

## What if the pad is located outside the air inlet opening?

If the pad is located outside the air inlet opening, it should be continuous, have no large obstructions and should be centered in elevation on the center of the pad so that the airflow is horizontal as it leaves the opening. When the height of the pad exceeds that of the air inlet opening, the pad will extend above and/or below the opening. When this occurs, the pad should be set back from the wall or sash at a distance of at least half the amount of the extension to provide ample room for air to pass uniformly through the entire pad. If possible the pads should be located on the prevailing wind side of the greenhouse. When the greenhouse is sheltered from prevailing winds by another building or greenhouse located within 25 feet, the location of the pads in relation to prevailing winds is not significant.

## How and why should I use baffles?

The cooling air passing through the house will tend to diverge at about a 7-degree-angle or one foot in every eight. Vertical baffles usually are installed particularly with the house, to reduce mixing and keep cool air down at plant level. The baffles should be transparent, spaced approximately 30 feet and held in a fixed vertical plane, and their lower edges should be well above plant level. In greenhouses containing raised benches, a substantial volume of air may travel under the benches to the fan without removing much heat. A baffle covering two-thirds of the distance from the bench to the ground will force most of the cooling air to crop level for more effective plant cooling.

## How do I maintain my water system?

All elements of the water system should be kept well covered, to protect it from insects and wind-born dirt, which will ultimately cause clogging. The water returned to the sump should be screened. The ends of the water distribution pipes should be provided with removable caps or valves

to allow easy flushing out for cleaning. Because water is used up in the evaporative cooling process, a supply of makeup water is needed. An automatic float valve should be used for this purpose and also to maintain a proper water level in the sump.

## Are winter and summer ventilation systems the same?

Essentially winter and summer ventilation systems are two separate systems having different characteristics and requirements. However, they must tie in with each other to switch from one system to the other during spring and fall. The transition is very important as it determines the inside to outside temperature difference available on a mild, sunny day, and it establishes the airflow design capacity of the winter ventilation system.

## Do I need to ventilate differently in the winter?

Mechanical ventilation essentially provides the same benefits regardless of the season, but winter calls for different airflow principals. In the winter, outdoor air is too cold to introduce directly on the plants. The goal of winter ventilation is to introduce the cold air in a turbulent manner. This causes the cold air to mix with the warmer air in the greenhouse, without producing cold drafts at plant level. This mixing is the result of using small high-velocity jets. In a greenhouse it is desirable to have many small, well-distributed openings rather than one large one for winter ventilation. It is important that all areas of the greenhouse are at the same temperature. To achieve this, the ventilating system must distribute the air uniformly throughout the house and maintain positive air movement and continuous circulation.

## Can I use gravity to circulate the air in my greenhouse?

A powered ventilating system has a real advantage over gravity systems that rely on thermal air currents because it has the energy required to provide uniform air distribution and mixing. Fans that

mechanically ventilate greenhouses, combined with perforated transparent plastic tubes, make an ideal system for introducing cold air into a greenhouse in the winter without cold drafts.

## What do I use thermostats for in my greenhouse?

Thermostats or controllers are used to turn fans on and off as required to meet changes in outdoor climate conditions and thereby maintain more uniform greenhouse temperatures with lower operation costs.

## What do I use a humidistat for?

During warm weather a Humidistat can be used to control the pump of the cooling pad system to help prevent excessive greenhouse humidity. A humidistat that is wired to operate exhaust fans also can help prevent excessive humidity.

## How can I find out more about ventilation?

You can find out more about ventilating and cooling greenhouses by contacting the NGMA for a free copy of the ventilation guidelines or download it from the web: [www.NGMA.com](http://www.NGMA.com)

Please contact the NGMA office for more information and other NGMA publications.



**VISIT US ON THE WEB:  
WWW.NGMA.COM**

20 W. Dry Creek Circle, Suite 110  
Littleton, CO 80120  
800-792-NGMA (6462)  
303-798-1338 • FAX 303-798-1315  
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H E L P F U L   H I N T S

# VENTILATING & COOLING GREENHOUSES



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## What is ventilation?

Ventilation is the exchange of air between the inside and outside of the greenhouse. It is used to remove heat from solar radiation, to replenish carbon dioxide and to help control the levels of relative humidity.

## What is a ventilation rate?

The ventilation rate refers to the amount of ventilation per unit area. It is measured as cubic feet of air-per-minute per square foot of greenhouse floor area (CFM per square foot) because the heat load derives from solar radiation and is directly proportional to floor area.

## What is the difference between natural and mechanical ventilation?

Natural ventilation results from the wind and stack action from ventilator sashes. Mechanical ventilation is created by electric fans and related equipment.

## What does cooling refer to?

Cooling consists of reducing the air temperature by the evaporation of water into the air-stream. The system that does this and moves the cooled air through the greenhouse and exhausts the warmed air is the cooling system.

## What is circulation?

Circulation is the movement and mixing of air in a greenhouse to promote uniformity in temperature and humidity and to provide proper air motion throughout the greenhouse.

## Why is circulation important to my plants?

Continuous circulation produces a gentle air movement which maintains a better leaf surface microclimate and prevents pockets of disease-producing high humidity.

## Why is ventilation important?

Ventilation allows for the better control of temperature. By allowing an increase in light intensity, which is important to good plant growth, the solar heat can be more effectively removed.

## Why should I use exhaust fans?

Exhaust fans are used to provide sufficient airflow through the greenhouse to remove solar heat as fast as it enters. Because the air is warmed gradually as it passes through the house, absorbing heat, the flow rate should be sufficient both to hold the temperature rise to a minimum and to be economically practical.

## How do I choose a system?

The selection and arrangement of the ventilating and cooling equipment is determined by the size and type of greenhouse structure, the direction of the airflow through the house, and the velocity of the airflow through the house. Allowances also should be made for air density, light intensity and the permissible temperature variation through the house.

## How do I get the best results from my system?

For optimum performance, it is necessary to properly size and arrange air inlet openings to produce a uniformly distributed, non-turbulent airflow pattern in the growing area to avoid the mixing of the lower air with the hot air in the upper section of the greenhouse. A definite airflow pattern in a given direction requires an air inlet opening continuous for the entire side or end of the greenhouse. The inlet opening should introduce the air in a horizontal direction at crop level, should not be deflected up or down and should have a low velocity to minimize turbulence and mixing.

## I have a hobby-house greenhouse - Do I need a ventilation and cooling system?

Most small or hobby-house greenhouses are generally affected in the same manner and subjected to the same conditions of cooling and ventilating that apply to commercial greenhouses. Therefore, the principals and design recommendation listed for commercial greenhouses are normally used. For very small greenhouses, however, package evaporative coolers provide simpler installation and more convenient operation.

## Do I need to change my system in the summer?

During the summer, mechanical ventilation alone will usually not maintain the desired greenhouse temperature because the outdoor air is too warm. Thus, a way for cooling the incoming air should be provided.

## What happens to the cooled air as it moves through the house?

As the cooled air moves through the house, it picks up solar heat and increases in temperature by the time it reaches the exhaust fans. This temperature increase is a result of the heat removal process and will vary depending on design. Increasing the airflow, or reducing the light intensity can reduce the temperature change. Increased fan capacity can produce increased airflow; shading can reduce light intensity; and good maintenance can minimize the infiltration of air leakage.

## Is elevation a factor in creating ventilation and cooling systems?

The air's capacity to remove heat depends on its weight not its volume. Because air is less dense at higher altitudes, the elevation of the greenhouse must be considered in design calculations. At higher elevations a greater volume of air is needed to provide the equivalent weight of air required at elevations that have been established as normal.

## How many fans are needed and what do I need to know before having them installed?

The size of fans selected determines the number of fans required. Adequate fans should be used to provide a spacing of not more than 25 feet along the exhaust side of the greenhouse. When possible, the fans should be located on the downwind side of the greenhouse. When three or fewer fans are used in a given installation, one of them should be a two-speed fan to provide for more flexibility of ventilation. Fans should be guarded properly to prevent workers or animals from coming in contact with any moving parts. For most reliable fan performance, only use fans that have been tested and rated by the Air Movement and Control Association (AMCA) standard test code and which bear the AMCA Certified Rating Seal.

## Where should the cooling pad be placed?

The cooling pad should be continuous along the entire side or end of the greenhouse. Pad height is determined by dividing the total pad area by the length. Pads should be confined and secured in a way that provides uniform airflow, prevents sagging, avoids puncturing holes or large openings in them and promotes uniform water flow through the entire length of the pads. The pads should be installed for ease of removal and withstand normal handling and usage. Whenever possible, the air inlet should be constructed in such a way that it can be readily opened and closed without removing the pads. It is preferable to have the pad assembly located inside the air inlet opening; this will produce less turbulent airflow through the house. For such an arrangement the air inlet opening need not be continuous but should be at least well distributed.