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Chilling Temperature and Duration Interact on the Budbreak of 'Perlette' Grapevine Cuttings

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Abstract. **A factorial experiment examined the interaction between chilling temperature (0, 2.5, 5.0, 7.5 and 10 °C) and duration (50, 100, 200, 400, and 800 h) on the budbreak of 'Perlette' (*Vitis vinifera* L.) grapevine cuttings. Cuttings stored at 0 °C exhibited the most rapid budbreak during the first 30 days after being placed under forcing conditions. After this period, chilling temperature had relatively little influence on cumulative budbreak, with cuttings stored between 0 and 10 °C generally exhibiting similar rates of budbreak. In contrast, the slope of the budbreak curves increased, indicating more rapid and uniform budbreak, with increased chilling duration. Significant interactions ($P \leq 0.0001$) between chilling temperature and duration were found for both the number of days required for 50% budbreak and total observed budbreak. The number of days required for 50% budbreak declined, while total observed budbreak increased, with increased chilling duration. Within the temperature range evaluated, a minimum exposure of 200 hours was required to achieve commercially acceptable levels of budbreak.**

Compared to many other deciduous fruit crops, grapevines require relatively little exposure to chilling to terminate rest (Chandler et al., 1937). Previous studies indicate that the chilling exposure necessary for normal bud growth ranges between 50 and 400 h at temperatures ≤ 7 °C (Chandler et al., 1937; Dokoozlian et al., 1995; Magoon and Dix, 1943; Nigond, 1957; Weaver and Iwasaki, 1977). Erratic and/or delayed budbreak, decreased shoot and cluster numbers per vine, and poor uniformity of fruit development are commonly reported in regions where grapevines suffer from inadequate winter chilling (Lavee et al., 1984; McColl, 1986; Wicks et al., 1984).

Grapevine budbreak generally improves with increased exposure to chilling temperatures. Weaver and Iwasaki (1977) reported that the budbreak of 'Zinfandel' cuttings was more rapid, and total budbreak improved, as exposure to 0 °C increased from 72 h to 672 h. The total budbreak of 'Perlette' cuttings increased rapidly as time of exposure to 3 °C increased from 50 to 400 h, then improved only modestly as exposure increased from 400 to 800 h (Dokoozlian et al., 1995). Total budbreak also improved as the chilling exposure (2 °C) of potted 'Thompson Seedless' vines increased from 168 to 1176 h (Kliewer and Soleimani, 1972). The range of temperatures effective for chilling grape buds is not well established. Nigond (1957) suggested that temperatures between 1 and 18 °C were effective for chilling. Weaver and Iwasaki (1977) showed that budbreak was more rapid when 'Zinfandel' cuttings were stored at 0 or 3.9 °C compared to 10 °C, although total budbreak did not differ among the treatments.

An improved understanding of the interaction of chilling temperature and duration on grape budbreak is needed to better predict budbreak rate and amount, as well as to assist in the selection of appropriate dormancy-breaking treatments (Dokoozlian et al., 1998). The objective of this study was to further examine the interaction of these factors on the budbreak of 'Perlette', an early-maturing, white seedless table grape cultivar commonly grown in low-chill regions.

Materials and Methods

Dormant 'Perlette' cuttings were collected from a commercial vineyard in the Coachella Valley near Thermal, Calif. The own-rooted vines were planted in 1985, bilateral cordon trained and spur pruned. Three-node cuttings of uniform diameter and internode length were prepared from the base of mature canes (nodes 4 to 6; cutting length = 25 to 30 cm) in mid-October, prior to onset of temperatures ≤15 °C. Cuttings were bundled into groups of 10 (representing one experimental unit) and wrapped in newspaper. Bundles were immersed in water, drained for several minutes, and placed in sealed plastic bags, which were stored in darkness at 0, 2.5, 5, 7.5 or 10 °C (±0.5 °C at each temperature) for 50, 100, 200, 400, or 800 h. A nonchilled control was included in the experiment. After chilling treatments were completed, the middle bud of each cutting was removed and the base was recut above the basal node. The cuttings were rinsed with distilled water, allowed to dry, and placed in 1-L plastic beakers with the basal 7 to 10 cm in distilled water, which was replaced each week. Containers were placed on laboratory benches under continuous white light (photon flux density = 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$) at 22 ± 1.5 °C, and the apical bud of each cutting monitored two to three times per week for budbreak. Budbreak was defined as first day that green tissue beneath the bud scales was observed. The experimental design was a randomized complete block, with each treatment replicated eight times using 10 cuttings per replicate. Data were analyzed using general linear modeling curve-fitting procedures in SAS (SAS Institute, Cary, N.C.).

Results and Discussion

Cumulative budbreak curves for temperature main effects revealed subtle differences in budbreak rate among the treatments (Fig. 1, upper graph). Cuttings stored at 0 °C exhibited the most rapid budbreak the first 30 d after being placed under growth-inducing conditions. After 40 d, however, budbreak was similar in cuttings stored at 0, 7.5, or 10 °C, while the budbreak of cuttings held at 2.5 and 5 °C lagged slightly behind. In contrast, the effects of chilling duration on budbreak were more distinct (Fig. 1, lower graph). The slope of the response curves increased, indicating more rapid and uniform budbreak, with increased chilling duration. Note that even brief (50 h) exposures to temperatures between 0 and 10 °C significantly advanced budbreak compared to the nonchilled control.

Significant interactions ($P \leq 0.0001$) between chilling temperature and duration were found for both the number of days required for 50% budbreak and total observed budbreak. The number of days required for 50% budbreak generally declined, indicating more rapid and uniform budbreak, with increased chilling duration (Fig. 2, upper graph). When chilling duration was 400 or 800 h, cuttings stored at 0 °C required fewer days to reach 50% budbreak than those stored at higher temperatures. Temperature effects on this parameter were more variable as chilling duration was reduced, however. For example, when chilling duration was 200 h, budbreak was more rapid on cuttings stored at 0 and 10 °C than on those stored at 2.5 or 5 °C. When chilling duration was 50 d, cuttings stored between 0 and 7.5 °C required fewer days to reach 50% budbreak than those stored at 10 °C. All treatments advanced budbreak compared with the nonchilled control, which required 99 d to reach 50% budbreak (data not presented). Total observed budbreak increased with chilling duration, and temperature effects on this parameter were quite variable (Fig. 2, lower graph). When chilling duration was 800 h, temperature had relatively little effect on total budbreak. Similar results were observed when chilling duration was 400 h, except that total budbreak was greater for

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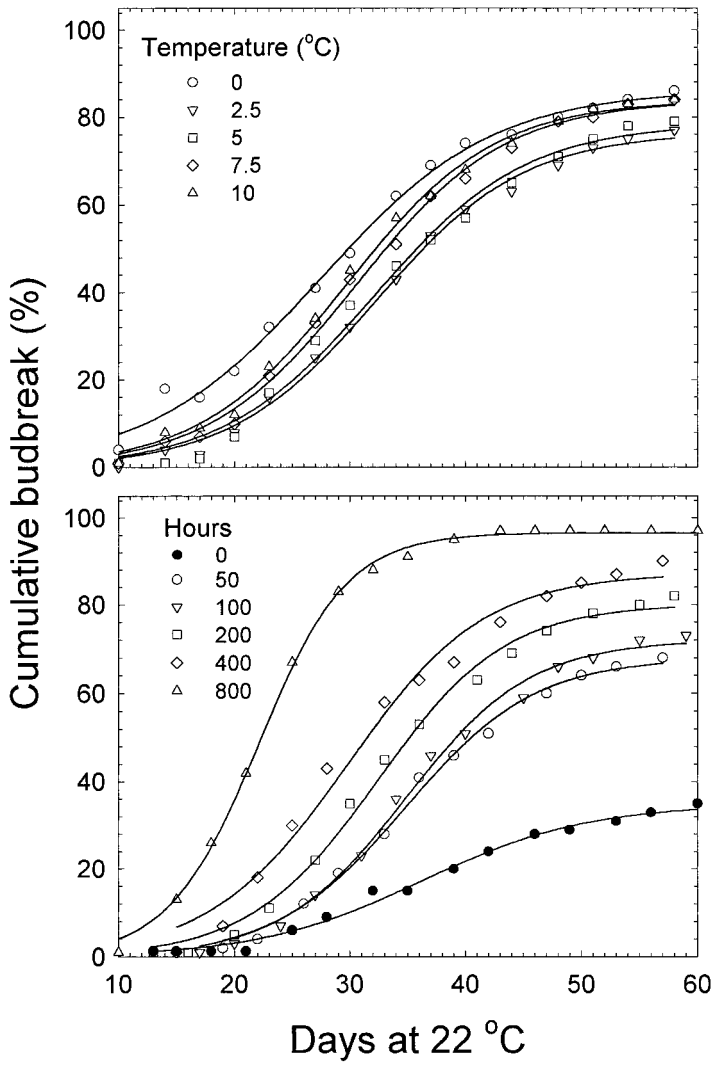

Fig. 1. Main effects of chilling temperature (upper graph) and chilling duration (lower graph) on cumulative budbreak of 'Perlette' grapevine cuttings after transfer to 22 °C (±1.5 °C). Regression equations for chilling temperature data (**upper graph**) are 0 °C: $y = 86.204/(1 + e^{-(x-27.392)/7.479})$, $r^2 = 0.9943$; 2.5 °C: $y = 76.511/(1 + e^{-(x-32.281)/6.326})$, $r^2 = 0.9963$; 5 °C: $y = 78.573/(1 + e^{-(x-32.081)/6.552})$, $r^2 = 0.9896$; 7.5 °C: $y = 83.818/(1 + e^{-(x-30.554)/6.400})$, $r^2 = 0.9960$; 10 °C: $y = 83.919/(1 + e^{-(x-32.29.704)/6.393})$, $r^2 = 0.9969$. Equations for chilling duration (**lower graph**) are 50 h: $y = 68.000/(1 + e^{-(x-34.738)/5.580})$, $r^2 = 0.9954$; 100 h: $y = 72.023/(1 + e^{-(x-34.727)/5.376})$, $r^2 = 0.9952$; 200 h: $y = 80.152/(1 + e^{-(x-32.312)/5.514})$, $r^2 = 0.9948$; 400 h: $y = 87.220/(1 + e^{-(x-29.674)/5.939})$, $r^2 = 0.9855$; 800 h: $y = 96.546/(1 + e^{-(x-22.017)/3.866})$, $r^2 = 0.9986$.

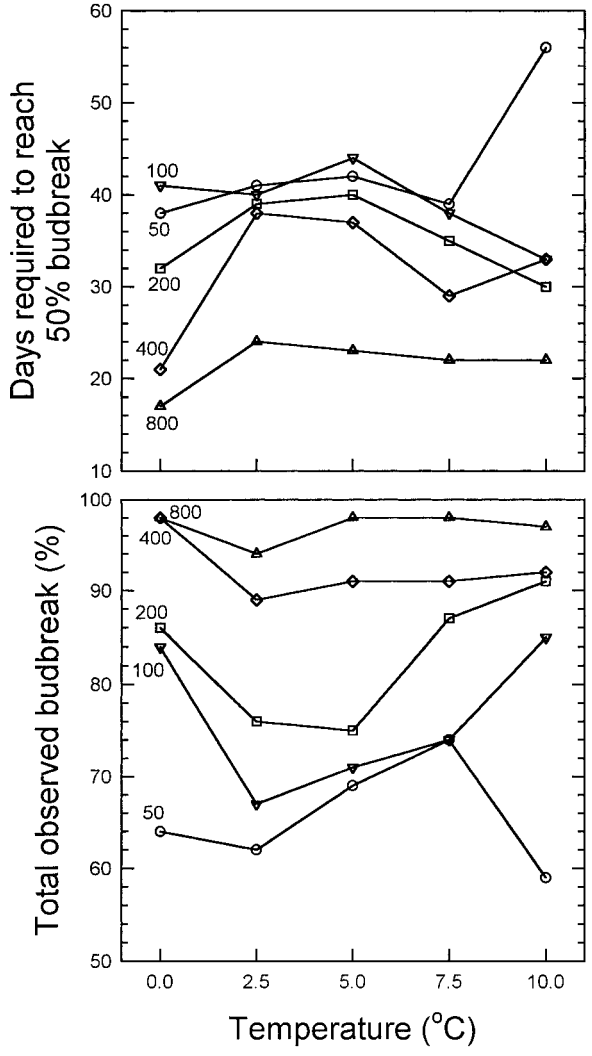

Fig. 2. Interaction of chilling temperature and duration on the number of days required to reach 50% budbreak (**upper graph**) and the total observed budbreak (**lower graph**) of 'Perlette' grapevine cuttings after transfer to 22 °C (±1.5 °C).

cuttings stored at 0 °C than for those stored at higher temperatures. When chilling duration was 100 or 200 h, total budbreak was lower for cuttings stored at 2.5 and 5 °C than for those held at other temperatures. When chilling duration was 50 d, cuttings stored at 5 and 7.5 °C exhibited significantly greater budbreak than those stored at 10 °C. All treatments improved budbreak compared to the nonchilled control, which reached ≈35% total budbreak.

Chilling temperatures between 0 and 10 °C had similar effects on budbreak in this study, with the exception that cuttings exposed to 0 °C commenced growth sooner than those held at higher temperatures. These results are similar to those of Weaver and Iwasaki (1977), who reported that 'Zinfandel' cuttings exposed to 0 °C commenced growth slightly before those exposed to 3.9 or 10 °C. These researchers also reported that cuttings exposed to 10 °C required >1000 h of chilling to achieve normal budbreak. In contrast, cuttings stored at 10 °C in this experiment required only 100 h exposure to achieve acceptable budbreak. While the current study suggests that temperatures between 0 and 10 °C must be considered when assessing chilling exposure, it also appears that 0 °C is more effective for advancing the budbreak of 'Perlette' than are higher temperatures. Further work is needed to determine temperature effects on the budbreak of other commercially important table grape cultivars.

In agreement with previous reports, budbreak was hastened in this study, and total observed budbreak improved, as chilling duration was increased. Magoon and Dix (1943) reported similar results for field-grown vines; budbreak advanced as exposure to temperatures ≤7 °C during the dormant period increased. Kliewer and Soleimani (1972) reported that the maximum observed budbreak of 'Thompson Seedless' increased linearly with time of chilling at 1.6 °C. Maximum observed budbreak was ≈25%, 47%, 50%, 56%, and 66%, respectively, for chilling durations of 0, 168, 504, 1176, and 1848 h. Dokoozlian et al. (1995) reported similar results for cuttings of 'Perlette', as maximum observed budbreak improved from 35% to 95%, respectively, as exposure to 3 °C increased from 0 to 800 h.

Grapevines grow under a wide range of environmental conditions, allowing commercial cultivation between ≈50°N and ≈50°S latitudes. Grapevines grown near the equator are normally not exposed to temperatures pre-

sumed effective for chilling, but budbreak occurs following vine defoliation and pruning (Araujo, 1994). Total budbreak and budbreak uniformity under these conditions are generally poor, however, with <50% total budbreak common unless hydrogen cyanamide or other chemical treatments are employed (Araujo, 1994). Similarly, nonchilled 'Thompson Seedless' and 'Carignane' grapevines exhibited ≈5% budbreak (Kliewer and Soleimani, 1972), while the maximum observed budbreak of nonchilled 'Perlette' cuttings in this study was ≈35%. Why some grape buds require chilling to grow, while others do not, remains unclear. This may be the result of the variability in dormancy status among buds on a single vine, even when considering buds of similar age or position on the shoot (Weaver et al., 1975). For example, buds that commence growth without chilling may represent a population of ecodormant buds—buds which grow following pruning if conditions are favorable. In contrast, buds that require chilling to grow may represent endodormant buds or buds that have entered into true dormancy. Once grape buds become endodormant, chilling may be necessary to terminate their rest (Lavee, 1984).

Since significant budbreak can occur in the absence of chilling (Dokoozlian et al., 1995), chilling should be considered a facultative rather than an absolute requirement for grapevine growth. Chilling facilitates commercial production by increasing total budbreak and accelerating the rate of budbreak. When chilling exposure during the dormant period is inadequate, appropriate dormancy-breaking treatments are necessary to assure commercially viable grape production (Lavee, 1984). The minimum level of budbreak necessary for commercial grape production varies with cultivar, region, and growing conditions. In the Coachella Valley of California, based on normal bud fruitfulness and anticipated fruit development, 75% total budbreak is considered necessary to achieve adequate yields (Neja et al., 1994; Wicks et al., 1984). In this and other desert table-grape growing regions, where early fruit maturity is an important objective, rate and uniformity of budbreak should also be considered when evaluating vine response to chilling exposure. While exposure to 200 h between 0 and 10 °C resulted in commercially acceptable levels of budbreak in this study, budbreak continued to improve as chilling duration was increased up to 800 h. This fact should be considered when evaluating chilling exposure in regions where early budbreak and fruit maturation are desired.

Additional work is needed to better understand how chilling exposure interacts with other environmental parameters and cultural practices to influence grape bud growth. In the current study, chilling was applied continuously without interruption by warm temperatures. As shown in several deciduous fruit species, accumulated chilling can be negated by temperatures ≥20 °C (Erez et al., 1979). The importance of this phenomenon to grape buds, commonly referred to as chilling negation, is unknown. Interactions between chilling exposure and photoperiod, as well as time of pruning, also deserve more attention.

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