Cost Effective Precision Agriculture for GreenHouse

Mr. Urvish Soni[1], Mrs. Zankhana Mehta[2]

[1] Lecturer, Instrumentation and Control, Government Polytechnic Ahmedabad, Gujarat, INDIA
[2] Lecturer, Instrumentation and Control, Government Polytechnic Ahmedabad, Gujarat, INDIA

ABSTRACT

"Measurement of environmental conditions accurately" is a basic key technique to understand your crop performance in greenhouse. Greenhouses should provide a controlled environment for plant production with sufficient sunlight, temperature and humidity. Various greenhouse automation equipment like computer software and sensors are connected and used to collect data in the greenhouse environment to boost crop yields. In this research paper we want to aggregate the technologies available and its effect in crop health and yield from green houses.

Keywords: - *Precision agriculture, Smart Green House technologies, Sensors, climate control computer, Heating, Cooling, Ventilation, Equipment for Greenhouses*

1. INTRODUCTION

Greenhouses is a mechanism that provides a controlled environment for plant production with sufficient necessary parameters like sunlight, temperature and humidity. Greenhouses need exposure to maximum light, particularly in the morning hours. Consider the location of existing trees and buildings when choosing your greenhouse site. Water, fuel and electricity make environmental controls possible that are essential for favorable results. For this reason, use reliable heating, cooling and ventilation. Warning devices might be desirable for use in case of power failure or in case of extreme temperatures.

1.1 Technology development

Technology development of instrumentation (sensing, recording, and controlling) has contributed to increasing what we will liquidate controlled surroundings agriculture. Use of computers in an agricultural (horticultural) instrumentation developed chop-chop within the Nineteen Eighties and that we will currently purchase tiny button-size sensors that may store weeks of recorded knowledge to transfer to your computer in a computer program format! Such technology development simplifies mensuration of microenvironments and plant interactions, allowing larger understanding. But sensors and recording devices became therefore 'user-friendly' that they allow much everybody to use such sensors by solely following the short users' manual. One caution emphasized during this lecture is that sensing element use and recording became really easy that one will simply build mistakes in their use while not knowing that the info obtained has very little price or desires careful interpretation, ensuing from such inappropriate use.

The house temperature necessities depend on that plants are to be mature. Most plants need day temperatures of seventy to eighty degrees F, with night temperatures somewhat lower. Ratio may additionally need some management, reckoning on the plants cultured.

Some plants grow best in cool greenhouses with night temperatures of fifty degrees F when they're transplanted from the seeding receptacle. These plants embody rhododendron, daisy, carnation, aster, beet, calendula, camellia, carrot, cineraria, cyclamen, orchid flower, lettuce, pansy, parsley, primrose, radish, snapdragon, sweet pea and plenty of bedding plants.

Some plants grow best in heat greenhouses with night temperatures of sixty five degrees F. These plants embody rose, tomato, poinsettia, lily, hyacinth, orchid flower, gloxinia, geranium, gardenia, daffodil, chrysanthemum, coleus, Schlumbergera baridgesii, calla, caladium, begonia, African violet, bulbous plant and liliaceous plant.

Tropical plants typically grow best in high humidness with night temperatures of seventy degrees F.

2.0 Heating

Himalaya, INDIA greenhouses should be heated for year-round crop production. An honest heating plant is one in every of the foremost necessary steps to booming plant production. Any heating plant that has uniform temperature management while not emotional material harmful to the plants is appropriate. Appropriate energy sources embody fossil fuel, LP gas, fuel oil, wood and electricity. The value and availableness of those sources can vary somewhat from one space to a different. Convenience, investment and operative prices square measure all any issues. Savings parturient may justify a costlier heating plant with automatic controls.

Greenhouse heater needs depend on the quantity of warmth loss from the structure. Heat loss from a greenhouse sometimes happens by all 3 modes of warmth transfer: conductivity, convection and radiation. Sometimes many varieties of warmth exchange occur at the same time. The warmth demand for a greenhouse is often calculated by combining all 3 losses as a constant in an exceedingly heat loss equation.

2.1 Conduction

Heat is conducted either through a substance or between objects by direct physical contact. the speed of physical phenomenon between 2 objects depends on the world, path length, temperature distinction and physical properties of the substance(s) (such as density). Heat transfer by physical phenomenon is most simply reduced by substitution a fabric that conducts heat speedily with a poor thermal conductor (insulator) or by putting Associate in Nursing dielectric within the heat flow path. Associate in Nursing example of this might be substitution the metal handle of a room pan with a picket handle or insulating the metal handle by covering it with wood. Air may be a terribly poor heat conductor and so a decent heat dielectric.

2.2 Convection

Convection heat transfer is that the physical movement of a heat gas or liquid to a colder location. Heat losses by convection within the greenhouse occur through ventilation and infiltration (fans and air leaks).
Heat transfer by convection includes not solely the movement of air however conjointly the movement of water vapor. Once water within the greenhouse evaporates, it absorbs energy. Once water vapor condenses back to a liquid, it releases energy. Thus once water vapor condenses on the surface of associate degree object, it releases energy to the surface surroundings.

2.3 Radiation

Radiation heat transfer happens between 2 bodies while not direct contact or the necessity for a medium like air. Like light, heat radiation follows a line and is either mirrored, transmitted or absorbed upon placing Associate in nursing object. Energy should be absorbed to be born-again to heat.
All objects unharness heat all told directions within the sort of energy. The speed of radiation heat transfer varies with the realm of Associate in Nursing object, and temperature and surface characteristics of the 2 bodies concerned. Radiant heat losses from Associate in nursing object may be reduced by close the thing with an extremely reflective, opaque barrier. Such a barrier (1) reflects the energy back to its supply, (2) absorbs little or no radiation therefore it doesn't heat up and re-radiate energy to outside objects, and (3) prevents objects from “seeing” one another, a necessary component for energy exchange to occur

2.4 Factors Affecting Heat Loss

Heat loss by air infiltration depends on the age, condition and kind of greenhouse. Older greenhouses or those in poor condition typically have cracks around doors or holes in building material through that massive amounts of cold air could enter. Greenhouses lined with massive sheets of glazing materials, massive sheets of covering material, or one or double layer of rigid or versatile plastic have less infiltration (Figure 1).

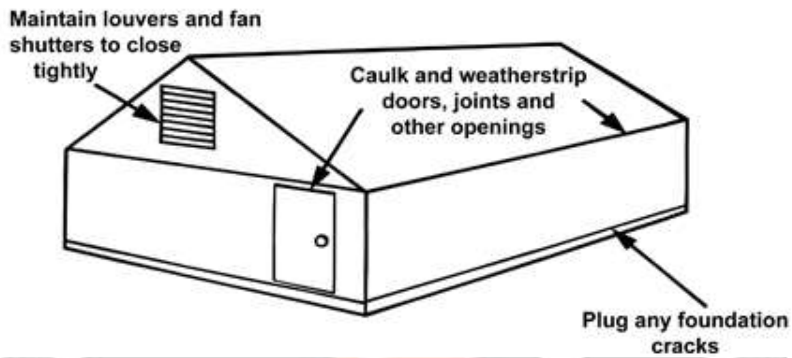


Figure 1. Energy loss due to infiltration.

The greenhouse ventilation system also has a large effect on infiltration. Inlet and outlet fan shutters often allow a large air exchange if they do not close tightly due to poor design, dirt, damage or lack of lubrication. Window vents seal better than inlet shutters, but even they require maintenance to ensure a tight seal when closed.

Solar radiation enters a greenhouse and is absorbed by plants, soil and greenhouse fixtures. The warm objects then re-radiate this energy outward. The amount of radiant heat loss depends on the type of glazing, ambient temperature and amount of cloud cover. Rigid plastic and glass materials exhibit the "greenhouse effect" because they allow less than 4 percent of the thermal radiation to pass back through to the outside.

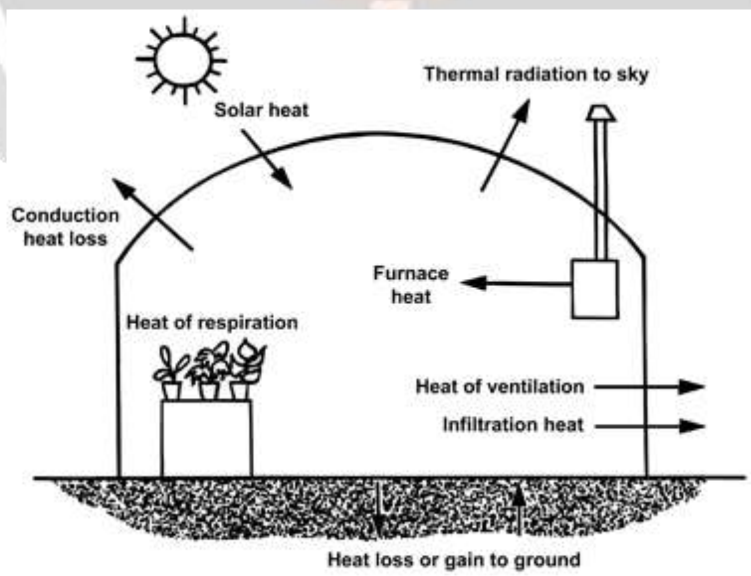


Figure 2. Energy losses and gains in a greenhouse.

2.4.1 Other Heating System Design Considerations

Plastic greenhouses usually have a humidness buildup among the enclosure since virtually no cracks or openings exist as in a very glass house. High humidness will result in increased prevalence of leaf and flower diseases. A forced air heating helps combine the air among the house and helps stop temperature variation among the house. In fact, it's fascinating to own fans on the walls to flow into and blend the nice and cozy air with the cooler air close to the surface. They'll be operated ceaselessly throughout cold periods albeit the heater isn't on.
Duct systems to equally distribute the heated air from the forced heat air chamber square measure fascinating. 2 or a lot of tiny heating unit's square measure desirable to 1 larger unit, since 2 units provide a lot of protection if one unit malfunctions.
An alarm system is nice insurance ought to the heating malfunction or if an influence failure happens. Some greenhouse operators opt to have battery battery-powered warning device to warn them if the temperature gets out of the suitable vary.

2.5 Ventilation

Ventilation reduces within temperature throughout sunny days and provides CO2, that is important to the plants' chemical process. Another advantage of ventilation is to get rid of heat, dampish air and replace it with drier air. High humidness is objectionable since it causes wetness condensation on cool surfaces and tends to extend the prevalence of diseases.

Some glass homes area unit louvered by operated by hand ventilators within the roof. This methodology is typically not satisfactory for ventilating plastic lined homes thanks to the fast temperature fluctuations attainable. Ventilating fans area unit extremely counseled in Georgia.

Winter ventilation ought to be designed to stop cold drafts on plants. This has been a retardant with some systems victimisation shutters at one finish of a house associated an fan at the opposite. the matter is reduced by inserting the intake high within the gable and victimisation baffles to deflect the incoming air.

Draft-free winter ventilation is provided by victimisation the convection tube system, consisting of exhaust fans and recent air inlets placed within the gable and finish wall. this can be connected to a skinny plastic tube extending the length of the greenhouse. The tube is suspended on a wire close to the ridge and has holes on its entire length. The fans is thermostatically controlled. Fan operation produces a small atmospheric pressure drop within the greenhouse, inflicting recent air to flow into the body of water and inflate the tube, that discharges air into the house through the holes within the tube. The holes emit "jets" of air that ought to project horizontally to produce correct distribution and mixture with heat air before reaching the plants.

The thermostat stops the fans once the required temperature is reached; the tube collapses and ventilation stops. During a tightly created greenhouse, it makes very little distinction wherever fans area unit placed in convection tube ventilation since the air distribution is decided by the tubes. Less fan capability is typically needed for the convection tube system than for the other winter ventilating system. Extra air is critical because the outside temperature rises to the purpose wherever full capability of the tube is reached. The skin air is typically heat enough by this point to be admitted through doors or alternative openings at plant level.

Fans is also side or probably combined with a cooling pad to be used in physical change cooling. In fact, air is also force through the pad with or while not water within the pad. In heat periods, enough air must be force from the house to produce an entire air exchange each sixty seconds. Management fans by a thermostat or humidistat to produce correct temperature and humidness.

Greenhouses equipped with associate physical change cooling pad system having 3 fans or fewer ought to have one fan with a two-speed motor to stop excessive temperature fluctuations and fan sport. Choose all fans to work against a small pressure (⅛ in. static water pressure). Fans not rated against slight pressure sometimes move solely sixty to seventy percent of the rated air flow once put in in greenhouses. It's counseled that solely fans that are tested associated their performance verified by a freelance testing laboratory, like AMCA, be used, since that's the sole assurance that the planning ventilation rate is being achieved.

2.6 Exhaust Fans in End Wall

Fans in the end wall (Figure 4) are the most common method of forced ventilation. The air enters through the motorized shutter (winter) and is pulled through the greenhouse by the exhaust fans.

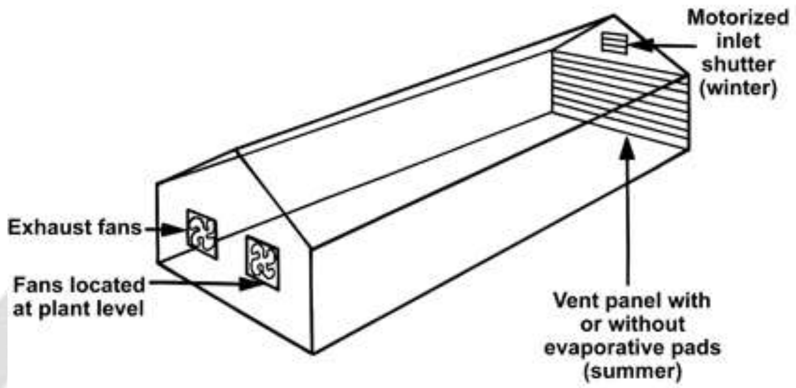


Figure 4. Fans in end wall.

The exhaust fans ought to be ready to move little air volumes while not drafts (winter and yet provide enough fan capacity for an air exchange within the house each minute during summer. One air exchange per minute (without physical change cooling) ought to keep the temperature regarding eight degrees F on top of outside temperatures. common fraction of this air volume can turn out a few 15-degree F temperature rise, whereas 2 air exchanges per minute can cause a temperature rise of regarding five degrees F. Ideally, the length of the house mustn't exceed one hundred twenty five feet exploitation this methodology. Homes up to 250 feet long, however, are satisfactorily aerated exploitation this methodology. Temperature variations square measure bigger in longer homes, thus higher ventilation rates square measure fascinating. No air should be allowed to enter the house at the perimeters or at the fan finish.

Glazing in glass homes should be set and therefore the homes in sensible repair to stop vital quantities of air unseaworthy into the house. If cooling pads square measure used throughout summer, disconnect the motorized shutter and shut it to stop hot air from getting into through the shutter and bypassing the cooling pads. you'll connect a perforated plastic tube to identical body of water shutter to produce sensible air distribution for weather ventilation.

The same principle applies for multiple ridge homes, provided every finish wall is thus equipped. One two-speed fan is typically employed in little hobby homes.

The total body of water gap within the finish wall for summer ventilation (shutter and physical change pad vent) ought to give regarding 1.5 sq. feet per 1,000 cubic feet per minute of air moving through the in operation fans. The motorized shutter and one or 2 fans may well be connected on one thermostat whereas the remaining fans square measure connected to a distinct thermostat, with air being provided to those fans through the vent panel containing the physical change pad.

2.6 Pressure Fans in End Walls

Ventilation for greenhouses that are 100 feet or shorter can be accomplished by mounting pressure fans, which blow air into the house, high in the end walls. See Figure 5.

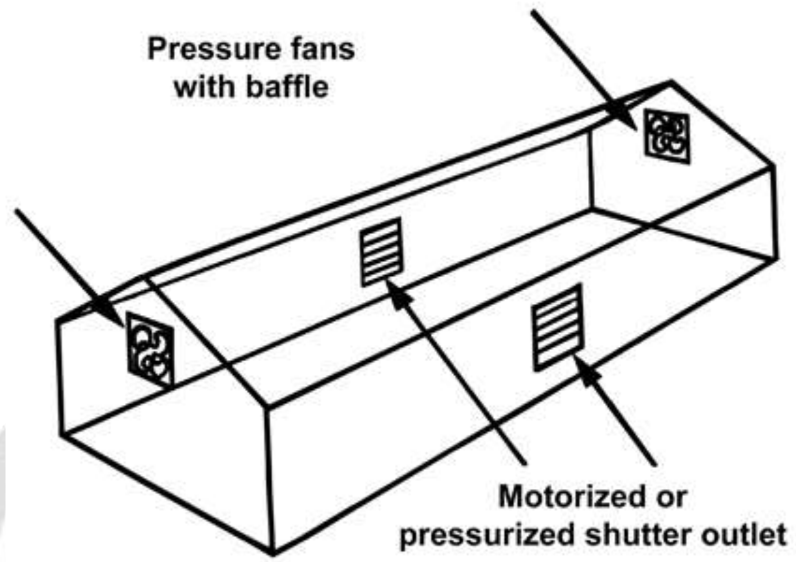


Figure 5. Pressure fans mounted high in the end walls.

The fans in the end wall are usually two-speed and controlled by separate thermostats. To avoid high velocity air striking plants, a baffle is placed in front of the fans to direct the air in the direction desired. The fans should have a protective hood to prevent rain from being blown into the house.

One pressurized system where evaporative cooling is possible is shown in Figure 6. This system places the pressure fans in the side wall. The pressurized system with fans in the side wall does not work well when the foliage is dense and lots of tall, growing plants are present. Notice the air outlet and inlet are on the same side of the house in this case, with a box enclosure around the fan where cooling pads are installed.

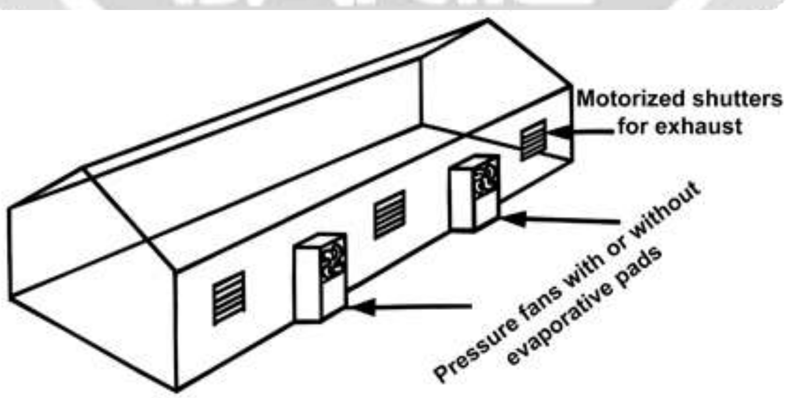


Figure 6. Pressure fans mounted in the sidewalls.

2.7 Evaporative Cooling

The heat absorbed on a dark surface perpendicular to the sun's rays can be as high as 300 BTU/HR per square foot of surface. So it would be possible, theoretically, for a greenhouse to absorb 300 BTUs per hour for each square foot of floor area. This excessive energy leads to heat buildup and, on warm days, can cause plants to wilt.

Excessive heat buildup can often be prevented with shading materials such as roll-up screens of wood, aluminum or vinyl plastic as well as paint-on materials (shading compounds). Roll-up screens, which work well in hobby houses, are available with pulleys and rot-resistant nylon ropes. These screen can be adjusted from outside as temperature varies. Radiation can be reduced by 50 percent with this method, which should reduce temperature rise proportionally if ventilation rate remains constant. Shading also reduces light striking the plants, which may limit their growth rate since light is essential to photosynthesis. This is a trade-off that is sometimes necessary to reduce temperatures.

If summer temperatures exceed those considered acceptable and cannot be corrected with reasonable ventilation rates and shading, the only alternative is evaporative cooling. A fan and pad system using evaporative cooling eliminates excess heat and adds humidity. This reduces plant moisture losses and, therefore, reduces plant wilting. Temperature is lowered, humidity is increased and watering needs are reduced.

An evaporative cooling system moves air through a screen or spray of water in such a manner that evaporation of water occurs. About 1,000 BTUs of heat are required to change 1 pound of water from liquid to vapor. If the heat for evaporation comes from the air, the air is cooled. Evaporation is greater when the air entering the system is dry; that is, when the relative humidity is low, allowing the air to evaporate a lot of water. The water holding ability of air is expressed in terms of relative humidity. A relative humidity of 50 percent, for example, means the air is holding one-half of the maximum water that the air could hold if saturated at a given temperature.

Theoretically air can be cooled evaporative until it reaches 100 percent relative humidity. Practically, a good evaporative cooler can reach about 85 percent of this temperature drop. The cooling effect for 85 percent efficient evaporative coolers is shown in Table 1.

Evaporative coolers are more effective when the humidity is low (Table 1). Fortunately, relative humidifies are usually low during the warmest periods of the day. Solar heat entering the house offsets some of the cooling effect. A well-designed ventilation system pro-viding one air volume change per minute is essential for a good evaporative cooling system. A solar heat gain of 8-10 degrees F can be expected using one air change per minute. If the outside air were 90 degrees F and relative humidity were 70 percent, the resulting temperature within the house would be about 93 degrees F (83 degrees F from Table 1 plus 10 degrees F).

Table 1. Cooling Capacity of 85 Percent Efficient Evaporative Coolers

	Relative Humidity			
Outside Air	**at 30%**	**at 50%**	**at 70%**	**at 90%**
Outside Air Temperature ºF	**Cooled Air Temperature ºF**			
100	79	86	91	96
90	70	77	83	87
80	63	69	74	77

70	54	60	64	68

If a cooling efficiency of 85 percent is to be realized, at least 1 square foot of pad area (aspen fiber) mounted vertically should be provided for each 150 CFM of air circulated by the fans. Many pad materials have been used successfully, provided a complete water film does not form and block air movement through the wet pad. Table 2 gives recommended air flow through various pad type materials.

Table 2. **Recommended Airflow Rate through Various Pad Materials.**

Pad Type	Airflow Rate through Pad (CFM/ft2)
Aspen fiber mounted vertically (2-4 in. thick)	**150**
Aspen fiber mounted horizontally (2-4 in. thick)	**200**
Corrugated cellulose (4 in. thick)	**250**
Corrugated cellulose (6 in. thick)	**350**

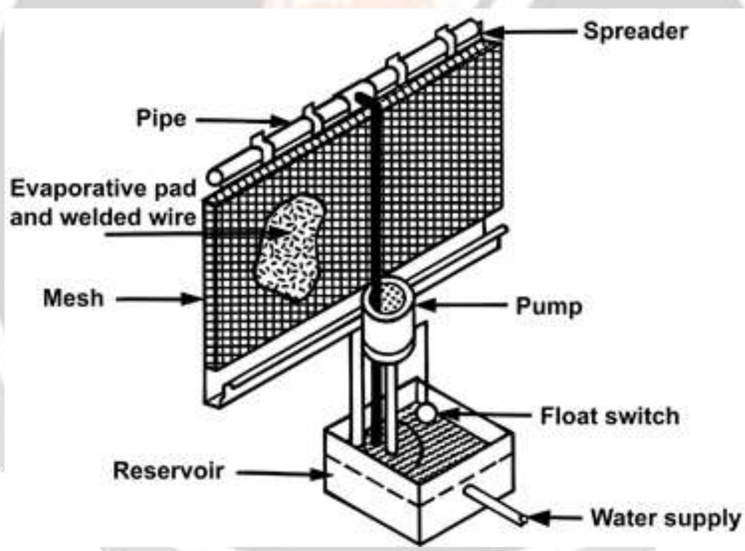


Figure 7. Typical evaporative cooling system.

Aspen pads are usually confined in a welded wire mesh. A pipe with closely spaced holes allows water to run down a sheet metal spreader onto the pads (Figure 7). The flow rate of the water supplying header pipe is listed in Table 3. Water than does not evaporate in the air stream is caught in the gutter and returned to a reservoir for recycling. The reservoir should have the capacity to hold the water returning from the pad when the system is turned off. Table 3 shows recommended reservoir capacity for different type pads.

Table3. Recommended Water Flow Rate and Reservoir Capacity for Vertically Mounted Cooling Pad Materials.

Pad Type	**Min. Flowrate per Length of Pad (gpm/ft)**	**Min. Reservoir Capacity per Unit Pad Area (Gal/ft2)**

Aspen fiber (2-4 inches)	0.3	0.5
Corrugated cellulose (4 inches)	0.5	0.8
Corrugated cellulose (6 inches)	0.8	1.0

A cover of some sort is needed to prevent air flow through the pads during cold weather. These can be manually operated or automated. Float control easily controls water supply. It is desirable to use an algaecide in the circulating water to prevent algae growth on the pads. You must, therefore, prevent rain water from entering the evaporative cooling water, causing dilution of the chemical mixture.

Evaporative pads in an endome on the suction side of fans that discharge air into houses (pressure fans) have not worked well, primarily due to the distribution of the cooled air. The same is true of package unit evaporative coolers where poor air distribution is concerned. These units can handle air volumes of 2,000 to 20,000 CFM. The problem with them is the difficulty providing uniform cooled air distribution. The closer the units are spaced along the walls, the better the air distribution will be. Package coolers have been used in small houses, and in houses with good air distribution, with considerable success. The pressurized system forces air, which must displace air within the house, into the greenhouse. Vents must be provided for air circulation.

2.8 Mist Cooling

Evaporative cooling by spraying tiny water droplets into the greenhouse has met with limited success. The droplets must be tiny, and this requires tiny, closely spaced nozzles operated at relatively high pressures — an expensive design. Water must be well filtered to prevent nozzles from clogging. Uniform distribution of the water droplets throughout the house is difficult to accomplish.

If the mist system carries any minerals in the water, deposits will be left on plant foliage. This accumulation can reduce photosynthesis substantially and can lead to salt toxicity. The mist system can also cause wet foliage, leading to disease problems, particularly when the droplet size is too large.

Mist cooling does not cool as effectively as a conventional evaporative cooling pad system but it is less expensive. The system requires no collection pan or sump. It can cause runoff or puddling beneath the pads if all the water sprayed on the pads is not vaporized.

A system that is actually a combination of a cooling pad and misting (or fogging) system is shown in Figure 8. This is sometimes called a "fogging pad" system. Some growers have used it with success.

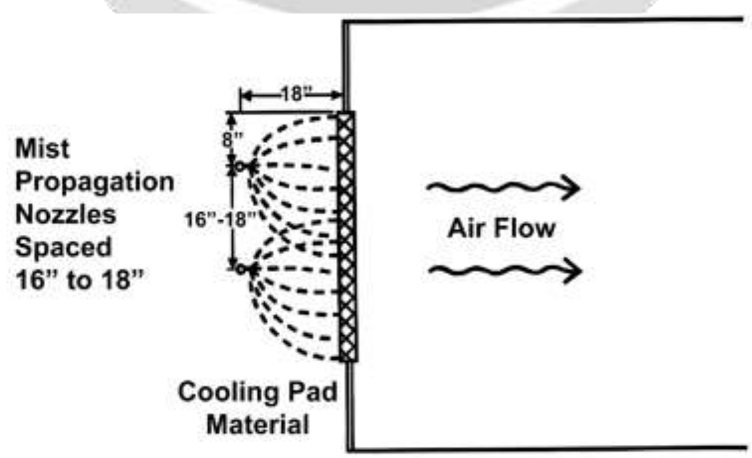


Figure 8. Mist nozzle used as evaporative cooling.

The system should provide approximately 20 gallons of water per minute to be sprayed on the pad (typically 20, 1-gpm spray nozzles) for each 48-inch fan in the ventilation system. This amount of water, however, will not always be needed.

Warmer air will evaporate water faster than cooler air. The amount of water added to the pads can be adjusted using a combination of valves, time clocks and thermostats. As the temperature in the greenhouse increases, so does the frequency of mist nozzle operation.

2.9 Natural Ventilation

Some greenhouses can be ventilated using side and ridge vents, which run the full length of the house and can be opened as needed to provide the desired temperature. This method uses thermal gradients, creating circulation due to warm air rising.

Houses with only side vents depend upon wind pressure for ventilation and are usually not satisfactory. The warm air must be allowed to rise through the ridge vent while cooler air enters along the sides. The vent size is important. Ridge vents should be about one-fourth the floor area and the side vents about the same size. The roof vents should open above the horizontal position to provide about a 60-degree angle to the roof. Most of these vents are manually operated.

3.0 Greenhouse Sensor System Principles

A sensor is any tool that measures some chemical or physical characteristics and alters the results into an electrical signal collected by the main automation computer and then this data can be easily read and interpreted by the grower. Automation can make growing easier with lots of instrumentation to be a more precise grower and get all elements feed to a crop that it is looking for.

However, user input is always required by you the grower to set limits, create schedules and create your own feed formulas, the automated software helps with controlling all the things you use to have to do manually, opening a vent for instance and keeping a close eye on all data values. If the pH of the water gets too high for instance, our software will trigger an alarm, before you would have to test for pH your self or by some other semi-automated sensor.

3.1 Outside Weather Station

We can't control the weather outdoors, would be nice though wouldn't it? But having some instrumentation on top of the greenhouse in the way of a professional weather station it great to read all outside weather conditions like temperature, solar, temperature, wind and rain conditions. These all effect the greenhouse and how you should make adjustments to the inside of the greenhouse, again all of these signals can be read, then trigger a control in the greenhouse, if the solar level gets too high, trigger all vents to open for instance.

3.2 Temperature and Humidity conditions in all greenhouse compartments

Greenhouse temperatures rise under intense sunlight. This rise in temperature is referred to as "solar gain". To enter the greenhouse, light has to travel through the greenhouse glass or plastic, in doing so the light loses some of its energy which is converted to heat. Without a cooling system, the temperature and humidity within the greenhouse can rise to over + 45 °C. To successfully optimize the environment within the greenhouse means countering the adverse effects of the external environment with the proper greenhouse controls and automation to ensure temperature and humidity levels stay optimal for crop health and growth.

3.3Fan, Co2, HID lighting, shading, fog and pad control

With expandable control and modules for our greenhouse control equipment, there is no limit to what you can automate or control. Fans, Co2, Lighting, etc can all be configured and controlled by our growing software. This means that you will have precise control over the internal environment to optimize for the perfect growing conditions for crop.

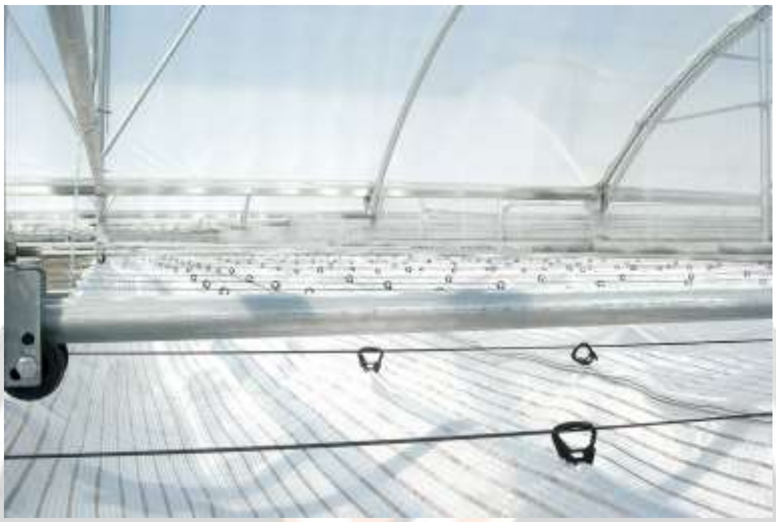
3.4 Irrigation and Misting Programs

Keeping crops fed well on a schedule with precise feed control, systems work down to the milliliter (mL) which means that you will save on both water and fertilizer costs. Most growers report that they save around 30% on water costs and 40% on fertilizer costs annually. This not only means big savings for the grower, but because of the exact formulas going out to the crops each day on a proper timed schedule, you will see a large increase in plant heath yields as well.

4.0 Equipment for Greenhouses

4.1 Screens for greenhouses

Screen helps control the amount of light, humidity and temperature inside the facility, which turns to an improvement of the crop conditions and a reduction of the energy costs. The screen has a flexible and easily-folding structure that once folded takes up minimum space and allows entering the maximum amount of light. It may be automatically run by means of a solar radiation sensor.



4.2 Hot air heating

The hot air generators are especially recommended in those cases where there is not an important requirement for continuous heating and as an occasional defence against freezing temperatures. The purpose of this system is to increase the productivity of the crops and their maturity in cold weather, using medium level technology.

The distribution of hot air is carried out using fans and hoses.

4.3 Water heating

This is a Centralised heat generation system using natural gas, diesel, biomass, geothermal heat. Water circulates through metal or PVC-Polyethylene pipes as a heat transporting agent, depending on the temperature of the hot water source, the temperature increase requirements and the crop.

We offer a wide range of solutions in this area, from basic systems, to the most sophisticated systems with Open Buffer heat storage systems and use of CO2 coming from combustion gases.

4.4 Extractor fan

The extractor fans allow forcing the ventilation inside greenhouses when the natural ventilation using roof and/or perimeter vents, does not allow reaching the desired rate of air renewal, which is an innate need for producing crops as well as livestock farms.

They are often used in combination with evaporative cooling panels or water misting systems for the purpose of obtaining a certain level of cooling.

4.5 Air circulation fans

The air circulation fans or recirculation fans help obtain a suitable air movement contributing to maintain a homogeneous interior climate, avoiding hot air accumulation at the upper section of the greenhouse, reducing substantially the degree of water condensation and favouring the crops' transpiration and CO_2 absorption.

They may be used as support for the extractor fans or as humidifier systems or for applying treatments.

4.6 Climate control

The controllers are guided by the information collected by the different sensors installed, in order to maintain suitable levels of solar radiation, temperature, relative humidity and CO_2 concentration for the crop; thus achieving the best evolution of the crops regarding their performance, early maturity and quality.

5.0 Conclusion

Precision Agriculture in green house is possible by use of right method and right equipment with understanding of crop basic needs and external environmental conditions. The paper suggests different techniques and equipment for greenhouse.

6. ACKNOWLEDGEMENTS

We are thankful our head of department Prof. M.V Dabhi, who gave us proper guidance to move ahead in this project. Our friends and family, who always gave us support & inspiration for this project. Dr. Sachin Gajjer (Nirma University) & Prof. Sandip Mehta (Nirma University) who gave us knowledge about sensors and wireless communication also helped in calculating efficiency of our product.

Last but not the least, on the list are Dr. Namrata Bajaj, who helped us to prepare this report and improve our format for preparing the report.

7. REFERENCES

[1]. Franklin, J. (1998). Plant Growth Chamber Handbook. (Iowa Agriculture and Home Economics Experiment Station Special Report No. 99 (SR-99) and North Central Regional Research Publication No. 340.). Ed. by R. W. LANGHANS and T. W. TIBBITS. 21×27·5 cm. Pp. viii 240 with 20 tables and 45 text-figures. Ames, IA, USA: Iowa State University, 1997. Price p/b: $15.00, ISBN 0361 199X. New Phytologist, 138(4), 743-750. doi:10.1046/j.1469-8137.1998.00149-7.x

[2] Urvish Pravinkumar Soni, and Mehta Zankhana. "Cost Effective Precision Agriculture Using Mobile Wireless Sensor Rover" International Journal Of Advance Research And Innovative Ideas In Education Volume 2 Issue 2 2016 Page 1316-1322

[3] Urvish Soni, and Zankhana Mehta. "Cost Effective Precision Agriculture Using Magnetized water and Instrumentation" International Journal Of Advance Research And Innovative Ideas In Education Volume 3 Issue 4 2017 Page 2610-2618

[4] AMCA. Air Movement and Control Association International, Inc. 30 West University Dr., Arlington Heights, IL 60004-1893.

[5]ASABE. Engineering Practice. 1993. Heating, Ventilating and Cooling Greenhouses. ASAE EP 406. American Society of Agricultural Engineers. St. Joseph, MI 49085.

[6]Hellickson, M.A., and J. Walker. 1983. Ventilation of Agricultural Structures. American Society of Agricultural Engineers: St. Joseph, MI 49085.

8. BIOGRAPHIES

	**Mr. Urvish Soni** Bachelor of Technology Instrumentation and Control Engineering Nirma University, INDIA Contact: Urvish.ic@gmail.com +91 9428532878
	**Mrs. Zankhana Mehta** Bachelor of Engineering Instrumentation and Control Engineering Shantilal Shah Engineering College, Bhavnagar, INDIA Contact: zankhana_mehta@yahoo.com +91 9375165738