Table 1. Effect of various microsprinkler irrigation treatments on survival and regrowth of young 'Hamlin' orange trees, 10 Apr. 1986.

Treatment[z]	Tree survival[y] (%)	Height of live wood[y] (cm)	Rating[x]
Unirrigated	100	43.5	1.8
Intermittent 5/10	100	44.3	1.4
Intermittent 5/15	100	42.5	1.4
Constant irrigation	100	58.5	2.9
	NS	NS	NS

[z]All trunks were wrapped with (R-11) fiberglass insulation. Microsprinkler irrigation rate was 38 liters·hr^{-1} applied in a 90° pattern. Intermittent 5/10 = 5 min on-time and 10 min off-time. Intermittent 5/15 = 5 min on-time and 15 min off-time.

[y]Means of 4 measurements per treatment.

[x]Rating 1 = severe leaf and wood damage; 2 = moderate leaf and wood damage; 3 = leaf damage only; 4 = moderate leaf damage; 5 = undamaged. NS, not significant.

measured on 10 Apr. were similar for all treatments (Table 1). However, appearance, vigor and canopy regrowth appeared visually but not statistically better for constantly irrigated trees compared with the other treatments. The freeze protection provided by tree wraps plus intermittent irrigation was acceptable for commercial use under the weather conditions tested in this study while using about one-fourth the amount of water as constant irrigation. Intermittent irrigation did not protect more of the tree than wraps alone; however, it maintained trunk temperatures under the wrap at 1.5° to 3.0°C above those of wrapped trees without irrigation, suggesting that intermittent irrigation may provide a superior source of freeze protection than wraps alone under severe freeze conditions like those of 1983 (2) and 1985 (8).

Intermittent irrigation combined with tree wraps was effective for trunk protection under the wrap for young citrus trees for air temperatures as low as −7.1°C, suggesting that growers may be able to cycle their irrigation during moderate radiative freezes. However, caution should be exercised when using the system during moderate freezes (−4.0°) under advective conditions due to evaporative cooling effects on the unwrapped, upper portion of the tree. Similarly, Perry et al. (7) observed that increases in wind speed significantly decreased optimum off-time for exposed apple blossoms. Optimum off-times for unwrapped trees in their study ranged from 1.5 to 4 min, which are similar to our values of 2 min. The presence of a wrap, however, greatly extended the optimum off-time for young citrus trees.

The use of tree wraps and intermittent irrigation improves grower flexibility in deciding when and if to apply microsprinkler irrigation. Growers have the option of using tree wraps alone, or intermittent or constant microsprinkler irrigation depending on the severity and type of freeze. In addition, this system allows growers to delay turning on irrigation until necessary by trickling water through the irrigation lines.

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Effect of Cyanamide in Overcoming Grape Seed Dormancy

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Additional index words. *Vitis vinifera*, chilling, germination, breeding cycle

Abstract. **Treatment with a 0.5–2% cyanamide (H_2NCN) solution for 5 min effectively substituted for chilling in seed of four *Vitis vinifera* L. cultivars, allowing immediate germination. Treatment could shorten the breeding cycle.**

Hastening grape seed germination is of interest in breeding as well as for testing and using germplasm. The recommended practice is to subject imbibed seed to 3 months of moist stratification at 5°C before planting (4, 5, 11). In some instances, chilling periods of 8 (2) or 9 weeks (14) have been suggested. Germination percentages have been found to fluctuate, depending upon maternal genotype, season, and temperature (9). Early maturing genotypes have a very low germination percentage because of undeveloped embryos (1). Various dormancy breaking treatments have been tried with grape seed (5, 8, 11, 14). Giberellic acid treatments seemed most promising. However, GA_3 treatment often caused exceedingly tall seedling growth (14) or resulted in a high percentage of abnormal seedlings (12). Recently, a sequential treatment of H_2O_2, GA_3, and a shortened prechill period was recommended (3). Calcium cyanamide (6) and, later, soluble forms of cyanamide were effective in breaking dormancy of grape vines (13) and single bud cuttings (7, 13).

Our experiments were designed to determine the effect of cyanamide treatment on breaking dormancy of *Vitis vinifera* seed and hastening germination. In 1984 we experimented with open-pollinated seed of early maturing 'Queen of Vineyards', midseason 'Oz', and late maturing 'Ribier' ('Alphonse Lavalle') and 'Dabouki'. In 1985, experiments were repeated with 'Queen of Vineyards' and 'Oz'. The early maturing 'Cardinal' also was included in the trials.

Seeds were soaked for 5 min in 0.5%, 1%, and 2% solutions of hydrogen cyanamide (H_3NCN, Sigma) dissolved in water. Triton-100 (Rohm & Haas, Philadelphia) at 0.03% concentration was added as a surfactant. Untreated seed subjected to 0, 45, and 90 days of chilling was used for a comparison. Only seeds that sank during washing (presumed viable) were used. Fifty seeds per treatment

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Table 1. Effect of cyanamide on percentage of chilled and unchilled *Vitis vinifera* grape seed in 1984.

Cyanamide treatment (%)	Pretreatment chilling (days)	Treatment date[z]	Sowing date[z]	Cultivar: Queen of Vineyards[y]	Oz[y]	Ribier[x]	Dabouki[x]
0	0	---	1	0 h[w]	0 i	20 cd	23 bcde
0	45	---	2	24 c	18 e	52 a	39 ab
0	90	---	3	16 b	16 f	34 abc	31 abcd
0.5	0	1	1	2 g	26 d	35 abc	34 abc
1	0	1	1	4 f	28 c	37 abc	44 a
2	0	1	1	16 b	28 c	42 ab	20 bcde
0.5	45	1	2	6 e	28 c	52 a	25 abcde
1	45	1	2	8 d	10 g	34 abc	19 cde
2	45	1	2	24 a	26 d	23 cd	8 e
0.5	45	2	2	8 d	34 b	42 ab	20 bcde
1	45	2	2	2 g	36 a	28 bcd	34 abc
2	45	2	2	8 d	34 b	34 abc	20 bcde
0.5	90	1	3	2 g	10 g	30 bcd	20 bcde
1	90	1	3	12 c	4 h	13 d	16 dc
2	90	1	3	4 f	18 c	27 bcd	11 e

[z]1 = Immediately after harvest; 2 = 45 days after harvest; 3 = 90 days after harvest.
[y]50 seeds per treatment.
[x]Four replicates of 20 seeds per treatment.
[w]Mean separation in columns within treatments by Duncan's multiple range test, 5% level.

were used with 'Queen of Vineyards' and 'Oz' in 1984 and four replicates of 20 seeds each were used with 'Ribier' and 'Dabouki'. In 1985, five replicates of 20 seeds per treatment were used with 'Queen of Vineyards', 'Oz', and 'Cardinal'. Seeds were chilled in a refrigerator in moist pine shavings at 4° ± 1°C for 45 or 90 days, then germinated in a peat–perlite mixture in the greenhouse. Alternating temperatures (20°–30°) were used for the first week (1); later, temperatures were kept at 25° ± 2°. Germination counts were made 4, 5, and 6 weeks after sowing. Only results for the 6th week count are given. Statistical analysis was performed according to the SAS–Funcat method (10).

In 1984, all treatments of 'Queen of Vineyards' resulted in a higher germination percentage than the unchilled check. A 2% dip of cyanamide, performed immediately after harvest, was equal in effect to a 90-day chill period (Table 1). The 2% rate was much more effective than the 1% or 0.5% rates for seed treated immediately after harvest and given <90 days of chill. The treatment resulting in the highest percentage of germination was a 2% dip, immediately after harvest with cyanamide, followed by 45 days chilling. Treating the seed and then chilling it for 90 days proved harmful, compared to most treatments, except with the 1% concentration. Treatments by cyanamide when followed by prolonged chilling (90 days) did not give positive results and were omitted from experiments in 1985.

With the midseason cultivar 'Oz', positive results with cyanamide in 1984 were even more pronounced than with 'Queen of Vineyards'. Treating the seed immediately after harvest, regardless of concentration, proved significantly better than chilling the seed for either 45 or 90 days (Table 1). The combined treatment of first chilling the seed for 45 days and then applying cyanamide resulted in a germination percentage significantly higher than any other treatment. Again, applying cyanamide immediately after harvest and later chilling the seed for 90 days resulted in low germination percentages, except with the 1% concentration.

Results with the medium-late cultivars, 'Ribier' and 'Dabouki', were less striking. Seeds were collected rather late (end of September) with both cultivars. A comparatively large percentage of seed (20% and 23%, respectively) germinated without any treatment or chill period. With both cultivars, a 45-day chill period proved adequate. However, treatment of both cultivars (with the exception of the 2% dip of 'Dabouki') with cyanamide immediately after harvest resulted in germination percentages of nonchilled seeds statistically similar to those obtained after 45 or 90 days of chilling without treatment. Contrary to results obtained with 'Queen of Vineyards' and 'Oz' during the same year, the combination of cyanamide treatment with a chilling period did not increase percentage of germination of 'Ribier' and 'Dabouki' significantly compared to chilling or cyanamide alone, perhaps due to the relatively high germination rates (20% and 23%, respectively) with unchilled, untreated seed in both cultivars compared to no germination for unchilled, untreated seed in 'Queen of Vineyards' and 'Oz'.

'Dabouki' seed seemed more sensitive to the 2% cyanamide concentration. The 0.5% and 1% rates applied immediately after harvest were significantly better than the 2% rate. Application of 2%, followed by 45 or 90 days of chilling resulted in the lowest germination percentages.

In addition to repeat experiments with 'Queen of Vineyards' and 'Oz', 1985 tests also were performed with 'Cardinal' (Table 2). Seed germination in 'Cardinal' is usually low, because of a large percentage of poorly developed embryos.

Germination percentages for 'Queen of Vineyards' in 1985 were higher than in 1984, with germination after 90 days chilling double that obtained in the untreated check after 45 days of chilling (Table 2). A 2% cyanamide treatment immediately after harvest was equally as effective as a 45-day chill treatment. The combined treatment of 45 days chilling followed by a 1% cyanamide dip was as effective as chilling for 90 days. A 1% cyanamide concentration applied to 'Queen of Vineyards' immediately after harvest was not sufficiently active in increasing germination (both in 1984 and 1985), while the 2% concentration proved effective. Higher concentrations or longer treatment periods were not tried.

Results with 'Oz' in 1985 were less pronounced than in 1984. As with 'Queen of

Table 2. Effect of cyanamide on percentage of germination of chilled and unchilled *Vitis vinifera* grape seed in 1985. Five replicates of 20 seeds per treatment.

Cyanamide treatment (%)	Pretreatment chilling (days)	Treatment date[z]	Sowing date[z]	Cultivar: Queen of Vineyards	Oz	Cardinal
0	0	---	1	0 d[y]	0 b	0 c
0	45	---	2	20 c	18 a	13 a
0	90	---	3	38 a	21 a	11 a
1	0	1	1	10 cd	19 a	8 ab
2	0	1	1	21 bc	22 a	8 ab
1	45	1	2	28 b	18 a	14 a
2	45	1	2	23 bc	17 a	11 a
1	45	2	2	40 a	27 a	8 ab
2	45	2	2	27 b	18 a	2 bc

[z]1 = Immediately after harvest; 2 = after 45 days of harvest; 3 = 90 days after harvest.
[y]Mean separation in columns within treatments by Duncan's multiple range test, 5% level.

Vineyards', the highest germination percentage was obtained with 45 days of chilling followed by a 1% cyanamide treatment, but even this treatment was not significantly different from the other, except the unchilled check. Both the 1% and the 2% concentration applied at harvest time were as effective as a 45- or 90-day chilling period.

Because of the inherently low germination percentage of 'Cardinal', results should be interpreted with caution. Germination rates of this cultivar are increased by using in vitro culture (unpublished results). Response to cyanamide treatment was similar; all treatments except 2% cyanamide after 45 days of chilling were significantly better than the unchilled check.

Our results clearly demonstrate the potential of cyanamide in the range of 0.5–2% for replacing chilling to break grape seed dormancy and hasten germination. Its use could provide immediate germination at a rate equal to that obtained by a 45-day chill period. Furthermore, based on our 1985 results, a combined treatment of 45 days prechill followed by a 1% cyanamide treatment would offer, in certain cultivars, a possibility for obtaining maximum germination in <90 days.

Our work shows that, in the cultivars tested (with the exception of "Queen of Vineyards"), a 45-day chill period is sufficient for maximum germination.

The mode of action of cyanamide in breaking dormancy is not yet known. Shulman et al. (13) have shown that H_2NCN increases the respiration of grapevine cuttings, as measured by CO_2 evolution. It is possible that more than one factor is involved in breaking dormancy of grape seed.

The prospect of advancing grape seed germination by 45–90 days, without recourse to a chilling period, would be important in breeding. It should, under suitable circumstances, enable the development of hybrids for planting in the vineyard by late fall or early winter, e.g., 6–9 months after the cross has been made.

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Pruning Effects on Productivity and Vegetative Growth in the Highbush Blueberry

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Additional index words. yield components, path analysis, *Vaccinium corymbosum*

Abstract. **The effect of pruning was evaluated by removing varying amounts of different-sized canes from 15-year-old highbush blueberry plants. As much as 40% of a bush could be removed before yield was reduced. There was a significant correlation ($P < 0.05$) between percent base area removed and berry weight, suggesting a compensation for reduced basal area by increasing berry weight. The number of new canes also was significantly correlated with the number removed. The size of canes removed was less important than the percent basal area removed, except in the most extreme treatment (40% removed), where the removal of medium-sized (1–2.5 cm) canes had a greater effect than the elimination of large canes.**

Pruning is assumed to increase berry size and maintain long-term productivity in the highbush blueberry (1, 3, 6). While pruning necessarily involves the removal of some bearing wood, this loss is thought to be compensated for by the increased productivity of the remaining wood. Unfortunately, there are only a few quantitative studies that substantiate these ideas. Johnston (3) performed pruning trials over two years on plantings of blueberry bushes taken from the wild. Moderately pruned bushes produced more fruit than either unpruned or heavily pruned bushes, but this effect could not be ascribed to pruning alone because competing trees and shrubs had been removed from the pruned plots but not from the unpruned check plots. Brightwell and Johnston (1) found that mean yields in 10-year-old bushes were lower for pruned than unpruned bushes, even though berry size increased with the severity of pruning. Howell et al. (2) observed that when large, dense bushes were sawed off at ground level, their yields surpassed those of unpruned controls by the third season of harvest.

The influence of pruning appears to be regulated by cane age and number. Shutak and Marucci (6) suggest that cane productivity begins to decline after 6 years because older canes do not produce vigorous shoots, and berry size consequently is reduced. Pritts and Hancock (5) determined that productivity in unpruned wild highbush blueberries peaked when the plants were ≈15–20 years of age; at that point, increases in cane numbers were offset by reductions in yield per cane.

In this study, the effect of pruning was evaluated by removing varying amounts of different-sized canes from previously unpruned 15-year-old 'Jersey' plants. Yield per bush, fruit number per bush, individual fruit weight, and cane production per bush were measured.

Two adjacent rows of 'Jersey' were studied at the Horticultural Research Center, Michigan State Univ., East Lansing, on a soil spinks loamy-sand with pH 4.3 (Psammentic Hapludalff, sandy, mixed, mesic). The plants were maintained according to standard

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