Use of Plant Growth Regulators for Freeze Protection and Increasing Fruit Set: Preliminary Results

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Summary:

Whole tree applications were made to 'Bartlett' pear before (March 26) or after (April 6) repeated freeze events during the pre- and bloom period in 2008. Following an unusual freeze event on April 20, treated trees were rated for fruit retention. ProGibb + Promalin showed significant benefit when applied with BlightBan after the freeze events. Promising results were also found with ProGibb + Promalin (no BlightBan) and BioForge™ (Stoller® USA) applied before freezes. While the latter two treatments did not show significant differences from all other, less-effective, treatments, they were not statistically different than the most effective treatment, thus, showing an intermediate benefit. These preliminary results indicate good potential for future amelioration of freeze damage and improvement in fruit set, particularly with freezing events, in European pear.

Branch test applications made to 'Bartlett' pear in the same orchard as whole tree tests evaluated treatment effects on bloom progression and fruit set by CPPU and 6-benzyladenine (synthetic and naturally-occurring cytokinins, respectively), urea and boron polyamine. After the freeze events from March 30 through April 4, bloom was most advanced by CPPU, but not different from the untreated control. 6-BA and urea were most delayed, but not different from the control. Fruit set on April 25 after all freezes was highest in the control, not different in the Boron Polyamine treatment, but substantially reduced in the other treatments. The same trend held true on May 15, although there were no significant differences. Total fruit loss from the initial number of inflorescences ranged from 83% (control) to 100% (urea). Unfortunately, fruit set evaluation was not made prior to the unexpected late freeze of April 20, therefore, no conclusions with respect to efficacy can be made in this trial with regard to protection from freezes during bloom.

Problem and its Significance:

Inadequate winter chilling or cycles of warm and cold dormant season weather, unseasonably warm temperatures prior to a freeze, and the increasing potential for global warming emphasize the importance of freeze damage mitigation to pear production in California, as well as improving parthenocarpic set when pre-bloom and bloom conditions are poor. Inadequate chilling interferes with the normal process of floral bud development by reducing vascular development into the bud so that nutritional and plant growth regulator resources may not be at adequate levels for good sink strength and reproductive growth. These factors alter bloom patterns and can impact fruit set. Inadequate chilling or warm-cold cycling in the dormant season also reduces cold-hardiness and predisposes buds to lower tolerance to freezing conditions, both in critical temperatures and in critical length of exposure.

Numerous studies show benefits of plant growth regulators, nutrients, vitamins and various other substances on fruit set and/or cold hardiness. Nutrient treatments and plant growth regulators can affect both return bloom and in-season fruit set in pome species, depending on cultivar, and application timing, form(s) and concentration(s) of gibberellin used, as well as the age of the bearing wood (1 year-old vs 2 year-old), as reported by Deckers and Schoofs (2006). Thus, any treatments for freeze mitigation and/or in-season fruit set improvement must be followed with data on return bloom and cropping.

Objectives:

1. Reduce the potential for freeze damage to buds by pre-freeze and post-freeze treatments.
2. Improve fruit set, particularly through parthenocarpy, when bloom conditions are poor (spread-out bloom, inclement temperature and rain conditions, post freeze) by application of PGRs, BlightBan and BioForge™

Plans and Procedures:

Plant material, experimental design, treatments: Whole tree replication

European pear trees [‘Bartlett’, ~40 yr old; (*Pyrus communis* (L.)] were selected at the Carpenter Ranch in Lake County, an orchard prone to freeze damage during bloom development. Treatments were applied by mistblower at ~100 gallons per acre, either pre- or post-freeze, depending on the chemical (Table 1); 4 single-tree replicates were used for each treatment and the experimental design was a complete randomized block design within 6 rows of trees. Some treatments included A506, BlightBan, applied according to the best results obtain in past trials (Elkins et al., 2004).

Measurements and data analysis.

Temperature data was obtained from the Lake County Amos Network, for Scotts Valley, monitoring freezing temperatures during bloom development. Treatment effects were evaluated by rating cropload after more than a month of repeated freeze events, on 15 May. Rating was done after all fruit drop related to a very late frost (20 April) had occurred. Rating was on a scale of 0 to 3, with 0 = no fruit, 1 = very few fruit, 2 = moderate fruit retention, 3 = many fruit retained, on a whole tree basis. Return bloom and yields in 2009 will be evaluated.

Statistical Analysis Systems software (SAS Institute, Cary, NC) was used to perform means separations and the analyses of variance (PROC GLM) for experimental measurements.

Plant material, experimental design, treatments: Branch tests

This trial was conducted in the same orchard as the whole tree tests. Four uniform trees were chosen and limbs were randomly assigned treatments for 4 replicates per treatment, blocked on the four trees. Each replicate limb had 20 to 30 inflorescences and was treated by handheld sprayer to drip with materials shown in Table 2. Treatments were applied either pre- or post-freeze, depending on the chemical. All inflorescence buds/flowers were counted and rated as to stage of bloom, fruit set and damage before freezing temperatures (March 24) and after repeated freeze events (April 5). Bloom stages were: swollen bud, cluster bud, finger bud, white bud, first open bloom, 50% open blooms, and full bloom. Mean bloom stage for a given replicate limb was calculated for each sampling date to evaluate a cumulative progression through bloom. The formula used for this calculation assumed a weighting factor for each bloom stage equivalent to that bloom stage ‘number’ (1 for swollen bud and 8 for full bloom) to emphasize the value of individual inflorescences progressing to full bloom. Thus, for any given treatment/replicate/sampling date combination, the formula was:
((#inflorescences in ‘swollen bud stage’ x 1)+((#inflorescences in ‘cluster bud stage’ x 2)+…((#inflorescences in ‘full bloom stage’ x 8))/total number of inflorescences.

On April 25 (after final freeze event) and May 15 (after fruit drop), fruit set was evaluated on replicate limbs.

Statistical Analysis Systems software (SAS Institute, Cary, NC) was used to perform means separations and the analyses of variance (PROC GLM) for experimental measurements.

Results and Discussion

Freezing temperatures were experienced repeatedly during inflorescence development from March 30 through April 7 (Figure 1).

Whole tree tests: ProGibb + Promalin showed significant benefit with respect to crop load rating when applied with BlightBan after the freeze events (Table 3). Promising results were also found with ProGibb + Promalin (no BlightBan) and BioForge™ (Stoller® USA) applied before freezes. While the latter two treatments did not show significant differences from all other, less-effective, treatments, they were not statistically different than the most effective treatment, thus, showing an intermediate benefit. No damage to fruit surfaces or abnormal shapes were found. These preliminary results indicate good potential for future amelioration of freeze damage and improvement in fruit set, particularly with freezing events, in European pear.

Branch tests: On March 24 mean bloom stage was not significantly different among replicate limbs; no treatments had been imposed. Mean bloom stage ranged from 2.3 to 2.9, equivalent to 'cluster bud' to 'tight bud', respectively. After the freeze events from March 30 through April 4, mean bloom stage was evaluated on April 5 (Table 4). Bloom was most advanced by CPPU, but not different from the untreated control. 6-BA and urea were most delayed, but not different from the control. Fruit set on April 25 after all freezes was highest in the control, not different in the Boron Polyamine treatment, but substantially reduced in the other treatments. The same trend held true on May 15, although there were no significant differences. Total fruit loss from the initial number of inflorescences ranged from 83% (control) to 100% (urea). Unfortunately, fruit set evaluation was not made prior to the unexpected late freeze of April 20, therefore, no conclusions with respect to efficacy can be made in this trial with regard to protection from freezes during bloom.

Table 1. Chemical treatments imposed on whole trees in 2008 to increase cold hardiness of pear buds to late freeze.				
Active ingredient	Commercial product	Rate of active	Application timing	Treatment
GA_3 & GA_{4+7} + 6-BA	ProGibb & Promalin + 0.5% BreakThru	10 g/A and 0.5 pt/A at each timing	Prior to freeze event at inflorescence expansion	1
			After freeze event, 6 hr-1 day post freeze	2
			After freeze event, 6 hr-1 day post freeze & prior to 20% flowers open	3
GA_3 + Dithane	ProGibb, Dithane + 0.5% BreakThru	10 g/A., label	24 hr after freeze	4
GA_3 & GA_{4+7} + 6-BA + A506	ProGibb & Promalin + BlightBan+ 0.5% BreakThru	10 g/A and 0.5 pt/A at each timing; label rate BlightBan	Prior to freeze event at inflorescence expansion	5
			After freeze event, 6 hr-1 day post freeze	6
			After freeze event, 6 hr-1 day post freeze & prior to 20% flowers open	7
A506	BlightBan+ 0.5% BreakThru		Prior to freeze event at inflorescence expansion	8
Proprietary + 2% urea nitrogen + 3% potash	BioForge™ (Stoller USA)	1 pint/A	Prior to freeze event at inflorescence expansion	9
Untreated control				10

Table 2. Chemical treatments imposed in branch tests in 2008 to increase cold hardiness of pear buds to late freeze.

Active ingredient	Commercial product	Rate of active	Application timing
CPPU (label = KT-30)	Prestige (Valent) is closest, however, the manufacturer provided CPPU with a proprietary adjuvant; + 0.5% BreakThru	2.5 ppm	6-24 hr after freeze
6-BA	MaxCel + 0.5% BreakThru	25 ppm	6-24 hr after freeze
Urea	Urea phosphate = N-pHource 44 (Western Farm Service)	0.5% final nitrogen	3 days before anticipated freeze
Boron polyamines	Boron Polyamine (Monterey AgResources)	16 oz/A	After freeze event, 6 hr-1 day post freeze & prior to 20% flowers open
Untreated control			

Table 3. Crop load rating of 'Bartlett' pear after repeated freeze events. Treatments to reduce freezing damage and increase flower and fruit retention were made to whole trees by mistblower (~100 gallons/acre). Freeze events were experienced March 30-31, April 2-5, April 7 and April 20.

Treatment	Rating[y]
BioForge, before freeze	1.0 ab[x]
ProGibb + Promalin, before freeze	0.75 b
ProGibb + Promalin, after freeze	1.4 ab
ProGibb + Promalin, after freeze + 20% bloom	0.6 b
ProGibb + Dithane, before freeze	0.6 b
ProGibb + Promalin + BlightBan, before freeze	0.4 b
ProGibb + Promalin + BlightBan , after freeze	2.0 a
ProGibb + Promalin+ BlightBan, after freeze + 20% bloom	0.8 b
BlightBan, before freeze	0.2 b
Untreated control	0.4 b

[x]Mean separation within columns by Duncan's Multiple Range Test, $P = 0.05$.
[y] Rating was on a scale of 0 to 3, with 0 = no fruit, 1 = very few fruit, 2 = moderate fruit retention, 3 = many fruit retained, on a whole tree basis.

Table 4. Effects of treatments on bloom progression and fruit set of 'Bartlett' pear after repeated freeze events. Treatments to reduce freezing damage and increase flower and fruit retention were made to limbs by handheld sprayer, 'to drip'. Freeze events were experienced March 30-31, April 2-5, April 7 and April 20.

Treatment	Mean bloom stage [y], April 5	%Fruit set		Total %fruit loss
		April 25	May 15	
CPPU (label = KT-30), after freeze	6.45 a[x]	29.7 bc	12.1 a	98.8 a
6-benzyladenine, after freeze	5.48 b	16.0 c	7.2 a	96.9 ab
Urea, before freeze	5.40 b	0.0 c	0.0 a	100 a
Boron Polyamine, after freeze	5.89 ab	68.9 ab	16.9 a	90.3 ab
Untreated control	5.92 ab	73.8 a	18.7 a	82.9 b

[x]Mean separation within columns by Duncan's Multiple Range Test, $P = 0.05$.
[y] Bloom stages were: swollen bud, cluster bud, finger bud, white bud, first open bloom, 50% open blooms, and full bloom. Mean bloom stage calculated as: ((#inflorescences in 'swollen bud stage' x 1)+((#inflorescences in 'cluster bud stage' x 2)+…((#inflorescences in 'full bloom stage' x 8))/total number of inflorescences

Pertinent literature

Deckers, T. and Schoofs, H. 2002. Improvement of fruit set on young pear trees cultivar conference with gibberellins. Acta Hort. (ISHS) 596:735-743.

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Figure 1. Temperature data during the freeze events in the bloom period, 2008.