Use of the Dynamic Model and chill portions to time chemical rest-breaking treatments in 'Bing' sweet cherry, 2005

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Summary:

4% Dormex + 0.5% AgriDex (v/v) applied on January 5 at 49 chill portions (calculated from the onset of chill accumulation by the Dynamic Model) advanced bloom 11 days earlier than the untreated control, and full bloom was advanced 5 days earlier than the control. No significant difference in truss bud death compared to the control was found with this treatment. Bloom period from 'first flower' to full bloom with this Dormex treatment was 16 days; that of the control was 9 days. On May 17, first harvest, 90% of fruit for the earliest Dormex treatment was dark red or mahogany, compared to 60% for the control. All fruit for this Dormex treatment were of marketable color at this date, while 10% of the control fruit were straw/pink. The next best Dormex treatment (Jan 10, 54 chill portions by Dynamic Model) was almost as good as the Jan 5 treatment for bloom advance and fruit maturity. The last Dormex treatment (Jan 14, 57 chill portions by Dynamic Model) was applied too late when chill accumulation was calculated by onset of the Dynamic Model, and 82% truss bud death resulted. This was the only treatment that increased bud death. The earliest CAN17+Entry treatment (Jan 5) was similar to the second Dormex treatment for bloom and fruit maturity advance. All rest-breaking treatments advanced flowering compared to the control.

Chill accumulation was substantial prior to November 1, when calculated by the Dynamic Model. The difference between chill portions prior to Nov. 1 and the traditional timing of onset of accumulation (Nov. 1) was sufficient to move the last Dormex treatment into an application that was 'too late', based on high bud mortality. This result supports the practice of timing chill accumulation 'start' by the Dynamic Model, rather than by calendar date. We have re-examined recent years' results of dormancy-breaking spray trials in light of re-thinking the start of chill accumulation from the calendar date of November 1 to a timing set by the Dynamic Model, when it first shows chill portion accumulation. Additional testing is needed to validate this approach. We anticipate that this adjustment may better enable timing of rest-breaking chemical applications so as to avoid phytotoxicity and to obtain the best effect in bloom advance and compression, fruit maturity advance and synchronization, fruit set and reduction of floral (and vegetative) bud death.

Problem and Its Significance:

Use of rest-breaking chemicals in sweet cherry production has become widespread in California and those used include dormant oils, CAN17 + surfactants and Dormex. However, growers experience variable success with these treatments. In previous work, we found that truss bud break response in 'Bing' cherry trees elicited by Dormex and CAN17 sprays varied with spray timing and, in the case of the CAN17 sprays, the type of surfactant used. A number of factors appear to be contributing to the observed variation in response. In previous work, we identified and clarified some of these factors, including the differences in activity of the chemical rest-breaking agents themselves, the concentration and method of application (i.e. carrier volume used per acre) and spray timing. With respect to spray timing, we believe that a minimum amount of effective chill accumulation is required for a given cultivar before rest-breaking agents can be effectively applied and that this threshold may be an important indicator of when to spray. Since 2003 we have recommended use of the 'Dynamic Model' (Fishman et al., 1987 a,b) as a tool for assessing when to spray rest-breaking agents.

In the 2002-2003 dormant season, we found that the best results for bloom advance and compression after Dormex treatment occurred with chill accumulation of 48 chill portions (CP), accumulated from November 1 (53 CP from onset of Dynamic Model, see Table 2). Next best results with Dormex were found with application that year at 55 CP (59 CP, Dynamic Model). Best CAN17 results in that year were with treatment at 55 (59) CP as well. Fruit maturity was most advanced by Dormex at 48 (53) CP and CAN17 at 55 (59) CP. In this experimental season, we had timed applications to fall about 1 week apart, and subsequently observed effects in light of the chill accumulation that had accrued on those dates. In developing an overall historical review of many years of dormancy work, we proposed a pattern of chill accumulation that seemed to best fit our experimental results, and found that the Dynamic Model and the chill portions form of chill accumulation best described the experimental data. Thus, in the 2003-2004 dormant season, we timed treatments to fall at certain chill portion intervals to test our theory. In that year the best results fell at chill portion timings that were close to those of the previous year, substantiating our theory.

Objectives:

1. Integrate the use of the Dynamic model into California sweet cherry production
   - a. Validate by timing treatment sprays based upon the Dynamic Model and the chill hour model and calculate the amount of chilling accumulated with each model
   - b. Test the validity and usefulness of the model against different rest-breaking agents
2. Reduce the variation in response to rest breaking agents.

Materials and Methods:

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 and compared to the California Irrigation Management Information System (CIMIS) Lodi West Station 166 for calculations of chill hours and Dynamic Model chill portions. The experimental site was in Lodi on West Lane. This orchard produced its first large crop in 2004. We applied treatments to 12 trees within a row, using four rows (2 treatments per row with guard trees between treatments) and guard rows between treatment rows. Treatments included an unsprayed control, 4% Dormex + 0.5% Agri-Dex® (applied at intervals of 42, 47 and 50 CP calculated from November 1) and 25% v/v calcium ammonium nitrate (CAN17) + 2.0% v/v Entry® (applied at intervals of 42, 50 and 53 CP from November 1). Actual chill portion accumulation when measured by onset of the Dynamic Model was 49, 54, and 60. A single CAN17 treatment was inadvertently applied without Entry, on 10 January at 47 (54) CP. All treatments were applied with a commercial airblast sprayer at a volume of 100 gallons per acre.

Evaluation of flowering and bud death, fruit maturity:

Two limbs per each of replicate tree were randomly chosen prior to truss bud opening, each at opposite sides of the tree and in mid-canopy. Total numbers of truss buds were counted on the selected limbs and the numbers of truss buds with at least one flower open were recorded on February 28, March 3, 5, 7, 9, 11 and 13. Date of first flower open was recorded or estimated and full bloom date was recorded for each tree or estimated for each tree. Days from first flower open to full bloom were, thus estimated as well. Bud death was counted on March 14.

Fruit maturity was evaluated at time of first picking, on an overall treatment basis, estimating the percentage of each maturity color present.

Statistical analyses and chill model calculations:

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 percentage data arcsine transformation was made in order to meet ANOVA assumption of normality, although actual means were shown (Adler and Roessler, 1964). Chilling accumulation was calculated from hourly data and the Dynamic Model was used to calculate chill portions (Fishman et al., 1987; Erez et al., 1998, 1990).

Results and Discussion:

Effects on flowering:

Bloom progression was most advanced by treatment with Dormex + Agri-Dex applied on 5 January (42CP); first flower was open on 25 February and full bloom occurred on 12 March (Table 1). By the time the control changed from 0% to 20% of truss buds with at least one flower open (9 March), the best Dormex treatment was at 98% of truss buds with at least 1 flower open. Almost as good an advance was found with Dormex applied on 10 January at 47 CP, such that 94% of truss buds were in bloom on 9 March, and date of first flower open was 27 February, with full bloom on 12 March. Full bloom for the control occurred on 17 March. The best CAN17 + Entry treatment for bloom advance was applied on 5 January at 42 CP, with first bloom on 27 February and full bloom on 17 March. The CAN17 + Entry treatment applied on 14 January at 50 CP was almost as good. The CAN17 treatment applied on 10 January without Entry was not as good as any of the other CAN17 treatments in advancing bloom, but was better than the control.

Bloom compression, measured as days from first flower to full bloom was not decreased by any Dormex or CAN17 treatments, with the exception of the last Dormex treatment, however, one must take into account that ~82% of floral buds were killed by this treatment, so very few buds opened at all and this was not representative.

It appears, as we have observed in previous years, that rest-breaking treatments advance bloom, but that toward the end of bloom there is a 'catch-up' period when virtually all treatments, including the control, become close to full bloom. In the 2004-2005 season, chill accumulation was more than adequate, thus, no straggly, spread-out bloom occurred without rest-breaking treatments applied, as can happen in a low-chill year. Despite adequate chill accumulation, rest-breaking chemicals are useful to advance bloom.

Effects on floral bud death:

Floral bud death was very high (~82%) in the Dormex treatment applied at 50 CP (Table 1). We found ~19% of bud death occurred with the first Dormex treatment, but this was not statistically different from the control, which had ~11% bud death. In fact, no rest-breaking treatment caused bud death that was significantly different than the control except this 'late' Dormex treatment.

Effects on fruit maturity:

We found that fruit maturity was advanced by rest-breaking treatments with the best advance by Dormex treatments, followed by CAN17 + Entry treatments. However, effects of very light cropping, particularly with high bud death must be considered to have influenced maturity, thus actual percentages of fruit in given maturity classes are less reliable.

Re-evaluation of chill accumulation and recommendations for treatments:

This year's results show the best advancement of bloom were achieved by Dormex or CAN17 treatments applied at earlier CP chilling accumulations than observed in most of our earlier work. In the 2004-2005 season, however, chill accumulation timed by the Dynamic Model indicated that chill accumulation actually began well before November 1 and that 7 to 8 chill portions had already accumulated by November 1 (Table 3). When CP accumulations for the various treatment dates were corrected for this difference, we found that the best results for bloom advance and compression for 2004-2005 was with Dormex applied at 49 CP; Dormex applied at 54 CP almost as good. CAN17 + Entry applied at 49 CP was also almost as good as the first Dormex treatment in advancing bloom. Fruit maturity was advanced similarly. High phytotoxicity (bud death) resulted with Dormex applied at 57 CP. Thus, by starting CP accumulation at the onset of Dynamic Model chilling, rather than a calendar date of November 1, the best timings for this season agree with our previous results: Dormex is best applied within a 49-54 CP range and CAN17 between a wider range of 49-59 CP(Table 2).

As noted earlier, a high rate of bud death was observed in late-treated Dormex trees. There is much evidence in the literature that Dormex applications made too close to end of rest can cause phytotoxicity. If November 1 is used as the start of CP accumulation, one would expect the 50 CP timing of this treatment to be in a 'safe' range previously recommended (Southwick et al., 2003 CCAB report). Using a CP accumulation starting at the onset of chilling instead of November 1, however, this latest treatment was applied at 57 CP, outside the previously recommended safe range. Thus, like the effects on bloom and fruit maturity, the observed bud death adds support to the notion that rest-breaking treatments may be best timed from the onset of chill accumulation rather than a calendar date. This hypothesis warrants further study.

Conclusions:

4% Dormex + 0.5% AgriDex (v/v) applied on January 5 at 49 chill portions (calculated from the onset of chill accumulation by the Dynamic Model) advanced bloom 11 days earlier than the untreated control, and full bloom was advanced 5 days earlier than the control. No significant difference in truss bud death compared to the control was found with this treatment. Bloom period from 'first flower' to full bloom with this Dormex treatment was 16 days; that of the control was 9 days. On May 17, first harvest, 90% of fruit for the earliest Dormex treatment was dark red or mahogany, compared to 60% for the control. All fruit for this Dormex treatment were of marketable color at this date, while 10% of the control fruit were straw/pink. The next best Dormex treatment (Jan 10, 54 chill portions by Dynamic Model) was almost as good as the Jan 5 treatment for bloom advance and fruit maturity. The last Dormex treatment (Jan 14, 57 chill portions by Dynamic Model) was applied too late when chill accumulation was calculated by onset of the Dynamic Model, and 82% truss bud death resulted. This was the only treatment that increased bud death. The earliest CAN17+Entry treatment (Jan 5) was similar to the second Dormex treatment for bloom and fruit maturity advance. All rest-breaking treatments advanced flowering compared to the control.

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Table 1. Treatment effect on 2005 bloom progression, floral bud death, dates of first truss bud open (TBO) and full bloom (FB), and days from TBO to FB (days to full bloom; DTFB) by Dormex and CAN17 applied to 'Bing' sweet cherry 2005 in Lodi, San Joaquin County, California. Chill portions (CP)[y] are based on temperatures recorded hourly on site in trial orchard. Note: Jan 10 treatment with CAN17 was without Entry.

Treatment	Applied on	CP (Nov 1/ calculated from Dynamic Model	Bloom progression (%truss buds with flowers open)							%Floral bud death	TBO	FB	DTFB
			28 Feb	March									
				3	5	7	9	11	13				
Control			0.0b[x]	0.0c	0.0c	0.0c	20.4c	70.0b	97.6b	10.5bc	8 Mar a	17 Mar a	9.2d
4% Dormex + 0.5% Agri-Dex	Jan 5	42/49	18.7a	55.4a	73.2	91.4a	98.1a	99.6a	100a	19.4b	25 Feb e	12 Mar e	16.6a
	Jan 10	47/54	11.6a	54.2ab	73.2a	88.8a	94.3a	99.7a	99.7a	2.9c	27 Feb d	12 Mar e	13.4c
	Jan 14	50/57	0.0b	10.5c	28.1b	61.9b	90.0a	100a	100a	81.8a	4 Mar b	14 Mar d	7.6d
25% CAN17 + 2% Entry	Jan 5	42/49	15.5a	36.1ab	56.1a	71.6ab	90.2a	99.8a	100a	5.0c	27 Feb d	15 Mar c	15.7ab
	Jan 14	50/57	0.0b	33.4b	60.3a	76.6ab	95.1a	96.6a	100a	2.8c	28 Feb d	15 Mar c	14.7bc
	Jan 18	53/60	1.9b	10.8c	31.5b	55.6b	83.9a	95.1a	100a	2.0c	2 Mar c	16 Mar b	13.5c
25% CAN17 (no Entry)	Jan 10	47/54	0.0b	0.0c	0.2c	15.6c	57.0b	93.1a	100a	4.5c	6 Mar a	16 Mar b	9.3d

[x] Mean separation within columns by Tukey's, *P* = 0.05. Percentages transformed by arcsine; actual means are shown.
[y] Fishman et al., 1987.

Table 2. Treatment effect on 2005 fruit maturity (color) and crop load by Dormex and CAN17 applied to 'Bing' sweet cherry 2005 in Lodi, County, California. Estimation by visual evaluation on May 17. Chill portions (CP)[y] are based on temperatures recorded hourly on site in t Note: Jan 10 treatment with CAN17 was without Entry.

Treatment	Applied on	CP (Nov 1/ calculated from Dynamic Model	Crop load and percentage of fruit in each maturity (color) class				
			Cropload	Straw/Pink	Light red	Dark red	Mahogany
Control			moderate	10	30	40	20
4% Dormex + 0.5% Agri-Dex	Jan 5	42/49	very light		10	20	70
	Jan 10	47/54	moderate		30	50	20
	Jan 14	50/57	very light		30	50	20
25% CAN17 + 2% Entry	Jan 5	42/49	very light	10	10	30	50
	Jan 14	50/57	very light	10	30	40	20
	Jan 18	53/60	moderate	10	20	30	40
25% CAN17 (no Entry)	Jan 10	47/54	moderate	80	20		

Table 3. Comparison of three years results with respect to best dormancy treatments and timing of applications. Chill calculations for treatment dates: Lodi Station 0.1P (2002-03), San Joaquin County, California; 2003-04 and 2004-05 on-site data loggers.

Treatment most effective	Dormant season	Applied	Chill portions [x]		Best performance in			
			from Nov. 1	from onset with Dynamic Model	Bloom	Fruit set	Fruit maturity	Floral bud death
4% Dormex + 0.5% Agri-Dex	2002-03	21 Jan	48	53	best of all		best of all	no difference
		30 Jan	55	59		best (=CAN)		no difference
	2003-04	13 Jan	48	50	best		best	
		16 Jan	50	52	almost as good		best	
	2004-05	Jan 5	42	49	best		best	not significantly different from control (which was 11%)
		Jan 10	47	54	almost as good			
		Jan 14	50	57				worst (82%)
25% CAN17 + 2% Agri-Dex	2002-03	21 Jan	48	53		best (=Dormex)		no difference
		30 Jan	55	59	best of CAN		best of CAN	no difference
	2003-04	13 Jan	48	50	best		next best	
		16 Jan	50	52	almost as good		best	
	2004-05	Jan 5	42	49	best of CAN		best of CAN	not significantly different from control (which was 11%)
		Jan 14	50	57	almost as good			

[x] Fishman et al., 1987.

Table 4. Chill accumulation for 2004-2005 at selected sites (including experimental sites with dataloggers) and historic accumulation for Lodi West CIMIS station.

	Start date of CP accumulation	Chill portions cumulative						Chill hours cumulative					
Location		1-Nov	1-Dec	1-Jan	1-Feb	1-Mar	31-Mar	up to Nov 1	1-Dec	1-Jan	1-Feb	1-Mar	31-Mar
Nicolas CIMIS station	20 Sept (1 CP until Oct 20)	8	26	49	73	90	100	67	266	607	1082	1197	1285
Lodi, cherry leaf removal trial	19-Oct	7	25	48	73	87	94	68	284	636	1143	1285	1365
Lodi, cherry dormancy trial	20 Sept (1 CP until Oct 19)	8	27	48	71	88	96	64	219	531	873	1010	1096
Lodi West CIMIS station	20 Sept (1 CP until 20 Oct)	8	26	49	73	90	98	65	256	568	911	1048	1134
Linden, San Joaquin Weathernet	20 Sept (1 CP until Oct 19)	7	27	48	73	88	99	84	276	598	1021	1143	1225
Live Oak, San Joaquin Weathernet	20 Sept (1 CP until Oct 19)	7	27	48	73	89	97	65	256	578	1044	1188	1278
Lodi 0.1-P, San Joaquin Weathernet	20 Sept (1 CP until Oct 19)	8	26	49	73	90	98	81	287	617	1080	1233	1325
Lodi West CIMIS station 2000-1	11-Oct	5	Data is incomplete at this station for these years										
Lodi West CIMIS station 2001-2	22-Oct	1											
Lodi West CIMIS station 2002-3	18-Oct	5	20	41	61	78	90	105	297	567	806	1047	1194
Lodi West CIMIS station 2003-4	31-Oct	2	20	42	65	84	89	43	283	507	755	950	1005

Table 5. Chill portion (CP) accumulation evaluated for several years and sites in California.

1994-95 Hollister	CP	Date of first CP	1995-1996 Hollister	CP	Date of first CP	1996-97 Hollister	CP	Date of first CP
1 Nov	2	21 Oct	1 Nov	2	8 Oct	1 Nov	8	25 Sept
1 Dec	21		1 Dec	8		1 Dec	19	
1 Jan	43		1 Jan	25		1 Jan	35	
1 Feb	59		1 Feb	45		1 Feb	53	
1 Mar	73		1 Mar	54		1 Mar	71	
31 Mar	88		31 Mar	67		31 Mar	82	
1997-98 Morgan Hill	CP	Date of first CP	2003-04 Kettleman	CP	Date of first CP	2004-05 Kettleman	CP	Date of first CP
1 Nov	3	10 Oct	1 Nov	2	31 Oct	1 Nov	4	26 Oct
1 Dec	14		1 Dec	16		1 Dec	21	
1 Jan	36		1 Jan	35		1 Jan	43	
1 Feb	54		1 Feb	58		1 Feb	65	
1 Mar	73		1 Mar	75		1 Mar	80	
31 Mar	88		31 Mar	78		31 Mar	86	
2002-03 Lodi West	CP	Date of first CP	2003-04 Lodi West	CP	Date of first CP	2004-05 Lodi West	CP	Date of first CP
1 Nov	5	18 Oct	1 Nov	2	31 Oct	1 Nov	6	20 Oct
1 Dec	20		1 Dec	20		1 Dec	24	
1 Jan	42		1 Jan	42		1 Jan	45	
1 Feb	62		1 Feb	65		1 Feb	70	
1 Mar	79		1 Mar	84		1 Mar	85	
31 Mar	91		31 Mar	89		31 Mar	94	
Linden 1998-1999	CP	Date of first CP	Winters 1999-2000	CP	Date of first CP	Linden 2000-2001	CP	Date of first CP
1 Nov	3	25 Oct	1 Nov	0	9 Nov	1 Nov	6	11 Oct
1 Dec	21		1 Dec	12		1 Dec	27	
1 Jan	45		1 Jan	29		1 Jan	50	
1 Feb	66		1 Feb	51		1 Feb	73	
1 Mar	83		1 Mar	71		1 Mar	92	
31 Mar	100		31 Mar	80		31 Mar	99	