EFFECTIVENESS OF HORIZONTAL AIR FLOW (HAF) IN GREENHOUSES

Jay S. Koths
Extension Floriculturist

Air flow in greenhouses is beneficial in many ways. Many efficient methods of moving greenhouse air have been developed. In many installations, horizontal air flow (HAF) has proven to be an efficient system. HAF has previously been reported in this Newsletter three times. (1,2,3)

The HAF concept is simple. Picture the greenhouse as a big box filled with air (which is a fluid). The air in a box 30'x100'x10' will weigh about 1 1/2 tons. Now start moving this 1 1/2 tons in a circular pattern. It will flow. Comparatively little energy is required to keep it moving. This mass flow characteristic is the basis for the efficiency of HAF.

Professors Walker and Duncan, agricultural engineers at the University of Kentucky, reported research (4,5) which substantiates HAF efficiency. It is perhaps the most complete report to date on this system of air movement in greenhouses.

In their reports, Professors Walker and Duncan compared the following six systems of air movement in a 33'x90' greenhouse.

1. Vertical convection--Commonly known as turbulator or Dutch mill, fans are mounted vertically in the ridge.

2. Horizontal air flow (HAF)--Called horizontal convection by Walker and Duncan, the system did not exactly follow previous recommendations. (1,3) The

placement of two of the fans was closer to the ends of the greenhouse and all were nearer the sides so that mass flow efficiency may have been impaired. This was countered by excessive horsepower, the fans being 1/4 hp instead of 1/10 or 1/12 hp. By changing the position of the fans to blow at a 15^{o} angle from the sides, they achieved greater efficiency.

Our work would indicate that the same efficiency could be obtained by placing smaller fans in this greenhouse at 15 or 20 and 50 feet from the ends and 8 feet from the walls. (1) Rated fan capacities, given in the research, are omitted here since Prof. Walker states that there is some problem in relating rated capacities to air delivery when flow of larger air masses is being considered. (6)

3. Sidewall Ventilation--This commercial environmental control unit provides heat, ventilation or simple air flow and was shown to be very effective. Power requirement (1.5 hp) was excessive.

4. Overhead Perforated Plastic Sleeve--This is sold under several trade names and is sometimes combined with heating and/or ventilating. It utilizes a 1/3 hp fan blowing into an overhead plastic tube to distribute air the length of the greenhouse.

5. Two Perforated Plastic Sleeves--Two tubes as in "4" but having 1/4 hp motors.

6. Ground Perforated Plastic Sleeves--A 1/2 hp fan forced air through six plastic tubes lying on the ground about 5 feet apart. While this should give excellent air dispersal, the volume was insufficient to achieve 40 f.p.m., the minimal air movement suggested by Walker.

The air flow speeds under the above system were measured at 6" and 30" above a newly transplanted crop of lettuce and cucumbers. The HAF and sidewall systems were more effective than the others as indicated in these quotes from Walker and Duncan:

"The horizontal convention system where four fans were used to generate a horizontal clockwise rotation of air proved highly effective. The total fan capacity was relatively low, and there was only one small area where the flow was below 40 fpm when fans discharged air parallel to the greenhouse sidewalls. There were no such regions below 40 fpm when the fans were pointed 15^{o} towards the center of the house. The velocities varied from 30 to 200 fpm at 6 inches above the ground for the system discharging air parallel to the sidewalls and from 50 to 200 fpm for the system where the fans were pointed inward. The variation was largest directly in front and behind the fans, a location which is above the plant canopy. The dispersion time of smoke from a smoke bomb was the shortest for any of the systems tested, being 1 minute." (4)

"The sidewall system also proved highly effective with only one corner having velocities below 40 fpm. The total connected horsepower was 1 1/2 hp, which was the largest power requirement of the systems evaluated." (4)

"The overhead perforated sleeve systems were not fully effective in creating 40 fpm air velocity at ground level... The two-tube system was more effective than the single-tube system with only about 1/4 of the greenhouse area having air velocities below 40 fpm." (4)

"Based on the results of this study, the horizontal convention system (HAF) is the most effective method of creating positive air movement within a greenhouse. If 40 fpm is considered to be the minimum velocity level, four fans pointed 15^{o} towards the center can effectively create the desired velocities at floor level. Such a system effectively moves the entire air mass within the greenhouse in a circular pattern around the house. The velocity variation at ground level of 50 to 200 fpm is within acceptable air velocity limits in plant growth structures." (4)

"Two other systems were studied: (1) overhead vertical convection units (turbulators), and (2) perforated plastic sleeves on the ground. Neither of these systems moved air effectively within the greenhouse. The turbulators were commercial units rated for 2500 square feet of greenhouse space. The actual space served by the units was only 1485 square feet, considerably less than recommended. Even so, low velocities were observed everywhere within the greenhouse." (5)

With this data of Walker and Duncan in mind, it would seem appropriate to update the HAF recommendations of 1967 (1) which have worked so well.

For individual houses:

1. Fans of 1/12-1/10 hp are efficient. Commercial, continuous duty motors should be used.
2. Use approximately one fan per 50 feet of wall on both sides of the house.
3. Install the first fan 15 to 20 feet from the end of the house, the last one 40 to 50 feet from the end toward which it is blowing.

4. All fans should be installed about 1/4 of the way across the house and pointed directly down the house to minimize turbulance.

For ridge and furrow houses:

1. Move the air down one house, back the other. Connecting gutters must be sufficiently high to permit air movement.

2. Use large low-horsepower fans. A 1/4 hp 30" fan will provide more than 40 fpm (perhaps) in two 20'x100' connected houses. For two 30'x125' houses, place a fan in the center of each house about 30 feet from the near end of one, the far end of the other.

3. Since a 1/4 hp fan will service perhaps 4000 square feet of greenhouse, it is generally not advisable to use larger fans unless the greenhouses are especially wide and long or you just happen to have one that is not being used.

References

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