Managing Harvest Date by Breaking Dormancy at Different Bud Physiological Stages

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Following determination of bud physiological stages on Flame Seedless canes under laboratory conditions, field trails were established on eight-year-old vines to break dormancy and advance harvest. Vines were pruned on 16 November, 2 December, and 16 December. Control vines were pruned on 23 December, as the grower did. Hydrogen cyanamide (Dormex 49%, SKW, Trotsberg, Germany) was applied at pruning and 5, 10, and 15 days later at doses ranging from 0 to 8% a.i., on each treatment. Percent budbreak, number of clusters, and yield per vine were evaluated on eight replicates for each treatment. Clusters were harvested at 15° to 16° Brix, 19 mm diameter, and above 80% color. Most treatments broke dormancy 22 to 35 days after cyanamide application and percent budbreak ranged from 50% to 85%. No toxicity was found with the highest doses; however, after 14 December, those concentrations tended to reduce and delay budbreak. Applying cyanamide 5, 10, and 15 days after pruning delayed budbreak by five days as compared with the treatment applied at pruning. Harvest started on 20 May, and by 31 May the best treatments were totally harvested. Harvest was initiated on control plants by 9 June. Vines pruned and sprayed at endodormancy (2 December) with 8% Dormex advanced harvest and achieved 12 kg per vine.

Chemical applications and cultural practices can be used to overcome dormancy and enhance shoot growth where insufficient chilling results in delayed and erratic budbreak and time of bloom. Among the chemical treatments, hydrogen cyanamide (HC), has been found especially valuable in overcoming dormancy of several species of deciduous fruit trees (3,9,10,15,16). A common characteristic of HC use is its effectiveness at near-lethal dosages (4,12). Because of its narrow effective range, variable effectiveness in overcoming dormancy and toxicity are reported (6,12). The effective concentration and timing to break dormancy varies with time, bud physiological stage, and genotype (1,3,4,8,9,12,14). In addition, plant nutritional status (17), post-application temperature, and variations between seasons in chilling accumulation (2,3,11) are possibly factors influencing observed results.

Presently, the relationship between the developmental stage of the buds and their response to HC is not clear in most crops. Considerable information on timing of hydrogen cyanamide application is available for grapevines. However, these data are not based on bud physiological development as affected by environmental conditions. In Sonora, México, most growers prune during the third week of December, and apply HC at rates ranging from 4% to 6%, regardless of bud developmental stage and accumulated chilling units. Therefore, a major problem is the inability to define, in any particular season, appropriate timing and concentration. Since production is focused on reaching early markets, it is necessary to determine objectively the effective rate and time of application to attain desired results.

The objectives of this study were: *(a)* to reduce budbreak variability in response to HC applications relating the time of application to the environmental conditions and bud physiological stage; and *(b)* to find the best treatment capable of improving budbreak and advancing harvest date.

Materials and Methods

The experiment was conducted in a commercial vineyard near Pesqueira, Sonora, in the Hermosillo Valley. Mature, cordon-trained and spur-pruned Flame Seedless grapevines were used in this study. Vine spacing was 2.44 m in the row and 3.66 m between rows. Cultural practices were similar to those normally performed for Flame Seedless table grapes grown in this region, and vines were drip-irrigated. Determination of bud physiological stages was accomplished by collecting canes from field-grown vines at weekly intervals (from September to December) and evaluating the rate of bud emergence during three weeks under laboratory conditions as outlined by Shulman *et al.* (10) and modified by Siller-Cepeda *et al.* (13). Chilling hours $\leq$10°C (HB10) were monitored during the same period.

The experiment was designed as a randomized complete design along six rows, consisting of 588 single vine experimental units; *i.e.*, eight replications per treatment, and designed as follows. The four pruning dates were: *(a)* 16 November; *(b)* 2 December; *(c)* 16 December; and *(d)* 23 December (regional control). There were five HC concentrations: *(1)* 0%; *(2)* 2% (v/v)

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Dormex; *(3)* 4% (v/v) Dormex; *(4)* 8% (v/v) Dormex; and *(5)* 16% (v/v) Dormex (active ingredient, H_2CN_2 - 50%). The middle four vines in each plot were used for data collection. Vines in the experiment were pruned as above and HC was applied immediately after pruning or five, 10 or 15 days later. The appropriate experimental units were treated with a Dormex solution using a back sprayer at the rate of 600 L/ha. Twenty-four two-bud spurs were retained on each vine at pruning. Following treatment applications, 10 two-bud spurs were selected on each cordon and four of the middle vines of the plot were marked to follow budbreak. Vines were monitored weekly to determine the date of bud emergence and the uniformity of shoot growth following budbreak. Budbreak was defined as the appearance of green leaf tissue observed beneath the bud scale. The number of clusters per vine were recorded prior to berry thinning. Shoot thinning adjusted the number of shoots to 48 prior to anthesis.

Clusters were thinned with 10 mg/L GA_3 at 50% bloom to decrease berry set. The vines received two 80 g/ha GA_3 berry-sizing applications. The first was applied at 5 to 6 mm berry diameter and the second was applied four to six days after the first application. Vines were girdled at berry set. Each practice was performed at the specific developmental stage mentioned above; therefore, timing varied significantly among treatments. After veraison, at *ca.* 40% color development, ethrel (400 mg/L) was applied to enhance color development. Date, cluster number, cluster weight, and yield of packable and unpackable fruit on each vine was recorded at harvest. Harvest was initiated in each treatment when berries attained a diameter of 19 mm, 15 to 16 °Brix and above 80% color.

Results and Discussion

From 10 October to 31 December, there were 461 hours measured at or below 10°C (HB10). Cumulative chilling on pruning dates used in this experiment are shown in Figure 1. On 16 November, 95 HB10 had accumulated. On 2 December, 215 HB10 had accumulated, while on 16 December, cumulative HB10 corresponded to 341. The cooperator pruned his vines on 23 December, which represents the regional control, and 419 HB10 had accumulated at that time.

Budbreak response of single-node cane cuttings under laboratory conditions indicates that canes collected from 1 November to *ca.* 21 November were in a paradormant stage; 50% budbreak was reached in less than three weeks (Fig. 1). It took more than 132 HB10 for the plants to go into a shallow endodormant stage, were budbreak percentage under laboratory conditions was below 50%. Deeper endodormancy was reached in late November to early December, at *ca.* 220 HB10 (Fig. 1). As more chilling accumulated, plants overcame dormancy. Budbreak was greater than 50% after chilling was above 350 HB10. Other studies, using 4°C as the upper limit for chilling accumulation, showed that Flame Seedless single-node cuttings required between 200 and 250 hours to obtain 50% budbreak (14).

The period between the cyanamide application and budbreak in the field varied from 22 to 35 days, depending on the application date and environmental conditions. Generally, the later the treatment, the shorter the interval to initiate budbreak (Fig. 2, 3, and 4).

Significant differences in budbreak due to cyanamide concentration were measured on vines sprayed right after pruning, when 95 HB10 had accumulated (Fig. 1, 2A). The best performance was found with the 4% HC concentration; it induced the earliest and highest budbreak compared to other treatments. Initial budbreak occurred 35 days after application and 45 days later, 85% of the buds had broken, almost twice that of the others. Budbreak of the controls occurred 75 days after pruning and 78% of the buds had broken 115 days later (Fig. 2A). Delaying application after pruning by five days (21 November, 111 HB10) resulted in similar budbreak responses as shown above; however, it occurred five days later (Fig. 2B). The highest concentrations were needed to attain comparable budbreak results when applications were delayed by 10 or 15 days (26 November, 159 HB10; and 2 December, 215 HB10), as vines were in a deeper dormancy (Fig. 2C, D). Other studies using early pruning dates have shown that high cyanamide doses (12% Dormex) are necessary to increase budbreak (8); however, they did not mention the cumulative chilling or the bud physiological stage at the time of pruning.

Vines sprayed with HC right after pruning on 2 December, when 215 HB10 had accumulated (close to deeper endodormancy), showed again that the highest doses were necessary to significantly increase budbreak over the other treatments (Fig. 3). Similar results have been reported on Perlette grapevines in the Jordan Valley (8). It also occurred in our experiment on vines

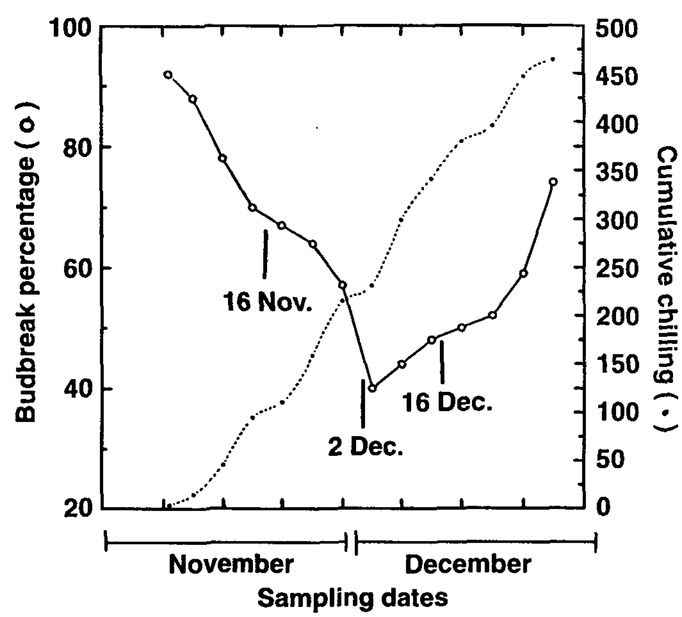

Fig. 1. Budbreak response of Flame Seedless single-node cuttings collected from the field on different dates, and evaluated over three weeks under laboratory conditions. Cumulative hours below 10°C from 10 October to 31 December.

pruned on 16 November with HC application on 2 December (Fig. 3A, 2D). All cyanamide treatments applied on this date initiated budbreak 33 days after application, while the untreated vines broke dormancy 75 days after pruning. On vines sprayed five days after pruning (7 December, 231 HB10 accumulated), there were no differences between the 4%, 6%, and 8% cyanamide concentrations on the initial and final budbreak percentage (Fig. 3B). Vines pruned on 2 December and HC applied 10 and 15 days later (14 December, 299 HB10 and 19 December, 380 HB10) showed a tendency

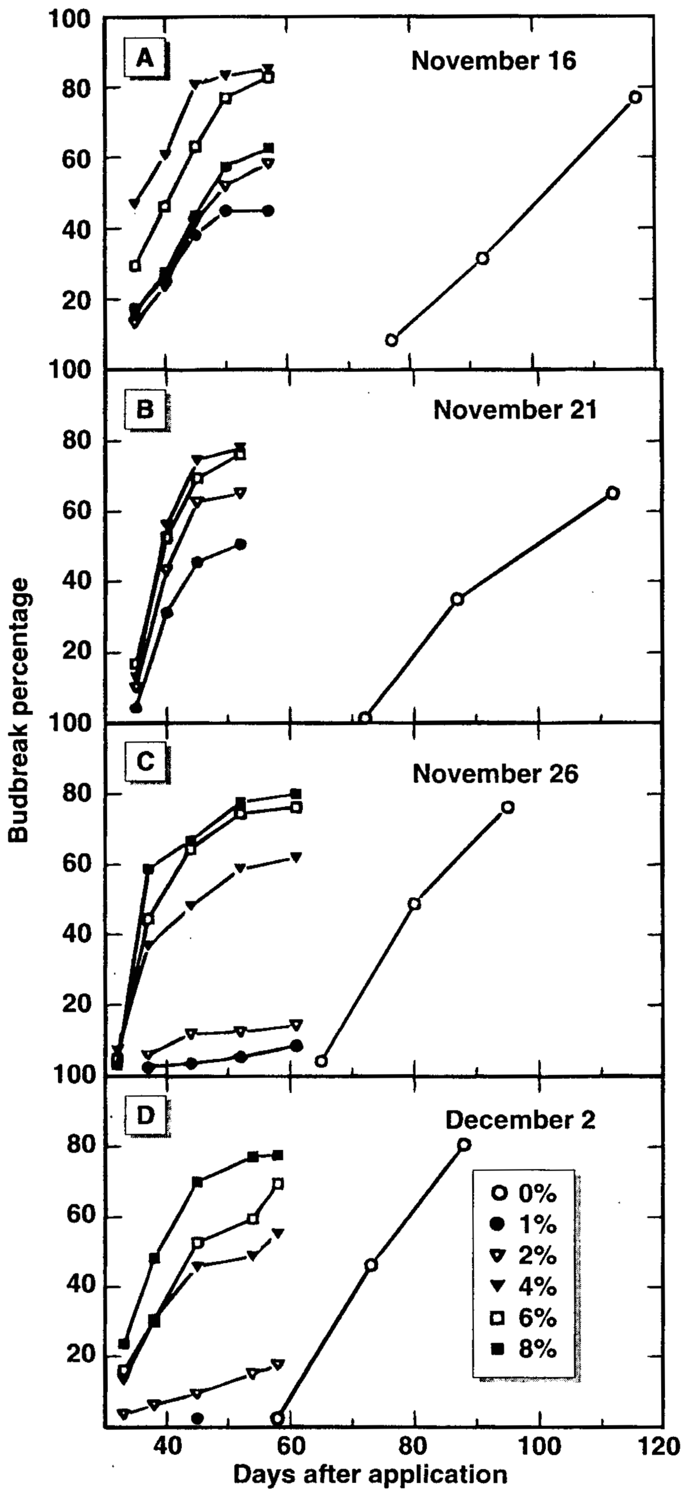

Fig. 2. Rate of budbreak of field-grown Flame Seedless vines pruned on 16 November and sprayed with hydrogen cyanamide on: (A) 16 November; (B) 21 November; (C) 26 November; and (D) 2 December.

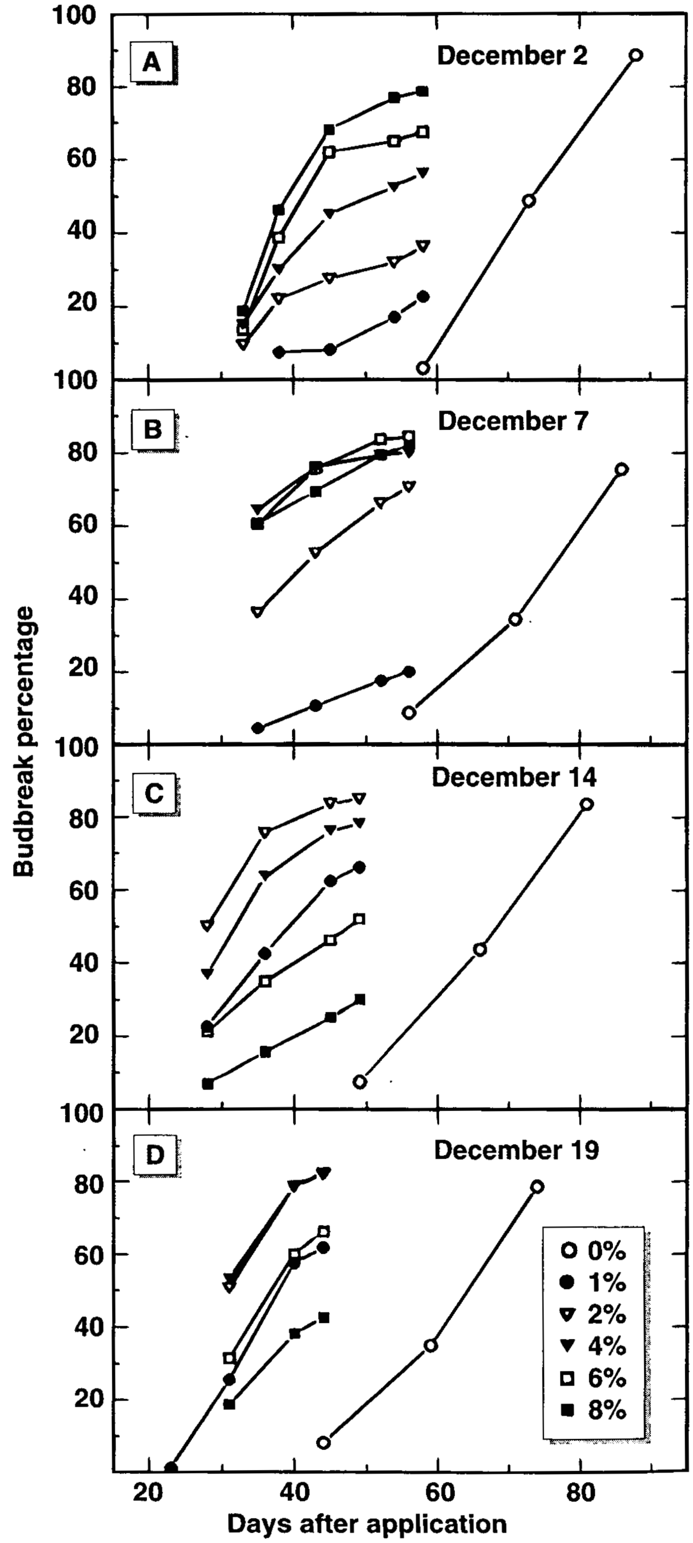

Fig. 3. Rate of budbreak of field-grown Flame Seedless vines pruned on 2 December and sprayed with hydrogen cyanamide on: (A) 2 December; (B) 7 December; (C) 14 December; and (D) 19 December.

to reduce and delay budbreak when the highest doses were applied (Fig. 3C, D). In peaches (12) and grapes (8,12), high concentrations applied after chilling requirements were met resulted in reduced and delayed

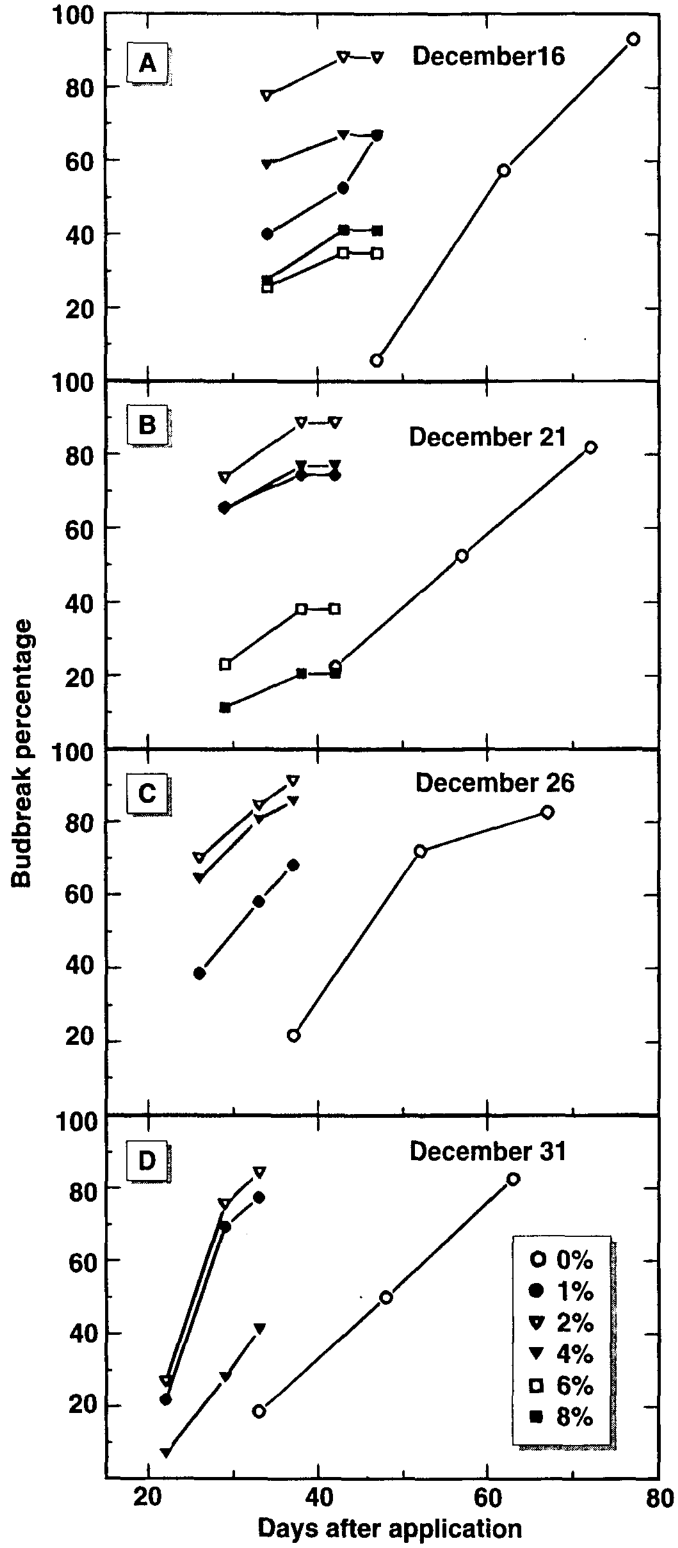

Fig. 4. Rate of budbreak of field-grown Flame Seedless vines pruned on 16 December and sprayed with hydrogen cyanamide on: (**A**) 16 December; (**B**) 21 Decemer; (**C**) 26 December; and (**D**) 31 December.

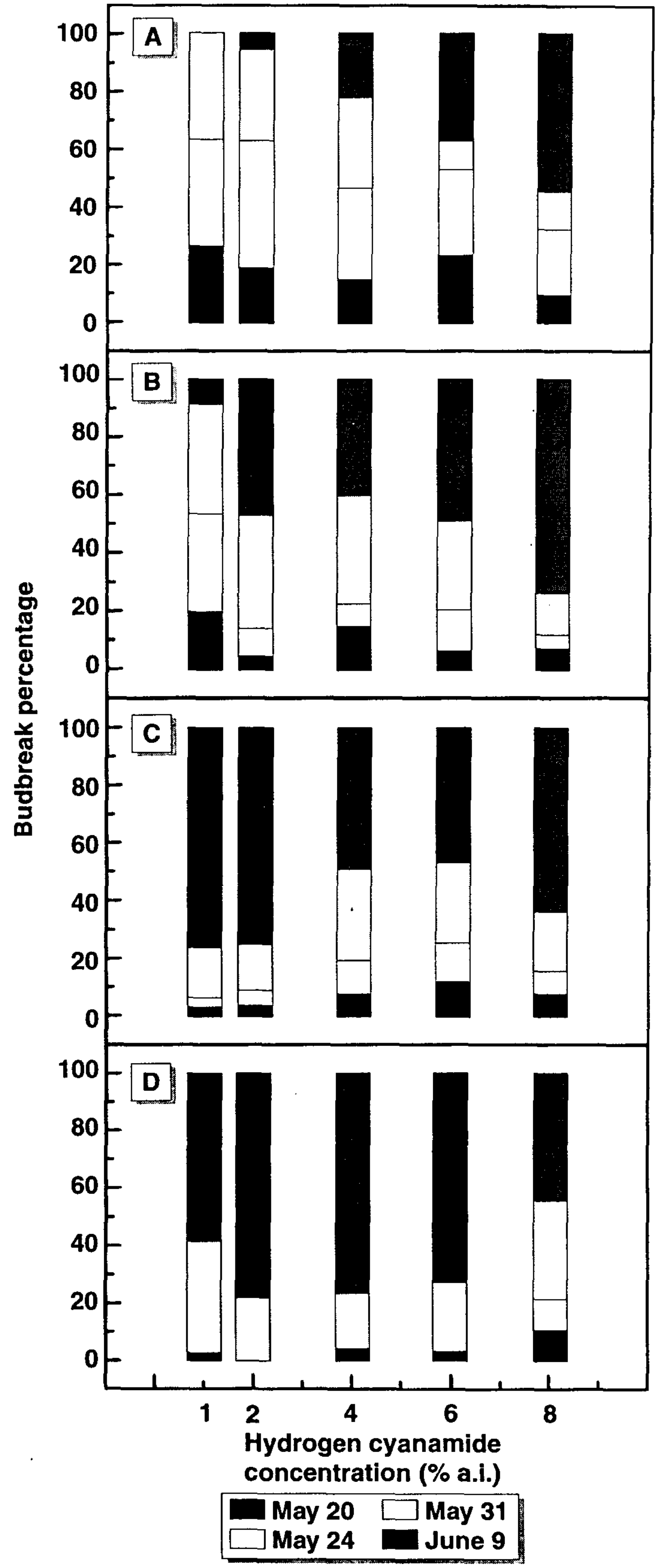

Fig. 5. Percentage of harvest on each picking date of Flame Seedless vines pruned on 2 December and sprayed with hydrogen cyanamide on: (**A**) 2 December; (**B**) 7 December; (**C**) 14 December; and (**D**) 19 December.

Table 1. Yield and yield components of Flame Seedlees grapevines pruned on 16 November and several rates of hydrogen cyanamide applied 0, 5, 10, or 15 days later.

Treatments	16 November			21 November			26 November			2 December		
	a	b	c	a	b	c	a	b	c	a	b	c
1%	492	2.0	0.98	492	1.3	0.65	669	2.5	1.67	593	3.7	2.2
2%	575	2.7	1.53	554	4.5	2.49	555	4.8	2.65	651	7.7	5.0
4%	492	1.0	0.49	555	3.8	2.12	642	11.5	7.37	679	22.3	15.2
6%	—	—	—	525	5.2	2.71	529	15.3	8.11	591	21.2	12.5
8%	492	0.7	0.33	492	4.5	2.21	492	19.8	9.76	506	24.2	12.2

a Cluster weight in grams. b Clusters per vine. c Yield as kg per vine.

budbreak. In our study, the best responses on these application dates in inducing early and high budbreak were with 2% and 4% cyanamide.

Vines pruned on 16 December with HC applied 0 (341 HB10), 5 (396 HB10), 10 (447 HB10), or 15 days (464 HB10) later behaved similarly to plants pruned on 2 December with HC applied after chilling was satisfied. As dormancy was overcome by environmental conditions, lowered dosages were sufficient to induce early budbreak, and shorter intervals between application date and budbreak initiation were observed (Fig. 4A, B, C, and D). On all application dates for this pruning treatment, 2% cyanamide gave the best response. Although, on 23 December (data not shown) and 31 December, a 1% concentration induced similar budbreak results (Fig. 4D). Untreated vines initiated budbreak between 35 and 48 days after pruning on 16 December and attained between 82% and 92% budbreak, indicative that chilling was fulfilled (Fig. 4A, B, C, and D).

Most of the crop was lost due to cool weather conditions shortly after budbreak for vines pruned on 16 November with HC applied 0 and 5 days later (Table 1). Other studies have shown that vines pruned on 14 November and sprayed with cyanamide halted growth, and the inflorescences never attained normal development due to cool weather (8). The damage observed on our treatments with early pruning was similar to a reported physiological disorder (early bunch or inflorescence necrosis) related with nitrogen metabolism. This disorder causes an abscission of reproductive parts, presumably induced by ammonium toxicity and has been reported in vineyards of temperate zones, where cool temperatures are present right after budbreak (5,7). Vines sprayed on 26 November (10 days after pruning) initiated budbreak a few days later and escaped the cool weather conditions (Fig. 2C). Therefore, this treatment increased crop load and cluster number, but only at the highest concentrations (Table 1). Production per vine increased two-fold when HC increased from 2% to 4% on 2 December (15 days after pruning), as compared with vines sprayed with the same concentrations on 26 November. However, most of the crop was not picked until 9 June. Crop uniformity and increased number of clusters and yield per plant were observed at the highest concentrations of HC (6% and 8%) for vines pruned on 16 November and HC application on 2 December. On these vines, 45% of the crop was picked on 20 May, and by 31 May the harvested yield represented 90% of the total (data not shown).

For the 2 December pruning date (215 HB10), vines sprayed on the same day with 2% and 4% cyanamide were similar in yield, *ca.* 10 kg per vine (Table 2). Vines sprayed with the 8% cyanamide solution, had a yield of 12.4 kg, almost twice that of the 1% treatment (Table 2). Similar yields have been reported on vines pruned on 1 December (8). Regardless of the similar crop load among the 2% and 4% HC treatments, vines sprayed with 2% cyanamide were completely harvested by 31 May (Fig. 5A). Only 48% the total crop was harvested on 31 May for vines sprayed with 8% cyanamide (Fig. 5A). Vines pruned on 2 December with HC applied on 7 December showed a variation in yield (Table 2). Due to low yield,

Table 2. Yield and yield components of Flame Seedlees grapevines pruned on 2 December and several rates of hydrogen cyanamide applied 0, 5, 10, or 15 days later.

Treatments	2 December			7 December			14 December			19 December		
	a	b	c	a	b	c	a	b	c	a	b	c
1%	531	12.8	6.8	481	13.2	6.3	643	24.2	15.6	688	13.1	9.0
2%	557	19.3	10.8	599	18.5	10.5	603	25.5	15.4	710	24.3	17.3
3%	569	18.6	10.6	575	15.0	8.6	554	14.5	8.0	649	25.7	16.7
4%	574	15.4	8.8	607	23.2	14.0	615	15.7	9.6	695	19.5	13.6
8%	603	20.6	12.4	623	21.2	13.2	745	11.2	8.2	625	20.0	12.5

a Cluster weight in grams. b Clusters per vine. c Yield as kg per vine.

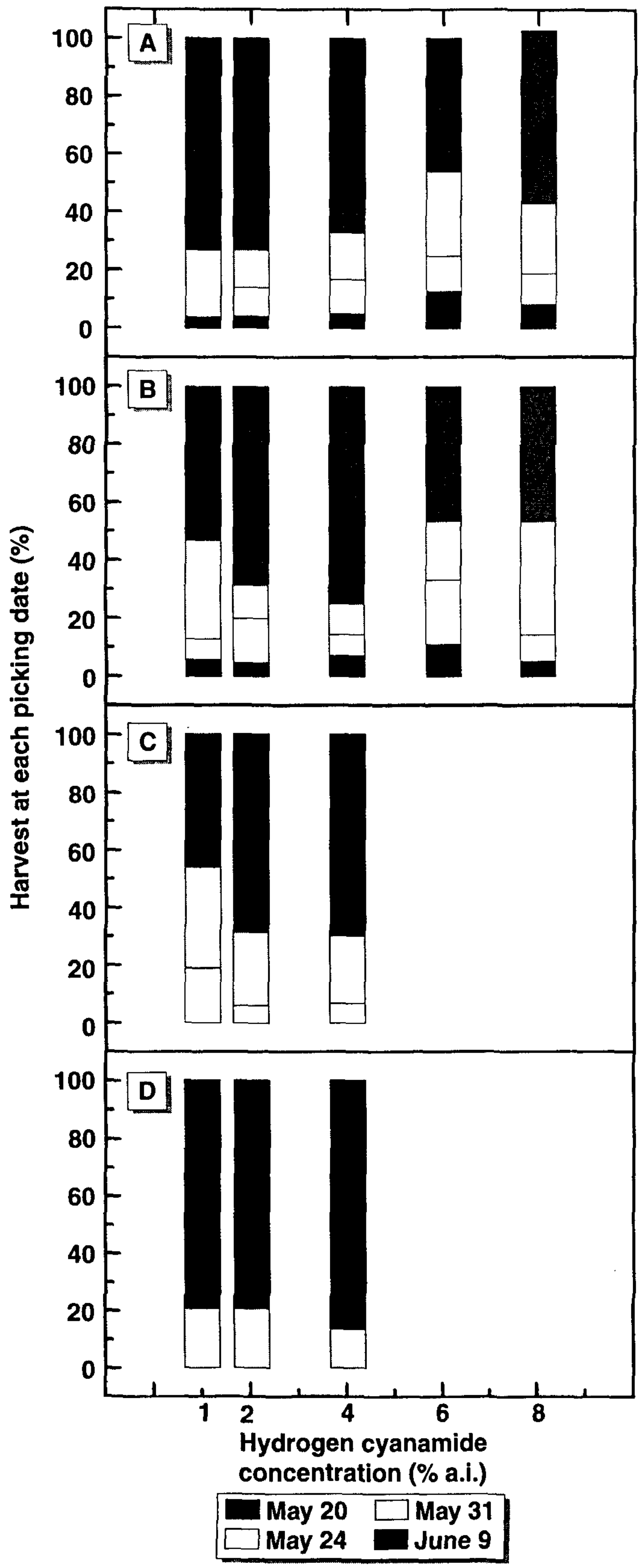

Fig. 6. Percentage of harvest on each picking date of Flame Seedless vines pruned on 16 December and sprayed with hydrogen cyanamide on: (A) 16 December; (B) 21 December; (C) 26 December; and (D) 31 December.

92% of the clusters in the 1% cyanamide dose was harvested by 31 May. However, with the middle concentrations, only 50% of the crop was picked by 31 May. For these treatments, yield ranged between 8.6 and 14 kg per plant (Fig. 5B and Table 2). Application of cyanamide on 14 December resulted in yield reductions at the highest doses, as compared with the lowest ones (Table 2); nonetheless, 50% of the total crop (4.7 kg) was picked by 31 May (Fig. 5C). Vines sprayed 15 days after pruning (19 December) increased the number of clusters and yield per vine in all treatments except the 1% dose (Table 2). Except for the vines sprayed with the 8% HC solution cyanamide applications on this date delayed most of the picking until June 9 (Fig. 5D).

Yield components of vines pruned on 16 December and sprayed with cyanamide 0, 5, 10, and 15 days later are presented in Table 3. HC application right after pruning, increased yield per vine at all concentrations; however, only the 6% treatment was 50% harvested by 31 May (Fig. 6A). The other HC treatments did not advance harvest date, since more than 60% of the crop was picked by 9 June. Grapevines sprayed on 21 December presented similar patterns for the highest concentrations, as nearly 50% of the crop was harvested by 9 June (Fig. 6B). On later application dates (26 and 31 December), and especially with doses above 1%, harvest was delayed, since picking was not initiated until after 24 May, and most of the crop was picked on 9 June. For the 1% concentration applied on 26 December, 50% of the vines' yield (4.5 kg) was harvested by 31 May (Fig. 6C, D).

Final budbreak percentages and yield components for pruning on 23 December are shown in Table 4. Whereas most growers prune during the third week of December and apply cyanamide rates ranging from 2% to 3% (4% to 6% Dormex), our results demonstrated that vines sprayed with HC rates from 0.5% to 4% a.i. (1% to 8% Dormex) had similar budbreak and yield, even though our lowest rates are half the commercial dose. However, harvest was delayed, since picking continued until 9 June (data not shown). Therefore, during dormancy seasons like this, in which, chilling was already satisfied, a cutback on cyanamide cost was potentially feasible.

The information presented here suggests that by following bud physiological stages, which depend on environmental conditions, it is possible to figure out effective cyanamide timing and dosages and obtain early harvests. Thus, the effective rate and application timing will depend on climatic conditions. Pruning and applying cyanamide 5, 10, or 15 days later delay budbreak and picking date as compared to applying immediately after pruning; still, these treatments induced early budbreak and could be a useful tool to avoid competition when labor is used for applications. As vines overcome dormancy, rates must be reduced to avoid problems related to budbreak variability, toxicity, and waste of product. It is clear that early pruning and cyanamide treatment cause an early budbreak, which advances harvest. Nevertheless, if cool conditions are

Table 3. Yield and yield components of Flame Seedlees grapevines pruned on 16 December, and several rates of hydrogen cyanamide applied 0, 5, 10, or 15 days later.

Treatments	16 December			21 December			26 December			31 December		
	a	b	c	a	b	c	a	b	c	a	b	c
1%	763	20.3	15.5	579	22.2	12.8	470	21.0	9.9	676	19.5	13.2
2%	630	32.1	20.2	623	24.7	15.4	528	26.5	14.0	665	27.5	18.3
4%	672	24.9	16.7	613	24.0	14.7	568	25.6	14.6	606	20.6	12.5
6%	593	19.2	11.4	537	16.7	9.0	—	—	—	—	—	—
8%	633	24.5	15.5	591	15.0	8.9	—	—	—	—	—	—

a Cluster weight in grams. **b** Clusters per vine. **c** Yield as kg per vine.

Table 4. Yield and yield components of Flame Seedless grapevines pruned on 23 December and with hydrogen cyanamide applied right after pruning.

Treatments	23 December			
H_2CN_2	a	b	c	d
0.5%	63.7	531	16.7	8.8
1%	91.2	533	26.8	14.3
2%	85.0	522	27.2	14.2
3%	76.2	507	24.8	12.6
4%	66.9	673	27.8	18.7

a Budbreak percentage after 60 days. **b** Cluster weight in grams.
c Clusters per vine **d** Yield as kg per vine.

expected when the vines initiates growth a few days later, the risk of loosing the crop may increase.

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