

Air humidity - unit conversion

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Published in the Grower 59(4), 2004, p. 48-49 (title adjusted)

The settings in the climate control computer have a great impact on the energy use in a greenhouse. Temperature control is obviously very important for energy consumption. Humidity control is just as important, but less known for having an effect on energy use. This article looks at air humidity, in particular relative humidity, dewpoint and vapour pressure deficit, and also at the reasons for humidity control. The next article will look at how humidity control can be done more energy-wise.

Saturation and condensation

Warm air can hold much more water vapour than cold air. This basic fact is very important for climate control and energy use. For every 10 degrees increase in temperature, the maximum water content nearly doubles (see Table). When air of a certain temperature is saturated with water, we call this 100% relative humidity. For instance, air of 20 °C can contain 17.3 gram of water vapour per m³ air at maximum, whereas air of 30 °C can contain 30.4 g/m³ water vapour. If the temperature is raised from 20 to 30 °C while the amount of moisture remains at 17.3 g/m³, the moisture content at 30 °C is only 58% of its saturation level (17.3 versus 30.4 g/m³), and we say the relative humidity is 58%. If saturated air of 20 °C cools down to 15 °C, some moisture has to disappear out of the air, because air of 15 °C can hold not more than 12.9 g/m³. The surplus moisture disappears out of the air by condensing on a cold surface.

Relative humidity and disease control

Growers are familiar with relative humidity (RH) expressed in % (discussed above). Not many people understand 'dewpoint'. Dewpoint is expressed in degrees celcius. Dewpoint is an accurate measure of air humidity and a good indication of the likelihood of condensation to occur. If air has a temperature of let's say 23 °C and a dewpoint of 17 °C, it means that condensation will occur if the air temperature drops to 17 °C, or if the air comes in contact with a surface of 17 °C or less. There will be no condensation as long as the temperature stays above the dewpoint.

If the dewpoint is close to the air temperature, the RH is close to 100% (e.g. 95% or higher). It is then very likely that condensation will occur on cold surfaces such as glass, fruit and sometimes even on plant leaves. Condensation on fruit and leaves happens especially early in the morning. Then everything warms up from the night temperature to the day temperature, but the fruit are very slow to warm up due to their mass. They stay colder than their surrounding for quite some time and thus they attract condensation. Free water on fruit (or leaves) stimulates germination of fungal spores, which causes the outbreak of fungal diseases such as Botrytis. The climate control computer can help reduce disease incidence by preventing condensation on the plants. Good humidity control is the key.

Vapour pressure deficit for transpiration control

Air humidity can also be expressed as vapour pressure deficit (VPD) with units kilopascal (kPa). VPD is an indication of the amount of water that is missing compared to saturation (i.e. compared to 100% RH). Vapour pressure deficit is the driving force for transpiration: the higher the vapour pressure deficit, the more pressure on the plant to transpire. Technically it is better to use VPD rather than RH in relation to transpiration control. Some computers use both RH and VPD and some offer the choice between RH and VPD. Table 1 shows the relation between Relative Humidity, Absolute Humidity, Vapour Pressure Deficit and Dewpoint.

Methods of humidity control

Ways to control air humidity include heating, venting, fogging, misting and using roof sprinklers. The last three are means to increase the air humidity, and we won't consider them. Heating and venting are means to reduce the air humidity.

Heating increases the temperature, so that the air can hold considerably more water vapour. If the absolute humidity remains as it was, heating will decrease the RH and increase the VPD (see Table). The dewpoint is not affected by heating; it remains the same as long as the absolute water content remains the same.

Venting causes air exchange: it replace greenhouse air by outside air. Greenhouse air is warmer and wetter than outside air. So ventilation removes warm humid air from the greenhouse, and replaces it with cooler drier air from outside. If needed the heating may be activated as well (together with venting) to ensure that the target temperature is maintained. This will at the same time reduce the RH. So quite often heating and venting work together to achieve the required temperature and air humidity.

Reasons for humidity control

Greenhouse control computers are often set to maintain a certain air humidity, for instance 70 or 80 % RH. It is not always clear why a certain humidity target is chosen or which target level is good. Also, computers can use a so-called minimum pipe temperature. This means that the heating pipes are kept above a certain temperature, say 45 °C, even if it is sufficiently warm in the greenhouse. If it gets too warm, the pipes will stay at their minimum temperature, and the vents will open. (Obviously, if it gets too cold, the pipes will get hotter.)

The minimum pipe temperature is used for several reasons including stimulating transpiration, stimulating air movement, so-called activation of the plants, keeping the plants dry when the humidity is high, or enabling CO2 enrichment. The choice of the minimum pipe temperature is quite arbitrary.

Maintaining a target humidity level as well as using minimum pipe temperature use a lot of energy. Sometimes heating and venting is initiated at the same time. This can be beneficial at times, but it costs a lot of energy. Therefore it is better to decide why heating is required at a certain time, and then try using it more sensibly. In a next article we will look at (1) reducing disease incidence and (2) controlling transpiration by using humidity control.

Table. Air humidity in different units.

RH = relative humidity (%); abs.hum. = absolute humidity (g/m³); VPD = Vapour Pressure Deficit (kPa) and Dewpoint (°C). 1 kPa (kilo-Pascal) = 10 mbar (10 millibar), both are units for vapour pressure and for VPD.

RH %	10 °C			15 °C			20 °C			25 °C			30 °C		
	abs. hum. g/m ³	VPD kPa	Dew point °C	abs. hum. g/m ³	VPD kPa	Dew point °C	abs. hum. g/m ³	VPD kPa	Dew point °C	abs. hum. g/m ³	VPD kPa	Dew point °C	abs. hum. g/m ³	VPD kPa	Dew point °C
100	9.4	0	10.0	12.9	0	15.0	17.3	0	20.0	23.1	0	25.0	30.4	0	30.0
95	8.9	0.06	9.2	12.2	0.09	14.2	16.5	0.12	19.2	21.9	0.16	24.1	28.9	0.21	29.1
90	8.5	0.12	8.4	11.6	0.17	13.4	15.6	0.23	18.3	20.8	0.32	23.2	27.4	0.42	28.2
85	8.0	0.18	7.6	10.9	0.26	12.5	14.7	0.35	17.4	19.6	0.48	22.3	25.9	0.64	27.2
80	7.5	0.25	6.7	10.3	0.34	11.6	13.9	0.47	16.4	18.8	0.63	21.3	24.3	0.85	26.2
75	7.1	0.31	5.8	9.6	0.43	10.6	13.0	0.59	15.4	17.3	0.79	20.3	22.8	1.06	25.1
70	6.6	0.37	4.8	9.0	0.51	9.6	12.1	0.70	14.4	16.2	0.95	19.1	21.3	1.27	23.9
60	5.6	0.49	2.6	7.7	0.68	7.3	10.4	0.94	12.0	13.9	1.27	16.7	18.3	1.70	21.4
50	4.7	0.61	0.1	6.4	0.85	4.7	8.7	1.17	9.3	11.6	1.59	13.9	15.2	2.12	18.4
40	3.8	0.74	-2.9	5.2	1.02	1.5	6.9	1.41	6.0	9.2	1.90	10.5	12.2	2.55	14.9
30	2.8	0.86	-6.7	3.9	1.20	-2.4	5.2	1.64	1.9	6.9	2.22	6.2	9.1	2.97	10.5