USE OF THE DYNAMIC MODEL AND APPLICATION OF REST BREAKING AGENTS IN CALIFORNIA PRUNE PRODUCTION, 2005

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Abstract

We evaluated the effects of dormant oil and CAN17 (calcium ammonium nitrate) on bud break and bloom progression in >French= prune in a commercial orchard in the area of Live Oak, CA. CAN17 + Entry (Wilbur-Ellis) applied at 59 and 63 chill portions (CP; chill accumulation units calculated by the Dynamic Model) on January 17 and 21, respectively, advanced and compressed bloom significantly compared to all other treatments. Most rest-breaking treatments improved fruit set and reduced reproductive bud death, compared to the control. Fruit set was 2.6% in the control and the CAN + Entry treatments that most advanced bloom each had 21.6% fruit set. The most effective oil treatments for advancing and compressing bloom were at the same timings as the best CAN17 treatments, although the oil treatments were somewhat less effective. All rest-breaking treatments advanced fruit maturity equally, compared to the untreated control, as measured by fruit firmness (lb pressure per square inch). Although chill hour (CH) calculations might also be used for timing these treatments, when chill portion and chill hour accumulations are compared for the 2004-2005 dormant season at several different sites, differences from site-to-site are small for chill portions, and much greater for chill hours. This fact supports experimental evidence from numerous trials in sweet cherry in which rest-breaking treatment timings based on the Dynamic Model tend to be more consistent than the timings based on the >chill hour= model. Chill accumulation prior to November 1 occurred, when the Dynamic Model was used to calculate chill portions. Similarly, chill hour accumulation, when calculated by the chill hour model (1 CH = 1 hour # 45 °F), began prior to November 1, thus we used the Dynamic Model to >fix= onset of chilling, rather than the traditional calendar date of November 1.

Objectives and Background

Our goals were to use rest-breaking chemicals (CAN17 and horticultural oil) to >tighten= and advance bloom, test the validity of the Dynamic Model and chill portions for timing treatments, and to evaluate treatment effects on flowering, fruit set, bud death and fruit maturity, which may be advanced by advancing bloom. The chilling requirement for >French= prune (*P. domestica*) is not well defined and is assumed to be 700-1700 hours chill hours (Chandler et al., 1937). Lack of clear understanding of chilling required by >French= prune increases the >guess factor= for timing dormant treatments, especially under California conditions in which warm winters (e.g. 1225 CH) can result in flower bud drop, abnormal flowers and delayed and/or sparse leaf-out. Too little chill accumulation may also result in poor fruit set, reduced leaf area due to a lack of growing points, uneven fruit development, sunscald on bark (due to poor foliation), and a weak tree prone to insect damage. A >sharp= or >snowball= bloom typically occurs at 1980 or more CH. Full bloom may vary by as much as three weeks, with full bloom date affected more by heat accumulation than by chilling, unlike bud break. Accelerating bloom may result in an earlier harvest date, which would be advantageous in spreading out harvest.

Use of rest-breaking chemicals has potential to partially substitute for chilling in >French= prune. Many California prune growers use oil in the dormant season (early January) to tighten and advance bloom. Rest-breaking agents (RBs) have become commonly used in California cherry production. The most commonly used rest-breaking agents include Dormex and CAN17 (+ various surfactants). In addition, oils are still widely used in the cherry industry. These RBs are used to advance and coordinate cherry fruit maturity for fewer harvests. In 2005, a trial in >Bartlett= pear used similar techniques to time dormant oil applications, with the result of advanced bloom, improved fruit set, improved fruit size, reduction of undersized fruit from 45% in untreated trees to 7%, with no reduction in yield.

Plans and Procedures

Our trial was located at John Heier Farms in Live Oak. The orchard is planted at a spacing of 20' x 18', 121 trees per acre. Treatments included an unsprayed control, 25% v/v calcium ammonium nitrate (CAN17) + 2.0% v/v Entry[7] and horticultural oil (Wilbur-Ellis Supreme oil) applied on January 12, 17, 21 and 24, when chill portions (CP) accumulated were 56, 59, 63 and 66, respectively. Corresponding chill hours (CH) were 555, 681, 760, and 821. Chill hours and chill portions (Fishman et al., 1987; Erez et al., 1990, 1998) were calculated from hourly temperature data recorded by a California Irrigation Management Information System (CIMIS) weather station that is nearest to the orchard location and from a data logger placed in our treatment site. All treatments were applied with a Stihl mistblower at a calculated volume of 100 gallons per acre to single replicate trees in a complete randomized block design, using four single tree replicates per treatment chemical/date combination. Two limbs from each replicate tree were randomly chosen prior to flower bud opening, at opposite sides of the tree and in mid-canopy. Rate of bud opening was evaluated from sequential data taken over time, full bloom date was recorded and fruit set was evaluated after small fruit drop. Fruit maturity appeared to be very consistent among rest-breaking treatments as evaluated by firmness (lb pressure per square inch) prior to harvest, thus fruit were not further evaluated. All rest-breaking treatments were compared to the control with respect to firmness.

Analyses of variance were performed with Proc GLM in SAS (SAS Institute Inc., Cary, NC) and mean separations tested by Tukey=s 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). In addition, we will continue to assess the value of calculating chill accumulation by the Dynamic Model by cutting floral shoots from trees and forcing them under warm temperatures to calculate 50% bud break (or an equivalent method), which is a general indicator of chill requirement. This portion of the trial is currently being conducted.

Results and Discussion

CAN17 + Entry applied at 59 and 63 CP on January 17 and 21, respectively, advanced bloom significantly compared to all other treatments (Table 1). On March 7 the untreated control had 4.3% open flowers, while the CAN + Entry treatment at 59 CP was at 70% open flowers and CAN + Entry at 63 CP was at 63% open flowers. The most advanced oil treatment on this date was at 29% open flowers, which was also significantly better than the control. CAN + Entry applied at 66 CP was at 47.6% open flowers, thus, all but the earliest CAN + Entry treatment significantly advanced bloom. Two days later, March 9, the best CAN + Entry treatments were at 94-95% of full bloom while the control was at 39% of full bloom. On this date, all rest-breaking treatments had bloom that was significantly more advanced than that of the control and the percentages of full bloom ranged from 66% to 95% among experimental treatments. All experimental treatments had reached 99-100% full bloom on March 11 and the control was then at 96.5% of full bloom.

Most rest-breaking treatments improved fruit set and reduced reproductive bud death, compared to the control. Bud death in the control was 3.5% and only the earliest oil application was the same, statistically, as the control. All other treatments reduced bud death to less than 1%. Fruit set was 2.6% in the control and the CAN + Entry treatments that most advanced bloom each had 21.6% fruit set, which was statistically equal to that of the last CAN + Entry treatment (15.3%) and the oil treatment applied at 59 CP (19.5%). Thus, both CAN + Entry treatments at 59-63 CP were highly effective at advancing and compressing the bloom period, improving fruit set and decreasing floral bud death. A slightly later CAN + Entry treatment was almost as effective. The most effective oil treatments for advancing and compressing bloom were at the same timings, although oil was somewhat less effective. These treatments also improved fruit set and reduced bud death. Earlier timings for each rest-breaking treatment were less effective. Fruit firmness was equal among rest-breaking treatments and less than the untreated control (Table 1), therefore maturity was advanced equally by rest-breaking treatments. Advance in maturity by 1-1.4 lb pressure, as observed in this trial, may allow earlier harvest by 1-2 weeks, enabling growers to spread-out harvest and reduce the impact at dryer facilities.

Although chill hour calculations might also be used for timing these treatments, when chill portion and chill hour accumulations are compared for the 2004-2005 dormant season at several different sites (Table 2), differences from site-to-site are small for chill portions and much greater for chill hours. Chill accumulation prior to November 1 contributed to overall chilling, whether calculated as chill portions or as chill hours (Table 2). When we compared year-to-year and site-to-site data for onset of chill accumulation, we found that chill accumulation prior to November 1 is the rule, rather than the exception, when the Dynamic Model is used to calculate chill accumulation (Table 3). Similarly, chill hour accumulation, when calculated by the chill hour model (1 CH = 1 hour # 45EF), began prior to November 1 in most cases (data not shown). In our cherry dormancy trial 2004-2005, we found that some rest-breaking treatments produced bud phytotoxicity and that this could be explained by the timing at which they had been applied. When chilling was calculated by the >chill hour= model, applications were within the >safe= period; applications were also deemed within the safe period if chill portions were calculated beginning November 1. When chill portion accumulation by the Dynamic Model was used to time >onset=, the additional CP accumulated represented a timing that was >too late=. This evidence supports the supposition that chill accumulation onset should be timed by the Dynamic Model, rather than by calendar date.

References

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

Chandler, W.H., M.H. Kimball, G.L. Philp, 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. Calif. Expt. Sta. Bull. 611.

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.

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., Linsley-Noakes., and Allan, P. (1990) The Dynamic Model for rest completion in peach buds. Acta Hort. 276: 165-173.

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.

Table 1. Treatment effect on bloom progression by horticultural oil and CAN17 applied to >French= prune, 2005. Chill portions (CP)[z] and chill hours (CH)[y] are based on temperatures recorded hourly on site in trial orchard.

Treatment (applied @ 100 gallons/acre)				Bloom progression (%flower buds open on flowering shoot)						
				2 Mar	7 Mar	9 Mar	11 Mar	%Dead buds	%Fruit set	Firmness (lb)
Control	Applied on	CP	CH	0.0 [x]	4.3 d	39.2 d	96.5 b	3.5 a	2.6 d	4.0 a
25% CAN17 + 2% Entry	12 Jan	56	555	0	20.2 cd	74.1 bc	99.9 a	0.1 b	11.4 bc	2.9 b
	17 Jan	59	681	0.9	70.0 a	94.9 a	100.0 a	0.0 b	21.6 a	2.8 b
	21 Jan	63	760	0.7	63.0 ab	94.0 a	99.8 a	0.2 b	21.6 a	2.6 b
	24 Jan	66	821	0	47.6 b	93.9 a	100.0 a	0.0 b	15.3 ab	3.0 b
1% Wilber-Ellis Superior oil	12 Jan	56	555	0	14.4 cd	66.2 c	98.0 ab	2.0 ab	5.2 cd	2.8 b
	17 Jan	59	681	0.4	29.1 c	86.2 ab	99.2 a	0.8 b	19.5 a	3.1 b
	21 Jan	63	760	0	21.1 cd	80.9 abc	99.1 a	0.9 b	10.3 bcd	2.6 b
	24 Jan	66	821	0.0ns	9.9 cd	69.4 bc	99.7 a	0.3 b	9.4 bcd	3.0 b

[x] Mean separation within columns by Tukey=s, *P* = 0.05; ns = non significant. Percentages transformed by arcsine; actual means are shown.
[y] 1 hour # 45EF.
[z] Fishman et al., 1987.

Table 2. Chill accumulation for 2004-2005 at selected sites in California (including experimental sits with dataloggers). Chill portions (CP)[y] and chill hours (CH)[x] are based on temperatures recorded hourly.

Location	Start of CP accumulation	Chill portions cumulative						Chill hours cumulative					
		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
Prune dormancy trial	20 Sept (1 CP until 18 Oct)	8	25	47	71	86	87 (on 14 Mar)	27	170	440	910	1005	1032 (on 14 Mar)
Nicolas CIMIS station	20 Sept (1 CP until 20 Oct)	8	26	49	73	90	100	67	266	607	1082	1197	1285
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 19 Oct)	7	27	48	73	88	99	84	276	598	1021	1143	1225
Live Oak, San Joaquin Weathernet	20 Sept (1 CP until 19 Oct)	7	27	48	73	89	97	65	256	578	1044	1188	1278
Lodi 0.1-P, San Joaquin Weathernet	20 Sept (1 CP until 19 Oct)	8	26	49	73	90	98	81	287	617	1080	1233	1325

[x] 1 Chill hour is 1 hour # 45EF.

[y] Fishman et al., 1987.

Table 3. Chill portion (CP) accumulation evaluated for several years and CIMIS 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	