e-GRO Edible Alert

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Why does condensation happen on your plants?

When moist air meets a surface having a temperature lower than its dewpoint, oversaturated humidity in the thin layer of air touching the surface turns into liquid water (dew, or condensate). This rather simple phenomenon is often overlooked and misunderstood. A typical misunderstanding is that condensation happens only when the greenhouse air is saturated or nearly saturated (i.e. 100% relative humidity). This is not true, and condensation can happen inside a greenhouse whose air humidity is not yet saturated. In fact condensation does not happen even when the air humidity is 100% if the surfaces are all higher temperature than the air (i.e. dewpoint).

This article aims to assist growers and other greenhouse professionals to understand some of the critical psychrometric properties, saturation humidity (or saturation vapor pressure) and dewpoint. Understanding them would assist growers to avoid creating the conditions causing unnecessary condensation dripping onto or forming on crops.

Warmer air can hold more moisture (humidity). Saturation level of humidity doubles every 10 degrees Celsius (18 degrees F) (Figure 1). When air cools down, the capacity to hold moisture (humidity) is lowered, shown as lower saturation levels in Figure 1. When air temperature decreases further to the level where the air no longer can hold the humidity, excessive humidity becomes small droplets of liquid water or dew (or fog when floating in the air). This process, turning humidity (vapor) into liquid water, is called condensation and the temperature at which condensation occurs is called dewpoint. Air at the dewpoint temperature has 100% relative humidity. When greenhouse has a localized low temperature area (e.g., near cold surface) dew forms on such a cold surface due to condensation.

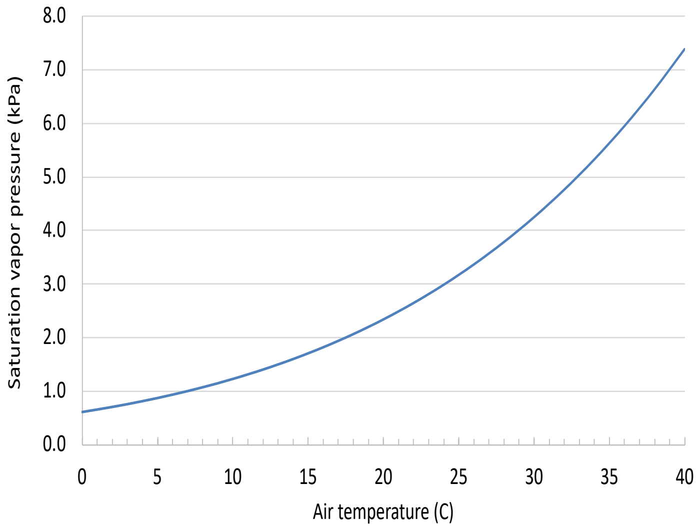

Figure 1. Saturation vapor pressure (kPa) or the maximum amount of moisture that air can hold at different air temperatures. Saturation level of humidity (vapor pressure) generally doubles every 10 degrees Celsius (18 degrees F)

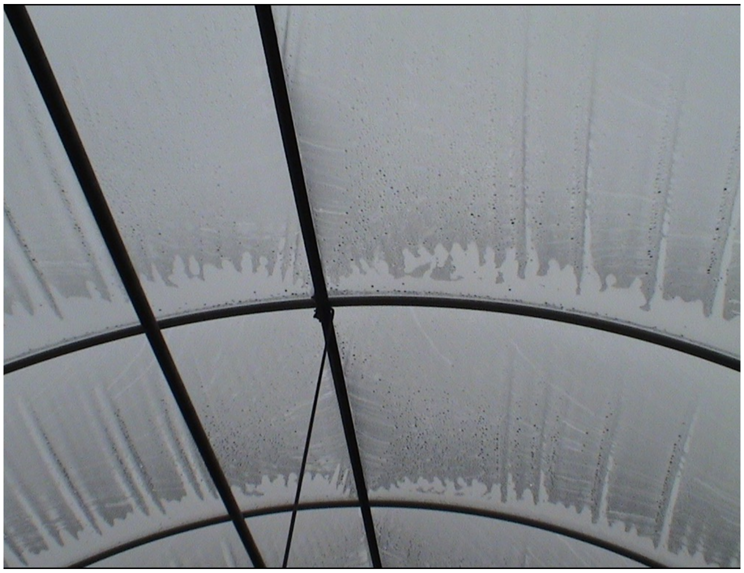

Figure 2. Condensation observed on the surface of polyethylene film glazing covering over an arc-roof greenhouse (Photo credit: Dr. Peter Ling, Ohio State University).

How to find dewpoint temperatures. There are a number of web-based resources available for dewpoint calculators based on air temperature and relative humidity. A psychrometric chart is a useful tool if you wish to better understand properties of moist air when heating and cooling are considered. Digital psychrometric charts are also available, and the author has used one available from Let'sGrow (https://gpe.letsgrow.com/psychro).

The following three cases are presented to better understand condensation risk management in crop production.

Condensation case 1. Condensation on internal surfaces of roof or side walls of greenhouse is often seen in cold seasons (Figure 2). This is because the surface temperature is lower than the dewpoint of the air inside the greenhouse. For example, when the air temperature inside the greenhouse is 60 °F (16 °C) and relative humidity is 70 %, the dewpoint is 50 °F (10 °C) (determined by online calculator). When the internal surfaces of greenhouse roof and walls have a temperature lower than this dewpoint (50 °F) as a result of the cold outdoor temperature, condensation happens within the thin layer of air adjacent to the cold surfaces. Condensation on the roof surface is problematic when the condensates drip onto the crops below. Carefully analyzing the pattern of condensation forming and dripping to eliminate collection points of condensate is an effective approach in all types of greenhouses. Surface treatments to reduce the surface tension and thereby making condensate a thin film rather than droplets are also available (e.g., AntiCondens, ReduSystems, the Netherlands).

Condensation case 2. Condensation on harvested produce is often seen when a postharvest cold chain is broken. For example, when harvested produce is stored at 40 °F (4 °C) and moved to a packing area of 68 °F (20 °C) air temperature and 40 % RH, condensation can form on your produce as the produce surface temperature coming out of a 40 ˚F cooler is likely lower than the dewpoint. The dewpoint of air inside the packing area is 43 ˚F (6 ˚C). Lowering temperature and humidity (and therefore dewpoint) of the packing area can avoid condensation.

Condensation case 3. Plants growing inside the greenhouse lose or gain heat depending on the surrounding environment. In some cases, plant leaf temperature could be a few degrees lower than air temperature. When this happens, this could cause problematic condensation on plant leaves. For example, a greenhouse glazed with single-layer polyethylene film could allow much heat loss from the plant leaves via longwave radiation. Similarly, a glass greenhouse in a very cold outdoor climate could allow cold leaf temperatures when thermal curtains are not used effectively. When plant leaf temperature is below the dewpoint of greenhouse air, condensation forms on the leaves. Growers need to pay attention to not just air temperature and humidity, but also dewpoint and leaf temperature. Accurate air temperature measurements were discussed in a previous eGro Alert (Kubota, 2022) and leaf temperature measurement is always encouraged with appropriate instrumentation (e.g., infrared radiometer or direct measurement using fine wire thermocouples). Persistent wet leaf surface facilitates infection by plant pathogens and must be avoided for crop health and quality. Solutions can include further reducing the air relative humidity (reducing dewpoint) or introducing thermal screens to prevent radiative heat loss from the plants at night. Radiative heating systems directly increase leaf temperature and are another approach to maintain plants free from condensation (even at 100% relative humidity in the air as shown in Table 1). Another effective approach is to provide airflow over plants to encourage evaporation of condensates as quickly as possible.

Literature Cited

Kubota, C. 2022. Are your air temperatures accurate? eGro Edible Alert. Vol 7 (12).

Table 1. Example relationships between air temperature, relative humidity (RH), dewpoint and leaf temperature causing condensation. Condensation likely forms on leaves **when leaf temperature is lower than the dewpoint of the air**. Dewpoint of the air is determined based on the air temperature and relative humidity using an online tool.

Air Temp (F)	RH (%)	Dew-point (F)	Leaf temp (F)	Condensation risk on leaves?
60	85	55	55	**Maybe**
60	85	55	60	**NO**
60	85	55	65	**NO**
60	90	57	55	**YES**
60	90	57	60	**NO**
60	90	57	65	**NO**
60	95	58	55	**YES**
60	95	58	60	**NO**
60	95	58	65	**NO**
60	100	60	55	**YES**
60	100	60	60	**Maybe**
60	100	60	65	**NO**

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