red were the least hardy.

Introduction

The State Fruit Experiment Station of Southwest Missouri State University is located in the west Ozarks of Missouri with an average annual precipitation of 104 cm. The Experiment Station is located in Mountain Grove at 442 meters above sea level where the winters are generally mild. Temperatures below −18°C on consecutive nights are unusual for this area. The soils are classified in the Viraton series. This is a slowly permeable silt loam underlain by a fragipan at a depth of 41-89 cm (10).

Winter bud hardiness data were collected from dessert and wine grape cultivars and numbered selections in the State Fruit Experiment Station vineyards after record breaking low temperatures of mid-January 1982. These temperatures provided an excellent opportunity to evaluate winter bud hardiness. The purpose of this study is to ascertain the winter bud injury suffered by these *Vitis* cultivars and selections after exposure to low winter temperatures.

Materials and Methods

Weather. The grape yield in 1981 at the Fruit Experiment Station was light, due probably to the drought of 1980. Temperatures in 1981 were close to normal and annual precipita-

[1]Research Associate, State Fruit Experiment Station, Southwest Missouri State University, Mountain Grove, MO 65711.