Management of Dormant Sprays by Chill Accumulation in Bartlett Pear

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Summary:

- A temperature gradient down the rows affected bloom and fruit development such that untreated controls at either end of treatment groups tended to show a range of response. The warmer end bloomed earlier, but also had more than six- times higher inflorescence bud death in some rows as a result of freezing temperatures.

- **CAN17 + Entry:** Considerable inflorescence bud expansion was observed by 9 March, with numerous inflorescences expanded, in the earliest treatment (23 Dec, 30 chill portions, CP). The CAN17 treatment group was more advanced in inflorescence and vegetative bud expansion than any other treatment group, however, more dead buds were seen in this group as well, indicative of the damage sustained by freezing temperatures in mid-February. As a result of greater susceptibility to freeze damage due to advanced bud expansion, normal bloom and crop were eradicated in the CAN treatment group. Type I rat tail blooms were not killed, as they developed later than the primary bloom.

- **Defoliation:** Earliest defoliation on 26 Oct, 0 CP, delayed bloom development. Defoliation on 3 Nov, 2 CP tended to advance bloom. Fruit weight and firmness were greatest in the trees defoliated on 26 Oct; proportion of the crop that was #1 fruit was greatest. This defoliation resulted in a reduction of the crop, by reduction of #2 fruit by approximately 50%.

- **Dormant Plus oil:** Dormant oil tended to delay inflorescence and flower opening, but not full bloom date. Treatment location within the row appeared to affect fruit size, weight and firmness more than treatment, based on untreated fruit at either end of treatment group. Dormant oil tended to reduce crop load with the greatest reduction in the 23 Dec, 30 CP treatment, which also reduced the proportion of #1 fruit significantly, as well as estimated total yield. Soluble solids were least in this treatment, indicating maturity delay.

- **EvenBreak + BreakThru:** Bloom tended to be delayed by EvenBreak, a modified CAN product designed to be applied 3-4 weeks before bloom for rest-breaking. Crop load was reduced by EvenBreak by reduction of #1 fruit, resulting in an estimated 43% reduction in yield of #1 fruit and a 34% reduction in estimated total yield.

- In a separate trial located adjacent to this trial, CPPU (synthetic cytokinin; Prestige, Valent BioSciences) applied at petal fall + 2 weeks doubled the percentage of the crop that was #1 fruit, significantly increased weight of both #1 and #2 fruit, and advanced maturity based on soluble solids. Effects appear to be due to both thinning of the crop at both post-bloom timings (petal fall + 2 weeks and petal fall + 4 weeks) and a direct effect on size increase during Stage I growth. This trial was supported by the registrant of CPPU (KIM-C1, Fresno, CA) and was limited in scope. These results, however, are consistent with cytokinin action and other trial results in apple, almond, and prune.

Problem and Its Significance:

Pear growers in the Sacramento River Delta, and to some extent, other pear-growing areas in California, use dormant oils for pest control and dormant bud growth stimulation. It is generally believed that well-timed applications can advance flowering, improve uniformity of flowering and fruit ripening overall, as well as time of fruit ripening. "Delayed foliation" or irregular bud break caused by inadequate winter chilling results in lower yields in the long term, poor tree architecture, less uniform fruit size and makes other orchard management practices (such as pest control) more difficult. Traditionally, dormant oils have been applied in early to mid-January based on experience and calendar date. However, bud development and full bloom dates may differ from year to year with variable weather cycles and chill accumulation experienced by the plant. With our trials in sweet cherries testing dormant oils and other rest-breaking chemicals, we found that the traditional calendar date model led to year-to-year variation in response that did not support bloom phenology well. In order to better time applications and control variation in flowering response, we investigated various models based on chill accumulation. Based on nearly 10 years experience with chill accumulation mathematical models and rest-breaking agents in sweet cherry, we determined that the Dynamic Model (Fishman et al., 1987) using chill portions (CP) to identify effective spray timing of rest-breaking sprays significantly reduced variation in response compared to the same accumulated chilling when calculated as chill hours.

Using calendar date (e.g. November 1) to 'start the clock' for annual chill accumulation is arbitrary. The Dynamic Model indicates the start of chill accumulation when temperatures are consistently cold enough, long enough, to form 'chill portions'. Testing the 'onset of dormancy' by experimental methods such as bud-forcing and defoliation, should be used along with rest-breaking treatments to validate the effectiveness of a chill model. One method of testing stage of dormancy is by forcing excised shoots; buds will break at varying rates or in varying amounts (e.g. 25, 50, 100% bud break) depending on how much chilling has accumulated. A second method is by defoliating trees. If defoliation occurs too soon, trees have not accumulated sufficient reserves and are not dormant—bloom delay tends to occur or trees will resume growth prior to dormancy altogether. If defoliation occurs at the start of dormancy, the amount of chilling required to break dormancy is reduced (depth of dormancy is reduced) and bloom occurs earlier (Lloyd and Firth, 1990)..

Rest-breaking agents are being used on different crops with variable success. A number of factors appear to be contributing to the variation in response with the use of rest-breaking agents. Different cultivars, as well as different crop species, have different chilling requirements and therefore appear to respond somewhat differently to rest-breaking chemicals, concentrations of those chemicals, and time of application by season. Other sources of variation include the activity of the chemical rest-breaking agent used, the concentration and method of application (i.e. carrier volume used per acre). In sweet cherry in California, we found that chemical defoliants applied at concentrations lower than used for rapid defoliation advanced and compressed bloom and tended to increase fruit set. Treatment at approximately 3 CP gave the best 'rest-breaking' response. In 2005 we began rest-breaking treatments in 'Bartlett' pear; 2% Volck Supreme oil advanced opening of both inflorescences and individual flower buds of >Bartlett= pear when applied in late December (41 CP) and mid-January (63 CP). Fruit size (diameter and weight) of #1 fruit was increased, %undersized fruit was greatly reduced, a trend toward thinning was found, without reduction in total yield.

2005-2006 Objectives:

<u>Experiment 1</u>: Determination of dormancy onset ('start of chill accumulation')

Apply chemical defoliants to single tree replicates beginning mid-October and ending mid-November and/or force excised shoots beginning mid-October and ending mid-December.

Experiment 2: Use of the Dynamic Model and rest-breaking treatments to advance and tighten bloom. At regular chill portion intervals apply dormant oil, CAN17 and EvenBreak (modified CAN product). Test the Dynamic Model with temperature data for calculation of chill portions and evaluate the calculated results with respect to bud break and flowering behavior in Bartlett pear. Evaluate fruit set and fruit quality in response to treatments.

1. 4% Dormant Plus® emulsifiable oil (UAP; upper label concentration)

2. EvenBreak® + Break-thru® (nonionic surfactant), single treatment at 1 to 3 weeks before bud swell. EvenBreak is a modified CAN17 product (Western Farm Service) developed for late application. This product purportedly does not advance bud break but acts to 'tighten' bloom.

3. CAN17 + Entry (nonionic surfactant)

Plans and Procedures: 2005-2006,

Site location, temperature data and plant material:

Chill accumulation was calculated from hourly temperature data from two WatchDog Model 110-Temp 8K (Spectrum Technologies, Inc.) data loggers placed in our treatment site (Joe Green Ranch on Lambert Road, Courtland; Figure 1). The experimental site was near Courtland and consisted of approximately 40-year old >Bartlett=/=Winter Nelis= trees planted on a 10'x19' spacing and microsprinkler-irrigated. A temperature gradient down the rows from northwest to southeast has been reported by the grower. As this can affect bloom and fruit development, we placed untreated controls at either end of treatment groups whenever treatment groups included more than a single chemical treatment to evaluate a range of response.

Unseasonably warm days/warm nights and warm days/cold nights in early February were followed by several days of cold days and sub-freezing night time temperatures (Figure 2).

Table 1: Treatment list

Experiment 1: Defoliations

1% CuEDTA (RNA Corp) + 2% fertilizer-grade urea (Cheng et al., 2000; Dong et al., 2001; Guak et al., 2001; Guak and Fuchigami, 2002) were applied by orchard speed sprayer on 26 October, 3 and 10 November at 0, 2 and 4 CP, respectively. Defoliation occurred on treated trees before untreated controls. Response was by recording bud break, bloom progression, fruit development and cropping, as described below.

Experiment 2: Use of the Dynamic Model and rest-breaking treatments to advance and tighten bloom

4% Dormant Plus® emulsifiable oil, CAN17 + Entry and EvenBreak + BreakThru were tested for rest-breaking responses. Treatment applications were timed by the Dynamic model (Table 1) and chill portion accumulation. All treatments were applied with a commercial airblast sprayer at a volume of 100 gallons per acre to 6 single-tree replicates per treatment within a single row and treated trees within a treatment 'block' were separated from the next treatment by 2 guard trees. Treatment groups (CAN17 vs EvenBreak vs Dormant Plus oil) were placed in single rows by group and at least 1 guard row was between treated rows. Data was recorded from each treated tree, with inflorescences and flowers counted on 4 large limbs per tree, approximately in 4 quadrants, selected prior to inflorescence opening. Date of first open flower was recorded and bloom progression recorded as: percentage of inflorescences and flowers within inflorescences open beginning 30 March and ending 27 April, full bloom date (100% of all flowers in an inflorescence open), days to all inflorescences open, and days to all flowers open. Inflorescence bud expansion was observed beginning 9 March. Digital photographs were also used to document early stages of bloom and fruit development. Numbers of Type I rat tail blooms (side blooms appearing during and immediately after the primary bloom) were counted beginning 27 April and ending 18 May. Dead inflorescence buds were counted at the end of bloom.

Fruit were counted on the west half of each tree for estimation of crop load and yield was calculated from this number and the weight of 20 fruit selected at random from the counted half of the tree. This 20-fruit sample was used to determine percentage of undersized fruit (#2, less than 2 1/2" in diameter), and weight and diameter of a 10-fruit subsample was used to determine soluble solids, firmness, fruit size and weight of #1 fruit. Firmness was measured by UC pressure tester on opposite cheeks after removal of peel.

Statistical analyses:

Analyses of variance were performed with Proc GLM in SAS (SAS Institute Inc., Cary, NC) and mean separations tested by Duncan=s Multiple Range Test, $P = 0.05$, for all but the EvenBreak trial. All data was normal and did not require transformation (Adler and Roessler, 1964). EvenBreak treatment results were evaluated using two-sample *t*-tests.[1]

CPPU (2-chloro-4-pyridyl)-N'-phenylurea; Prestige, Valent BioSciences) trial:

Although this was a separate, privately-funded trial, it occurred contiguously with the 'dormancy' trial and is briefly reported here for comparison. Treatments of 10 ppm CPPU were applied at 2 and 4 weeks past petal fall and fruit evaluated as in this trial. The treatments were limited to two trees each, for crop destruct, and results are considered preliminary, yet consistent with those of other trials, albeit not in 'Bartlett' pear. Applications were made by mistblower to two single tree replicates per treatment, adjacent to each other, but separated from other treatments by guard trees. Fruit and cropping were evaluated as in the 'dormancy' trial.

Results and Discussion:

Chill accumulation began on 27 October at the trial site, so that 1 chill portion had accumulated by November 1, the traditional starting date of chill accumulation. An early warming trend followed by freezing temperatures resulted in widespread inflorescence bud death throughout the orchard (Fig. 2). This effect was most prominent in the CAN17 treatments, which showed the earliest budscale and bud expansion, signifying the greatest response to rest-breaking agents. Even when not fully-expanded, these buds were probably actively respiring and no longer fully dormant at the time of freezing temperatures, therefore, their susceptibility to the freeze was the greatest. This theory is substantiated by the next-higher death rates of buds in several control (untreated) trees at the SE end of the rows where the orchard was warmer and bloom was naturally advanced ahead of the NW end.

CAN17 + Entry**:** Considerable inflorescence bud expansion was observed by 9 March, with numerous inflorescences expanded, in the earliest treatment (23 Dec, 30 CP). The CAN17 treatment group was more advanced in inflorescence and vegetative bud expansion than any other treatment group. As a result of greater susceptibility to freeze damage, normal bloom and crop were eradicated in the CAN treatment

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[1]A two-sample *t*-test (also called an unpaired *t*-test) compares results from two treatments applied to different experimental units while a paired *t*-test evaluates subjects that have each received both treatments at differing times.

group, however, rat tail flowers bloomed later and were neither killed by CAN17 nor by the freezing conditions which affected more-advanced primary bloom.

Bloom progression:

Defoliation**:** No statistically significant differences were found among treatments with respect to rate of inflorescence or flower opening except on Apr 17 and 20 (Fig. 3). Earliest defoliation on 26 Oct, 0 CP, delayed bloom development and that of 3 Nov, 2 CP, tended to advance inflorescence and flower opening. Date of first flower open and days from first flower open to all inflorescences or flowers open was not clearly affected by defoliation treatments (Table 2). Full bloom dates were not affected by treatment.

Dormant Plus oil: Dormant oil tended to delay inflorescence and flower opening, but not full bloom date (Fig. 4; Table 3). Dates of first flower and of all inflorescences open appeared to be affected more by position within the row, northwest to southeast, than by a clear treatment effect., however, the number of days from start to finish of bloom was least in the dormant oil treatments ('days from first flower').

EvenBreak + BreakThru**:** Bloom tended to be delayed by EvenBreak, a modified CAN product designed to be applied 3-4 weeks before bloom for rest-breaking (Fig. 5; Table 4). Numerically, EvenBreak reduced the period of bloom ('days from first flower'); bloom compression such as this has been the advertised result of this product's use.

Inflorescence bud death and rat tail bloom production:

Defoliation: Bud death appeared to be influenced more by position within the row, northwest to southeast, than by a clear treatment effect (Table 5). Rat tail bloom production was slightly decreased by defoliation at 2 CP.

Dormant Plus Oil: No significant differences were found in bud death (Table 6); rat tail production was reduced by treatment at 43 and 54 CP.

EvenBreak + BreakThru**:** No significant differences were found in bud death or rat tail production (Table 7).

Cropping and fruit quality

Fruit diameter was unaffected by defoliation (Table 8), but fruit weight tended to be increased by the earliest defoliation. If a real effect is indicated, it would appear that nitrogen resources absorbed prior to chill accumulation may have accounted for improved fruit weight. Firmness was also greatest in this fruit, indicating that a delay in maturity may also have resulted. If minimum fruit size for #1 fruit was achieved earlier, an earlier harvest might be indicated, with greater firmness for improved storage.

Dormant oil applications did not result in clear effects on fruit diameter or weight (Table 9). Firmness as an indicator of maturity decreased with position toward the southern and warmer end of the row. It is doubtful that oil applications, therefore, induced early maturity as was found in two Volck oil application timings in the 2005 trial.

EvenBreak applications did not affect fruit size or firmness (Table 10).

Defoliation prior to chill accumulation (26 Oct, 0 CP; Table 11) resulted in a reduction of the crop, by reduction of #2 fruit, of approximately 50%. The response was due to a thinning effect with reduction in fruit number per half tree of 34%. Estimated yield of #1 fruit was not reduced, however, that of #2 fruit was reduced without significant reduction in total estimated yield. Soluble solids were not different among treatments.

Dormant oil tended to reduce crop load with the greatest reduction in the 23 Dec, 30 CP treatment, which also reduced the proportion of #1 fruit significantly, as well as estimated total yield (Table 12). Soluble solids were least in this treatment, showing a delay in maturity. The untreated control at the SE end had the highest number of fruit, lowest percentage of crop = #1 fruit, the highest estimated #2 yield, indicating a positional effect of warmer temperature at bloom (which was a very cold period in 2006, leading to a protracted bloom). Thus, an overset occurred, reducing the number of #1 fruit to about 33% of the total crop.

EvenBreak reduced the number of fruit per half tree, by reducing the percentage of the crop that was #1 fruit (Table 13).

In a separate trial located adjacent to this trial, CPPU (synthetic cytokinin; Prestige, Valent BioSciences) applied at petal fall + 2 weeks doubled the percentage of the crop that was #1 fruit, significantly increased weight of both #1 and #2 fruit, and advanced maturity based on soluble solids (Table 14). Effects appear to be due to both thinning of the crop at both post-bloom timings (petal fall + 2 weeks and petal fall + 4 weeks) and a direct effect on size increase during Stage I growth (Table 15). This trial was supported by the registrant of CPPU (KIM-C1, Fresno, CA) and was limited in scope. These results, however, are consistent with cytokinin action and other trial results in apple, almond, and prune.

Overall, position in the orchard may have affected bloom and cropping as much as did any particular rest-breaking treatment. It was not possible to position all treatment groups in either the cold area, nor the warm area of the orchard, which would have necessitated working across rows—impractical for orchard sprayers. Nor was it possible to time applications by chill accumulation differently for the cold vs warm parts of the orchard. Freezing temperatures exacerbated damage to buds and advance in bud development by CAN17, clearly the greatest advance based on visual evaluation, made it impossible to evaluate cropping, rat tail production and bloom compression by this potent rest-breaking agent.

Direct treatment effects on fruit set were difficult to detect, possibly because greatest advance in bud development resulted in greatest bud death, while bloom compression may have reduced fruit set during the cold bloom period; pollen tubes take longer to grow to the ovule in cold conditions and ovules abort before becoming fertilized. Thus, direct effects on yields and fruit quality were also more difficult to measure.

Conclusions:

We can conclude that defoliation prior to measurable chill portion accumulation delayed bloom while defoliation just after measurable CP accumulation started reduced the chill requirement, as postulated by Lloyd and Firth (1990). This substantiates the use of the Dynamic Model as a way to measure onset of chill accumulation and dormancy. Defoliation prior to rest improved fruit size and firmness, while thinning the least desirable fruit. This may be a tool to manage harvest timing and reduce the number of picks while reducing cullage.

Timing of dormant oil application for bloom and crop load management does appear to depend on the amount of chilling accumulated, not calendar date. Oil applied on 20 Dec in 2005 (41 CP) advanced bloom and improved fruit size, while application on 23 Dec in 2006 (30 CP) had the opposite effect. The oils used were different in the two years of testing, however; Dormant Plus oil will be retested in 2006-2007 dormant season.

EvenBreak does not appear to have a beneficial effect in pear; CAN17 should be retested at reduced rates so as to reduce the risk of pushing bloom into a frost-prone period.

We wish to acknowledge the support of the California Pear Advisory Board and the cooperation of the Joe Green Ranch and Chris Frieders, Manager.

Selected references:

Allan, P. (1999) Measuring winter chilling in areas with mild winters. Decid. Fruit Grow. 49: 1-6.

Cheng, L, S. Dong, P. Ding, and L. H. Fuchigami. 2000. Effects of copper chelate in combination with foliar urea on defoliation and reserve nitrogen levels of apple nursery trees with different background nitrogen status. HortScience 35(3).

Couvillon, G.A., And Erez A. (1985) Effect of level and duration of high temperatures on rest in the peach. J. Amer. Soc. Hort. Sci. 110:579-581.

Dennis, F. G. (2003) Problems in standardizing methods for evaluating the chilling requirements for the breaking of dormancy in buds of woody plants. HortScience 38(3):347-350.

Dong, S., L. Cheng, and L. H. FuchigamI. 2001. Effects of foliar urea application on reserve N and growth performance of 'Bartlett' young pear trees. HortScience 36.14.

Erez, A., And Couvillon G.A. (1987) Characterization of the influence of moderate temperatures on rest completion in peach. J. Amer. Soc. Hort. Sci. 112:677-680

Erez, A., Couvillon G.A., And Hendershott, C.H. (1979) Quantitative chilling enhancement and negation in peach buds by high temperatures in a daily cycle. J. Amer. Soc. Hort. Sci.104: 536- 540.

Erez, A., And Fishman S. (1997) The Dynamic Model for chilling evaluation in peach buds. 4th Peach Symposium. Acta Hort. 465: 507-510.

Erez, A., Fishman S., Gat Z., And Couvillon G.A. (1998) Evaluation of winter climate for breaking bud rest using the dynamic model. Acta Hort. 232: 76-89.

Fishman, S., Erez, A., And Couvillon G.A., (1987). The temperature dependence of dormancy breaking in plants: Two-step model involving a co-operation transition. J. Theor. Bio. 124: 437-483.

Guak, S., L. Cheng and L.H. Fuchigami. 2001. Foliar urea pretreatment tempers inefficient N recovery resulting from copper chelate (CuEDTA) defoliation of apple nursery plants. J. Hort. Sci and Biotech. 76(1):35-39.

Guak, S. and L.H. Fuchigami. 2002. Foliar applications of urea or ABA affect growth cessation, leaf senescence and abscission, cold acclimation, and levels of reserve nitrogen and carbohydrates in nitrogen-treated apple nursery plants. Journal of Horticultural Science and Biotechnology 77(2):137-142.

Lloyd, J. and D. Firth. 1990. Effect of defoliation time on depth of dormancy and bloom time for low-chill peaches. HortScience 25: 1575-1578.

Table 1. Treatments applied to 'Bartlett' pear 2005-2006 dormant season by orchard sprayer, Courtland, Sacramento County, CA. Treatments shown by Dates of application and chill portion accumulation[x] (CP) based on temperatures recorded hourly on site in trial orchard; data logger located at northwest (NW) end of orchard; untreated controls at both ends of treated row for temperature gradient effect. Treatments applied to block of 6 trees per treatment date, arranged within a single row per treatment group with timings successive down row from northwest to southeast.

25% CAN17 + 2% Entry (Wilbur Ellis)	**4% Dormant Plus oil (UAP)**
Control NW	Control NW
23 Dec (30)	23 Dec (30)
29 Dec (34)	29 Dec (34)
9 Jan (43)	9 Jan (43)
25 Jan (54)	25 Jan (54)
Control SE	Control SE
Defoliation = 1% CuEDTA + 2% urea	**1% EvenBreak + 6 oz. Break-Thru/**
Control NW	Control NW
26 Oct (0)	25 Jan (54)
3 Nov (2)	
10 Nov (4)	
Control SE	

[x] Calculated from the Dynamic Model (Fishman et al., 1987).

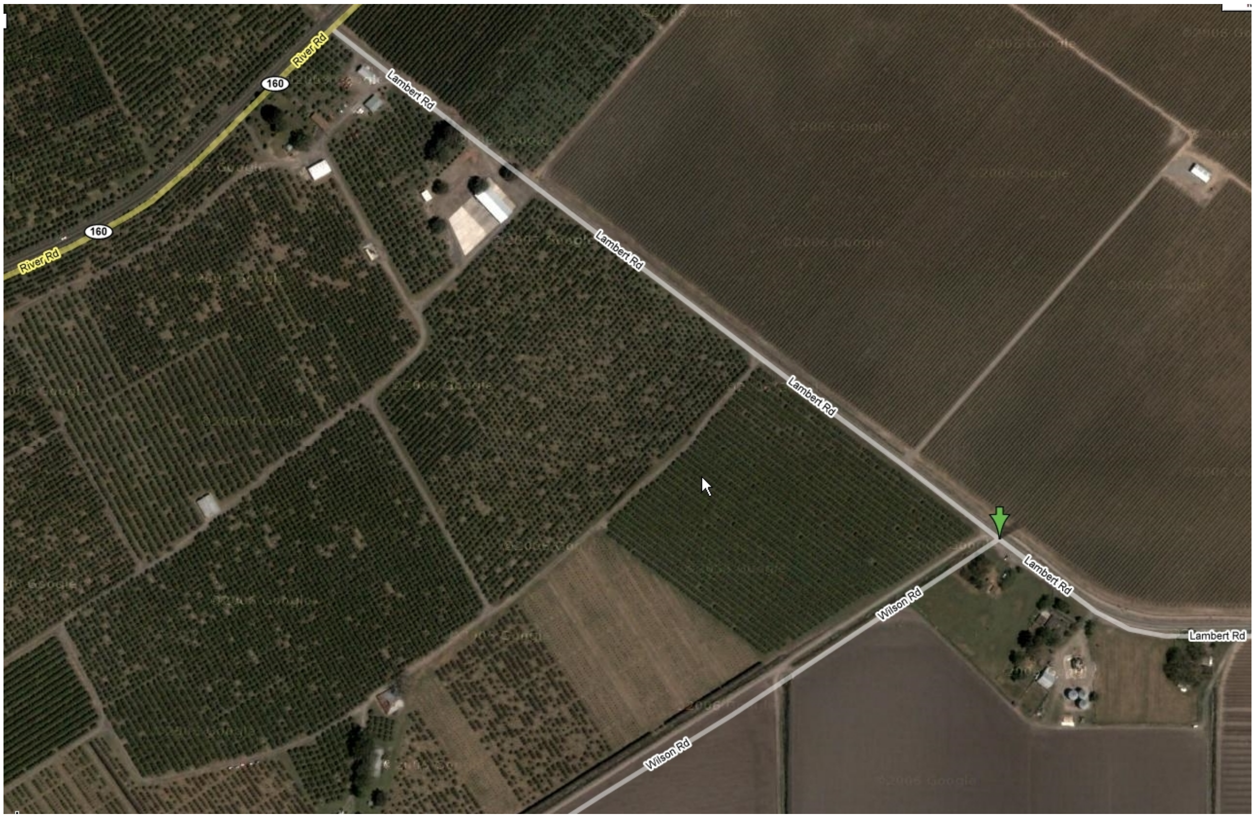


Figure 1. Location of trial orchard near Courtland, Sacramento County, CA on Lambert Road between River Road (Hwy 160) and Wilson Road. Trial site within orchard indicated in lower middle by arrow pointing in northwesterly direction, approximating the position of the data logger.

Figure 2. Temperature pattern during 2006 dormant period (daily minimum and maximum air temperatures; chill portions calculated by the Dynamic Model (Fishman et al., 1987).

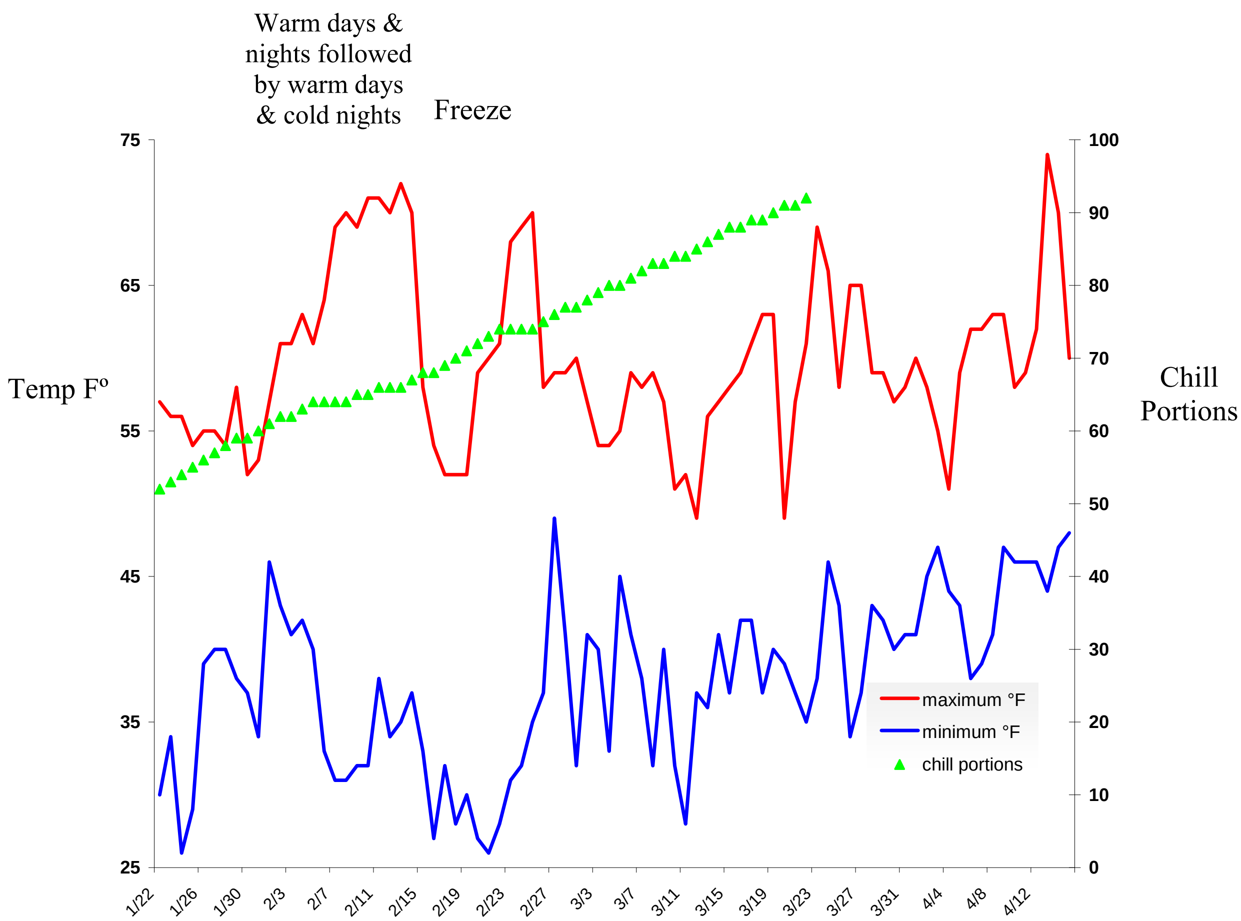


Table 2. Effect of defoliation[z] applied to'Bartlett' pear at 3 timings in 2005 on bloom progression, Courtland, Sacramento County, California. Chill portions [y] (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard; untreated controls at both ends of treated row for temperature gradient effect.						
Treatment timings (CP)	Order down row (northwest to southeast)	Date of first flower open	Date all inflorescences open	Full bloom date (all flowers open)	Days from first flower to	
					all inflorescences open	full bloom
Control NW	1	9 Apr b[x]	25 Apr	25 Apr	15.6 a	15.9 a
26 Oct (0)	2	16 Apr a	26 Apr	27 Apr	10.1 b	11.2 b
3 Nov (2)	3	9 Apr b	25 Apr	26 Apr	15.4 a	16.3 a
10 Nov (4)	4	11 Apr ab	25 Apr	27 Apr	13.3 ab	14.5 ab
Control SE	5	14 Apr a	25 Apr ns	25 Apr ns	10.5 b	11.0 b

[x] Mean separation within columns by Duncan's Multiple Range Test, *P* = 0.05.; ns = not significant

.[y] Calculated from the Dynamic Model (Fishman et al., 1987).

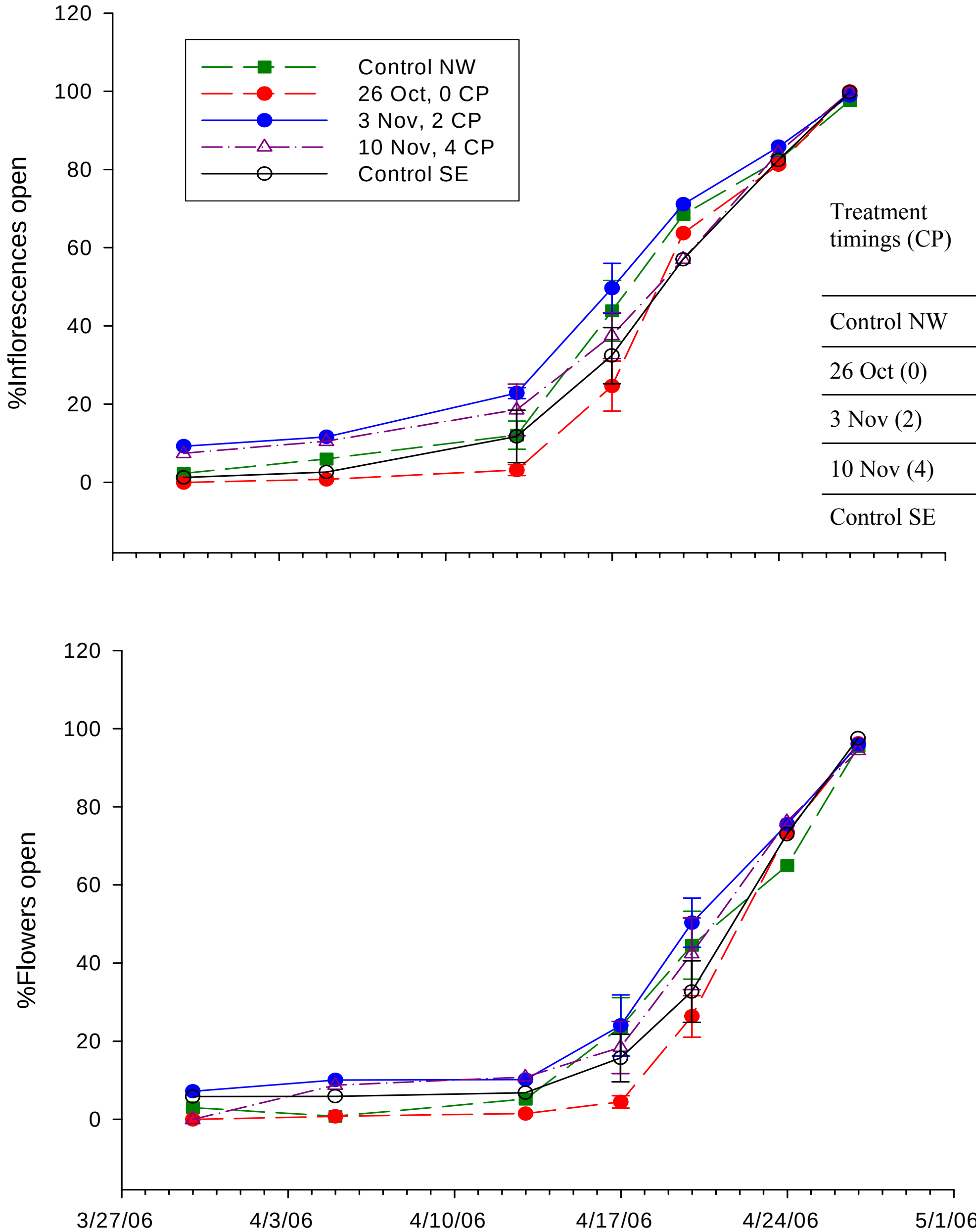
[z] 1% CuEDTA + 2% urea u per 100 gallons water per acre applied by orchard sprayer.

Table 3. Effect of 4% Dormant Plus oil applied to'Bartlett' pear at 4 timings 2005-2006 on bloom progression, Courtland, Sacramento County, California. Chill portions [y] (CP) are based on temperatures recorded hourly on site in trial orchard; untreated controls at both ends of treated row for temperature gradient effect.						
Treatment timings (CP)	Order down row (northwest to southeast)	Date of first flower open	Date all inflorescences open	Full bloom date (all flowers open)	Days from first flower to	
					all inflorescences open	full bloom
Control NW	1	12 Apr bc [x]	24 Apr ab	25 Apr	12.7 a	13.6 ab
23 Dec (30)	2	18 Apr a	26 Apr a	27 Apr	8.6 b	9.4 b
29 Dec (34)	3	14 Apr b	25 Apr ab	25 Apr	11.5 ab	11.4 b
9 Jan (43)	4	15 Apr ab	25 Apr ab	26 Apr	10.5 ab	11.4 b
25 Jan (54)	5	18 Apr a	26 Apr a	27 Apr	8.0 b	9.7 b
Control SE	6	9 Apr c	23 Apr b	26 Apr ns	14.4 a	17.6 a

[x] Mean separation within columns by Duncan's Multiple Range Test, *P* = 0.05.; ns = not significant.

.[y] Calculated from the Dynamic Model (Fishman et al., 1987).

Figure 3. Effect of defoliation with 1% CuEDTA + 2% urea (100 gallons water/acre) on bloom progression in 'Bartlett' pear, 2006 . Standard errors shown for dates with significant differences only.



Treatment timings (CP)	%Inflorescence buds open	
	17 Apr	20 Apr
Control NW	12.1 ab	43.9 ab
26 Oct (0)	3.2 b	24.7 b
3 Nov (2)	22.9 a	49.7 a
10 Nov (4)	18.7 a	37.7 ab
Control SE	11.9 ab	32.6 ab

Figure 4. Effect 4% Dormant Plus oil on bloom progression in ‘Bartlett’ pear, 2006 . Standard errors shown for dates with significant differences only.

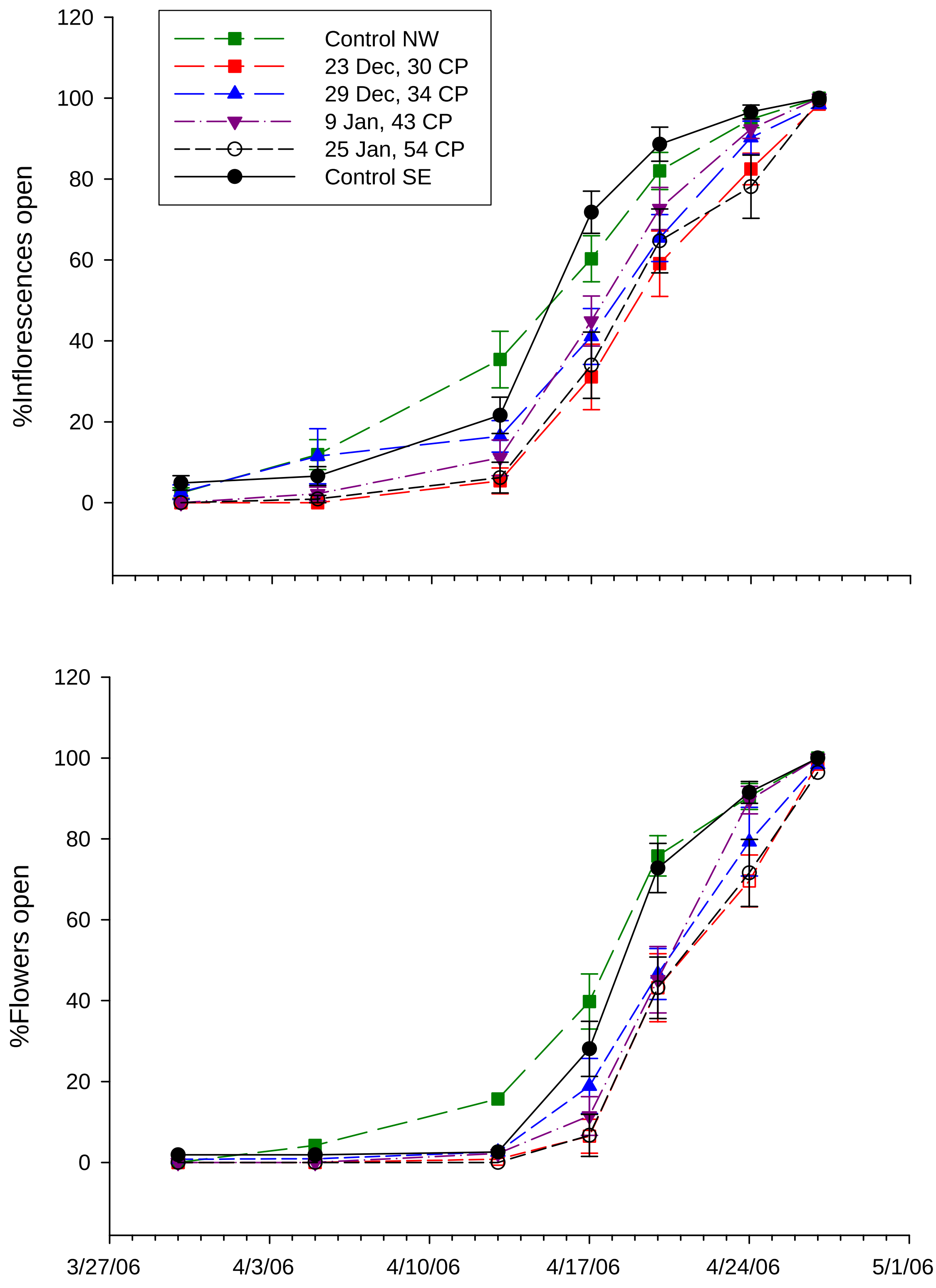


Table 4. Effect of EvenBreak + BreakThru [y] applied to'Bartlett' pear on 25 Jan (54 chill portions) on bloom progression, Courtland, Sacramento County, California. Chill portions are based on temperatures recorded hourly on site in trial orchard..					
Treatment timings (CP)	Date of first flower open	Date all inflorescences open	Full bloom date (all flowers open)	Days from first flower to	
				all inflorescences open	full bloom
Control NW	14 Apr[x]	24 Apr	26 Apr	9.8	11.7
EvenBreak + BreakThru	16 Apr ns	23 Apr ns	26 Apr ns	6.4 ns	9.8 ns

[x] Mean separation by Student's t-Test, P = 0.05; ns = not significant.

[y] 1 gallon EvenBreak + 6 oz. Break-Thru per 100 gallons water per acre applied by orchard sprayer.

Figure 5. Effect of EvenBreak + BreakThru on bloom progression in 'Bartlett' pear, 2006 . Standard errors shown for dates with significant differences only.

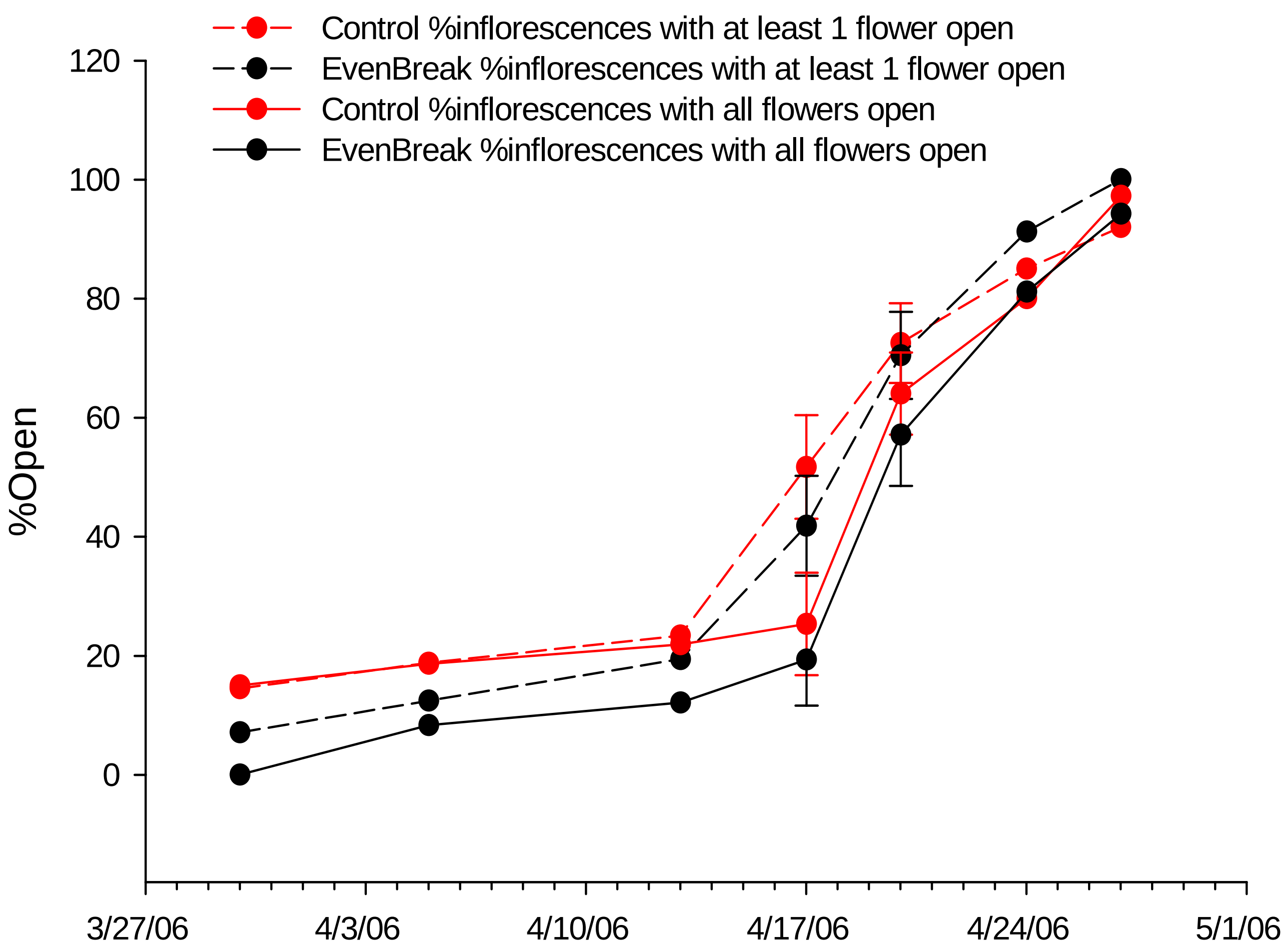


Table 5. Effect of defoliation [z] applied to'Bartlett' pear at 3 timings in 2005 on inflorescence bud death and rat tail bloom production, Courtland, Sacramento County, California. Chill portions (CP; Dynamic Model; Fishman et al., 1987) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.			
Treatment timings (CP)	Order in row, NW to SE	%Dead inflorescence buds	#Rat tail blooms/shoot produced 27 April-18 May
Control NW [x]	1	2.5 b [y]	2.1 ab
26 Oct (0)	2	8.1 ab	1.2 ab
3 Nov (2)	3	6.7 b	1.0 b
10 Nov (4)	4	16.0 a	2.6 a
Control SE	5	16.4 a	1.9 ab

[x] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[y] Mean separation within columns by Duncan's Multiple Range Test, *P* = 0.05.; ns = not significant
[z] 1% CuEDTA + 2% urea per 100 gallons water per acre applied by orchard sprayer.

Table 6. Effect of 4% Dormant Plus oil applied to'Bartlett' pear at 4 timings 2005-2006 on inflorescence bud death and rat tail bloom production, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.			
Treatment timings (CP)	Order in row, NW to SE	%Dead inflorescence buds	#Rat tail blooms/shoot produced 27 April-18 May
Control NW [x]	1	3.3 [y]	2.2 a
23 Dec (30)	2	4.4	2.0 ab
29 Dec (34)	3	7.2	2.2 a
9 Jan (43)	4	2.9	1.4 ab
25 Jan (54)	5	0.7	0.9 b
Control SE	6	0 ns	2.6 a

[x] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[y] Mean separation within columns by Duncan's Multiple Range Test, *P* = 0.05.; ns = not significant

Table 7. Effect of EvenBreak + BreakThru [y] applied to'Bartlett' pear on 25 Jan (54 chill portions) on inflorescence bud death and rat tail bloom production, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.			
Treatment timings (CP)	Order in row, NW to SE	%Dead inflorescence buds	#Rat tail blooms/shoot produced 27 April-18 May
Control NW	1	22.1 [x]	1.9
EvenBreak + BreakThru	2	15.9 ns	2.2 ns

[x] Mean separation by Student's t-Test, P = 0.05; ns = not significant.
[y] 1 gallon EvenBreak + 6 oz. Break-Thru per 100 gallons water per acre applied by orchard sprayer.

Table 8. Effect of defoliation [z] at 3 timings in 2005 on individual fruit diameter, weight and firmness of #1 fruit (diameter ≥ 2.5") applied to'Bartlett' pear, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.				
Treatment timings (CP)	Order in row, NW to SE	Fruit diameter (inches)	Fruit weight (g)	Firmness (lb)
Control NW [x]	1	2.6 [y]	169.7 ab	16.9 bc
26 Oct (0)	2	2.7	175.9 a	17.3 a
3 Nov (2)	3	2.6	161.5 b	16.8 c
10 Nov (4)	4	2.7	166.4 ab	17.0 bc
Control SE	5	2.6 ns	161.8 b	17.1 ab

[x] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[y] Mean separation within columns by Duncan's Multiple Range Test, *P* = 0.05.; ns = not significant
[z] 1% CuEDTA + 2% urea u per 100 gallons water per acre applied by orchard sprayer.

Table 9. Effect of 4% Dormant Plus oil at 4- timings in 2005-2006 on individual fruit diameter, weight and firmness of #1 fruit (diameter ≥ 2.5”) applied to’Bartlett’ pear, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.				
Treatment timings (CP)	Order in row, NW to SE	Fruit diameter (inches)	Fruit weight (g)	Firmness (lb)
Control NW [x.]	1	2.6 [y]	170.2 a	17.3 a
23 Dec (30)	2	2.7	152.9 b	17.4 a
29 Dec (34)	3	2.7	172.2 a	16.5 a
9 Jan (43)	4	2.6	170.7 a	14.5 b
25 Jan (54)	5	2.6	165.7 a	13.2 c
Control SE	6	2.6 ns	153.1 b	13.0 c

[x.] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[y] Mean separation within columns by Duncan’s Multiple Range Test, $P = 0.05$.; ns = not significant

Table 10. Treatment effect on individual fruit diameter, weight and firmness of #1 fruit (≥ 2.5” diameter) by EvenBreak + BreakThru applied to Bartlett pear 25 Jan at 54 chill portions (CP); Courtland, Sacramento County, California. CP are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.			
Treatment	Diameter (inches)	Weight (g)	Firmness (lb)
Control NW	2.6[y]	169.2	16.4
EvenBreak + BreakThru [x]	2.6 ns	165.7 ns	16.1 ns

[x] 1 gallon EvenBreak + 6 oz. Break-Thru per 100 gallons water per acre applied by orchard sprayer.
[y] Mean separation by Student’s t-Test, P = 0.05; ns = not significant.

Table 11. Effect of defoliation [z] at 3 timings in 2005 on crop load, fruit size, soluble solids and yield components applied to'Bartlett' pear, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.									
Treatment timings (CP)	Order in row, NW to SE	#Fruit/half tree	%Crop = #1 fruit[y]	Estimated #fruit/tree		Estimated yield (kg)			%SS
				#1	#2	#1	#2	Total	
Control NW [w]	1	207.0 a[x]	48.0 b	198.7	215.3 a	51.4	22.8 a	74.1	11.2
26 Oct (0)	2	135.0 b	68.0 a	179.1	90.9 b	54.3	10.4 b	64.7	11.0
3 Nov (2)	3	159.8 ab	61.0 ab	193.5	126.0 b	52.6	14.0 ab	66.6	10.6
10 Nov (4)	4	178.2 ab	63.0 ab	229.0	127.6 b	64.5	14.1 ab	78.6	10.6
Control SE	5	192.8 ab	55.0 ab	207.2 ns	178.3 ab	55.1 ns	19.6 ab	74.7 ns	11.0 ns

[w] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[x].Mean separation within columns by Duncan's Multiple Range Test, $P = 0.05$.
[y]#1 fruit (≥ 2.5" diameter).
[z]1% CuEDTA + 2% urea per 100 gallons water per acre applied by orchard sprayer.

Table 12. Effect of 4% Dormant Plus oil at 4 timings in 2005-2006 on crop load, fruit size, soluble solids and yield components applied to'Bartlett' pear, Courtland, Sacramento County, California. Chill portions (CP) are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.									
Treatment timings (CP)	Order in row, NW to SE	#Fruit per half tree	%Crop = #1 fruit[z]	Estimated #fruit/tree		Estimated yield (kg)			%SS
				#1	#2	#1	#2	Total	
Control NW[w]	1	195.0 a [x]	52.0 abc	200.4 ab	189.6 ab	55.6 abc	21.4 ab	77.1 a	10.6 ab
23 Dec (30)	2	127.5 b	47.4 bc	118.9 c	136.1 b	31.2 d	14.8 b	46.0 b	9.8 b
29 Dec (34)	3	186.0 ab	68.0 a	253.4 a	118.6 b	74.4 a	13.2 b	87.6 a	10.3 ab
9 Jan (43)	4	182.5 ab	60.7 ab	218.9 ab	146.1 b	63.4 ab	14.4 b	77.7 a	11.1 ab
25 Jan (54)	5	176..8 ab	46.0 bc	155.0 bc	198.6 ab	41.3 bcd	22.8 ab	64.1 ab	10.5 ab
Control SE	6	214.2 a	34.0 c	146.1 bc	282.4 a	35.1 cd	30.7 a	65.8 ab	11.9 a

[w] Untreated controls placed at either end of treated trees for temperature gradient in orchard.
[x].Mean separation within columns by Duncan's Multiple Range Test, $P = 0.05$.
[y]#1 fruit (≥ 2.5" diameter).

Table 13. Treatment effect on crop load, fruit size, soluble solids and yield components by EvenBreak + BreakThru applied to Bartlett pear 25 Jan at 54 chill portions (CP); Courtland, Sacramento County, California. CP are based on temperatures recorded hourly on site in trial orchard; datalogger located at northwest (NW) end of orchard.								
Treatment	#Fruit per half tree	%Crop = #1 fruit[z]	Estimated #fruit/tree		Estimated yield (kg)			%SS
			#1	#2	#1	#2	Total	
Control NW	232.0 a[y]	63.0 a	292.3 a	173.6	83.4 a	19.4	102.8 a	11.3
EvenBreak + BreakThru[x]	178.5 b	50.0 b	175.4 b	181.6 ns	47.5 b	20.6 ns	68.0 b	10.3 ns

[x] 1 gallon EvenBreak + 6 oz. Break-Thru per 100 gallons water per acre applied by orchard sprayer.
[y]Mean separation by Student's t-Test, P = 0.05; ns = not significant.
[z] #1 fruit (≥ 2.5" diameter).

Table 14. Effects of 10 ppm CPPU applied at petal fall (PF) + 2 weeks or PF + 4 weeks (11 and 25 May, respectively) on ‘Bartlett’ pear in 2006: number of fruit per half tree, percentage of crop that is #1 fruit (≥ 2.5” diameter), weight of #1 and #2 fruit, estimated yields and soluble solids.								
	#Fruit per half tree	%Crop = #1 fruit	Weight (g)		Estimated yield (kg)			%Soluble solids
			#1 fruit	#2 fruit	#1 fruit	#2 fruit	total	
Control	262.2 a[x]	38.0 b	240.0b	105.5b	52.0a	33.7a	85.8a	11.4 a
CPPU 11 May	191.2 a	79.0 a	310.0a	117.5a	93.2a	9.5b	102.7a	11.8 a
CPPU 25 May	241.8 a	48.5 b	270.0b	112.5ab	63.4a	28.4a	91.8a	11.3 a

[x]Mean separation within columns by Duncan’s Multiple Range Test, *P* = 0.05.

Table 15. Effects of 10 ppm CPPU applied at petal fall (PF) + 2 weeks or PF + 4 weeks (11 and 25 May, respectively) on ‘Bartlett’ pear in 2006: individual fruit diameter, weight and firmness of #1 fruit (≥ 2.5” diameter).			
	Fruit diameter (cm)	Fruit weight (g)	Firmness (lb)
Control	2.60b[x]	155.5b	17.6a
CPPU 11 May	2.68a	172.8a	16.6b
CPPU 25 May	2.65ab	165.7a	16.7b

[x]Mean separation within columns by Duncan’s Multiple Range Test, *P* = 0.05.