HORTSCIENCE 30(6):1244–1247. 1995.

Chilling Exposure and Hydrogen Cyanamide Interact in Breaking Dormancy of Grape Buds

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Additional index words. Vitis vinifera, grapevine, Dormex

Abstract. **An experiment was conducted to examine the interaction between chilling exposure (0, 50, 100, 200, 400, and 800 hours at 3C) and hydrogen cyanamide (H_2CN_2) concentration [0%, 1.25%, and 2.50% (v/v)] on the budbreak of dormant grape buds (*Vitis vinifera* L. 'Perlette') collected in late fall before the onset of temperatures ≤13C. Budbreak at 22C was most rapid for cuttings exposed to 800 chill hours and least rapid for cuttings that received no chilling. Budbreak of cuttings receiving 50 to 200 hours of chilling was similar and lagged behind that of cuttings exposed to 400 or 800 hours. Maximum observed budbreak improved with increased chilling exposure. Hydrogen cyanamide hastened the growth of all chilling treatments and increased the percent budbreak of cuttings receiving ≤400 chill hours. When cuttings were not treated with H_2CN_2, the number of days required for 50% budbreak declined sharply as chilling exposure increased from 0 to 400 hours. In contrast, this interval was reduced only slightly as chilling increased from 400 to 800 hours. Hydrogen cyanamide-treated buds exhibited a more gradual decline in the number of days required for 50% budbreak with increased chilling exposure. In this study, the physiological efficacy and economic benefits of H_2CN_2 applications diminished with increased chilling exposure.**

Dormant grapevine buds have a chilling requirement that is satisfied by low exposure to low temperatures (Kliewer and Soleimani, 1972; Weaver and Iwaski, 1977). The precise temperature and duration of chilling required for optimum budbreak of grapevines has not been established. However, the chilling requirement of grape is generally thought to be less than that of most deciduous fruit species (Chandler et al., 1937). Grapevines suffering from inadequate winter chilling exhibit delayed and erratic budbreak, decreased shoot and cluster counts per vine, and poor uniformity of fruit development (Lavee et al., 1984; Wicks et al., 1984). Fruit yield and quality are reduced as a result (Wicks et al., 1984).

About 15% of California's table grapes are produced in the Coachella Valley, the principal desert growing region in the state. This region produces some of the earliest maturing table grapes in the Northern Hemisphere, and cultural practices that accelerate fruit ripening are highly desirable. Due to warm autumns and winters, obtaining sufficient chilling for normal budbreak often is a problem in this region (Wicks et al., 1984). To overcome this problem, growers apply hydrogen cyanamide (H_2CN_2) on the vines immediately following pruning. Hydrogen cyanamide advances budbreak and improves the budbreak uniformity of grapevines grown under low-chill conditions (Lavee et al., 1984; McColl, 1986; Wicks et al., 1984). Many factors influence the response of grapevines to H_2CN_2, including pruning date and application time (McColl, 1986; Wicks et al., 1984), application rate (Wicks et al, 1984), bud physiological stage (Nir et al., 1984), and cultivar (Lavee et al., 1984).

Chilling exposure also is a critical factor influencing the response of grapevines to H_2CN_2. Hydrogen cyanamide generally does not improve budbreak or advance fruit maturation in regions where grapevines receive sufficient chilling (800 h at 7C) for normal budbreak (Jensen and Bettiga, 1984; Williams, 1987). To our knowledge, specific information regarding the influence of chilling exposure on the response of grapevine buds to H_2CN_2 is not available. Our purpose was to examine the chilling exposure × H_2CN_2 treatment interaction on the growth of dormant grape buds.

Received for publication 26 Sept. 1994. Accepted for publication 16 May 1995. We thank M. Bianchi, M. Moriyama, and N. Ebisuda for their assistance. We gratefully acknowledge financial support provided by the California Table Grape Commission. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Materials and Methods

Three-node dormant cuttings were taken from the basal portion of mature canes (nodes 4 to 7) in a commercial vineyard ('Perlette') located in the Coachella Valley near Thermal, Calif. Care was taken to select cuttings with uniform diameter and internode length. The cuttings were collected in late October, before the onset of temperatures ≤13C. The cuttings were bundled into groups of 10 (10 cuttings = one replication) and wrapped in newspaper. The bundles were immersed in water, allowed to drain for several minutes, and placed in sealed plastic bags. The bags were stored at 3 ± 0.5C for 0, 50, 100, 200, 400, or 800 h. After chilling treatments were completed, the middle node of each cutting was removed, and the cuttings were recut above the basal node and rinsed with distilled water. Hydrogen cyanamide was applied by immersing the apical bud of each cutting into the appropriate solution (0%, 1.25%, or 2.50% H_2CN_2) for 10 sec. Nontreated cuttings were immersed in distilled water. After drying, cuttings were placed in 1-liter plastic beakers containing distilled water. The basal 8 to 10 cm of each cutting was maintained in distilled water, and the water was replaced each week. Containers were placed on benches in the laboratory under continuous white light (photon flux density = 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$) at 22 ± 1.8C, and monitored two to three times per week for budbreak. Budbreak was indicated by the presence of green tissue beneath the bud scales. The design was a randomized complete block, with each treatment replicated eight times using 10 cuttings per replication. Data were analyzed using general linear model and curve fitting procedures in SAS (SAS Institute, Cary, N.C.).

Results and Discussion

When 'Perlette' buds were not treated with H_2CN_2, budbreak was most rapid and uniform for cuttings exposed to 800 h of chilling, followed by cuttings receiving 400 h (Fig. 1, top). Budbreak was similar for cuttings exposed to 50 to 200 h, and the growth of these buds was slower than those receiving 400 or 800 h. The budbreak of cuttings exposed to 0 to 200 h exhibited a straight line; the growth of cuttings exposed to 400 or 800 h was best fit to an exponential curve (Table 1). Thus, the growth of cuttings exposed to ≤200 h was more erratic and less uniform than growth of cuttings exposed to ≥400 h. Cuttings treated with 1.25% or 2.50% H_2CN_2 commenced growth more rapidly and uniformly than nontreated cuttings (Fig. 1, middle and bottom). Hydrogen cyanamide particularly enhanced the growth of buds exposed to <400 h. The budbreak of cuttings receiving like chilling treatments and treated with 1.25% or 2.50% H_2CN_2 was similar.

When cuttings were not treated with H_2CN_2, the days required for 50% budbreak declined sharply as chilling exposure increased from 0 to 400 h (Fig. 2). Buds with no chilling exposure required 100 days to achieve 50% budbreak; buds exposed to 400 h of chilling re-

quired only 28 days to reach this stage. The time to 50% budbreak advanced only slightly, from 28 to 22 days, when chilling increased from 400 to 800 h. When buds were treated with H_2CN_2, a much more gradual and only slight decline in the number of days required for 50% budbreak was observed with increased chilling exposure. Buds with no chilling required 20 and 21 days, respectively, to reach 50% budbreak when treated with 1.25% or 2.50% H_2CN_2. In contrast, buds exposed to 800 h chilling required 14 and 15 days, respectively, to respond similarly.

Maximum observed budbreak rose rapidly for control cuttings as chilling exposure increased from 0 to 400 h, then leveled off as chilling approached 800 h (Fig. 3). Maximum budbreak was 35%, 47%, 46%, 55%, 83%, and 95% for cuttings exposed to 0, 50, 100, 200, 400, and 800 h, respectively. When cuttings were treated with H_2CN_2, a more gradual increase in budbreak was observed with increased chilling. Maximum budbreak was slightly higher for cuttings treated with 2.50% H_2CN_2 compared to those treated with 1.25% H_2CN_2. Maximum budbreak was 89%, 83%, 87%, 91%, 95%, and 91% for cuttings receiving 0, 50, 100, 200, 400, and 800 h, respectively, and treated with 1.25% H_2CN_2. In comparison, the maximum budbreak of vines receiving the same number of chillling hours and treated with 2.50% H_2CN_2 was 91%, 91%, 92%, 99%, 99%, and 99%, respectively.

The chilling requirement of grapevines and the role that chilling plays in the regulation of bud growth has not been well defined. In tropical regions, grapevines may grow continuously with little or no exposure to chilling temperatures (Araujo, 1994). However, once bud endodormancy is induced, exposure to chilling temperatures is believed necessary for uniform budbreak (Lavee et al., 1984). Magoon and Dix (1943) reported that the number of days required for grapevine budbreak declined as exposure to chilling temperatures <7C increased. Weaver and Iwasaki (1977) reported that budbreak was more rapid for 'Zinfandel' cuttings exposed to 0 and 3.9C compared to cuttings exposed to 10C. In our study, maximum budbreak after 60 days at 25C was ≈5%, 10%, 50%, 80%, and 100%, respectively, for cuttings stored at 3.9C for 0, 168, 336, 672, and 1344 h. Kliewer and Soleimani (1972) reported that the maximum budbreak of potted 'Thompson Seedless' grapevines increased linearly with hours of storage at 1.6C. Budbreak was ≈25%, 47%, 50%, 56%, and 66%, respectively, when chilling duration was 0, 168, 504, 1176, and 1848 h. Antcliff and May (1961) reported little difference in the budbreak of 'Thompson Seedless' cuttings stored 0 to 150 h at 4C. All samples in their study reached 50% budbreak after 10 to 11 weeks under forcing conditions. In our study, 400 h at 3C were sufficient to achieve commercially acceptable levels of budbreak (≥80%) for 'Perlette'. This value does not represent a general minimum chilling requirement for grapevines because, as previously discussed, the response of grape buds to chilling temperatures and durations is highly variable. Previous studies revealed that the chilling requirement of grapevines is influenced by many factors, including daylength (Fennel and Hoover, 1991), cultivar (Kliewer and Soleimani, 1972), time of year or sample date (Antcliff and May, 1961), and bud position on the cane (Weaver et al., 1975). Studies using standardized plant materials and methodologies are needed to establish the chilling requirement of commercially important table grape cultivars and to understand the role of chilling in the regulation of grape bud dormancy.

Previous studies have shown that H_2CN_2

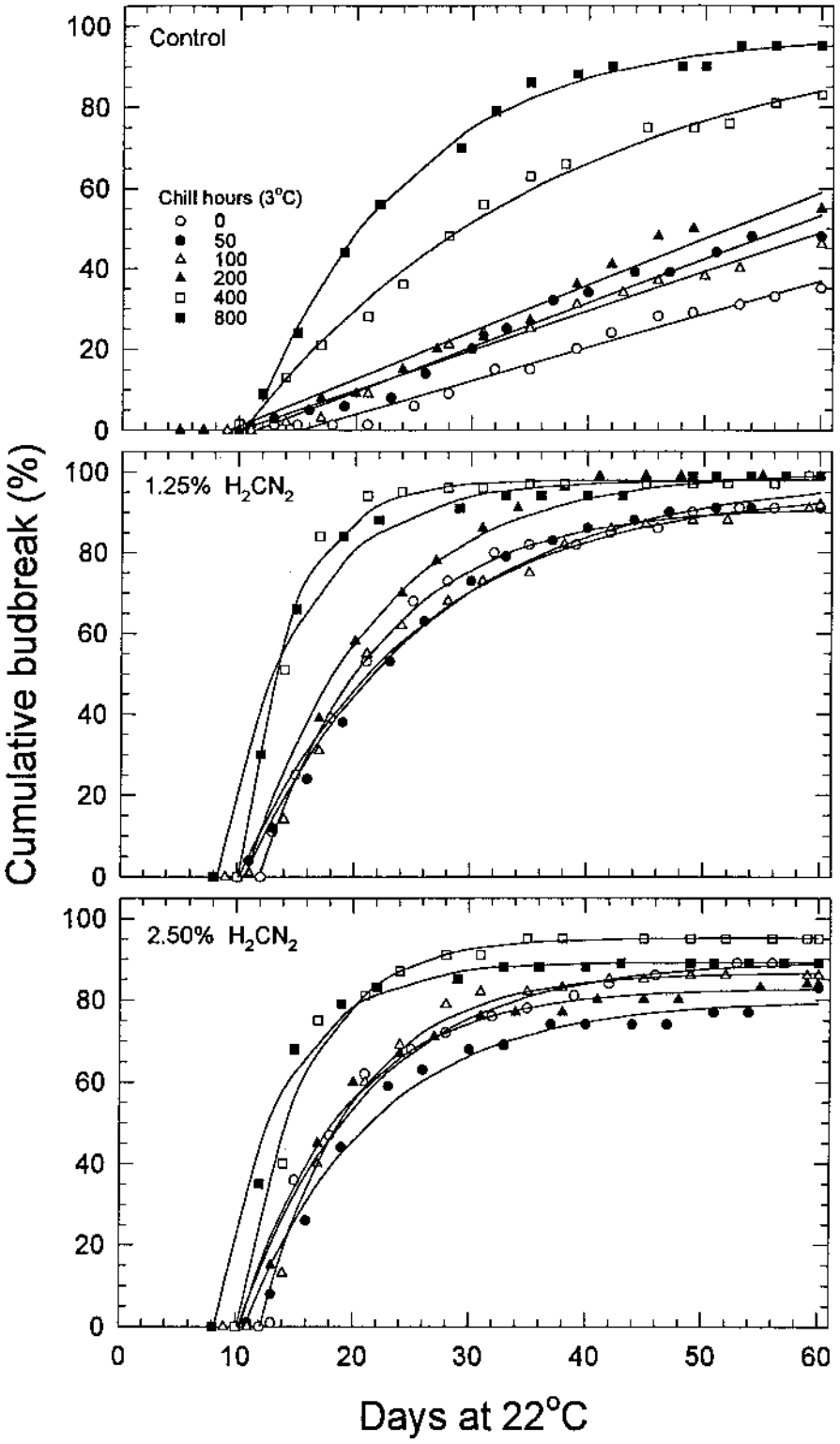

Fig. 1. Influence of chilling exposure and hydrogen cyanamide concentration on the cumulative budbreak of 'Perlette' grapevine cuttings. Cuttings were kept under continuous white light (photon flux density = 100 μmol·m^{-2}·s^{-1}) at 22C. Data points represent the mean of eight 10-cutting replications in each treatment. Data were fitted to the equations in Table 1.

Table 1. Regression equations for chilling exposure and hydrogen cyanamide treatments in Fig. 1.

Chilling hours at 3C	Regression equation	r^2
H_2CN_2, none		
0	$y = -12.47 + 82x$	0.9777
50	$y = -12.41 + 1.10x$	0.9759
100	$y = -9.71 + 0.98x$	0.9787
200	$y = -10.54 + 1.16x$	0.9749
400	$y = 100.28 - 145.93e^{(-0.036x)}$	0.9917
800	$y = 97.88 - 225.59e^{(-0.076x)}$	0.9951
H_2CN_2, 1.25%		
0	$y = 91.36 - 290.29e^{(-0.097x)}$	0.9975
50	$y = 98.93 - 195.26e^{(-0.064x)}$	0.9938
100	$y = 95.61 - 188.95e^{(-0.067x)}$	0.9860
200	$y = 100.00 - 269.25e^{(-0.092x)}$	0.9878
400	$y = 97.98 - 993.64e^{(-0.230x)}$	0.9884
800	$y = 97.90 - 326.38^{(-0.146x)}$	0.9786
H_2CN_2, 2.50%		
0	$y = 86.64 - 406.45e^{(-128x)}$	0.9812
50	$y = 80.01 - 215.31e^{(-0.092x)}$	0.9863
100	$y = 89.61 - 232.54e^{(-0.093x)}$	0.9699
200	$y = 82.84 - 274.07^{(-0.116x)}$	0.9897
400	$y = 95.22 - 564.55e^{(-0.176x)}$	0.9876
800	$y = 89.17 - 370.53e^{(-0.175x)}$	0.9855

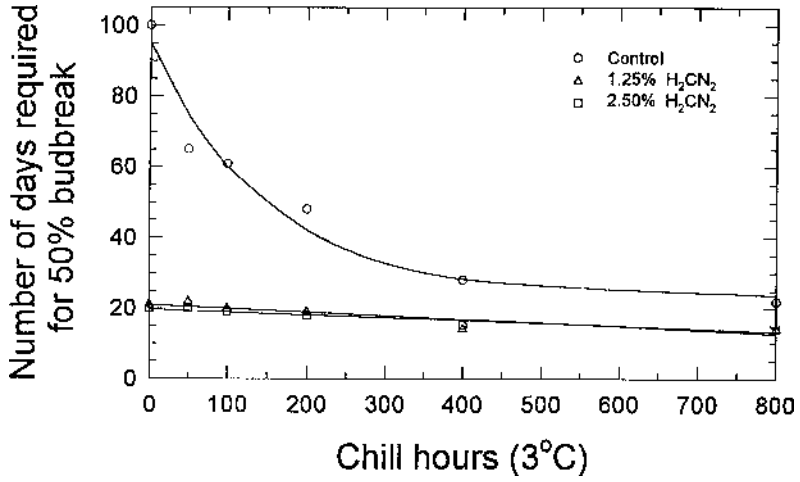

Fig. 2. Chilling exposure × hydrogen cyanamide concentration interaction on the number of days required for 50% budbreak for 'Perlette' grapevine cuttings. Cuttings were kept under continuous white light (photon flux density = 100 µmol·m^{-2}·s^{-1}) at 22C. Data points represent the mean of eight 10-cutting replications for each treatment. Data were fitted to the following equations: Control: $y = 71.64e^{-0.007x} + 23.50$, $r^2 = 0.9613$; 1.25% H_2CN_2: $y = 21.03 - 0.01x$, $r^2 = 0.8023$; 2.50% H_2CN_2: $y = 19.77 - 0.008x$, $r^2 = 0.9003$.

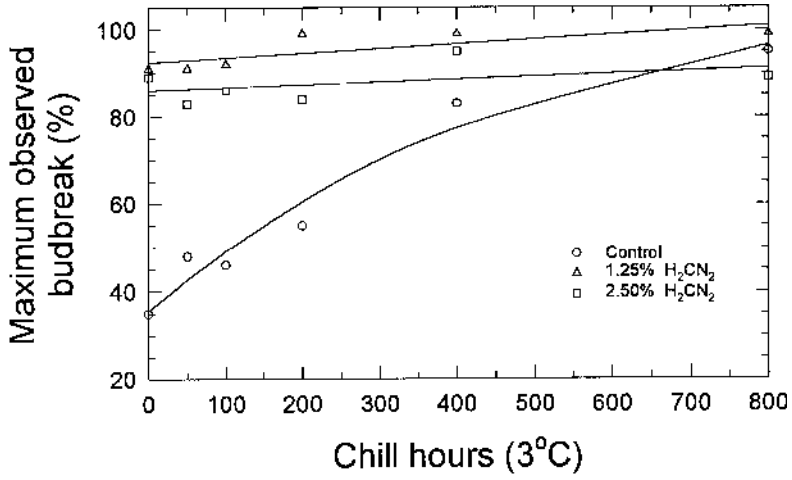

Fig. 3. Chilling exposure × hydrogen cyanamide concentration interaction on the maximum budbreak of 'Perlette' grapevine cuttings after 60 days under continuous white light (photon flux density = 100 µmol·m^{-2}·s^{-1}) at 22C. Data points represent the mean of eight 10-cutting replicates for each treatment. Data were fitted to the following equations: Control: $y = 112.45 - 76.88e^{-0.002x}$, $r^2 = 0.9625$; 1.25% H_2CN_2: $y = 92.40 + 0.01x$, $r^2 = 0.5837$; 2.50% H_2CN_2: $y = 86.03 + 0.01x$, $r^2 = 0.1907$.

improves budbreak and hastens fruit maturity when applied to grapevines in regions where insufficient chilling is a problem (Lavee et al., 1984; McColl, 1986; Wicks et al., 1984). Budbreak and fruit maturation were advanced 2 to 3 weeks in these studies when H_2CN_2 was applied immediately after pruning. Hydrogen cyanamide also increased total budbreak and budbreak uniformity, greatly enhancing fruit yield and quality. In contrast to the results of field studies (Lavee et al., 1984; Wicks et al., 1984), the growth of buds treated with 1.25 and 2.50% H_2CN_2 were similar in this study.

The results indicate that when chilling exceeds 400 h at 3C, the response of grapevines to H_2CN_2 is greatly reduced. Normally, there is little benefit when H_2CN_2 is applied to vines grown in regions that accumulate large amounts of chilling because the budbreak of nontreated vines in these regions is sufficient (Jensen and Bettiga, 1984; Williams, 1987). Hydrogen cyanamide may hasten growth in these regions, but it usually has little effect on maximum observed budbreak, budbreak uniformity, or fruit maturation date. In this study, H_2CN_2 hastened the growth of buds exposed to 800 h at 3C but did not increase their maximum budbreak.

The physiological and presumed economic benefits of H_2CN_2 diminished in this study as the chilling requirement of dormant grape buds was fulfilled. Hydrogen cyanamide improved budbreak when chilling exposure at 3C was between 0 and 400 h. However, maximum observed budbreak of H_2CN_2-treated and nontreated cuttings was similar when buds received 800 h. Hydrogen cyanamide does not improve the budbreak of grapevines once their chilling requirement is satisfied.

Literature Cited

Antcliff, A.J. and P. May. 1961. Dormancy and bud burst in Sultana vines. Vitis 3:1–14.

Araujo, F.J. 1994. Table grape production in tropical America, p. 31–37. In: J.M. Rantz (ed.). Proc. Intl. Symp. Table Grape Production. Amer. Soc. Enol. Viticult., Davis, Calif.

Chandler, W.H., M.H. Kimball, G.L. Philip, W.P. Tufts, and G.P. Weldon. 1937. Chilling requirements for opening of buds on deciduous orchard trees and some other plants in California. Univ. of California College Agr. Expt. Sta. Bul. 611.

Fennell, A. and E. Hoover. 1991. Photoperiod influences growth, bud dormancy, and cold accumulation in *Vitis labrusca* and *Vitis riparia*. J. Amer. Soc. Hort. Sci. 116:270–273.

Jensen, F. and L. Bettiga. 1984. The effect of hydrogen cyanamide on budbreak of Thompson Seedless, Emperor, and French Colombard, p. 15–16. In: R.J. Weaver (ed.). Proceedings of bud dormancy in grapevine: Potential and practical uses of hydrogen cyanamide on grapevine. Univ. of California, Davis.

Kliewer, W.M. and A. Soleimani. 1972. Effect of chilling on budbreak in Thompson Seedless and Carignane grapevines. Amer. J. Enol. Viticult. 23:31–34.

Lavee, S., Y. Shulman, and G. Nir. 1984. The effect of cyanamide on budbreak of grapevines *Vitis vinifera* L., p. 17–29. In: R.J. Weaver (ed.). Proceedings of bud dormancy in grapevine: Potential and practical uses of hydrogen cyanamide on grapevine. Univ. of California, Davis.

Magoon, C.A. and I.W. Dix. 1943. Observations on the response of grapevines to winter temperatures as related to their dormancy requirements. Proc. Amer. Soc. Hort. Sci. 42:407–412.
McColl, C.R. 1986. Cyanamide advances the maturity of table grapes in central Australia. Austral. J. Expt. Agr. 26:505–509.
Nir, G., Y. Shulman, L. Fanberstein, and S. Lavee. 1984. The involvement of catalase in the dormancy of grape buds, p. 40–43. In: R.J. Weaver (ed.). Proceedings of bud dormancy in grapevine: Potential and practical uses of hydrogen cyanamide on grapevine. Univ. of California, Davis.
Weaver, R.J. and K. Iwasaki. 1977. Effect of temperature and length of storage, root growth and termination of bud rest in Zinfandel grapes. Amer. J. Enol. Viticult. 28:149–151.
Weaver, R.J., S. Lavee, and J.O. Johnson. 1975. Rooting and end of rest in 'Carignane' cuttings as affected by collection time and cane segment used. Amer. J. Enol. Viticult. 26:164–167.
Wicks, A.S., J.O. Johnson, E. Bracho, F.L. Jensen, R.A. Neja, L.A. Lider, and R.J. Weaver. 1984. Induction of early and more uniform budbreak in *Vitis vinifera* L. cvs. Perlette, Thompson Seedless, and Flame Seedless, p. 48–58. In: R.J. Weaver (ed.). Proceedings of bud dormancy in grapevine: Potential and practical uses of hydrogen cyanamide on grapevine. Univ. of California, Davis.
Williams, L.E. 1987. The effect of cyanamide on budbreak and vine development of Thompson Seedless grapevines in the San Joaquin Valley of California. Vitis 26:107–113.