Influence of Naphthaleneacetic Acid (NAA) and Abscisic Acid (ABA) on the Development of Bitter Pit on Honeycrisp Apples.

Duane W. Greene and Jacob Aliengena
Stockbridge School of Agriculture, University of Massachusetts Amherst

Bitter pit is a physiological disorder that affects many apple cultivars. It is characterized by dark circular lesions that develop just below the skin surface of an afflicted apple. Honeycrisp is one of the most susceptible apple cultivars grown in the United States. Thus, economic losses due to this disorder can be great. There are management strategies that are presently used to help reduce the losses due to bitter pit. These include the use of calcium sprays throughout the summer, careful control of vegetative growth by judicious use of fertilizer, especially nitrogen, and less aggressive dormant pruning. The use of these preventatives' practices can be helpful, but in many years fruit losses due to bitter pit may be unacceptably high. Recent reports by Todd Einhorn and other scientists at Michigan State University have shown that post-bloom applications of naphthaleneacetic acid and abscisic acid (ABA, Protone) could reduce the incidence of bitter pit on Honeycrisp apples. This investigation was undertaken to determine if multiple post-bloom applications of NAA, ABA, or the combinations of NAA and ABA on Honeycrisp apples growing in Massachusetts could reduce the incidence of bitter pit at harvest and/or following regular air storage.

Materials and Methods

A block of mature Honeycrisp/M.9 apples was selected at the University of Massachusetts Cold Spring Orchard. Trees in this block have consistently had a high level of bitter pit at harvest. Trees in this block were selected and treatments were assigned after a severe frost occurred on the night of May 18 when fruit size averaged about 5 mm. Due to fruit damage, the decision was made to apply no thinners. Even if we did decide to thin, what to put in the spray tank would have been a guess. Tree rows ran down a slight slope and damage to fruit became progressively more severe going from the top of the row to the bottom. Replications were established by tree position in the row to ensure that all trees had similar cold damage. There were six replications and four treatments: an untreated control, NAA at 10 ppm, ABA at 100 ppm, and a treatment with both 10 ppm NAA and 100 ppm ABA that were applied together in the same spray tank.

Regulaid surfactant at 1 pt/100 gal. was included in the ABA sprays. Treatments were applied at a tree row volume dilute rate of 100 gal/acre at 30, 44 and 60 days after bloom. There was a guard tree on each side of the treatment trees. Fruit set was surprisingly good, making hand thinning necessary. No drop control compounds were used in this block in 2023.

High temperature during the first two weeks of September did not permit development of good, characteristic red color. The first Honeycrisp harvest was made on September 8, and it was based primarily on the starch rating (Table 2.). The second harvest was made on September 13. Good red color still had not developed. However, since there were no drop control chemicals on these trees and hot weather was forecast to continue, we decided to make the second and last harvest on that date. All remaining harvestable fruit were harvested at that time. In total, about 125 fruits were harvested from each tree and evaluated for bitter pit. During the first part of each harvest day,

fruit quality assessment was assessed to document fruit maturity at each harvest date. This was followed later in the day by harvesting fruit to evaluate for bitter pit.

All fruits were evaluated for bitter pit in three different ways. First, fruits were rated for bitter pit using a 0 to 3 scale (0= no bitter pit, 1=low, 2=moderate and 3=high amount of bitter pit). Bitter pit was also quantified by counting the number of pits present on each apple and recording that number. The third method to quantify bitter pit was by expressing the percentage of fruit evaluated that had bitter pit. Following bitter pit evaluation at harvest, fruits were kept at room temperature for five days and then they were placed in regular air storage at 32° F for 12 weeks. Fruits judged to have bitter pit were eliminated. Following the cold storage period, fruits were removed and evaluated for bitter pit again, similar to the evaluation done at harvest.

Results

The incidence of bitter pit in harvested fruit is shown in Table 1. When the incidence of bitter pit on fruit harvested is expressed as the percentage of fruit with bitter pit, only fruit that received both NAA and ABA had less bitter pit. This was true for both fruit evaluated at harvest and fruit that were evaluated following 12 weeks in cold storage. When bitter pit was quantified either by using a rating system or by counting the actual number of pits on a fruit, there were no statistical differences among treatments. Fruit quality was evaluated on each harvest date. Red color was not evaluated because of the very warm temperatures leading up to and through the first two weeks in September which was substantially high that typical color did not develop. Starch rating (which was taken) and ground color (not taken) were in the range that we considered fruit ready for as part of a normal commercial harvest.

Although soft scald was not rated, the incidence of

Table 1. Influence of post-bloom applications of naphthaleneacetic acid (NAA) and abscisic acid (ABA) to Honeycrisp/M.9 apples on the amount and severity of bitter pit at harvest and following 3 months of air storage at 32˚F. Belchertown, MA, in 2023.

Treatment[1]	Fruit with bitter pit (%)		Pits per fruit (No.)		Bitter pit rating (0-3)	
	Harvest	Storage	Harvest	Storage	Harvest	Storage
Control	11.1 a	24.7 ab	9.5 a	12.7 a	1.8 a	2.1 a
NAA	10.2 ab	24.5 ab	11.7 a	14.5 a	1.9 a	2.1 a
ABA	8.3 ab	28.7 a	11.8 a	13.1 a	2.2 a	2.1 a
NAA + ABA	5.0 b	11.5 b	8.0 a	13.3 a	1.8 a	1.9 a
Significance						
NAA	NS	NS	NS	NS	NS	NS
ABA	NS	NS	NS	NS	NS	NS
NAA x ABA	*	*	NS	NS	NS	NS

[1]Treatments were applied as a dilute TRV spray at 30, 44 and 60 days after bloom.
*= Statistical differences among treatments were detected at odds 19:1.
NS= Non-significant differences among treatments.

Table 2. Apple maturity parameter at harvest of Honeycrisp/M.9 apples treated with post-bloom spray applications of naphthaleneacetic acid (NAA) and abscisic acid (ABA). Belchertown, MA in 2023.

Treatment[1]	Fruit weight (g)	Flesh firmness (lb)	Soluble solids (%)	Starch rating (1-8)
		---------- Harvest 1 - September 8 ----------		
Control	203	14.1	11.1	5.9
NAA	203	14.4	11.1	6.2
ABA	204	14.6	10.9	6.3
NAA + ABA	200	14.4	10.6	6.2
Significance	NS	NS	NS	NS
		---------- Harvest 2 - September 13 ----------		
Control	216	13.7	10.8	6.0
NAA	219	13.5	10.7	6.5
ABA	218	13.9	10.8	6.1
NAA + ABA	213	13.4	10.7	6.6
Significance	NS	NS	NS	NS

[1]Treatments were applied as a dilute TRV spray at 30, 44 and 60 days after bloom.

this storage disorder was minimal. We surmise that the five-day pretreatment at room temperature prior to placing the fruit into cold storage was sufficient and essentially eliminated fruit losses due to this disorder.

Discussion

The incidence of bitter pit in Massachusetts apple orchards in the 2023 growing season was uncharacteristically low. The reason for this is unclear, although the severity of bitter pit does vary from year to year. The 2023 growing season was abnormally wet with record amounts of rain falling during the season which favored root growth. With abundant soil moisture, we suggest that roots were able to grow into and explore a larger volume of soil; thus, they were able to absorb more calcium from a larger volume of soil.

Bitter pit was quantified using three different methods: percentage of the harvested fruit that had or developed bitter pit, the average number of pits on affected fruit, or by a severity rating system. Only fruit that received three sprays of NAA and ABA showed a reduction in the incidence of bitter pit at harvest and following storage. However, this was true only when bitter pit severity was expressed as percent of fruit with bitter pit but not when severity was expressed as either the number of pits per fruit or when expressed as a severity rating.

It is legitimate to ask if the reduction in bitter pit is real since only one of the methods of assessing bitter pit severity was significant. Only one rate of NAA and ABA was used. Since a standard curve was not run prior to doing the experiment, we cannot say for certain that the best rates for NAA and ABA were selected. Furthermore, one can ask if both NAA and ABA are required to get the maximum response, as suggested from these data? Other questions that need to be answered are whether there are additional benefits of applying these growth regulators at this stage of fruit development. Since flower bud formation in Honeycrisp occurs relatively early, are these sprays applied early enough to enhance flower bud formation?