RESPONSES OF GRAPEVINES TO SHOOT BREAK-OUT FOLLOWING INJURY BY SPRING FROST

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ABSTRACT

The cultivars 'Tokay,' 'Carignane,' 'Zinfandel,' 'Chenin blanc,' and 'Grenache' were used in shoot break-out experiments in seven vineyards in San Joaquin County. A total of 45 single-vine plots were used in a completely randomized block within each vineyard. The shoots were 1 to 8 inches long at the time that some had been injured by frost. In each trial the shoots on 15 vines were broken out by hand and on a second group only frost-damaged shoots were removed. All shoots on control vines were left untouched. At harvest, clusters were separated into classes depending on the origin of the supporting shoots. Analyses of variance revealed no significant increases in yields due to either treatment.

Treatment of vines injured by spring frost in California was first reported in 1933, by Winkler (2). He recommended shoot break-out as a stimulus to crop recovery for vinifera cultivars with fruitful secondary growing points when the shoots were injured to a point below the flower clusters but not all the way to the base.

When Winkler (3) studied the failure of such treatment of vines injured by frost in May, 1960, in the Napa Valley, he found that the shoots had become woody, and that shoot removal either tore or dried the secondary growing points. He concluded that shoot removal should be done immediately after frost damage only when the shoots were herbaceous, i.e., 3-6 inches long.

In trials with 'Folle blanche' in the Napa Valley in 1964, Lider (1) found yields after removal of all shoots or just those frost-injured did not differ significantly from yields of untreated control vines. Neither did he find a significant yield response when frost-damaged shoots were removed from 'Cabernet Sauvignon' and 'White Riesling' vines.

On March 26, 27, and 28, 1972, temperatures as low as 28°F damaged many vineyards in the grape-growing areas of San Joaquin County. This provided an opportunity for additional studies on the effectiveness of shoot break-out in stimulating crop recovery.

MATERIALS AND METHODS

Seven vineyards with various levels of frost injury were studied. Table 1 shows cultivars, vineyard location, stage of shoot development, and estimates of the percent of injured shoots.

Three shoot treatments were applied in all vineyards on March 31, 1972, three days after the last damaging frost, and when the shoots varied in length between one and 8 inches and were quite succulent: Treatment *A*, all shoots broken out; Treatment *B*, only frost-damaged shoots broken out; and Treatment *C*, control, no shoots broken out. Removal of all shoots whether injured or not (Treatment *A*) was used to test whether the growth of secondary growing points was influenced by lack of shoot competition. Treatment *B* was applied in accordance with Winkler's recommendation (2).

Rectangular-shape trials, consisting either of 3 rows of 15 vines or 5 rows of 9 vines, were set out

in each vineyard. The 3 treatments were completely randomized within each trial. Shoots were removed manually by breaking them off at the base.

The trials were hand harvested in late September or early October at a time that coincided with the growers' harvesting operations. The clusters on each vine were separated according to the origin of the supporting shoots, i.e., from either primary or secondary growing points, or basal, latent, or auxiliary buds (commonly termed second crop). Each class was then counted and weighed separately.

At the time of harvest, 10 berries were collected at random from each of the 5 classes of clusters segregated as to origin, and pooled to make a composite sample of 150 berries for each treatment in each vineyard. The data for °Brix, total acidity, and berry weight for a given vineyard were considered as a block in the analyses for variance.

Juice was extracted from the samples by grinding the berries in a mortar and squeezing the juice through several layers of cheesecloth. Ten ml of juice were titrated with 0.10N NaOH to a phenolphthalein endpoint, and the result was expressed as g tartaric acid per 100 ml juice. Degrees Brix were obtained with a refractometer.

TABLE 1

Stage of Development and Estimation of Frost Injury to Shoots at Time of Treatment on March 31 1972

Variety	Vineyard location	Shoot length (in.)	% shoots injured
'Carignane' (1)	Manteca	2-4	75-85
'Carignane' (2)	Ripon	1-4	20-25
'Tokay' (1)	Lodi	3-6	30
'Tokay' (2)	Lodi	2-4	60-70
'Zinfandel'	Lodi	2-5	40-50
'Grenache'	Manteca	4-8	95
'Chenin blanc'	Manteca	1-6	99

TABLE 2

Effect of Shoot Break-out on Cluster Number and Weight and of Yield of Fruit for 3 Vineyards[a]

		VINEYARD								
		'Carignane' (1)			'Carignane' (2)			'Tokay' (1)		
		Treatment			Treatment			Treatment		
		A	B	C	A	B	C	A	B	C
Primary growing points	clusters/vine	4.80*	14.92	13.15	4.27*	13.47	14.40	1.93**	9.20*	11.80
	lb/cluster	.38**	.62	.58	.76	.69	.78	1.42	1.38	1.58
	lb/vine	1.83*	9.19	7.51	3.23*	9.31	11.18	2.74**	12.20*	18.66
Secondary growing points	clusters/vine	3.73	3.53	3.23	1.60	1.67	2.27	1.00	.40	1.20
	lb/cluster	.22	.24	.25	.71	.61	.60	.46	.85	.56
	lb/vine	.83	.86	.82	1.14	1.02	1.36	.46	.34	.67
Basal buds	clusters/vine	27.47	25.46	21.38	9.40	12.87	13.87	11.80	9.33	8.33
	lb/cluster	.33	.40	.37	.67	.58	.69	.95	1.03	.98
	lb/vine	9.19	10.08	7.89	6.27	7.41	9.53	11.16	9.58	8.17
Latent buds	clusters/vine	35.93	49.85	51.92	19.73	20.40	26.47	8.40**	15.60	17.13
	lb/cluster	.31*	.38	.35	.52	.47	.52	.96	1.03	1.09
	lb/vine	11.08*	19.00	18.11	10.32	9.57*	13.81	8.08**	16.94	18.73
Auxiliary buds (Second crop)	lb/vine	1.13	1.51	1.59	1.*8**	2.27*	2.99	2.99	3.03	2.59
Total	clusters/vine	71.93*	93.77	89.69	35.00**	48.40	57.00	23.14**	34.53	38.47
	lb/cluster	.33	.43	.40	.65	.61	.68	1.10*	1.19	1.27
	lb/vine	24.07*	40.65	35.93	22.64**	29.59**	38.87	25.43**	41.19	48.83

* Significant at 95% level.
** Significant at 99% level.
[a] Treatments: A) All shoots broken out, B) Only frost-injured shoots broken out, and C) Control, no shoots broken out.

RESULTS AND DISCUSSION

In contrast to the results reported by Winkler (2), neither shoot removal treatment significantly improved crop yield over that of the untreated controls. These findings, however, agree with findings of Lider (1), except that in one of our trials with 'Tokay,' and in both 'Carignane' trials, yields were significantly lower than those of controls when all shoots were removed. Lower cluster weights, as well as fewer clusters per vine, accounted for the depressed yield (Table 2). Since there were significantly fewer clusters on shoots originating from primary growing points, it seems that a substantial number of clusters were uninjured by frost and were removed in the treatment *A* break-out. The crop from the primary growing points which accounted for 21 to 38% of the yields from the control vines in these 3 trials, was reduced to 11 to 14% when all shoots were removed.

Winkler (2) reported that crop recovery originates with fruitful lateral growing points which usually remain dormant but may be stimulated to grow if the shoots are killed back to the base or are broken out. In our study, fruit production from secondary growing points was not significantly enhanced by either break-out treatment in any of the 7 vineyard trials. Crop yields from this source were low in all vineyards, regardless of treatment, amounting to less than a pound of fruit per vine in most instances. Since the cultivars studied are known to have fruitful secondary growing points, it is likely that the growing conditions of the previous year had a strong influence on the lack of crop response. The 1971 growing season was characterized by a large crop, late in maturing. Carbohydrate accumulation was terminated abruptly on

TABLE 3

Effect of Shoot Break-out on Cluster Number and Weight, and of Yield of Fruit for 'Tokay' Vines

Origin of fruitful shoots	Crop yield	Treatment[a] A	B	C
Primary growing points	Clusters/vine	5.20**	12.53	13.07
	lb/cluster	.88**	1.04	1.12
	lb/vine	4.59**	13.00	14.59
Secondary growing points	Clusters/vine	1.67	2.80	1.20
	lb/cluster	.54	.55	.77
	lb/vine	.91	1.55	.93
Basal buds	Clusters/vine	13.73**	7.73	7.67
	lb/cluster	1.01	.93	.88
	lb/vine	13.93**	7.23	6.76
Latent buds	Clusters/vine	14.53	16.93	16.40
	lb/cluster	.87	.84	.88
	lb/vine	12.60	14.17	14.51
Auxiliary buds (Second crop)	lb/vine	.76	1.57	1.26
Total	Clusters/vine	35.13	40.00	38.33
	lb/cluster	.93	.94	.99
	lb/vine	32.79	37.52	38.05

** Significant at 99% level.
[a] Treatments: A) All shoots broken out, B) Only frost-injured shoots broken out, and C) Control, no shoots broken out.

TABLE 4

Effect of Shoot Break-out after Frost Damage on °Brix, Total Acidity, and Berry Weight by Origin of Fruitful Shoots[a]

Origin of fruitful shoots	Fruit characteristics	Treatment[b] A	B	C
Primary growing points	°Brix	20.3	20.6	20.7
	% TA	.70**	.67	.65
	g/berry	2.98*	3.18	3.17
Secondary growing points	°Brix	20.5	20.6	20.8
	% TA	.73	.67	.69
	g/berry	2.82**	2.99	3.00
Basal buds	°Brix	20.4	20.6	20.7
	% TA	.71**	.66	.66
	g/berry	2.98	3.18	3.16
Latent buds	°Brix	20.2	20.4	20.4
	% TA	.73**	.70	.69
	g/berry	3.05**	3.25	3.27
Auxiliary buds (Second crop)	°Brix	19.7	20.3	20.3
	% TA	.78*	.74	.73
	g/berry	2.92	2.96	2.95

* Significant at 0.05
** Significant at 0.01
[a] Data from 7 trials were assigned as replications in the analyses of variance.
[b] Treatment: A) All shoots broken out, B) Only frost-injured shoots broken out, and C) Control, no shoots broken out.

October 29, 1971, with temperatures in the low twenties.

Breaking-out all the shoots (Treament *A*) produced a significant yield increase from the basal buds of 'Tokay' in one vineyard. However, the increase merely counterbalanced the significant depression in yield from primary growing points, resulting in a total yield similar to that of control vines (Table 3). Removal of shoot competition did not enhance the development of the secondary growing points.

Total yields from the control vines were reasonably close to average production in most vineyards. The three cultivars which suffered the highest percentage of shoot damage responded similarly to others that were less severely injured.

Table 4 shows total acidity, °Brix, and berry weight for the 5 classes of fruitful shoots. Although there was no significant difference in °Brix, the fruits from Treatment *A* had significantly higher total acidity than did fruits from control vines. Also, average berry weights of fruits originating from primary and secondary growing points were significantly less than those of control fruits.

Lider (1) reported significantly higher °Brix values for 'Cabernet Sauvignon' fruits from primary growing points, in contrast to the results of our study. Shoots were less advanced at the time of frost damage in 1972 than when Lider applied his treatments in April, 1964, at which time the shoots were 12 to 18 inches long.

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