SOME RESPONSES OF GRAPEVINES TO TREATMENT FOR FROST IN NAPA VALLEY

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The coastal grape-growing region of California has experienced frequent spring frosts during the last 15 years.

On the morning of April 24, 1964, moderate to severe spring frost damage occurred in the Napa Valley. Following this frost, a series of tests were initiated at the Oakville Experimental Vineyards, operated by the Department of Viticulture and Enology of the University of California.

These tests were designed to give more information on vine responses to cultural treatments following frost damage to tender green shoots of various lengths.

Winkler (6), working with Tokay, Malaga, and Thompson Seedless in the San Joaquin Valley, found that different varieties of grapes require different considerations when post-frost treatments are applied.

On spur-pruned varieties such as Malaga and Tokay, favorable crop increases were obtained on frosted vines which were treated by tearing out the injured shoot. In Thompson Seedless and Sultana varieties, crop responses would not be expected because only the primary bud is fruitful in these varieties.

Winkler (4) has outlined criteria for determining the treatment to be given for different degrees of frost injury based on the fruiting habit of the vine.

He points out that where frost has completely destroyed the shoots, nothing should be done. Where shoots have been partially killed and clusters injured, stripping or tearing out of the injured shoots is recommended.

When only a few shoots remain uninjured, it may be well to remove these shoots in addition to the injured shoots. Winkler (5) further points out the necessity of completing the stripping operation immediately after the frost.

Stripping operations conducted in 1960 in some frosted vineyards failed to produce the expected response. This failure was attributed to the late date at which the frost occurred. At the time, the shoots had produced woody basal portions. When these woody shoots were torn off, the lateral buds were injured and few, if any, shoots were produced from secondary or tertiary buds.

The depletion of readily available foods for shoot growth may limit the response in some cases. Winkler proposes that up to 60% of the carbohydrate reserves stored in the fruit and spurs could have been utilized by the May 23, 1960, date.

The present study was made to further our knowledge of responses of certain wine grape varieties grown in the North coast region under climatic soil and conditions that exist there.

MATERIALS AND METHODS

Following the spring frost of April 24, 1964, in the Napa Valley, a series of trials was established to determine some effects of post-frost cultural treatments on grapevines and on the yield of fruit.

Several different methods were used in developing this information.

Effects of Cultural Treatments: Three varieties of grapes were used: Folle blanche, Cabernet Sauvignon, and White Riesling. Folle blanche, a medium-clustered heavy producer which is commonly spur-pruned, was selected to test treatment effects on wine grape varieties that are spur-pruned and produce fruitful secondary and tertiary buds. Cabernet Sauvignon, a medium-clustered cane-pruned wine variety, was selected because of its reported ability to respond with good crops following a frost. The White Riesling, a small-clustered cane-pruned variety, was used because of its inability to give good crops following

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damaging spring frosts.

The test on the Folle blanche was a completely randomized test using a check or control plus four different treatments involving removal of injured shoots following frost damage.

Treatments were completed within two days of the frost. The following treatments were established on each of ten single-vine replications:

A Check (no treatment)

B Injured and green shoots all removed by tearing out or brushing off with the gloved hand.

C Removal of only the shoots injured by frost using the gloved hand and tearing them out or rubbing them off.

D All injured and green shoots removed by *cutting* as close as possible to vine parts one year old or older.

E Removal of only injured shoots with pruning shears, as in *D*, but uninjured green shoots were left on the vine.

During harvest, fruit yields on each individual vine in the test were determined by weighing the fruit in aluminum picking containers on a standard spring-balance scale. The weights were recorded in kilograms per vine.

The Cabernet Sauvignon and White Riesling varieties involved only two different treatments with 12 vines per treatment:

1. Only the frost injured shoots were removed, by using the gloved hand to tear out or brush off the injured shoots. The green uninjured shoots were left on the vine.
2. Checks, receiving no treatment.

During harvest, the fruit yields were obtained in the same manner as that used in the Folle blanche test.

All the vines received the same cultural treatments during the remainder of the growing season.

Shoot Length of Certain Fruit Spurs: Spur pieces and shoots were collected from Folle blanche vines. The length of shoot growth evident on the spur at the time of collection determined the vines used. The shoots were divided into three categories, by length: *Long* shoots, 12 to 18 inches; *Medium* shoots, 6 to 10 inches, and *Short* shoots, 2 to 4 inches.

After selecting the vines the terminal shoot on the selected fruiting spurs was removed and placed in a paper bag. The terminal portion of the 1-year-old fruiting spur beyond the shoot selected above was removed at the diaphragm of the node where the shoot had been removed. This short section was discarded. A one-inch section measured from the first cut above was pruned off, and this short section was removed to the laboratory. The wood and bark were separated at the cambium by making a longitudinal cut on the spur piece, and then peeling off the bark. Each sample collected then consisted of the selected shoot, wood of the fruiting spur, and the bark of the fruiting spur. The identity of each was kept so that they could be maintained until analysis began.

The shoots, wood, and bark were then dried thoroughly in a forced-air oven for 36 hours at 70°C and then stored in envelopes at room temperature in good laboratory storage for 8 months.

At the time of analysis the 3 different portions were so combined that 4 replications of each respective shoot length were analyzed. Each replication consisted of material collected from six separate vines. These samples of wood, bark, and shoot were ground separately in a small Wiley mill to the desired fineness.

Extraction procedures developed by Winkler and Williams (7) were followed except that a 0.5% clarase solution was used for starch digestion (1, 2). Sugar determinations were made according to the method of McCune (1) and Philips (2). Analytical data is expressed as percentage values on a dry-weight basis.

Berry Weight, Cluster Weight, and Fruit Maturity: In the Folle blanche planting, 26 flower clusters from normal first-growth shoots not injured by frost were tagged just prior to bloom time. A like number of clusters from shoots that grew from secondary spur buds were also tagged.

Prior to maturity and at harvest, berry samples were taken. Those taken prior to maturity were 100-berry lots on which the standard sugar test was made. At

TABLE 1

Effect of Cultural Treatments on Yield in Kilograms of Fruit per Vine of the Folle blanc Variety. Oakville, California. Harvested October 5, 1964. Single-vine Replications.

	Replications										
Treatment	1	2	3	4	5	6	7	8	9	10	Av.
a	0.8	3.2	8.0	5.6	1.2	2.6	6.6	1.8	0.8	1.6	3.22
b	1.6	2.2	0.2	5.4	1.0	2.4	1.4	0.4	3.0	1.6	1.92
c	5.6	1.2	2.4	4.8	1.6	8.8	4.4	1.6	10.4	3.6	4.44
d	3.6	1.6	0.4	1.0	1.4	2.4	5.2	3.6	2.6	0.6	2.24
e	1.8	2.4	1.8	4.2	4.6	3.4	3.0	1.4	0.4	5.8	2.88

[a] Check vines not treated.
[b] All shoots removed by stripping.
[c] Uninjured shoots left on vine, but injured shoots removed by stripping.
[d] All shoots removed by pruning with pruning shears.
[e] Uninjured shoots left on vine, but injured shoots removed with pruning shears.

harvest, 100 more berries were used for maturity test after the clusters had been removed to the laboratory and weighed. The degree Balling was determined by thoroughly crushing the berries. A small amount of juice was placed on a standard laboratory refractometer, and the degree Balling recorded.

The tagged clusters from primary and secondary shoots were picked and weighed at harvest time. The weights were recorded in grams, and average weight per cluster determined.

From each of the 26 cluster lots, 124 berries were removed and weighed. The weights were recorded, and average weight per berry determined.

RESULTS AND DISCUSSION

Table 1 shows the effects of cultural treatments on yield of Folle blanche vines following a damaging spring frost at Oakville, California, in the Napa Valley. No significant differences among treatments could be shown.

Tables 2 and 3 show the results of the stripping of injured shoots on the cane-pruned varieties, Cabernet Sauvignon and White Riesling. Again, no significant differences were indicated between the treatments on these two varieties.

From the data it appears that the crop yield was not affected enough by these post-frost treatments to result in signifi-

TABLE 2

The Effect of Vine Treatment on Fruit Yield in Kilograms of White Riesling at Oakville, California. Single-vine Replications

	Replications												
Treatment	1	2	3	4	5	6	7	8	9	10	11	12	Av.
Stripped	0.8	1.3	1.0	1.0	1.8	2.6	1.6	1.6	2.4	0.6	1.4	1.4	2.43
Not Stripped	1.0	1.2	2.4	1.4	2.8	2.4	1.6	1.6	1.2	1.6	1.2	2.2	3.17

TABLE 3

The Effect of Vine Treatment on Fruit Yield in Kilograms of Cabernet Sauvignon at Oakville, California. Single-vine Replications

Treatment	Replications 1	2	3	4	5	6	7	8	9	10	11	12	Av.
Stripped	2.4	2.8	3.8	3.2	3.2	3.6	1.8	3.6	3.0	4.4	3.8	3.2	3.23
Not Stripped	2.0	4.6	4.0	3.6	3.8	3.6	4.8	3.6	3.2	3.4	3.6	3.8	3.67

cant or practical yield increases. The Folle blanche variety has a fruiting habit that should produce good responses to the treatments applied in this study; yet the untreated vines produced one of the favorable yields in this test.

Factors such as the extent of frost damage, state of growth of the various shoots on the vine, and temperature variations within the vineyard all influence to varying degrees the responses of the vines, and differing effects of these factors might account for results contradictory to Winkler's.

In tables 1, 2, and 3 the individual vine yields demonstrate the extreme variability that frost damage induces in crop production. For example, the variability expressed in the check treatments shows as much as a ten-fold difference among vines. An increased number of vines in each replication might help overcome some of this variation. In view of this great variability, an increase in number of treated vines would not have resulted in data contradictory to that presented here.

The results, showing no yield benefits from currently recommended post-frost treatments, are directly opposed to those reported in earlier tests (6). One might then question the use of these treatments after spring frost damage has occurred.

The carbohydrate levels of shoots, bark, and wood are presented in table 4. Only the averages of 4 replications of 6-vine composites are reported.

Only the green shoots showed a significant difference in total carbohydrates at the 5% level as determined by analysis of variance. The shortest length had the highest content. However, the intermediate length had less than the longest, so the trend is not consistent and no useful conclusion can be drawn.

The utilization of carbohydrates in fruiting spurs by shoots which have grown and then been killed by frost might have accounted for the lack of response to vine

TABLE 4

Average of Per Cent Total Carbohydrates of the Wood, Bark, and Shoots of One-year-old Spur Samples of the Folle Blanche Variety Collected at Oakville, California, April 25, 1964. Average is of Four Replications with Six Vines in Each Replication

Length of shoot development	Average per cent total carbohydrate: Shoots*	Spur wood	Spur bark
Short (2 to 4 inches long)	3.74	9.48	5.65
Medium (6 to 10 inches long)	4.41	9.08	5.67
Long (12 to 18 inches long)	3.31	8.96	5.38

* F significant at 5% level.

TABLE 5

Average Berry Weights, Fruit Cluster Weights, and Maturity of the Fruit Collected from Shoots Produced by Primary and Secondary Buds which Grew after Frost Damage of April 24, 1964, on Cabernet Sauvignon at Oakville, California

Source of fruit	Average wt. (g)		Maturity		
	per berry	per cluster	9/24/64	9/27/64	10/1/64[a]
Primary shoots	0.91	100.15	24.7°B	24.7°B	25.0°B
Secondary shoots	0.89	90.13	21.7°B	21.0°B	22.5°B

[a] Harvest date.

treatment, as suggested by Winkler (5) for the late May, 1960, frost.

From the results shown, one can conclude that the lack of response of the Folle blanche treatments in late April, 1964, could not be correlated with lowering of food reserves in the one-year-old fruiting spurs.

If the frost had occurred at a later date in vine development, when more food reserves had been utilized, it is possible that a significant difference in carbohydrates might have been obtained.

Table 5 shows the relationship between weight per berry, weight of cluster, and maturity of fruit produced on shoots from primary buds, and shoots which grow from secondary or tertiary buds. The comparisons show a 10% decrease in the weight of individual clusters produced on shoots which grew from secondary buds. This difference would be sufficient to influence the yield per acre. Since the re-growth following a frost produces clusters which are lighter in weight, the further removal of uninjured shoots, as was tried in the Folle blanche treatment, could influence yield still further. The maturity tests indicate a delay in ripening of the fruit produced on shoots which re-grew following frost. Since secondary and tertiary buds had to begin growth at a time when primary shoots were already 12 to 18 inches long, there would be a delay of several weeks in bloom date (too much to make up by harvest time of the primary crop), and thus an expected difference in fruit maturity between clusters.

The difference in maturity at harvest time points to the necessity for careful measurements of maturity of the fruit in the vineyard. If a large enough sample from both primary and secondary shoots is not taken, inaccurate maturity measurements would be made. Since the incidence of frost varies from one area to the other in the vineyard, it would be necessary to sample the differently affected areas separately and adequately. This is of prime importance to the winemaker in trying to get good mature fruit for production of good-quality wines.

SUMMARY

Removal of frost-injured shoots by stripping out or cutting them off failed to produce significant increases in yield of fruit over vines receiving no treatment. The lack of significant response was shown for one spur-pruned variety and two cane-pruned varieties of wine grapes.

The per cent total carbohydrate, calculated on a dry-weight basis, of the shoots, spur bark, and spur wood in late April failed to show significantly lower levels when correlated with the length of shoot development.

Cluster weights but not berry weights were heavier for clusters produced on shoots growing from primary buds than for clusters and berries on shoots grow-

ing from secondary or tertiary buds. Maturity began at an earlier date and was higher at time of harvest in clusters from primary buds not injured by frost.

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