APPLE (*Malus* x *domestica* 'Gala', 'Ginger Gold', 'Minneiska')
Frost injury

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Impact of Pristine and other Fungicides on Frost Damage in Apples, 2012.

BACKGROUND: Pyraclostrobin fungicide, one of the two components in Pristine, has been heavily promoted for its "plant health" benefits and is widely used on field crops such as corn and soybeans to promote plant health and improve yields despite the fact that university scientists have debated the economics and wisdom of this strategy. BASF has also presented in-house data at various specialist seminars showing that Pristine fungicide can make plants more resistant to environmental stresses such as drought and cold injury, but there are no published field data on whether Pristine applications can impact survival of flowers on tree fruit crops that are exposed to frost. Therefore, with frosts predicted for late April in 2012 when apple trees were in latter stages of bloom, we put together a quick field trial to evaluate the benefits of a Pristine application just prior to the predicted frosts. We also looked at impact of fungicide treatments in another plot where pyraclostrobin was included in some applications.

METHODS: In the first trial, Pristine was applied at about 6 pm on a Saturday evening, 28 Apr, prior to a predicted heavy frost. The treatment was applied to two Fulford Gala trees at one end of our N40 orchard and to six Minneiska trees at the other end of the same orchard. In both cases, the treated trees were paired with adjacent untreated control trees. The Gala trees were on M.9 rootstock and were planted in 2001. The Minneiska trees were on Bud.9 rootstock and were planted in 2003. The Minneiska trees were roughly 10-ft lower in elevation than the Gala trees. Temperatures at each of these two locations were recorded with an I-button temperature recorder set to record temperatures at the start of every hour beginning at noon on 27 Apr and continuing through noon on 30 Apr. The I-buttons were fastened to trees about 3 ft above ground. I-buttons were calibrated by first setting them to record at 1-min intervals over a 24-hr period for 48 hr in an incubator set at 41°F and then using the data from that calibration test to adjust final temperatures recorded by the respective I-button after they were placed in the field.

Unfortunately, temperatures on the night prior to the test application (night of 27-29 Apr) had dropped further than expected and lows of 30.1 and 30.2°F were recorded for the Gala and Minneiska trees, respectively. However, following the Pristine application, low temperatures recorded for the Gala and Minneiska trees, respectively, on the next two nights were 30.3 and 28.4°F for the night of 28-29 Apr and 30.3 and 28.4°F for the night of 29-30 Apr (Fig. 1). On 8 May, 50 arbitrarily selected fruitlets per tree were picked from both the treated and control trees and were measured with calipers to determine fruitlet diameter and then were sliced in half midway between the stem and calyx so that evidence of internal damage could be assessed. Another 50 fruit per tree from Gala trees were evaluated on 12 July by counting seed numbers in each fruit.

Data on frost damage was also collected from the Pond block fungicide trial reported on pages 19-25 of our 2012 Fungicide Tests report. This block included three treatments with Merivon (which contains pyraclostrobin). An I-button placed in a tree near the center of this orchard recorded a low temperature of 27.5°F on all three frost nights. Test treatments in this block were applied on 11 Apr (16 days before the first frost) and 2 May (5 days after the first frost). Elevation in this block varies by about 10 ft.

RESULTS: Pristine applications on 28 Apr impacted seed numbers, and to a lesser extent, fruit size (P=0.08) in the assessments made on 8 May (Table 1). However, both the treated and untreated Gala trees developed a full crop and there was no visually evident difference in fruit size or crop load. In fact, all four of the Gala trees were somewhat overcropped because no chemical or hand thinning was done on these trees. When seed count was assessed again on 12 July, there was no longer any evidence of treatment effects, perhaps because trees preferentially shed the fruit with low seed counts during June drop. On the row of 9 Minneiska trees, there was no visual effect of the Pristine treatment (6 trees) as compared to controls (3 trees). On all of the trees, there was a clean line midway up through the canopy below which there were not fruit. The tops of all of the trees had a roughly equivalent number of fruit with significant frost damage (frost rings, frost cracks) on the lowest of the surviving fruit. There was no visible benefit from the Pristine application.

In the Pond block, there was no evidence that fungicides impacted the amount of frost damage noted on fruit at harvest (Table 2, Fig. 2). This was not surprising since the blocking pattern used to assign treatments within the Pond block orchard was not optimized for measuring effects of frost damage because each of the replicates (i.e., block-factor for the randomized-block design) included both upper elevation and lower elevation trees.

CONCLUSION: We found no evidence that Pristine provided any commercial benefits for reducing frost damage in these trials. Even though we found an impact on seed count shortly after the frost, that did not translate into better survival on the Minneiska trees or differences in final fruit size or crop load on the Gala trees. The evidence that Pristine did have some effect on seed count suggests that Pristine might actually be affecting tree responses to cold injury in a very limited way, but the likelihood that those small effects could be translated into a significant improvement in cropping are relatively low given that we found no benefit from Pristine applied to the Minneiska trees where the consequences of frost injury in both treated and untreated trees varied from total crop loss to full cropping as one moved from the bottom to the top of each individual tree.

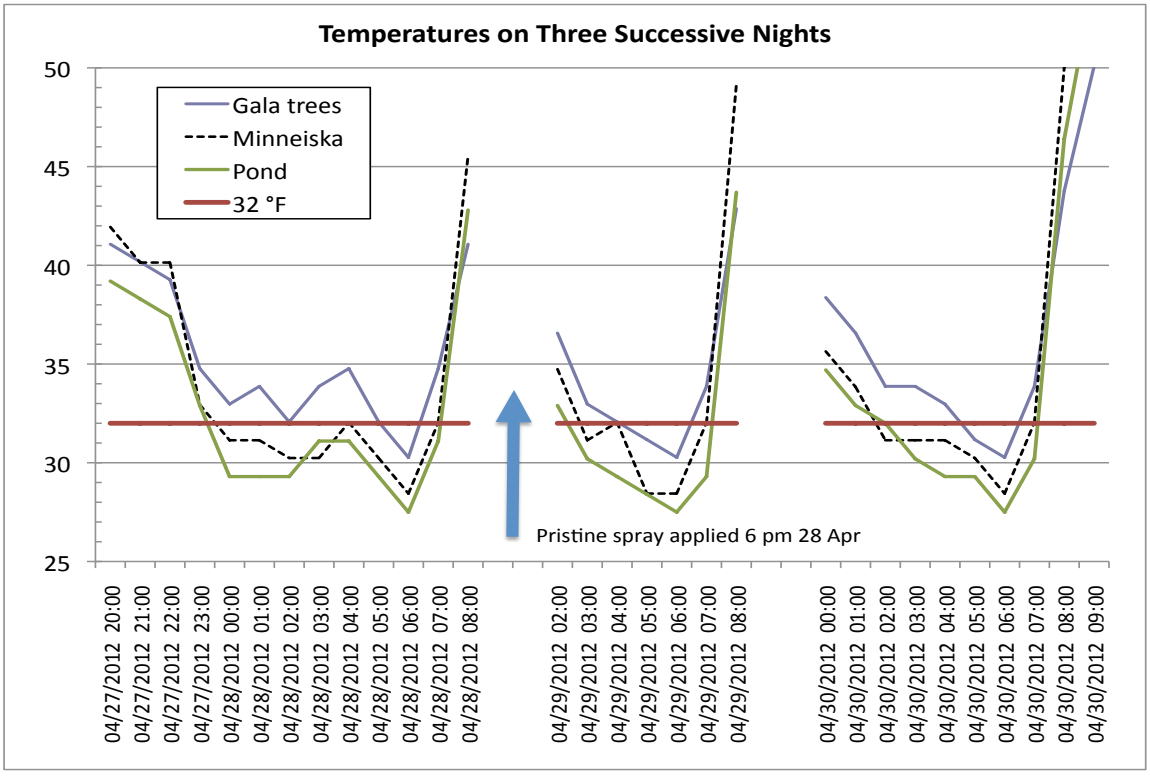

Figure 1. Temperatures on three successive nights (27-30 Apr) in the orchards where data was collected as derived from hourly readings on I-button recorders. Ironically, the lowest temperature recorded was 30.3 for the Gala trees, 28.4, for the Minneiska trees, and 27.5 for the coldest part of the Pond Block, and in all three locations that identical low temperature was recorded on each of the three nights. Pristine was applied to the Gala and Minneiska trees at the time shown. QoI fungicides were applied in the Pond block on 1 Apr (tight cluster), 11 Apr (pink), 2 May (petal fall) and were not designed to evaluate their effect on cold injury.

Table 1: Effects of Pristine on frost damage as determined by evaluating various indicators on two paired sets of Gala trees and one pair of Minneiska for a total of three replications.

Formulated product applied per 100 gal[z]	Mean fruitlet diameter on 8 May (mm)[y]	Ratings on 8 May: internal browning[x]	Ratings on 8 May: seeds numbers[w]	Percent fruit on 8 May with:[v] Normal seed count	No seeds	No internal browning	Complete browning	Mean seed count in Gala on 12 July[u]
Control	5.1	0.8	**1.6 b**[t]	**63.3 b**	3.3	13.0	30.6	4.97
Pristine 38W 5 oz	6.0	1.0	**1.9 a**	**90.6 a**	1.2	30.3	26.2	4.91
P value	0.082	0.150	**0.003**	**0.026**	0.288	0.120	0.288	

[z] Pristine was applied to drip using a handgun 5:30-6:30 pm on Sat, April 28, in advance of predicted frosts for the mornings of April 29 and 30. However, there were also frosts earlier in the week that may have caused damage prior to this spray. Treatments were applied to two paired sets of Gala trees and to one paired set of Minneiska trees. Data from the two trees were analyzed together.

[y] Fifty randomly-selected fruitlets per tree were harvested and their diameters were measured with calipers.

[x] Internal browning was rated on a scale of 1= totally brown interior; 2=limited browning evident; 3= no browning.

[w] Seed numbers were assessed on a subjective scale of 1= no seeds; 2= some seeds missing; 3= full complement of seeds.

[v] Based on evaluation of 50 fruitlets per tree harvested on 8 May.

[u] Based on counting seeds in 50 Gala fruit from each of two trees for each treatment. Seed counts per fruit ranged from 0 to 10, with means as shown in the table.

[t] Means followed by the same letter are not significantly different as determined using Fisher's Protected LSD test (P <0.05).

Table 2. Effects of treatments on factors that were or might have been related to freeze damage that occurred in late April.

Fungicides and rates of formulated products applied per acre (rates/100 gal = [rate/A]/3)	Ginger Gold fruit (%) [x] on 8 Aug that showed: Frost ring	Frost cracks	Golden Delicious fruit (%) harvested 1 Oct that showed frost damage
1. Control	26.0	21.0	19.2
2. Captan-80 2 lb + Manzate Pro-Stick 3 lb	14.0	8.0	9.3
3. Flint 2 oz + Manzate Pro-Stick 3 lb	23.6	9.0	9.0
4. Luna Sensation 4 fl oz + Manzate Pro-Stick 3 lb	29.0	17.5	7.3
5. Luna Tranquility 11.2 fl oz + Manzate P-S 3 lb	31.0	16.0	14.1
6. Merivon 4 fl oz + Sylgard 309 4 fl oz/100	22.0	10.0	7.9
7. (same as trt #6) + Manzate ProStick 3 lb	24.0	11.0	7.7
8. (same as trt #6) + Captan-80 2 lb	30.8	17.4	8.0
9. BAS700 3.3 fl oz + Sylgard 4 fl oz	32.4	11.9	6.3
10. (same as trt #9) + Manzate ProStick 3 lb	17.3	9.5	11.0
11. (same as trt #9) + Captan-80 2 lb	17.0	10.0	13.9
12. (same as trt #9) + BAS914 4 fl oz	22.4	19.4	14.5
P-values	0.269	0.597	0.555

[z] Treatments indicated were applied to drip with a handgun on 1 Apr (tight cluster), 11 Apr (pink), 2 May (petal fall), and 14 May (1st cover). Other fungicide sprays were applied via airblast to the entire orchard, including control plots as follows: Manzate Pro-Stick 3 lb/A was applied on 23 Mar (green tip), 20 Apr (bloom) and 25 May (2nd cover); Flint 2 oz/A + Captan-80 2 lb/A was applied on 1 Jun; Topsin M 70WSB 12 oz/A + Captan-80 2 lb/A were applied on 22 & 30 Jun, 25 Jul, and 2 Aug; Flint 2.5 oz/A was applied on 14 July: and Pristine 38W 15 oz/A was applied on 17& 29 Aug.

[x] Ginger Gold fruit evaluations on 8 Aug were from 75 fruit/tree.

[w] Golden Delicious fruit evaluations on 1 Oct were from 75 fruit/tree.

[w] Means followed by the same small letter are not significantly different (P≤0.05, Fisher's protected LSD).

Figure 2 (right): Golden Delicious apples rated as having frost damage. The apple in the lower left has frost cracks similar to those shown on Ginger Gold in Figure 2. The apple on the lower right shows frost-induced russet in a pattern that suggests the flower petals frost to the fruitlet surface during late bloom. The stem-end russetting on the apple in the rear may or may not be directly related to frost, but apples with severe stem-end russet were counted as having frost injury because this kind of damage was unusually prevalent in this block as compared to other blocks on our farm where the recorded temperatures 27-30 April were several degrees warmer than those recorded in this test block.