Techniques to Boost Plants' Stress Tolerance and Extend Fruit Marketability

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In August of 2018, I attended the 30th International Horticultural Congress in Istanbul, Turkey. It was an excellent opportunity to meet other scientists and to hear talks on horticultural topics, many of which were relevant to ECHO's network. Here is a synopsis of a few of those talks.

Salicylic Acid for Improved Stress Tolerance

Several presentations were given on salicylic acid (SA), a plant hormone that enhances disease resistance and tolerance to environmental stress factors such as heat, cold, and drought. A form of SA called acetylsalicylic acid (ASA) is the active ingredient of aspirin, a commonly available drug with which most people are familiar. I attended a talk by M.R. Shaheen, who observed that spraying tomato plant leaves with a 1.5 mM (millimolar) concentration of SA improved the crop's ability to withstand high temperatures (40°C). Most formal research is done with laboratory-grade SA instead of aspirin tablets, but Shaheen shared that aspirin can be used. While aspirin should not be viewed as a substitute for good farm management, it might help boost crop performance under less-than-ideal growing conditions. As with any new practice, minimize risk by experimenting on a small number of plants. Try varying the concentration, application interval, or application method. Do not make the concentration too high; avoid using more than two aspirin tablets per gallon of water. Depending on the purity of the pills, two 325-gram aspirin tablets dissolved in 3.8 liters (1 gallon) of water is the equivalent of about 1 mM ASA. Senaratna *et al.* (2000) reported negative effects with over 1 mM ASA on bean and tomato plants.

When spraying plants with ASA solution, timing matters. Shaheen recommended spraying tomato leaves when air temperatures reach 32°C and/or at flowering. I do not recall whether he sprayed SA more than one time after each of these events. Browsing online, I found examples of success with SA or ASA applied at specific times (e.g., growth stages or when yield-limiting temperatures, soil moisture levels, or pest populations are reached) or intervals (e.g., every two to three weeks). An approach like Shaheen's would boost plant defenses at critical growth stages and when plants are exposed to adverse conditions.

Besides foliar sprays, ASA can be applied by drenching soil with the solution or by soaking seeds in it. Senaratna et al. (2000) found that water containing 0.1 to 0.5 mM ASA increased the tolerance of bean and tomato seedlings to multiple stresses (heat, cold, and drought); this occurred when seeds were soaked in the ASA-water for 24 hours prior to planting, and also when the solution was used to saturate the soil of two-week-old potted seedlings.

Postharvest Practices for Longer Shelf Life of Fruits and Vegetables

A number of talks were devoted to reducing postharvest loss of perishable produce. Below are a few practical techniques that were discussed for mango and tomato.

Mango processing options

Md. Atiqur Rahman talked about several practices used in Bangladesh to extend the shelf life of mangoes: pre-harvest fruit bagging, a harvesting tool that minimizes fruit damage, use of stackable plastic crates, and hot water treatment. These practices are most applicable to farmers who sell their mangoes in distant markets. Below are summaries of the practices, based on parts of Rahman's talk, an FAO (2018) (http://www.fao.org/3/i8239en/I8239EN.pdf) publication (in which Rahman is listed as a contributor), and an extension document by Brecht *et al.* (2017) (https://edis.ifas.ufl.edu/pdffiles/HS/HS118500.pdf). These latter two documents are well-illustrated with photos and contain additional information on these and other postharvest practices.

Ensuring fruit quality: To fetch the best market prices, harvest mature mangoes that are still green or are starting to color. Such mangoes ripen properly off the tree and are not as susceptible as fully-ripe fruit to injury and spoilage during transport. Harvest mature green mangoes if subjecting the fruits to hot water treatment (discussed later). A commonly used indicator of the mature green stage is a widening of the fruit at the stem end, resulting in "shoulders" (see page 35 of Brecht *et al.* 2017). Be careful not to harvest too early, as this leads to poor flavor. Keep fruits free of blemishes, such as scars caused by insect feeding and wind damage; latex (sap) stains; disease-related defects; and mechanical damage due to improper handling.

Pre-harvest fruit bagging: This is done to reduce insect damage and to improve overall fruit quality. Six or seven weeks after fruit set, place a paper bag over each mango and wrap the bag at the stem end of the fruit (to keep the bag from dropping off the fruit; Figure 5). Leave the bags on the fruits in the tree until harvest. See research reports by Rathore and Pal (2016) (http://oaji.net/articles/2017/1192-1489507137.pdf) and Islam *et al.* (2017) (https://www.journalbinet.com/uploads/2/1/0/0/21005390/153.17.15.1__influence_of_pre-harvest_bagging_on_fruit_quality_of_mango___mangifera_indica_l.__cv._mollika.pdf) for information on improved fruit retention and quality.

Use of an appropriate harvesting tool: This tool consists of a pole with a blade to remove the fruit and a collection net to prevent fruit from dropping to the ground (Figure 6). Leaving a few centimeters of stem attached to the fruit reduces leakage of sap/latex onto the fruit.

Delatexing (removing latex from the fruit): This step and hot water treatment are done at a packing area. Delatexing improves fruit appearance and marketability by preventing sap stains. Use a pruning shears to trim off stems that were left on the fruits at harvest. Then place the fruits on metal or plastic mesh with the stem end down. Allow the latex to drip onto the ground below the rack for about 30 minutes.

Figure 5. Mango fruit bagging in Myanmar. *Source:* Brian Flanagan

Hot water treatment: This is a non-chemical way to minimize defects caused by postharvest diseases—stem end rot and anthracnose. For some markets, it is a requirement for control of fruit fly larvae. This practice is perhaps the most difficult to implement. Farmers using hot water treatment should harvest fruits at mature green stage, as green fruits are less susceptible to heat injury than those with color.

Figure 6. Examples in Myanmar of a mango harvesting tool equipped with a collection net and bladed edges to sever fruit stems. Note the hack saw blades used in the tool on the right. *Source:* Brian Flanagan

Place fruits in a tub of water heated to 55°C for 5 to 10 minutes; Stir the water, either manually or with a pump, to ensure uniform temperature throughout the tub. Hot water treatment hastens ripening, so if the fruits are to be shipped a long distance, cool them after the hot water treatment for 10 minutes in tap water at ambient temperature. Steve Sargent (2019), postharvest specialist at the University of Florida, commented:

> "Hot water treatments can be effective for decay control, but care must be taken to avoid thermal injury, so cooling with ambient water is a good practice. One key issue with any water treatment is sanitation. We recommend 150 ppm free chlorine in any type of water to kill fungi in particular; of course that will also kill decay bacteria and human pathogen bacteria as well. [Without the addition of chlorine], the water becomes an inoculation soup. For best results, the solution pH should be from 6.8 to 7.2."

Using an online chlorine dilution calculator (https://www.publichealthontario.ca/en/health-topics/environmental-occupational-health/water-quality/chlorine-dilution-calculator), 150 ppm chlorine in 1 liter of water is achieved with 3 ml of bleach containing 5.25% sodium hypochlorite. Sargent also cautioned that hot water treatment protocols (for water temperature, equipment and other aspects of the process) are very strict for exporting mangoes to the United States (USDA-PPQ 2016).

Stackable crates: Processed fruits are placed in crates with holes on the sides for ventilation. The crates are lined with clean paper, jute sacks, or plastic, to cushion the fruits against injury during transport to market. Where plastic crates are unavailable and baskets are used instead, it helps to line them with cushioning material for the same reason.

Tomato marketing issues and drying options

Presentations by J.W.H. van der Waal and O. Oyedele dealt with the tomato supply chain in Nigeria. Oyedele collected data from 146 tomato producers in Oyo state. Nearly two thirds (65%) of those farmers sold all of their tomatoes in rural markets, compared to only 21% who sold theirs in urban markets. Urban markets offered higher prices and access to a larger population, but rural markets are closer to farmers' fields. Farmers cited perishability and price fluctuation as two major marketing constraints.

Van der Waal evaluated methods of transporting tomatoes and found that the use of plastic crates helped preserve fruit quality during transport to markets. The crates reduce fruit injury due to their smooth sides, holes for ventilation, and the fact that they can be stacked without crushing tomatoes at the bottom of a truck bed. Fruit losses were reduced from 30% with woven baskets—which can only be used once—to 12% with crates. Van der Waal pointed out that crates are available in Nigeria, but adoption of crates is often limited because farmers do not want to risk losing them in the supply chain.

Figure 7. Elevated drying box in Tanzania. *Source:* Stacy Swartz

Prices of tomatoes vary depending on the time of year, fruit quality, and distance to markets. Staggered plantings and fruit drying were discussed as two options for coping with price fluctuations. Plantings can successfully be staggered in areas where there is a long enough period during which tomatoes can be grown (i.e., not too hot/dry or humid; irrigation is helpful). Drying extends the time over which fruits can be sold, and allows farmers to market their culls, fruits that are okay to eat but are small or misshapen. Drying tomatoes on an elevated platform or table (Figure 7) results in higher fruit quality than drying produce on the ground, where fruits are easily contaminated by dust, sand, and animals. An article entitled "Modernizing tomato production in

Nigeria (https://www.dw.com/en/modernizing-tomato-production-in-nigeria/a-48030446)" (Umar 2019) highlights some of the issues with sun drying tomatoes on the ground.

Zero Energy Cooling Chambers

To prolong the shelf life of fresh produce, fruits and vegetables must be stored under cool, humid conditions. Cool temperatures extend the life of harvested produce by slowing ripening. Humidity reduces water loss, keeping fruits and vegetables from drying out and shriveling. While refrigerators can provide cool, humid conditions, they are expensive to purchase and maintain. Zero energy cooling chambers (ZECCs) are a low cost alternative. W.B. Legesse presented work on ZECCs that were tested by AVRDC (World Vegetable Center) in Mali. The approach makes use of porous materials and the cooling effect of evaporation. An example of evaporative cooling is the pot-in-pot method described in *EDN 89* (https://www.echocommunity.org/en/resources/87ef239b-46f3-413c-b08b-d42528dae04c). A clay pot containing fruits/vegetables is placed inside a slightly larger clay pot. The gap between the two pots is filled with sand, which is kept moist. Produce in the inner pot is cooled as water evaporates through the sides of the outer pot. Evaporation, with associated cooling, happens as long as the surrounding air is not already saturated with moisture. For that reason, ZECCs work best in hot, dry conditions. The center in Mali experimented with ZECCs made with clay pots, burlap sacks, straw, and bricks (see Figure 8 for an example of a ZECC made with bricks). All of these materials reduced temperature, but sacks and straw dried out more quickly—and had to be rewetted more frequently—than clay pots and bricks.

Figure 8. An evaporative cooling chamber at AVRDC in Tanzania, made with bricks. *Source:* Stacy Swartz

For links to more information, see the following websites:

- MITD-Lab web page entitled Evaluation of Evaporative Cooling Technologies for Improved Vegetable Storage in Mali (http://d-lab.mit.edu/research/food/evaporative-cooling-vegetable-preservation/mali-evaluation)
- A Practical Action Technical Brief on Evaporative Cooling (https://www.echocommunity.org/en/resources/4b66b445-e7d9-40cc-b46a-f7d5eab4fcad)

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