Late-season Chemical Thinning of Apples

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Chemical thinning is one of the most difficult practices in the orcharding year. Optimal chemical thinning, however, is often critical to the success of a year's crop. Weather, timing, choice of chemicals, and concentration come together to affect chemical thinning, as do the previous season's level of cropping, winter temperatures, and tree health. In recent years, to enhance the degree of success, growers have utilized petal-fall thinning treatments, followed by multiple additional treatments as needed. Most often, these multiple applications of thinners give adequate results. Occasionally, however, the weather does not cooperate, either preventing treatment applications or reducing the trees ability to respond to treatments. Once fruit exceed 0.6 inches (15 mm) in diameter, they do not respond to normal chemical thinners. Historically, the only viable option for reducing fruit set beyond this point is by hand, and we all know that this practice is costly with much less benefit than chemical thinning soon after bloom.

Ethephon is often used to advance apple harvest, because when it breaks down in plant tissue, ethylene is released, and ethylene triggers ripening. In some parts of the US, it also is used as a chemical thinner, the mode of action also hinging on ethylene release. We have had very limited experience with ethephon as a chemical thinner, because it has often been thought to be too potent and possibly too variable in effect in our climate. On the other hand, it is the only chemical thinner that can work when fruit are larger than 0.6 inches. Because of the latter, we began a study in 2003 with the following objectives: 1) to gain more experience using ethephon to thin apples, 2) to determine the appropriate range of concentrations to use in our climate, and 3) to determine if potential variability of the ethylene response could be controlled with AVG (ReTain®).

Materials & Methods

This study was conducted first in 2003 and repeated in 2004 in a block of 10-year-old Gatzke McIntosh/M.26 at the University of Massachusetts Cold Spring Orchard Research & Education Center. Sixty trees were allocated among five replications, based on initial fruit set. Within each replication, half the trees were treated with AVG (200 ppm with 0.125% Regulaid® in 2003 and 400 ppm with 0.1% Silwet® L-77 in 2004) six days prior to ethephon application (Figure 1). On June 16, 2003 (fruit 0.8 inches in diameter) and on June 10, 2004 (fruit 0.9 inches in diameter), six untreated and six AVG-treated trees within each rep were allocated randomly among six thinning treatments (untreated, 0 ppm ethephon plus carbaryl, 200 ppm ethephon plus carbaryl, 300 ppm ethephon plus carbaryl, 400 ppm ethephon plus carbaryl, and 500 ppm ethephon plus carbaryl) (Figure 1). Carbaryl was included as Sevin® 80S at a rate of 1.25 pounds per 100 gallons (1 pound a.i./ 100 gallons).

Beginning just before treatment, fruit and leaf samples were taken periodically from each tree until 10 days after treatment in 2003 and 11 days after in 2004. These samples were enclosed in Mason Jars equipped with a septum cap for removal of gas samples. Three hours after sealing samples in the jars, a sample of air was removed from each, and the ethylene concentration of that air was measured.

In August, final fruit set was assessed for each tree (utilizing two representative limbs per tree selected prior to assigning treatments). On September 8, 15, and 22, 2003 and September 10, 17, and 24, 2004, 4-apple samples were collected from each tree, and the internal ethylene concentration was assessed. On September 15, 2003 and September 17, 2004, 20-apple

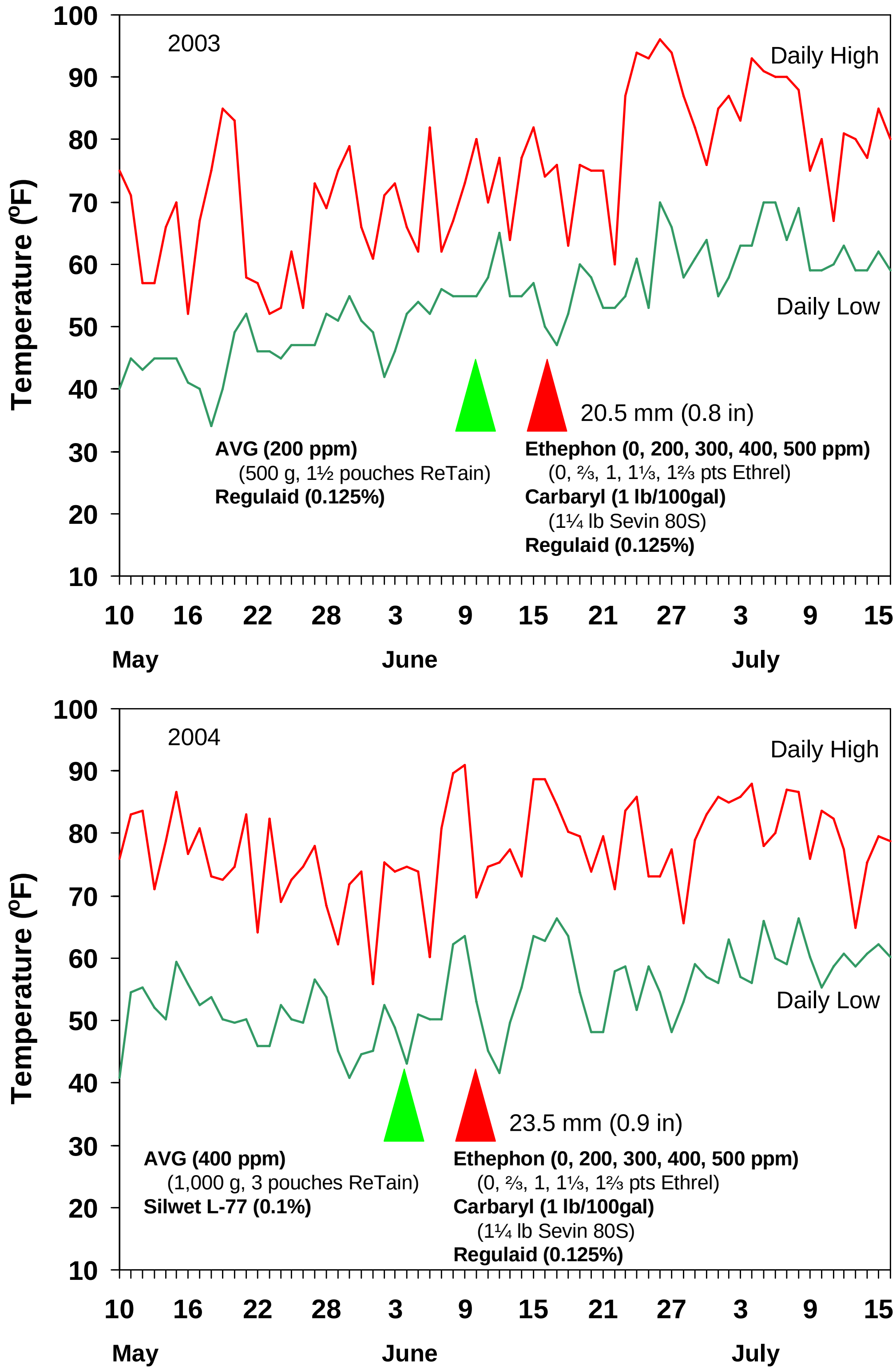

Figure 1. Temperature, timing, and concentrations of late-season thinning treatments to McIntosh in 2003 and 2004.

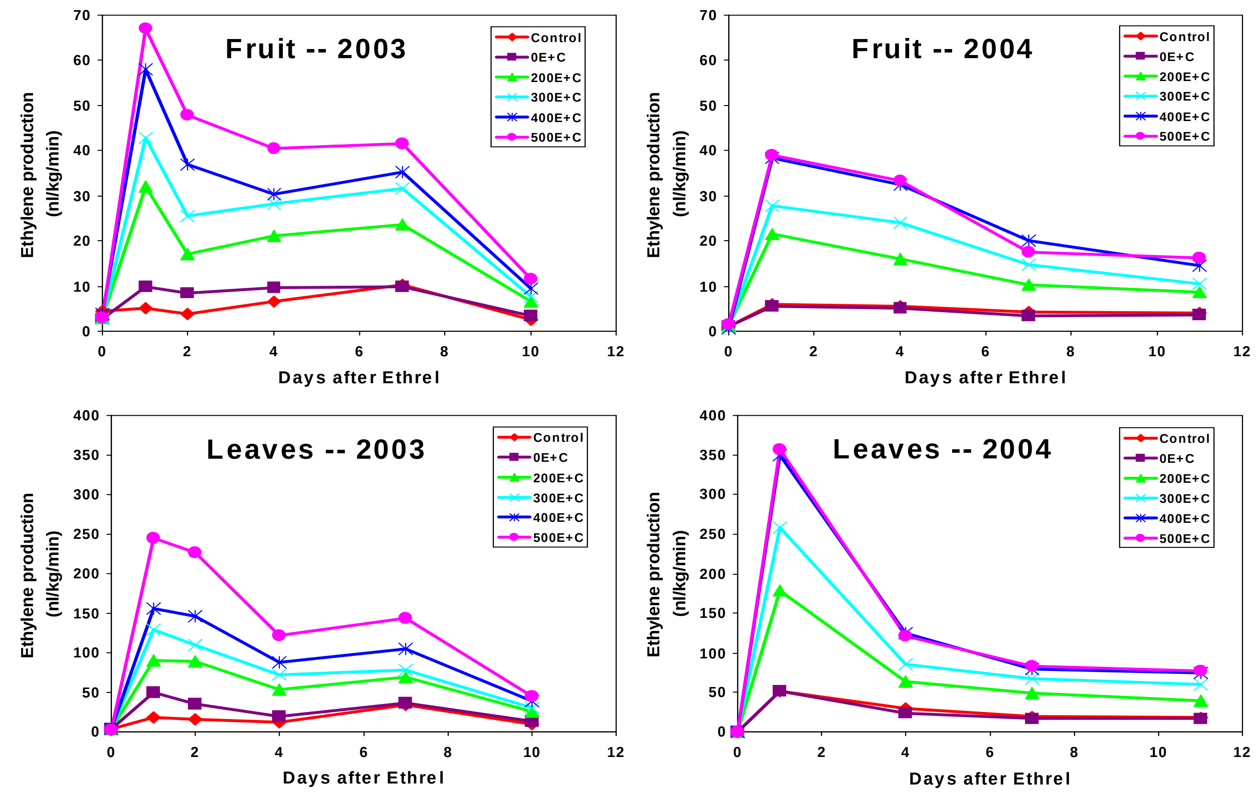

Figure 2. Ethylene production from fruitlets and leaves immediately following application of late-season thinning treatments to McIntosh in 2003 and 2004.

samples were collected from each tree and were weighed. Ten apples were selected at random from this sample for the measurement of flesh firmness (two punctures per fruit with Effegi penetrometer), soluble solids concentration (juice collected from firmness measurements assessed with hand refractometer), and starch pattern (equatorially cut fruit dipped in iodine-potassium iodide solution and compared to Cornell Universal Starch Chart).

Results

Daytime temperatures varied from 2003 to 2004 (Figure 1). In 2003, May and early June were relatively cool, with relatively few days greater than 80°F. Ethephon treatments were applied when temperatures were in the 70's, but about a week after application, we experienced several days in the 80's and 90's. The period leading up to application in 2004 was warmer than in 2003, three days in the 80's just prior to application. Just after application, temperatures were in the 70's, but rose to near 90 four days later.

Immediately following treatment, both fruit and leaves responded by dramatic increases in the production of ethylene (Figure 2). This increase in production began to dissipate very soon and reached near normal levels after 10 days. AVG had no consistent impact on ethylene evolution after treatment (data not shown) and did not have a substantive effect on any other measurement in this study, so no data on AVG's effects will be presented here.

Ethrel reduced final fruit set significantly each year, and the response was generally linear with concentration (Tables 1 and 2). Optimal set was obtained with between 200 and 300 ppm ethephon (plus carbaryl). Higher concentrations overthinned, and carbaryl alone (with 0 ppm ethephon) did not provide adequate thinning. Return bloom the spring after the 2003 treatments was increased considerably by 200, 300 and 400 ppm ethephon. In 2005,

Table 1. Effects of ethephon (Ethrel®) plus carbaryl (Sevin® 80S) on fruit set, fruit quality, and return bloom of Gatzke McIntosh in 2003. Ethephon and carbaryl (with 0.125% Regulaid®) were applied on June 16, when fruit were 0.8 inches (20.5 mm) in diameter.

Ethephon (ppm)	Carbaryl (lbs a.i./ 100 gal)	Initial fruit set (no./cm^2 LCA)	Final fruit set (no./cm^2 LCA)	Return bloom – 2004 (no./cm^2 LCA)	Internal ethylene (log ppm)	Flesh firmness (lbs)	Soluble solids (%)	Starch index value	Fruit weight (g)
0	0	19.0	8.6	9.2	-0.6	14.8	10.6	6.2	180
0	1	19.2	8.2	12.6	-0.8	15.1	11.1†	6.1	176
200	1	19.1	6.3	14.3†	-0.8	15.9	11.2†	5.7	168
300	1	19.2	5.6†	14.6†	-0.6	15.4	11.8†	5.6	185
400	1	18.7	3.7†	14.0†	-0.0	15.5	12.2†	5.7	184
500	1	19.1	2.5†	13.2	-0.4	15.1	12.6†	6.0	185
Significance[z]		ns	***L	*	ns	ns	***L	*	ns

†These means are significantly different from the untreated control at odds of 19:1 (Dunnett's Test, *P*=0.05).

[z] ***, *, ns: Differences among means are significant at odds of 999:1, 19:1, or nonsignificant, respectively (*P*=0.001, 0.05, or nonsignificant, respectively). L signifies that the relationship between ethrel concentration (with carbaryl) and the designated parameter is linear.

Table 2. Effects of ethephon (Ethrel®) plus carbaryl (Sevin® 80S) on fruit set, fruit quality, and return bloom of Gatzke McIntosh in 2004. Ethephon and carbaryl (with 0.125% Regulaid®) were applied on June 10, when fruit were 0.9 inches (23.5 mm) in diameter.

Ethephon (ppm)	Carbaryl (lbs a.i./ 100 gal)	Initial fruit set (no./cm^2 LCA)	Final fruit set (no./cm^2 LCA)	Return bloom -- 2005 (no./cm^2 LCA)	Internal ethylene (log ppm)	Flesh firmness (lbs)	Soluble solids (%)	Starch index value	Fruit weight (g)
0	0	14.1	9.5	11.1	0.2	16.0	11.4	6.3	154
0	1	14.1	8.9	10.2	0.3	15.5	11.1	6.2	161
200	1	14.1	6.7†	17.1†	0.4	15.7	12.1†	6.0	172†
300	1	13.8	5.3†	15.3	0.7	15.7	12.4†	6.2	167†
400	1	14.6	3.3†	19.1†	0.3	15.7	12.8†	6.1	164
500	1	14.6	2.6†	19.7†	1.1†	15.5	12.8†	6.3	163
Significance[z]		ns	***LQ	***L	*	ns	***LQ	ns	*

†These means are significantly different from the untreated control at odds of 19:1 (Dunnett's Test, *P*=0.05).

[z] ***, *, ns: Differences among means are significant at odds of 999:1, 19:1, or nonsignificant, respectively (*P*=0.001, 0.05, or nonsignificant, respectively). L signifies that the relationship between ethrel concentration (with carbaryl) and the designated parameter is linear. L and Q suggest that it is a quadratic relationship.

increasing concentrations of ethephon also resulted in greater return bloom (38-77% greater than the control). The level of set reduction resulting from ethephon treatment, even though considerably later in the season than normal chemical thinning, can positively effect flower-bud formation.

Average fruit size was increased by ethephon treatment in 2004 but not in 2003 (Tables 1 and 2). The lack of a statistically significant response in 2003 likely was due to variability from replication to replication. The sampled control fruit were inexplicably large in 2003. It is expected that thinning should result in greater size, but the highest concentrations of ethephon, with the lowest fruit set, did not increase fruit size. This lack of positive effect likely is related to the growth-inhibiting effects of ethephon at higher concentrations. It is imperative that we determine the lowest concentration of ethephon that can give adequate thinning, so as to avoid the potential negative effect of reducing fruit growth.

Fruit ripening seemed little effected by treatments (Tables 1 and 2). Internal ethylene was increased in fruit from only the 500-ppm treatment in 2004 but not from any treatment in 2003. Flesh firmness and starch index value were not affected, but soluble solids concentration was increased by ethephon each year. It is likely that reductions in fruit set will have more impact on fruit ripening than will any lingering, direct effects of June ethephon treatments.

Conclusions & Future Research

With McIntosh, ethephon provided consistent thinning in the two years of study. A concentration of between 200 and 300 ppm ethephon (2/3 and 1 pint Ethrel®/100 gallons, respectively) plus carbaryl (1 pound a.i./100 gallons) and Regulaid® (0.125%) gave optimal results. These two years of research, however, represent inadequate experience to recommend wide-scale use of ethephon for chemical thinning in Massachusetts; however, growers should consider applying ethephon to underthinned test blocks at a small scale. Research in 2005 will continue with McIntosh and additional varieties to gain more experience with the use of ethephon. Hand thinning will be included as an additional treatment, and economic comparisons also will be made between hand thinning and ethephon.

Acknowledgments

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