Forced Air Cooling on the Farm

Introduction

The preservation of quality in fresh market and storage crops on small and medium sized farms in the Northeast depends on the rapid reduction of pulp temperature and maintenance of relatively low temperatures to slow metabolic respiration.

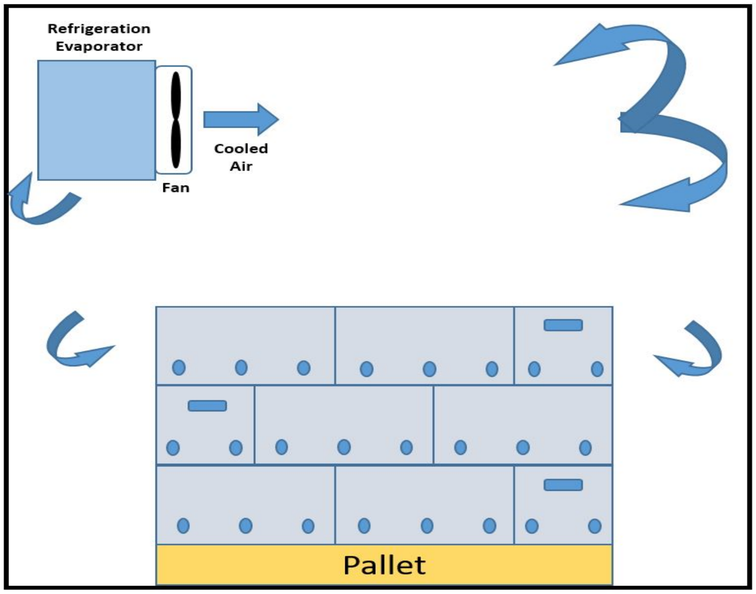
▲ *A commercial forced air cooler in a produce distribution facility*

There is strong foundational work showing that, rapidly reducing temperature at the start of the cold chain increases product quality when delivered to the consumer. Postharvest handling is critical for fresh produce farmers and the markets they sell to. Effort and expense invested in growing fruits and vegetables can be wasted without good handling practices at and following harvest (Gross 2014). Consumers expect the best from fresh produce. Quality and freshness are ranked with high importance among consumers. Farmers market respondents respectively rank quality (63%) and freshness (59%), as highly important factors in their buying decisions. Nearly 87% of the respondents indicated that availability and quality of fresh produce affected their decision about where to purchase (Gorindasamy 2002).

Key Points of Precooling

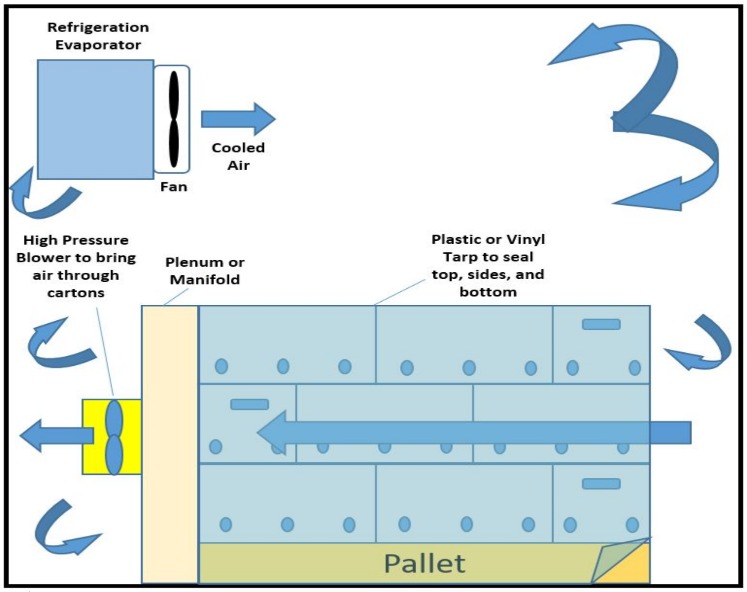
- Starts the cold chain by rapidly reducing respiration.
- Reduced respiration leads to higher quality over a longer storage and distribution time.
- Cooling is improved with the combination of active cooling and forced air flow with a blower.
- 1-3 CFM of air flow at 0.5 IWC static pressure per pound of product is the rule of thumb for sizing.
- Ventilated containers (e.g. holes or slats) are necessary to ensure air flow is actually through the product.
- Close up any large openings to prevent short circuiting air flow.

Room Cooling (Ambient)



▲ *Figure 1—Produce packed in cartons, lugs, or other containers will not cool rapidly even when placed in a cooler. The cold air does not have sufficient velocity or pressure to pass into the center of the pallet or even to the center of a single carton, even when the containers have vented sides. Heat removal from the produce depends on conduction through produce and cartons which is slow.*

Forced Air Cooling (FAC)



▲ *Figure 2—Using a high pressure blower, cool air can be pulled through cartons of produce to remove field heat and reduce product temperature to storage temperature more quickly. The heat removal rate from the produce is enhanced due to increased convective cooling in addition to conduction. This lowers respiration and leads to improved quality.*

Precooling involves flowing a controlled, chilled fluid (air or water) over the product to improve heat transfer for removal of field heat to depress respiration and initiate the cold chain.

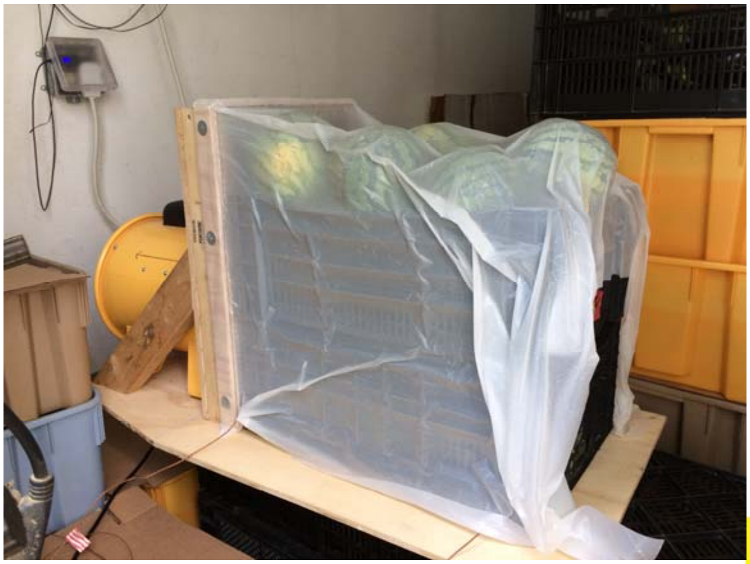
Precooling

One of the most important postharvest factors influencing quality is temperature. Temperature directly impacts the rate of metabolic respiration and associated decay. Produce which is not cooled quickly degrades in quality (Sargeant 1991). Table grapes, for example, deteriorate more in 1 hour at 90 °F then in one day at 39 °F or one week at 32 °F (Thomson et al 2008). Lower quality leads to a decrease in sales, inefficient use of storage space, and wasted labor due to time taken to grow, clean, and store product that doesn't sell. Coolers are a good addition to most farms, but fall short of meeting optimal precooling needs. When produce is packed in boxes, stacked on a pallet and directly placed into a cooler, cooling time will be a minimum of 24 hours and may take many days. (Thompson et al 2008).

One method to reduce cooling time is through forced air cooling (FAC). In FAC systems, refrigeration cools a space and blowers are set in position to actively draw the cold air through the produce. The cooling time drops from 24 hours to 10 hours or less when using a static cold rooms due to the increased air flow (increased convective heat transfer) (Thompson et al 2008, Boyette 1989).

Attempts have been made at smaller scale pre-coolers to reduce field heat at harvest in absence of coolers (Thompson and Spinoglio 1996). Retrofitting a cargo container with insulation and cooling with a large capacity air conditioner was also explored (Boyette & Rohrbach 1990). This forced-air cold room offered space for many pallets of produce but it still took many hours to reduce the temperature internally, especially for the boxes on pallets in the center of the container. The key is integrating both cooling and air flow effectively (see Figures 1 & 2).

This is a 4 foot tall version of a simple, portable forced air cooler. It is being used to cool a mixed pallet of fresh picked zucchini, summer squash, and peppers.



123 lbs of Watermelons will take a long time to cool, but forced air cooling removed field heat 2 times faster than ambient room cooling.

A mobile forced air cold box mounted on a trailer was constructed and demonstrated in Florida (Talbot and Fletcher 1993) aimed at farms growing produce on 5-50 acres. This unit could be self-built. Experiments showed that grapes could be cooled by 15 °F per hour. For denser produce like melons and tomatoes, the cooling times were longer. The construction cost at that time was close to $5,000.

We have built prototype FAC's for a single, fully or partially loaded pallet (figure 2) and also a 1-3 carton (either bulb crate or 1 1/9th bushel box) "counter-top" model. The construction details of these units are provided on the following pages.

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Construction Details for a Pallet Forced Air Cooler

▲ *The blower is just placed up to the cut-out hole, on a shelf. This unit has a very simple shelf and feet to add some stability.*

▲ *This Pallet sized Forced Air Cooler was easily constructed in an after-noon with decking screws, dimensional lumber and plastic sheeting.*

Framing:

2”x12” lumber to make a 43” wide x 74” tall x 11-1/4” deep plenum for suction air distribution.

Plenum Panel:

3/8” CDX Plywood with a 11-1/4” circle cut out for the blower suction inlet. Position this whole centered for even air pressure.

Plastic Wrap:

It is Important to channel air from one end horizontally through to the blower under suction, not pressure. We used 4 mil poly for our tests and it worked great. We attached it via duct tape initially, then wrapped the plastic around strapping and screwed it to the box with fender washers. Using wiggle wire would be a great upgrade and make replacing the plastic easier in the future.

Blower:

12” Portable Ventilation Blower. This blower can be purchased through Global International (Item#T9F246343) and other suppliers. It can be run at two speeds with flows of 1600 or 1400 CFM (at approximately 0.5 IWC). Smaller (8”) and larger (16”)diameter blowers are available for different sized coolers.

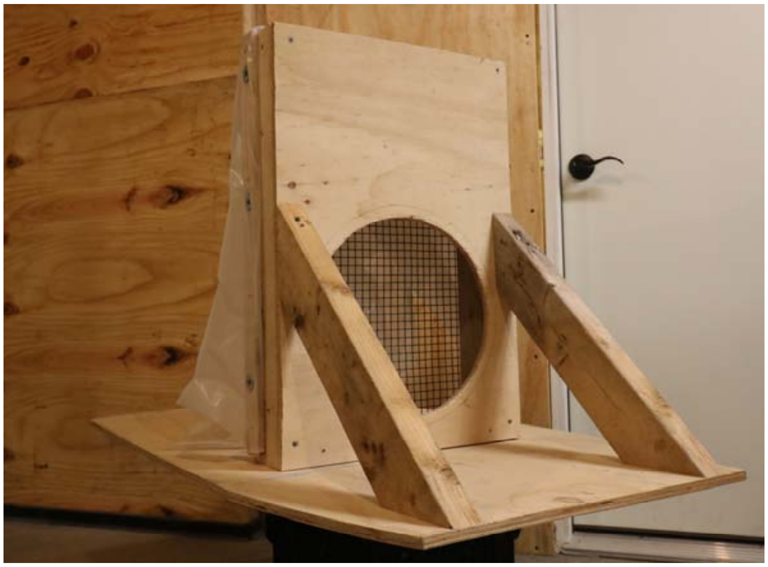
Alterations: ▶

After some field trials, it was discovered a smaller (shorter) unit works well. Many farms aren’t packing full 6’ pallets, and we found that a 4’ version was suitable.

Bill of Materials—Pallet Cooler

Framing Lumber, 2”x 12”x 8’ (Qty 3)	$55
Plywood, 4’ x 8’ x 3/8” (Qty 1)	$20
Decking Screws, 3” (1 box)	$10
Decking Screws, 1-1/4” (1 box)	$10
Fender Washers, 3/8” (1 box)	$10
Plastic, 4 mil, 20’x25’ (need ~8’x16’)	$25
Blower, 12” Portable Ventilation Blower	$125
Total Cost	**$255**

Construction Details for a Counter-top Forced Air Cooler



Farms that need to cool smaller volumes of produce can also benefit from forced air cooling. Whether cooling stacked pallets, pallet bins or individual cartons, the same principals apply. A smaller pallet cooler was noted on the previous page, but this concept can be scaled down even further to fit your needs. Here is a prototype, that could fit on a countertop with-in a walk-in cooler.

Framing:

Constructed of 2x4's on top of a horizontal base made from 1/2" plywood cut 24" deep and 44" wide. Angled reinforcements were needed to stiffen the assembly.

Plenum Panel

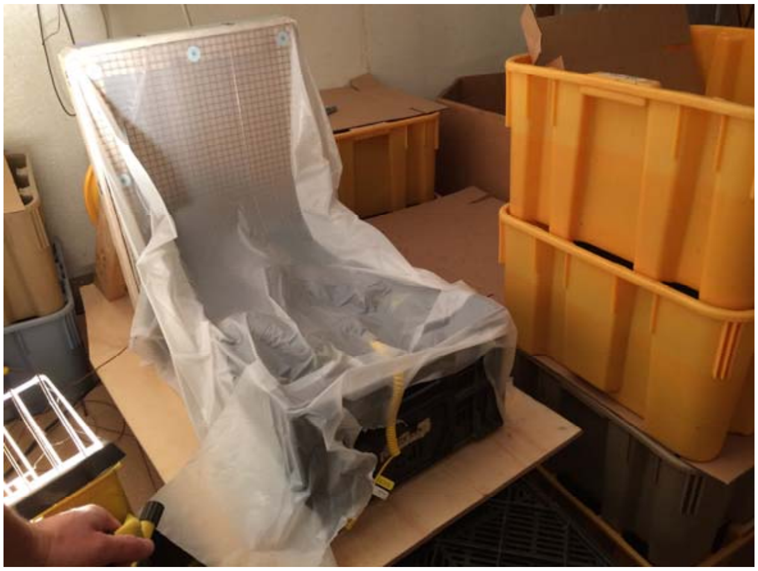
The plenum (vertical wall) was built 16" wide by 24" tall and assembled with decking screws. 1/2" Plastic coated hardware cloth was used to provide a back-stop for the carton being cooled, to keep the plenum space from being closed, and to provide proper air flow from the end of the crates through the product and out through the blower.

Plastic Wrap

4-mil poly is fastened to the top and two sides of the plenum, and long enough to extend over your desired number of bulb crates, or vented boxes you wish to cool at once. This was secured with decking screws through fender washers with the plastic wrapped around strips of plywood.

Blower

The blower used was the same 12" blower from Global International. A 11 1/4" hole was cut out of the plenum to provide the suction air inlet to the blower.



▲ *25lbs of eggplant cooled by 23°F in 30 minutes, while "room cooling" only dropped 8°F in the same amount of time.*

Bill of Materials—Carton Cooler

Framing Lumber, 2"x 4"x 8' (1)	$5
Plywood, 4' x 8' x 1/2" (1)	$25
Decking Screws, 3" (1 box)	$10
Decking Screws, 1-1/4" (1 box)	$10
Fender Washers, 3/8 (1 box)	$10
Plastic, 4 mil, 20'x25' (need 64"'x36')	$13
Blower, 12" Portable Ventilator Blower	$125
Total Cost	**$198**