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UNDERSTANDING THE VAPOR CYCLE HUMIDIFICATION & DEHUMIDIFICATION

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Understanding what Dehumidification means and why we need it.

INTRODUCTION

The subject of dehumidification and cooling is sometimes a bit foreign to many people in the Commercial Indoor Garden business. This paper will help in understanding humidity and dehumidification.

The HVAC (**H**eating **V**entilating and **A**ir **C**onditioning) industry, which is responsible for heating, cooling, humidifying and dehumidifying our Commercial Indoor Gardens (CIGs). This article should leave you with a better understanding of the who, what, when, where and whys of cooling and dehumidification.

Topics:

- Definitions
- Cooling and Dehumidification
- The Natural World Vapor Cycle
- Humidification & Humidity Gain
- Heat & Evaporation
- Transpiration
- Evapotranspiration
- VPD- Vapor Pressure Deficit
- Air Movement
- Relative Humidity
- Humidification
- The Dehumidification Process

Having a better understanding of common terms in the air conditioning and dehumidification process will make it easier for you to understand what the engineers and architects are talking about.

DEFINITIONS

1. Transpiration: Is the process where plants absorb water through the roots and then give off water vapor through pores in their leaves.

2. Evapotranspiration: This simply is the process of transpiration combined with the evaporation of water off the plants leaves.

3. Sensible Cooling Load (SC): This is the cooling required to cool a dry heat, typically from the lighting which adds no moisture to the system.

4. Latent Cooling Load (LC): This is the cooling required to remove the moisture in the air from the system.

5. Total Cooling Load (TC): This is the sum of the Sensible and Latent Cooling loads TC = SC + LC.

6. Sensible Heat Ratios: This is the ratio of the sensible cooling capacity of an air conditioning system to the total capacity of the system SHR = SC/TC. The lower the ratio, the higher the dehumidification capacity.

7. Btuh: This term stands for **B**ritish **T**hermal **U**nits per **H**our. This is the Imperial measure for energy in a system that needs to be cooled and dehumidified. Air conditioning units rate their cooling capacity according to Btuh (ex: Model:4HP14L601P will do 60,000 Btuh of cooling which is equal to a 5-ton unit).

8. Tons of Cooling: 12,000 Btuh = 1.0 ton of cooling. A ton of cooling was derived long ago and defined by the amount of energy required to raise 1-ton of water 1-degree Fahrenheit.

9. Watts: Equal an amount of electrical energy. Motors and lights emit their energy in the form of sensible heat load.

1 Kw = 1,000 W (1 Kilo watt = 1,000 watts)

1Kw = 3,413 BTUs

10. Relative Humidity: This is a term for water content in the air relative to its temperature and weight. Given the same weight of air, if air warms up the RH% will decrease. As air cools, the RH% will increase.

11. Dew Point: This is the temperature at which air is cooled to the point of which the air will no longer hold the water vapor in suspension and will start release the water vapor in the form of condensate or rain.

12. Water Vapor: Is the molecules of water suspended in the air.

13. Evaporation: Simply put, the process by which water moves from a liquid state (water in a glass) to a vapor state suspended in the air.

14. Vapor Pressure Deficit (VPD): Vapor Pressure Deficit is the difference (**deficit**) between the amount of moisture in the air and how much moisture the air can hold when it is saturated. The higher the deficit or differential the lower the RH generally is. The higher the RH the lower the deficit is. If there is no deficit in the pressures the no evaporation from the leaf will occur. VPD is sometimes referred as **Vapor Pressure Differential**.

15. Stomata: The pore like opening on a plant leaf that allows for the intake of carbon dioxide and to limit the loss of water due to evaporation. Plural: Stoma.

COOLING CAPACITY AND TERMS

Cooling capacity is a topic that many people do not fully understand. The following is an overview of cooling, terminologies and formulas that will give you a better understanding of cooling loads.

We all know we need air conditioning. So, what do mechanical engineers and HVAC (**H**eating **V**entilation **A**ir **C**onditioning) designers look at when deciding how much air conditioning is needed for a room.

First, there are 3 different forms of heat transfer: Conduction, Convection and Radiant Heat.

CONDUCTION

Conduction is the physical transfer of heat from a source to the target by direct contact.

EXAMPLES:

1. Touching a hot stove and getting burned.
2. Putting ice in your hand and having your hand cool down

CONVECTION

Convection is the transfer of heat by movement of liquids or gases

EXAMPLE:

Old fashion radiator warming up the area around the radiator. The hot water inside the radiator heats the steel radiator via conduction heating. The hot steel radiator then radiates heat and heats the wall near the radiator (Radiant Heating). If you are standing near the radiator you will feel the warmth from the radiator even though you are not touching the radiator. This is radiant heat.

RADIANT

Radiant heat transfer directly heats objects in an environment, not the air in between. Radiant heat is sometimes referred to thermal radiation.

EXAMPLE:

The heat felt by a campfire would be radiant heating.

GROW ROOM LOADS

Grow room load are the sum of the following loads

- External Load
- Internal Loads
- Ventilation Load

External loads include heat gain from:

- Radiant Heat Load
- Sunshine
- Thermal Load
- External Ambient Loads

Internal Loads

- Lighting Loads
- Motor Loads
- Moisture
- People Loads

A radiant heat load would be the sun shining on the house creating heat on the outside wall. If the sun went down, this radiant load would cease to exist.

Thermal load is different from radiant heat loads. Thermal load is a heat gain from the air around the building adding heat to the building. So, what is the difference? If the temperature is 110°F outside, this heat would be considered a thermal load. The sun would be a radiant load.

So, if the sun went down, the outside air temperature could still be 110°F. This hot ambient condition would still heat up the house even though the sun went down. This exemplifies thermal load.

HUMIDIFICATION

First it is best to disclose the almost obvious, “without humidification we would never need for dehumidification”. To better understand there are several questions we must answer first:

1. How does our environment get humid?
2. Why would I want to dehumidify the air?
3. How do we dehumidify the humid air?

We will answer these questions and give you a better understanding of the processes, terminology and the need for dehumidification.

HUMIDITY GAIN

How does our environment get humid? In the atmosphere increases as water evaporates from the surface and the atmosphere becomes less humid as the atmosphere release water vapor through rain. Rain will then cause a geographic area to become more humid at the ground level. Extreme evaporation from a geographic area can cause drought. The world does have two naturally occurring extreme conditions: humid tropical environments and dry desert climates. Most of the land masses are somewhere in between these extreme conditions.

Our outdoor natural humidification and dehumidification cycle is caused by 5 major components: heat, evaporation, transpiration, cooling and condensing. Without these processes, life as we know it on Earth would not exist.

The below figure (Fig.1), illustrates how the natural world dehumidification-humidification cycle occurs.

Fig 1.

Water enters the atmosphere through Transpiration (plants giving off moisture through their leaves) and Evaporation.

These two processes increase the moisture in the atmosphere. Water vapor in lower levels cannot be visually seen and for the most part is invisible.

As the moisture content increases in the atmosphere, the water molecules start to collect and bind to each other, forming condensation which can visual be seen in the form of clouds. At this point the moisture content is still suspended in the air.

Then, when the atmosphere cools down the air, the air can no longer keep the water (moisture) suspended, and the atmosphere starts releasing the water in the form of rain.

Then the cycle starts all over again. This is the Natural World Vapor Cycle.

Plant Growth

Moisture and heat are the two items necessary for plants to grow but too much moisture and heat can promote grow of some very undesirable enemies such as mold, mildew and fungi.

HEAT

The first major component is Heat. This component starts the cycle of humidification and dehumidification.

If a system had no heat gain and only cooling, all moisture would become one of two states, water and ice. Heat causes evaporation and lets water become the third state, vapor. It is the vapor in the environment that causes good things to happen as well as bad things (mold and mildew growth)

Heat added to the surface of water creates a **Vapor Pressure Deficit (VPD)** between the air and the water allowing evaporation to take place. Warm dry air has a lower pressure than the pressure at the surface of water. When warm dry air contacts the surface of water, evaporation takes place.

EVAPORATION

Evaporation means that the top water molecules on the surface move form a liquid form to a vapor form. These water molecules are then suspended in the air. The amount of moisture suspended in the air is defined by the relative humidity (RH%). This is the percentage of water in the air relative to the amount of water required to be suspended in the air before it would start condensing (falling out) out of the air.

Most moisture evaporation occurs through the heating of bodies of water such as lakes, rivers and oceans. Evaporation additionally occurs from plant and animals and generally regulates the temperature and water content of the plant or animal.

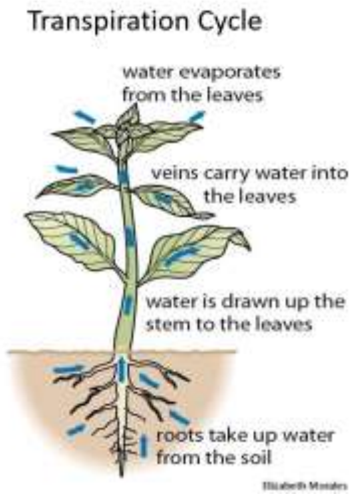
PERSPIRATION

People exhibit evaporation of moisture from their body/s skin hrough the process as perspiration, commonly known as sweating. Perspiration is the body’s attempt to cool the body by perspiring moisture through the skin and having the moisture evaporate, thus causing a cooling effect.

TRANSPIRATION

The transpiration cycle (Fig.2) is the process by which plants bring water from their roots and give off water through their leaves. The stoma of the plant serves two main purposes: to regulate the intake of CO_2 and to regulate the release of water from the plant.

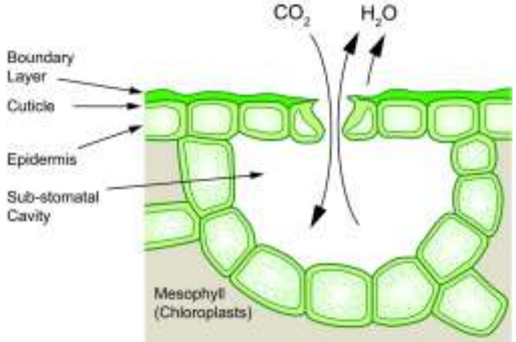
Fig. 2



STOMA (singular: Stomata) - Plants, essentially breath through their stoma which are tiny pores generally located on the underside of the plant leaves. During the day, the feeding period, the stoma open, breathing in CO_2 and exhaling O_2 and H_2O (Fig.3).

The stoma also helps regulate the hydration and temperature of the plant by releasing water and allowing evaporation of the plant moisture creating a cooling effect. Closing of the stoma during dehydration is a natural process of self-preservation. The effects of self-preservation are stress, stunted growth and possible early bloom. Both (Fig. 3) and (Fig. 4) shows the stomata of the plant. The stomata of the cannabis plant is located on the underside of the leaf.

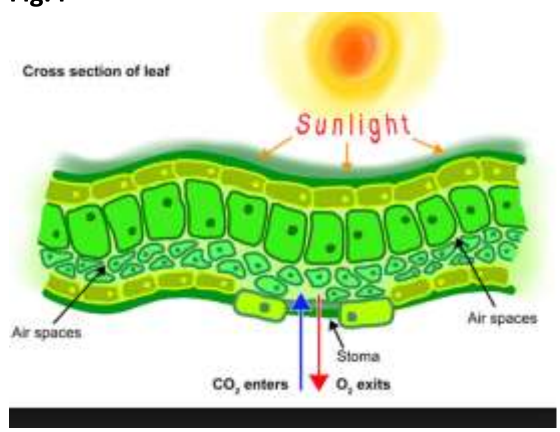
Fig. 3



Most plants with underside stoma are considered dicots (dicotyledon). Cannabis is a dicot and its stoma are shown in (Fig.4).

The stoma are integral to the health of the plant, photosynthesis and are essential to keep the nutrient flowing to the leaves so that when bloom occurs, a healthy and full flower is produced.

Fig.4



FEEDING - For the plant to feed, the nutrient must move from the roots up through the stalk of the plants and then into its branches and finally the leaves. The method of delivery for the nutrient is via water.

By watering the roots of a plant, the nutrients become soluble and can now be delivered to the rest of the plant.

So how do we get the water to move from the roots to the leaves? Nature took care of this for us as long as we abide by her rules.

The first step of feeding is to have the stoma open starting the transpiration process. As the stoma opens, water is allowed outside of the plant is now exposed to the atmosphere surrounding the plant leaf and is now waiting be evaporated into the air. Less humid air moves across the stoma and leaf and evaporates the surface water into the air. This allows the plant to draw more water from its roots and deliver more nutrients to the plant. Greater water flow through the plant means nutrients to feed the plant. More nutrients translate to faster and healthier plant growth.

EVAPOTRANSPIRATION

This is the name given to both the process of transpiration and evaporation into a single process name

To complete the evapotranspiration process, we need to ensure that we have proper evaporation.

When the sun is up (lights on) the stoma opens and when the sun goes down (light off) the stoma closes. It is vitally important to provide enough water to the plant roots during an evapotranspiration period. If the conditions are correct for evapotranspiration, and if the plant does not have enough water, plant dehydration occurs. Plant dehydration brings on stress and stress can bring on premature bloom.

VPD (VAPOR PRESSURE DEFICIT)

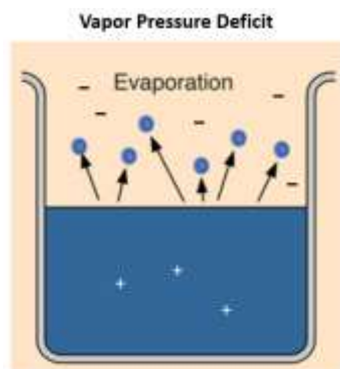
Vapor Pressure Deficit, or VPD, is the difference (**deficit**) between the amount of moisture in the air and how much moisture the air can hold when it is saturated. Once air becomes saturated, water will condense out to form clouds, dew or films of water over leaves.

Without VPD evaporation will not occur. VPD is the scientific process by which evaporation occurs.

All gasses in the air exert a certain "pressure." The more water vapor in the air the greater the vapor pressure.

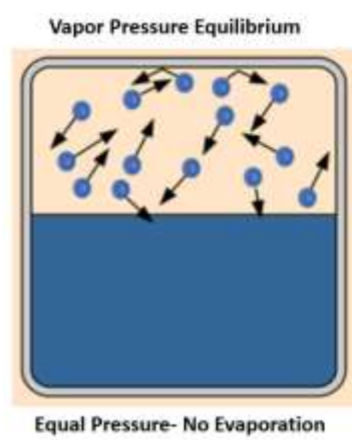
If the vapor pressure in the plant is greater than the vapor pressure in the air then you will have evaporation. This is represented by water in the jar (the plant) having a higher vapor pressure than the air Fig.6. This condition will induce evaporation.

Fig.5



Under Vapor Pressure Equilibrium (VPE) (a closed container) (Fig.6), the rate of evaporation is equal to the rate of condensation and the net evaporation is equal to zero.

Fig.6



RH% and **VPD** are typically **inversely related**. As the RH% decreases the VPD increases. This simply means, as the relatively humidity decreases the ability of the air to take on moisture increases.

So, what does a low VPD mean to the grower and owner?

- Low VPD causes low transpiration rates.
- Low transpiration rates cause slow nutrient flow through the plants.
- Low nutrient flow slows down the rate of growth.
- And finally, low growth rates translate to low production.
- Low production causes low profits.

How do we insure we have good VPD?

There are two very important parts to dehumidifying the air and achieving a good VPD.

- Air Movement
- Air Dehumidification

AIR MOVEMENT - If we have no air movement, very little dehumidification can take place as the air will become saturated with water vapor and the ability of the air to absorb more moisture will slow way down. Airflow is essential to the dehumidification process. Airflow is usually accomplished by having a circulating fan(s) in the air handler forcing the supply air down the duct systems and into the room and drawing the return air back to the unit from the return air duct.

DEHUMDIFICATION - Next, the airflow must be dehumidified. This is usually done by mechanically dehumidifying the air across a cold air coil. More about this process later in the article.

Essentially, we need to introduce drier air with a lower pressure deficit to the leaves of the plant, so evaporation can occur. We do this by circulating drier air to the indoor grow room.

The air conditioning system is the equipment responsible for moving the relatively humid air out of the space and returning less humid air to the space. This allows the moisture from the plants to evaporate to the drier air and removed from the room.

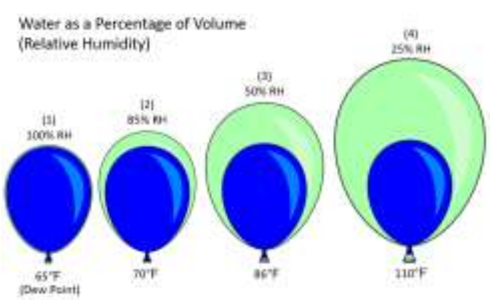
Many growers would like to have a room about 75°F @ 50% RH. What does this mean?

Next is to understand what relative humidity means.

<u>**RELATIVE HUMIDITY**</u>

Relative Humidity is a relative term referring to how much moisture air can retain before the air becomes saturated and can no longer hold any more moisture. This relationship between air and water vapor can see in the balloon illustration in (Fig.7).

Fig.7



RH% or relative humidity, the actual amount water vapor stays the same while the volume and or the weight of the air changes. The higher the temperature translates to a high molecular state which air can hold more moisture

Stage (1): The smaller balloon has a RH% of 100% at 65°F. This means that the air can no longer hold any more water vapor in suspension and as the air cools below 65°F, the water will start condensing out of the air in the form of condensate. This stage of air is commonly known as the "Dew Point" or the saturation point and the ability of the air to hold moisture is exceeded.

Stage (2): As the air in the balloon warms up to 70°F, the air now above the dew point and the water vapor can stay suspended in the air. We consider this a "relatively" humid environment. Although you can have some evaporation, this relative humidity does not allow for much evaporation. Thus, the ability of the air to absorb moisture is poor.

Stage (3): As the air further warms up to 86°F, the balloon will get larger and the relative humidity is reduced to 50%. Remember that the total amount of water stays the same, just the volume has changed because heat was added to the balloon causing it to expand. The ability of the air to absorb moisture is good.

Stage (4): As the air continues to heat up to 110°F, the relative humidity is now only 25%. The ability of the air to absorb moisture at 25% becomes best.

Next, the dehumidification process.

THE DEHUMIDIFICATION PROCESS

Although many plants, including cannabis, can grow in relatively humid environments such as the tropics, if the proper evapotranspiration does not occur, stagnant water will form on the leaf which promotes mold and mildew growth. This is unacceptable in today's commercial indoor gardens facilities operated aimed at quality production. Many codes now do not allow mold or mildewed plants to be sold to the public.

The natural cycle of dehumidification occurs all around the globe, every minute of every day (Fig.8).

But indoor garden changes the environment and creates a new world environment constructed by and controlled by the grower.

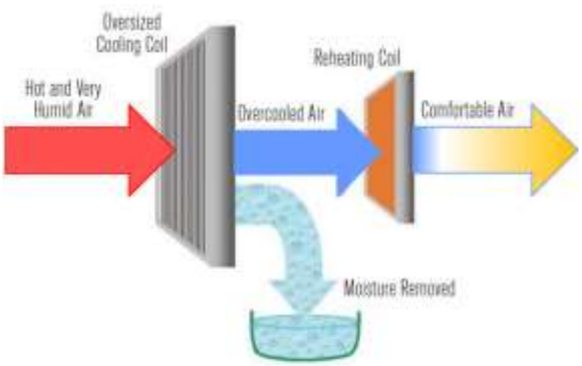
Fig.8

The purpose of dehumidification equipment in an indoor garden, is to remove moisture creating a lower pressure in the air (lower relative humidity) with respect to water, thus creating a **VPD** and allowing for evapotranspiration to occur.

Since the grow room will not blow up like a balloon, we must mechanically remove the moisture from the air to reduce the RH%. This is done through the air conditioning system. Air conditioning systems are responsible for both cooling and dehumidifying air. Air conditioning systems are generally closed loop systems that discharges air into the space via the supply ducts and then returns the air to the unit via the return ducts. Inside the unit there is a cold coil. When watering and evapotranspiration is occurring, the air get very humid. Thus, when the humid return air (85% rh) comes back to the AC unit, the return airstream flow over the cold coil (ex. 55°F), the moisture air condenses out of the airstream. This happens because air reached the 65°F dewpoint as shown in the illustration and moisture falls out of the air in the form of condensate.

The condensate (water) is then removed from the system via the condensate drain as seen in the below illustration (Fig.9).

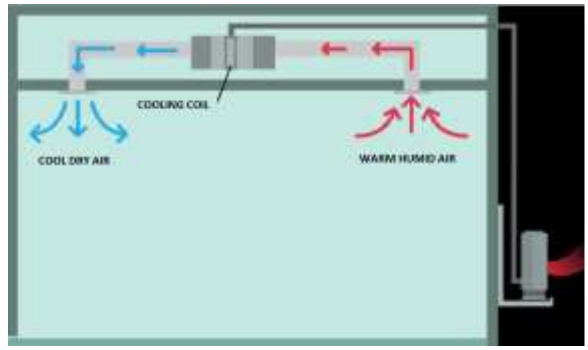
Fig.9



Because the air subcooled to remove moisture during the dehumidification cycle, the air may have to be reheated to prevent over cooling.

This is the dehumidification cycle that is responsible for removing the excess moisture out of the air.

Fig. 10



The proper selection of cooling and dehumidification equipment is essential to promote water flow through the plant and prevent catastrophic mold and mildew growth.

CONCLUSION

Health of the plants can be directly associated with the relative humidity and the ability of the plant to move moisture up the plant and out of the leaves through the stoma. Maintaining the correct relative humidity in the space is critical to this process.

There are many types of air conditioning units that will provide cooling and dehumidification to the space, but some systems are better at removing the higher amounts of moisture than others. In the closed environment of an indoor garden, it is paramount that plants have ample air flow and are provided with the correct temperature and humidity control for best growing practices.

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