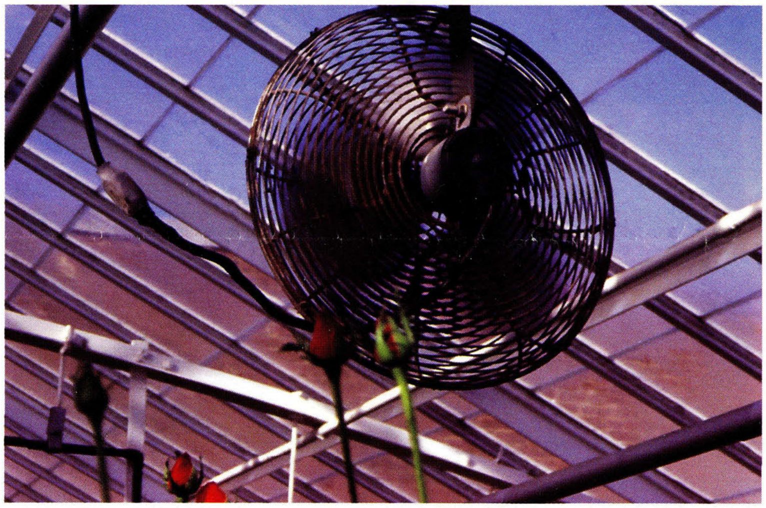
Grower 101: Horizontal Air Flow

Discover the many benefits of HAF along with fan selection and installation tips.

By John Bartok, Jr.



Top: *Typical HAF system in a hoophouse. Fans create a horizontal circular air pattern that mixes the air from end to end and ceiling to floor.* ***Middle:*** *Basket fans that are 12-20 inches with efficient permanent split capacitor motors keep operating costs to less than $.25 a day per fan.* ***Bottom:*** *A fan with a shroud will increase the throw of the air to more than 50 feet. These work well where tall crops or hanging baskets are grown. A guard is required if the fan is less than 7 feet from the floor. (All photos courtesy of John Bartok, Jr.)*

Since 1967 when Jay Koths, University of Connecticut floriculture specialist emeritus, introduced horizontal air flow (HAF), the concept has become the standard method for air circulation in greenhouses. Over the years improvements to fan design, installation techniques and efficiency have made the system a valuable tool that helps growers produce better quality plants.

HAF is based on the principle that air moving in a coherent pattern in a building like a greenhouse needs only enough energy to overcome turbulence and friction losses to keep it moving. In other words, it just has to be "kicked along." The fans need to be sized correctly and placed properly to do this because air is heavy. The air over each square foot of floor area in a typical greenhouse weighs about 1 lb. A 30x100-foot greenhouse contains about 1.5 tons of air. Once the air is moving, it will coast along like a train. That is why HAF is so efficient; it takes only four small fans to keep air moving at 50-100 feet per minute.

Benefits of HAF

More uniform temperature. As the air is moved in a horizontal pattern down one side and back up the other in a free-standing greenhouse or down one bay and up an adjacent one in a gutter-connected house, mixing occurs from side to side and floor to ceiling. We have instrumented a number of houses and seldom see more than a 2° F difference between any two points. Due to the constant movement of the air, heat supplied at one end is carried to all parts of the greenhouse quickly. Stratification is also eliminated.

Fewer disease problems. Research has also shown that air movement of 50-100 feet per minute is adequate to keep nighttime leaf temperatures almost identical with the surrounding air. When leaf temperature is allowed to cool much below the air temperature, the dew point is reached, and condensation occurs, harboring disease organisms. Radiant cooling on clear nights, especially in non-infrared-radiation poly-covered houses, will cool plant leaves several degrees below the air temperature. HAF will reduce this difference.

Higher carbon dioxide levels. During daylight hours, photosynthesis depletes the carbon dioxide in the boundary layer of air next to leaves. Moving air will replace the depleted layer with fresh air that has a higher carbon dioxide content. If supplemental carbon dioxide is added, a lower level is usually adequate to get the same plant responses, for instance, 1,000 ppm rather than 1,200 ppm.

Cooling effect. During warm days in the spring and fall, solar radiation warms exposed leaf surfaces to as much as 15° F above air temperature. This can cause burning of the leaves, flowers or fruit. HAF will remove this excess heat and increase plant growth.

Enhanced pesticide coverage. Most manufacturers of thermal and mechanical fogging equipment recommend the use of HAF for better distribution of spray material to leaf surfaces. The air movement created gives more uniform coverage and better penetration into the foliage.

Fan Selection and Installation

Fan capacity. Keeping the air mass moving at a velocity of 50-100 feet per minute requires enough energy to overcome turbulence and friction losses. A rule of thumb based on greenhouse trials and smoke bomb tests is 2 cu.ft. per minute of fan capacity for each square foot of floor area. For example, 6,000 total cu.ft. per minute fan capacity is needed in a 30x100-foot greenhouse (30x100 feet X 2 cu.ft. per minute per square foot). This can be reduced slightly in houses with plants grown only on the floor; it may need to be increased slightly in houses with crops such as tomatoes, roses or hanging baskets. If you installed fans having 1,600 cu.ft. per minute output, four fans would be needed.

Type of fan. Circulating fans with blades that are designed to operate against zero static pressure are more efficient than exhaust fans that are designed to force air through louvers. Select fans that have high efficiency because they normally operate 24 hours a day 8-9 months out of the year. Before purchasing, compare fans on an energy efficiency rating (EER = cubic feet per minute output per watt of electricity input). If the manufacturer does not provide this information, you can calculate it by dividing the cubic feet per minute output by amps X volts. This information is usually available in the fan literature. For example, a 1⁄15-horsepower, 16-inch-diameter fan has an output of 1,656 cu.ft. per minute and uses 0.9 amps at 115 volts. (EER = 1656/(0.9 X 115) = 16 cu.ft. per minute per watt) Efficiencies of 14-16 are average. Better fans have efficiencies of 18 or higher. Generally, permanent split capacitor motors have a higher efficiency than shaded pole motors.

Multi-speed and variable-speed fans are available from some suppliers. These are considerably more expensive and cannot be justified in most applications. Low-cost residential fans have been used by some growers with good results and by others with poor results. They are generally not designed with enclosed motors for the dusty, moist conditions in a greenhouse.

Circulating fans normally push the air about 30 times their diameter. A 20-inch fan will move the air about 50 feet. Resistance from hanging baskets or tall plants will reduce airflow some. Installing fans with shrouds will extend the distance the air will be pushed. The shroud can be a sheet-metal band or closely spaced wires on the fan guard in the area of the fan blades. This reduces the spread of the air stream as it leaves the blades.

To save money on the purchase of fans, some growers utilize the unit heater fans as part of the HAF system. They need to be located close to where the HAF fan would be placed, and the heater fan has to be fitted with a switch that allows it to operate continuously. Although this saves on the initial investment, operating costs increase as the unit-heater fan motor is usually ⅓ or ½ horsepower rather than the 1⁄10 that is common with the HAF fan.

Fan location. Ideally, the fan should be located in the center of the air mass that is being moved. In freestanding greenhouses fans should be located ¼ of the width of the greenhouse from the sidewall. In gutter-connected greenhouses the best location is usually in the center of the bay. In both types of greenhouses, the first fan should be located 10-15 feet from one endwall. This boosts the air coming around the corner. Subsequent fans are usually located 30-50 feet apart with the last fan at least 50 feet from the endwall. On the opposite side or adjacent bay, the same spacing holds with the first fan located 10-15 feet from the opposite endwall. The height of the fan is not critical, but it is best located above head height to get it out of the way. In many greenhouses there is a truss or collar tie ➧

that can be used for support. If the house contains hanging baskets, a location a couple of feet above or below them is best.

Short circuiting of the air stream across the house before it reaches the next fan can occur with a poor installation. This will show up as cold spots or areas of poor growth and is caused by not adding enough energy to the air or having the fans too far apart. The easiest way to check this is to use a smoke bomb available from heating system suppliers or companies such as Superior Signal Co., Inc. A fogger could also be used. Place the smoke or fog behind one of the fans after the airflow has stabilized. Watch its movement. Short circuiting will be easy to observe. Incense sticks also work well, especially for detecting turbulence in the airflow.

Airflow pattern can be checked with fog or a smoke bomb. The air should flow continuously down one side of the greenhouse and back up the other at a rate of 50-100 feet per minute without short-circuiting.

Control. Fans with 1/10-1/15 horsepower draw about 100 watts of electricity. Up to 15 fans can be placed on one 20-amp circuit. During the fall, winter and spring, the HAF system should run continuously. An on/off switch can control the fan circuit. A power relay could be placed in the circuit so that the HAF system is turned off if the exhaust fans are activated or vents opened. If a controller or computer manages the environment, the HAF fans should be operated during the heating, set point and low stage ventilation modes.

Cost. Standard HAF fans range in cost from $100 to 150. Operating cost depends on your cost of electricity. A 100-watt fan operating 24 hours a day will use 2.4 kilowatts of electricity. At $.10 a kilowatt hour, the cost is $.24 a day.

Maintenance. Most fan motors do not require lubrication. Dust and dirt should be cleaned from the fans occasionally to increase air flow and reduce motor temperature. Most growers have recognized the benefits of HAF air circulating systems. Use the above guidelines to fine-tune your system's performance and make it more efficient. GPN

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