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GREENHOUSE COOLING

TEXAS AGRICULTURAL EXPERIMENT STATION

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SUMMARY

Experiments started at College Station in 1949 show that the wet-pad exhaust fan system gives the most effective cooling of greenhouses for Texas conditions.

This type of greenhouse cooling is practical, economical and efficient. Year-round production is possible, with more accurate timing, greater yields and higher quality.

Installations made by commercial growers of florist and nursery crops in Texas show that the wet-pad exhaust fan system reduces labor costs and increases the quantity and quality of crops produced each year. Overall results are better market returns, improved working conditions, reduced water requirements and more consistent yields throughout the year.

The use of this cooling system extended the production periods and improved the quality and yield of the following crops: chrysanthemums, geraniums, snapdragons, kalanchoes, begonias, hydrangeas, lilies, poinsettias, azaleas, gloxinias and foliage plants.

The following crops also were produced successfully, were timed accurately and brought a high market return: calceolarias, cinerarias, stocks, primroses, carnations and tuberous-rooted begonias.

Extensive use of the wet-pad exhaust fan system of greenhouse cooling throughout the United States and in many other areas of the world during the past 3 years has shown that it is practical in nearly every climate. Since the origination of this system, more than 25 million square feet of greenhouse area have been cooled in various sections of the United States and Canada alone.

Automatically controlled systems are the nearest approach to ideal growing conditions for greenhouse production with lower production costs. Cooling equipment properly used will make production easier and will give the grower more control over his crops.

The system is economical to install and operate, and is considered a sound investment by all commercial growers who have installed it.

Flower size has increased and flower color retention has been improved with the use of greenhouse cooling.

Feeding programs have been increased with the use of cooling. More rapid and vigorous growth often has required increased rates and frequency of fertilizer applications.

Disease problems have been reduced by the conditions provided by this system.

This type of cooling is efficient and practical in areas having high relative humidity. Proper management of the equipment in these areas has shown even greater gains than in some areas of low relative humidity.

The effect on working morale of greenhouse employees has been an important factor in improving quality as well as better climatic effects on crops.

Greenhouse cooling is an advantage during the night as well as during the day. On many crops and in many areas, cool night temperatures are of greater importance than cool day temperatures.

Examples of some effects on florist crop production in Texas are: CHRYSANTHEMUMS—Production of year-round crops of high quality now possible with no delay in blooming or no distortion of flowers. CARNATIONS—Production in areas where this crop has been tried unsuccessfully without cooling can now be practiced profitably with high quality production throughout the year. SNAPDRAGONS—Can now be produced on year-round basis in all areas with recently developed summer varieties. ASTERS—Can now be produced as a high quality crop on a year-round basis in the same manner as chrysanthemums. OTHERS—Better response and higher quality on all pot plant crops, including those considered as winter crops, such as poinsettias, lilies and hydrangeas.

On the cover are potted chrysanthemums which flowered in August in a cooled greenhouse.

CONTENTS

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A. F. DeWERTH and R. C. JASKA*

PROFITABLE GREENHOUSE MANAGEMENT DEPENDS on the proper rotation of crops and the use of the entire bench space at all times. Producing plants of high quality also depends on the proper regulation of temperature, light, air and water. Weather conditions are important in scheduling crops, especially for favorable market conditions which normally occur during holiday periods.

EXPERIMENTAL PROCEDURE

Experiments with expedient forcing structures designed to overcome some of the difficulties of the high temperatures which occur in this area were started at College Station in 1949. Construction of a plastic screen enclosure made the summer production of some crops profitable.

Continued work with these forcing structures led to experiments designed to provide some practical method of cooling the more expensive glass greenhouse structures already in these areas.

The first experiments in cooling greenhouses were made with conventional squirrel-cage type evaporative coolers (Figure 1). Later a humidifying system was included in the trials on a comparative basis to develop cooling of the greenhouse areas by evaporation of the mist produced by these humidifying devices.

Trials with these two methods of cooling led to the development of a more practical, economical and efficient method of cooling for this area.

This cooling system has large-volume exhaust fans mounted on one side, one end or in the roof of the greenhouse, and wet fibrous pads mounted on the other side or end of the structure.

Air drawn through the pads is cooled by the evaporation of the water. This cooled air removes heat from the growing area as it passes through the greenhouse and over and under the plants and benches. The air is then removed from the house by the exhaust fans. The system provides an even, smooth flow of cooled, moist air which is well distributed over the growing area, without drafts or undue disturbance of the total volume of air in the greenhouse.

Trials with various crops comparing these three methods show that the best results to date have been obtained with the use of this wet-pad exhaust fan system.

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TEMPERATURE EFFECT ON PLANT GROWTH

Proper regulation of greenhouse temperatures is essential for developing high quality crops grown in greenhouses. Temperature affects plant growth because it influences the processes which occur within the plant. Photosynthesis, or food manufacture by plants, is one of these processes. All plant growth requires the energy generated by the breaking down of the foods manufactured by the plant. This plant process is called respiration, which is the direct opposite of food manufacture. Sunlight is important for promoting good plant growth because food manufacture takes place in plants only during daylight. Sunlight promotes firm texture in plant growth and develops high quality plants.

During dark, cloudy weather, or in heavily-shaded greenhouses, the rate of photosynthesis is low and very little food is accumulated within the plant. When temperatures are raised during such periods, the food supply is dissipated and plant development is not increased.

High temperatures must be accompanied by increased soil moisure and relative humidity because of the increased water loss through the plant.

Temperature also influences the formation and development of flower buds. The buds will not form on some plants unless the night temperature is near 50° F.

High temperatures delay flowering of chrysanthemums. In the summer, flowering often is delayed 6 or 7 weeks and flowers do not develop properly even after this extended delay (Figure 2).

Figure 1. Installation showing use of conventional evaporative cooler.

Figure 2. Contrast in blooms on chrysanthemums in identical plantings grown in a cooled and uncooled greenhouse at the Texas Agricultural Experiment Station.

Heavy shading on greenhouse glass during the summer to partially reduce high temperatures produces soft, succulent growth of reduced quality.

One of the most serious problems facing growers of greenhouse crops in Texas and other areas of the South and Southwest is that of extending the production period for greenhouse crops to a full 12 months each year. High temperatures during late spring, early fall and summer limit the variety of crops that can be grown in these areas.

Greenhouse temperatures usually are higher than prevailing outdoor temperatures, making costly greenhouse space practically unproductive in southern areas during hot weather.

ADVANTAGES OF COOLING

Following are some of the advantages of the wet-pad exhaust fan cooling system, which keeps greenhouse temperatures 15 to 20° cooler during warm periods without supplemental shading of the greenhouse glass.

Crops of higher quality and quantity are produced. The greenhouse area can be used to produce high quality crops throughout the year. Additional crops can be produced during the winter under Texas conditions and more crops per year can be produced in the same greenhouse area.

Less frequent watering is required to produce good plant growth. This saving in water and labor decreases the production cost of some crops as much as 50 percent and also saves water, a critical item with many Texas growers.

The use of less water gives a more even nutrient level because it reduces the leaching caused by more frequent waterings.

Little, if any, shading of the glass with whitewash or paint is needed. This reduces labor and material costs and produces heavier and more vigorous plant growth of higher quality.

The cooled atmosphere of the greenhouse increases employee efficiency. More comfortable working conditions lower labor costs.

Reduced insect and disease infestations give more profitable crop returns, higher quality production and lowered labor and material costs for insect and disease control.

This system provides filtered moist air for ideal plant growth and eliminates stagnant air. Controlled ventilation reduces the labor cost of opening and closing greenhouse ventilators.

Better crop production for the most favorable markets is possible because timing of crops is less hazardous and easier to control.

Less than 2 percent of the water recirculated is lost through evaporation and wastage.

This system of cooling is economical to install and operate.

INSTALLATION COSTS

Installation costs of this system vary with the type of construction and location of the greenhouse range. Studies show that the initial cost of installation is between 25 and 50 cents per square foot of greenhouse floor space cooled, depending on the size and type of installation.

Increased production and higher market returns because of better quality make this additional expenditure a sound investment.

INSTALLATION OF GREENHOUSE COOLING

The padding (of aspen wood excelsior or similar material) is installed, if possible, on the side or gable end of the greenhouse toward the prevailing wind.

This padding is saturated with water when the system is operating.

Proper operation of the system maintains temperatures inside the greenhouse 15 to 20° cooler than outdoor temperatures (Figures 3 and 4).

Fans can be located in the greenhouse side wall, gable end or greenhouse roof.

All ventilators should be closed when the system is operating, broken glass or other air leaks in the structure should be repaired and doors should be kept closed when not in use.

Baffles of polyethylene or other clear plastic material can be constructed for problem areas produced by variations in the greenhouse structure. This is especially advantageous in larger greenhouses when the air is pulled lengthwise through the greenhouse.

Amount of Air to Be Exhausted

The amount of air to be exhausted is expressed in cubic feet per minute (CFM) and is based on the square feet of area, or floor space, of the greenhouse. Approximately 7 CFM of air should be exhausted for each square foot of floor space.

Example:

Determine the area of the greenhouse by multiplying the width by the length:
40 feet wide × 200 feet long = 8,000 square feet.
Multipy the number of square feet by 7:
8,000 square feet × 7 = 56,000 CFM.

Square Feet of Pad Needed

The air should move through the pad at a velocity of 150 feet per minute to provide a sufficient amount of pad area for effective cooling. One square foot of pad area should be provided for each 150 CFM. For even distribution of this air, the pad area should be continuous, if possible, along the entire side or end of the house.

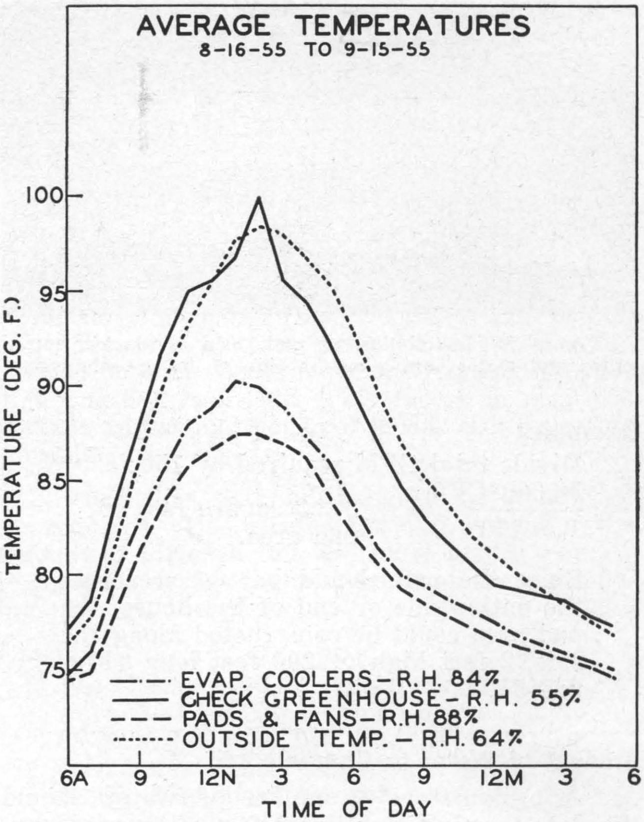


Figure 3

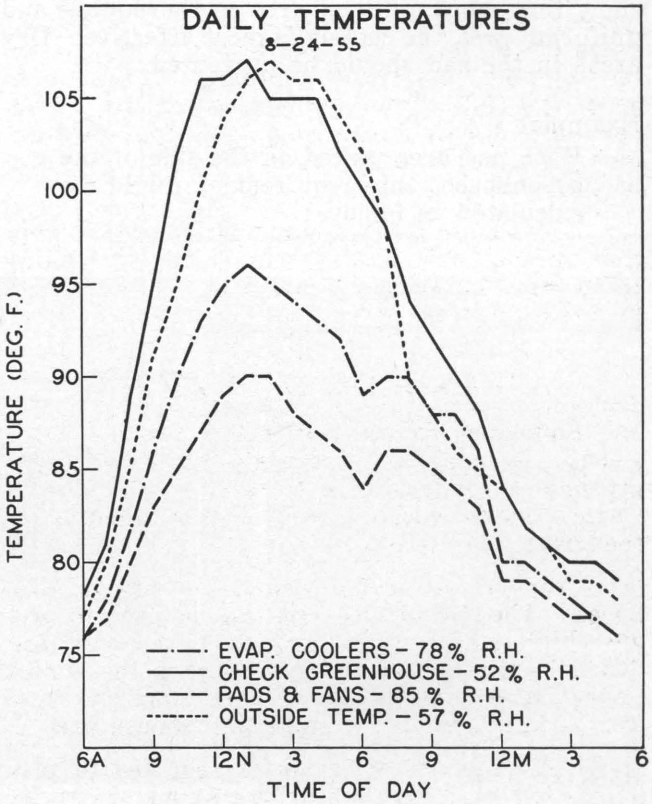


Figure 4

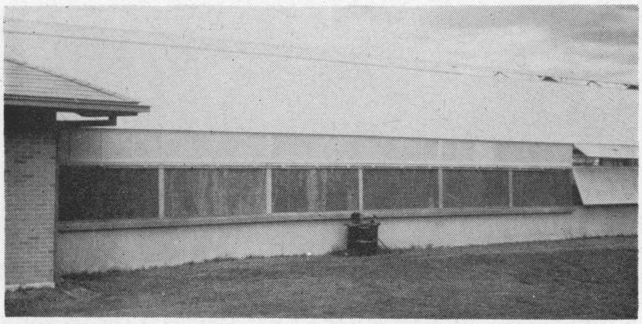


Figure 5. Installation of pad, drip conductor, return gutter and water supply on the side of the greenhouse.

Example:

Divide total CFM required by 150:

$$\frac{56{,}000 \text{ CFM}}{150} = 373.3 \text{ square feet of pad area.}$$

Since the pad should be placed across the entire side or end of the house, the pad area could be constructed along the side, 2 feet high × 200 feet long (Figure 5).

Amount of Water to Circulate

Approximately 1/3 gallon of water should circulate through each lineal foot of the pad area each minute. When this water is recirculated through the pad, less than 2 percent is lost through evaporation. A large amount of water is recirculated through the pad, but experiments show that when the pad area is thoroughly and uniformly wet, the cooling is most effective. Dry areas in the pad should be prevented.

Example:

With pad area placed on the side of the greenhouse, this requirement might be calculated as follows:

200 feet = lineal feet of pad

$$\frac{200 \text{ feet}}{3}$$ = approximately 1/3 gallon per lineal foot, which equals approximately 67 gallons of water per minute.

Pump Requirements

The pump selected should deliver the required amount of water against the head (water pressure) present in the water-circulating system. A self-priming centrifugal pump is satisfactory. The following procedure can be used to determine the size pump required.

Example:

For the pad area shown in the preceding example, a pump would be required that would deliver 67 gallons of water per minute against the total head in the system installed. In some instances it may be more practical to use two pumps, delivering half the total capacity each.

It is important to select the proper pipe sizes to deliver the water from the pump to the pad system. This varies with the length of pipe and the capacity in gallons per minute required to supply the system.

Construction of Cooling Pads

The pad system used should be constructed to obtain the maximum amount of cooling with the minimum resistance to the flow of air through the pad.

The pad system includes the drip conductor, the pad and the return gutter. These should be arranged so that the water is distributed evenly throughout the pad, without splashing or flood-

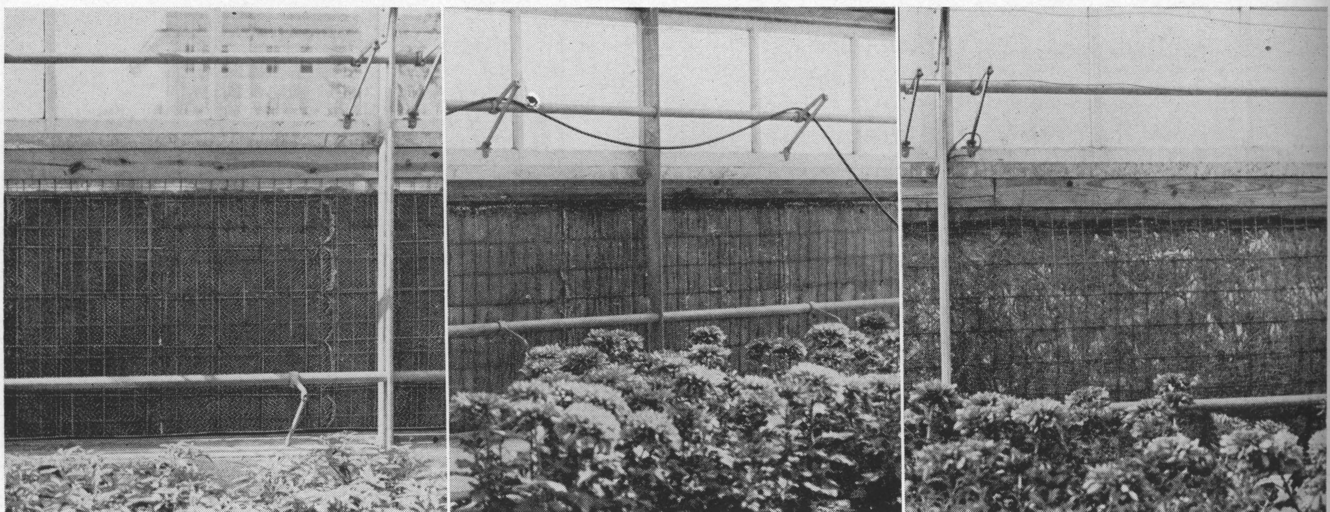


Figure 6. Comparative performance of three types of pads. The pads were installed May 1, 1957. The pictures were taken November 1, 1957. Left, experimental ceramic-coated metal pad; center, composition fiber pad; right, aspen wood pad.

ing, and it should recirculate continually in the same way.

Pads. Three pad materials were used in these trials with equal success: aspen wood fiber, a commercial pad made of a composition fiber enclosed in a metal grid, and a ceramic-coated metal pad (Figure 6).

Pad material should be approximately 2 inches thick in the pad and have a uniform density. A thickness of more than 2 inches is of little increased value. Material can be obtained in bulk form or as pre-made pads.

The pad should be supported on each side by a strong wire mesh and then laced to this mesh to prevent sagging at the top of the pad and to hold the fibers in place.

The best wire mesh is 12½ gauge wire galvanized after welding, with 2″ x 4″ mesh. Chicken wire was used in a portion of these tests, but it required more expensive framing to prevent sagging and stretching.

Drip conductors and gutters. An inexpensive and efficient drip conductor constructed by using a 4-inch slip-joint galvanized gutter with 3/16-inch holes drilled 4 inches apart in the bottom of the gutter worked well in these tests. Water level should be kept high enough to provide a full flow of water at all times. A similar gutter can be used at the bottom of the pad to carry the water back to the pump for recirculation (Figure 7).

The size of the holes and the spacing are important and vary with the type of installation. This consideration should be determined by the method used to conduct the water from the drip conductor to the pad. The entire pad should be uniformly wet at all times. The drip conductor should be level and the return gutter should have a fall of 1 inch per 100 feet. The water level in the drip conductors can be controlled by the installation of a gate valve.

Size and Number of Fans

The fans draw the air through the pads, thus operating against a resistance. This resistance is measured in inches (water column) and is usually referred to as static pressure (SP). The fan or fans selected should move the required amount of air at 0.1 inch SP. This factor is very important and should not be overlooked in selecting suitable fans.

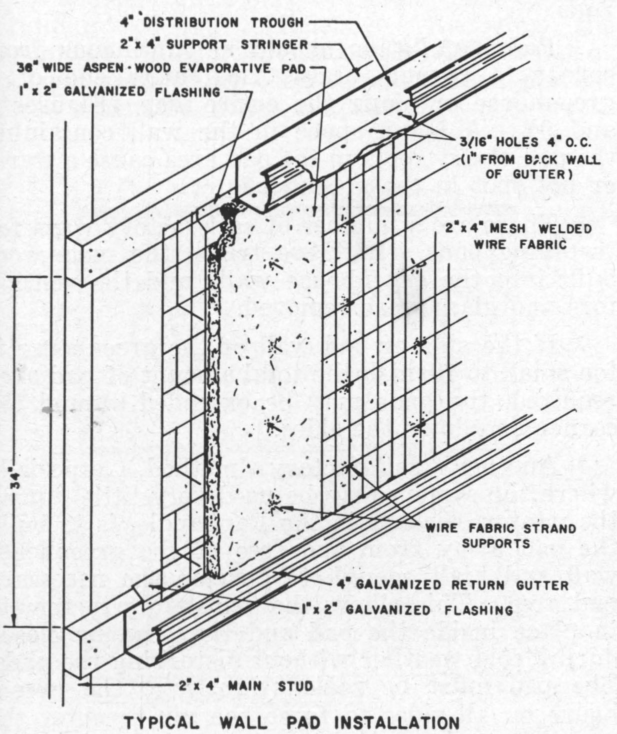
Select fans that will exhaust the amount of air required. Use a rated fan and determine the amount of air each fan will move at 0.1 inch SP to compensate for the resistance of the air moving through the pads.

Example:

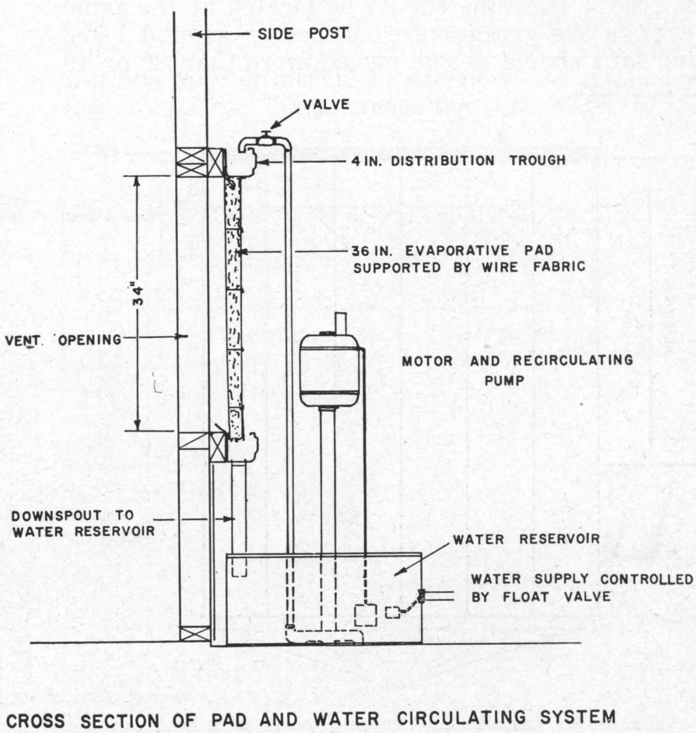
The fans used in these experiments were 30-inch fans which move 7,200 CFM at 0.1 inch SP. In the examples used here, eight 30-inch fans would be required to move the air necessary for cooling this pad area.

Example:

Eight 30-inch fans of the type used in these experiments would move a total of 57,600 CFM (8 x 7,200) at 0.1 inch SP.



TYPICAL WALL PAD INSTALLATION



CROSS SECTION OF PAD AND WATER CIRCULATING SYSTEM

Figure 7. Details of pad assembly construction.

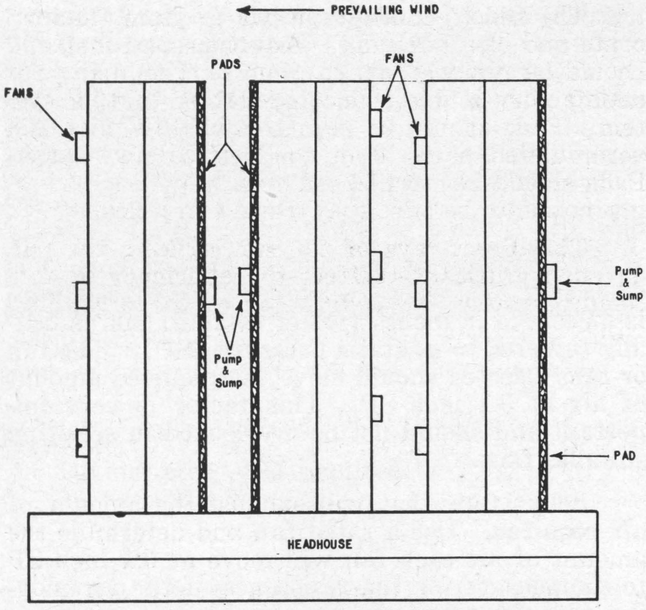


Figure 8. Installation showing pads and fans located in sidewalls of parallel houses.

Five properly selected 42-inch fans would move a total of 60,000 CFM (5 x 12,000) at 0.1 inch SP.

Either size fan could be used; however, fans of uniform size should be used in the same installation, if possible.

Location of Fans

The layout of the greenhouse range, and the arrangement or type of construction of the greenhouses influence the size and number of fans to be used. The fans should be located at the same level as the greenhouse benches or ground beds, and fans should not be placed more than 30 or 40 feet apart.

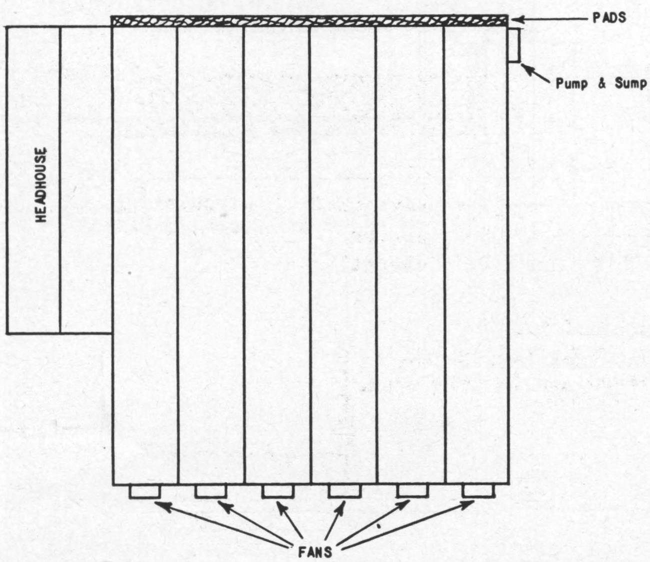


Figure 9. Installation showing pads and fans located on endwalls on ridge and furrow construction.

Installation and Operational Costs

Based on utility costs in the College Station area, the cost of cooling greenhouse areas averaged about 2 cents per hour for each 1,000 square feet cooled. The system used was about 85 percent automatic, including automatic fan shutters with thermostatically-controlled fans. One hundred percent automatic control could be developed by controlling the covering over the pads with automatic ventilators and controlling the water supply in the same manner. Costs vary with the amount of automatic control used on the system.

The water can be turned off at sundown and the fans operated on a 24-hour basis for the purpose of ventilation, with the conventional greenhouse ventilators closed. Since large greenhouse areas can be cooled more effectively than small ones, this rate might decrease considerably in large greenhouse areas.

OPERATION OF GREENHOUSE COOLING

A study was made of the practicability of the wet-pad exhaust fan system in the Houston area, which has higher relative humidity than prevails at College Station. The information obtained indicates that this system of greenhouse cooling is practical and efficient in most areas of the country.

When temperatures reach their peak, the relative humidity usually is lower; therefore, efficient cooling results with this system when the requirements are greatest during the hottest part of the day.

Pads

Pad installation should be continuous from corner to corner—across the entire end of a greenhouse or along the entire side (Figures 8 and 9). A blank space in the wall containing the pad or dry spots in the pad area cause a warm or hot spot in the greenhouse.

There are a number of satisfactory ways for installing pads. In these trials, the pads were built into the greenhouse walls and the ventilators and glass were removed.

If the side or end wall of the greenhouse is too small to furnish the total amount of pad area required, the pads may be extended around the corner and down the sides.

Another satisfactory method, especially where the system may be used very little during the winter, such as in the Panhandle, is to build the pad away from and free of the greenhouse wall and high enough to develop the necessary pad area. This allows the ventilators to remain in place inside the pad and they can be closed during cold weather without disturbing the pads. The pad must be sealed tightly to the greenhouse on all sides to force the air to enter the greenhouse through the pad and the roof should

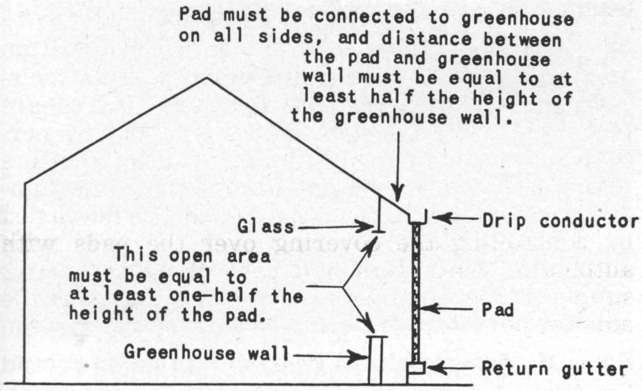


Figure 10. Installation showing pad system constructed outside the greenhouse wall.

be extended with glass to enclose the top of the pad (Figure 10).

Enough opening must be provided in the side or end of the greenhouse next to the pads to equal half the size of the total pad area. In this installation, the pad can be placed inside or outside the greenhouse structure, depending on the space available. For efficient operation, however, the pad should be located so that the distance from the greenhouse wall is at least half the distance that the pad extends beyond the opening in the wall through which the air enters.

For effective cooling, the pad area should be sized for a velocity of approximately 150 feet per minute. Some installations have worked satisfactorily at higher velocities, or with less pad area, but the velocity should never exceed 200 feet per minute.

Pads kept uniformly wet at all times produce maximum cooling efficiency. Reducing the amount of water recirculated through the pads does not save water because less than 2 percent of the circulated water evaporates.

The fibers in any type pad gradually deteriorate and clog with use. Any type pad material should be replaced annually or semi-annually for satisfactory and efficient operation of this system. Pads should be kept free of dust, dirt and accumulated salts from the recirculated water. Pads should be flushed out weekly with a syringing nozzle to be sure they always are clean.

The direct rays of the sun striking the pad do not significantly affect the efficiency of this cooling system. The direction of the prevailing wind in locating the pads is more important.

Water Supply

The construction of the water supply system requires careful attention. The drip conductor, return gutter and the water supply should be covered or screened to keep out debris.

When the water supply is turned off, all of the circulating water returns to the pump or reservoir tank. To avoid flooding, the operating level in the tank should be kept low enough to provide sufficient additional capacity for this drainoff from the pad area, which normally equals approximately 1 gallon of water per lineal foot of pad.

The makeup water in the tank can be controlled by a simple float valve. An overflow should be provided in case this float valve should stick open.

The constant evaporation of water from the sump or supply tank causes a gradual increase of salt concentration in the water being recirculated. Excessive accumulation can be prevented from clogging the water system by installing a bleeder or waste line in the return gutter or in the discharge line from the pump. Mineral content can be maintained at a satisfactory level by wasting approximately 1 percent of the water being circulated. This causes the float valve to in-

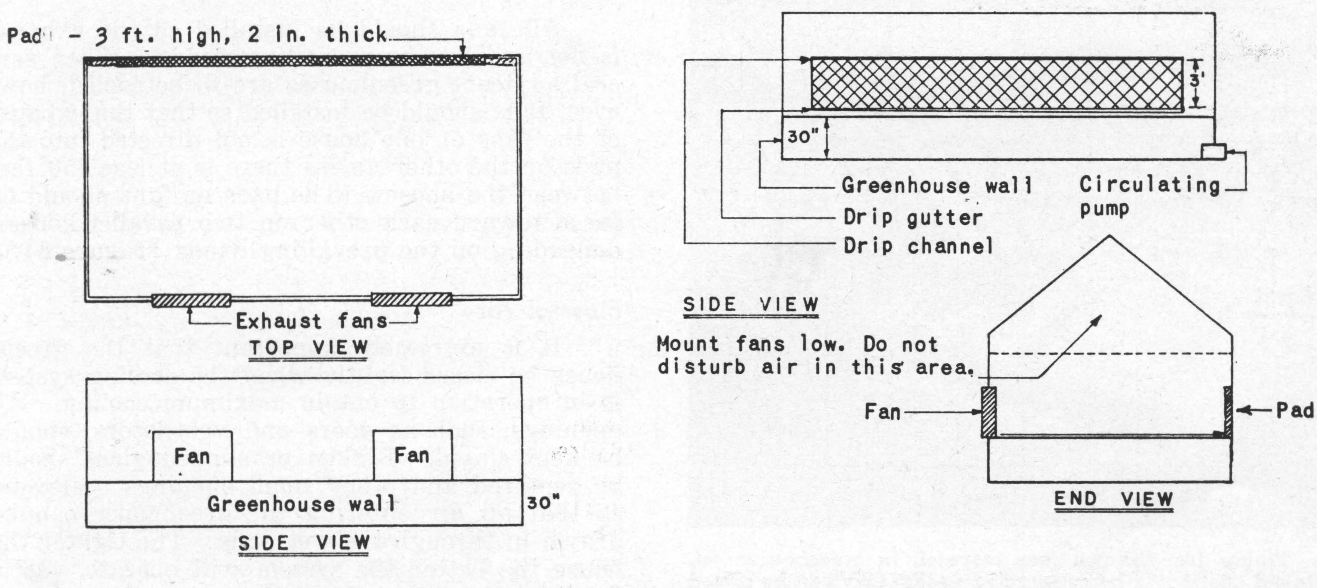


Figure 11. Top, end and side views of wet-pad exhaust fan installation.

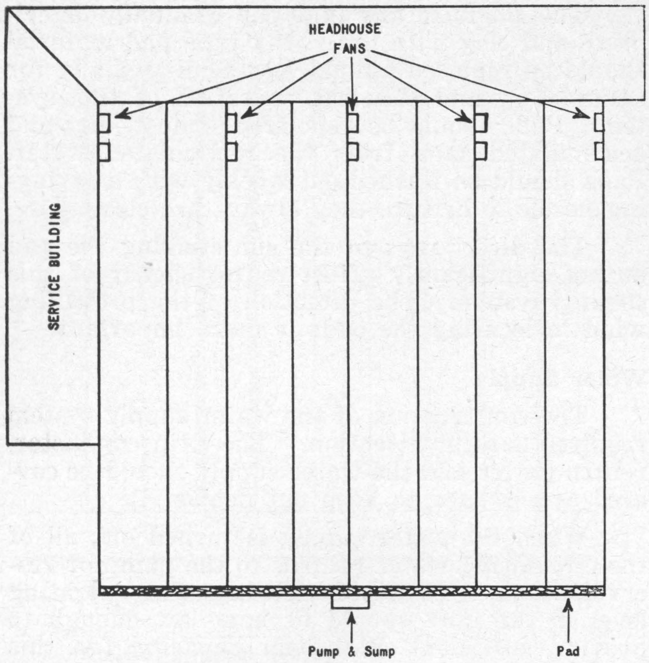


Figure 12. Installation showing fans mounted in roof on ridge and furrow construction.

troduce new water into the system in the same amount that is lost through wastage and evaporation.

At one stage of these trials, algae formed on the outside of the pads. Algae formation cannot be overcome without changing the pads, unless precautions are taken to prevent it before the system is put into operation. Adding 1 tablespoon of copper sulphate to each 50 gallons of water in the sump or water tank every 10 days prevents algae growth.

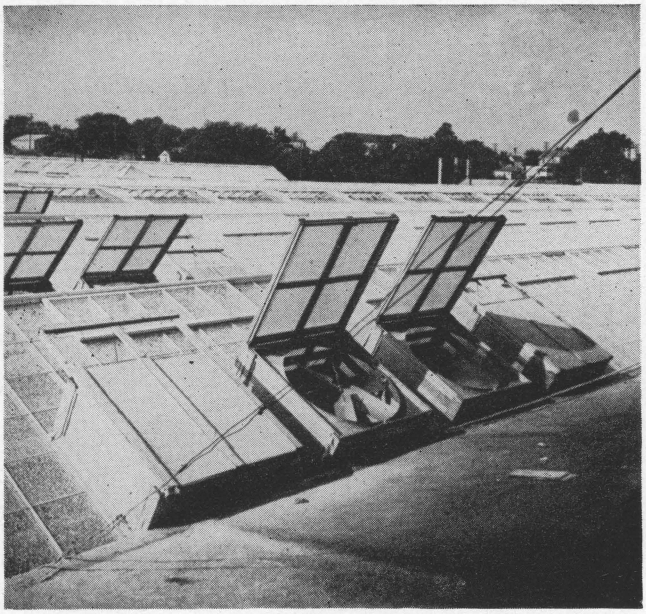


Figure 13. Exhaust fans mounted in greenhouse roof. Hinged lids should be constructed so that they can be raised and lowered from inside the greenhouse.

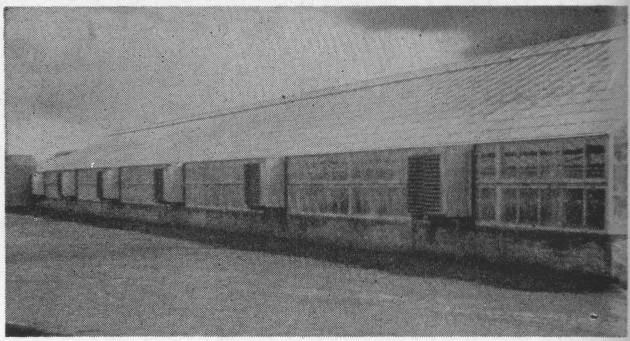


Figure 14. Fans mounted in side wall showing fan shutters.

Uniform wetting of the pad area is improved by the addition of 2 tablespoons of a household detergent every 2 weeks. The detergent acts as a spreader. Any wetting agent is satisfactory for this purpose.

Fan Installation

The most convenient and efficient place to install the fans for this system is in the side walls (Figure 11). When the side or end of a greenhouse is obstructed, the fans may be located in the roof near the eaves or in the furrows on a range of ridge and furrow construction (Figure 12).

Fans located on the roof should be equipped with a hinged lid that can be raised and lowered from inside the greenhouse (Figure 13).

When the pads are located on the opposite side wall from the roof-mounted fans for cross flow, space the fans on the roof so that each will handle 30 to 40 feet of pad area, as outlined for side wall fan installation (Figure 14).

When only one end of the greenhouse is used for the pad installation and the airflow is lengthwise through the house, the roof fans should be mounted at the opposite end of the house.

All fans should be installed so the exhaust is not against the prevailing winds. When several adjacent greenhouses are to be cooled, however, fans should be installed so that the exhaust of the fans on one house is not directed into the pads on the other unless there is at least 50 feet between the houses. The pads or fans should be faced toward each other on two parallel houses, depending on the prevailing winds (Figure 8).

Flow of Air

It is extremely important that the greenhouse be closed tightly when the cooling system is in operation to obtain maximum cooling. All openings, such as doors and ventilators, should be kept closed. Broken or slipped glass should be repaired and other small openings sealed up so that all air entering the greenhouse can be drawn in through the wet pads. The tighter the house the better the system will operate. It is for this reason that this system of cooling is more efficient in a plastic greenhouse structure because no air is pulled in through the glass laps.

As the air passes through the greenhouse, it will tend to diverge upward about 1 foot for every 8 feet traveled. Baffles may have to be constructed to divert this air back down to the growing area. These baffles can be constructed of an inexpensive transparent material, such as polyethylene or vinyl, and should be spaced approximately 30 feet apart.

Insect and Disease Control

Prevention of the entrance of bees into the greenhouse when this system is in operation eliminates pollination of the flowers and prolongs and increases the value of flower crops. Other large insects also are excluded and the entrance of smaller insects is retarded and decreased, thereby reducing the amount of insect control required.

Other airborne insects, such as thrips, can be controlled effectively when the system is in operation by the additions of non-volatile insecticides to the water being recirculated through the pad. Many airborne weed seed also are prevented from entering the greenhouse when the pads are flushed out regularly.

This system also provides excellent draft-free ventilation at all times, regardless of whether the pads are in operation. When only part of the fans are used for this purpose, they draw outside air in through the laps of the glass or when ventilators are barely cracked open. This air mixes with the warm air inside and keeps a controlled supply of air moving in the greenhouse, thereby reducing the possibility of disease infestation by several fungus diseases such as botrytis and mildew.

Automatic Controls

This system provides maximum cooling with a minimum resistance to air flow and will maintain a fairly constant relative humidity despite wide humidity fluctuations outdoors.

The greenhouse and the crops are kept much cleaner because of filtering out of large insects, dust, weed seed and other airborne debris.

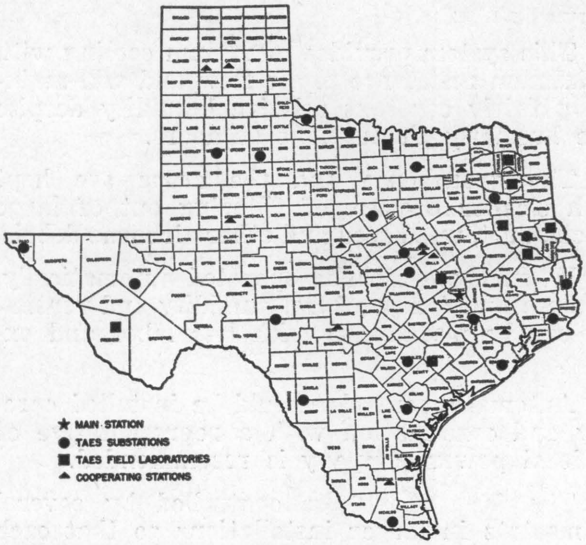
When the system is operated automatically, more uniform temperature, humidity and ventilation can be maintained with less labor and expense.

Automatic controls should be installed carefully and consultation with a representative of the local power company is recommended.

The fans should be controlled by several thermostats in larger installations so that each can be set at a slightly different temperature. When the temperature rises, more fans are turned on to increase the cooling capacity; as the temperature drops, the fans will go off in the opposite manner.

The pumps controlling the water in the pads also can be controlled by thermostats or with the use of humidistats. In areas where high relative humidity prevails in the early morning and the early evening, humidistats are preferred over thermostats. When thermostats are used for pump control, they should be set high enough to stop the pump and allow the pad to dry out before all the fans are stopped.

For small greenhouses, less than 1,000 square feet in area, such as those used by many amateurs and hobby gardeners, the installation of convential evaporative coolers would be most practical (Figure 1).



Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

- Conservation and improvement of soil
- Conservation and use of water
- Grasses and legumes
- Grain crops
- Cotton and other fiber crops
- Vegetable crops
- Citrus and other subtropical fruits
- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
- Chickens and turkeys
- Animal diseases and parasites
- Fish and game
- Farm and ranch engineering
- Farm and ranch business
- Marketing agricultural products
- Rural home economics
- Rural agricultural economics
- Plant diseases

Two additional programs are maintenance and upkeep. and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tomorrow's Progress

Texas Agricultural Experiment Station, R. D Lewis, Director, College Station, Texas.