The air-to-water ratio

The air-to-water ratio is the ratio between air and water in the pores of a media.

Composition of media:
Soil is a porous media, composed of solids, liquids, and voids. The solid components form the framework of the soil and consists of mineral and/or organic matter. The voids, also called pores, can be seen as empty spaces between the solid particles. The part of the soil occupied by air and water is referred to as the pore volume. These pores are filled with air and/or water, which ratio changes as water is added to or lost from the soil.

Water levels:
Not all of the water in the pores is available for plant use. Gravity will pull some of this water down through the soil below the crop's root zone. In most cases this so called gravitational water is not available to plants as the redistribution process mostly occurs quickly.

Air levels:
The air in the soil is similar in composition to that in the atmosphere with the exception of the levels of oxygen, carbon dioxide, and water vapor. Oxygen is used by plant roots and soil microbes and at the same time carbon dioxide is being released. Thus oxygen levels are generally less in soil than atmospheric levels and carbon dioxide levels are generally higher than atmospheric levels.

Factors that determine the difference between atmospheric air and air in soil are:

- Depth: Oxygen levels generally decrease with depth due to slow diffusion rates of oxygen from the surface through the soil.
- Pore size distribution: Soils with large pores promote more rapid oxygen diffusion into and through the soil, and carbon dioxide movement out of the soil. Soils with small pores have slower oxygen diffusion into the soil

and carbon dioxide diffusion out of the soil. Sandy soils generally have low total porosity but large individual pores. Clay soils generally have high total porosity but small individual pores.

- Aeration and drainage: Soils with large pores generally have good drainage (less water) and aeration, while soils with small pores generally have poor drainage and aeration. Thus, sands generally have good drainage, while clays have poor drainage and are more likely to become anaerobic (deprived of oxygen) as microbes use oxygen more rapidly than it is replenished through diffusion.
- Water filled pores: Soils with more pores filled with water have less space available for air, thus become anaerobic more rapidly than drier soils.
- Water vapor: Relative humidity (RH) is the amount of water vapor in air, relative to the max. amount of water vapor this air can hold at a certain temperature. The air in soil has a relative humidity close to 100%. This is much different than atmospheric air, which may vary between 5% and 100%.

Field capacity (FC):

The remaining amount of water that is left after the redistribution of gravitational water is called field capacity. The actual volume of water present when the soil is at field capacity depends on the soil texture.

Permanent wilting point (PWP):

Plants make use of the water retained in soil pores after the gravitational water has drained. As water is removed by plants or by evaporation, the remaining water around the soil particles becomes thinner and is held more tightly. When dehydrated further, the water is held too tightly and the plant is unable to take up any of the remaining water. At this phase the plant has removed all available water and the water content of the soil has reached the permanent wilting point.

Plant available water (PAW):
The volume of water in the soil that can be used by a plant is called plant available water and is commonly expressed as the depth of water per unit depth of soil. It is the difference between the soil at field capacity and the remaining volume at the permanent wilting point (the lower limit). Different soils have different volumes of plant available water.

Depletion volume (DV):
The decrease of plant available water due to water uptake by the plant since the last irrigation is called the depletion volume. Irrigation schedules are often based on not exceeding the allowable depletion volume. This allowable depletion of plant available water depends on the soil and the crop.

Potential evapotranspiration (PET):
Evapotranspiration is the process by which water is lost from the soil to the atmosphere by evaporation from the soil surface and by the transpiration process of plants growing in the soil. Potential evapotranspiration is the maximum amount of water that can be lost through this process under a given set of atmospheric conditions.

During daytime plants extract water from the soil next to the roots and potential evapotranspiration is high. The plant takes water up faster than it can be replaced and the zone around the root begins to dry, called daytime wilting.

Most crops will recover overnight from daytime wilting, if not too much of the plant available water has been depleted. This is called the allowable depletion and can range from 40% or less for sandy soils to up to 60% for clayey soils. The allowable depletion depends on the type of crop, its stage of development, and its sensitivity to drought stress.

Sensitivity to drought stress:
The amount that crop yield or quality is reduced by drought stress.

Irrigation schedule:

For setting up the right irrigation schedule, you should take 3 major factors into account:

- Effective root depth (ERD) is the depth that the root zone of the plant can reach and where it gets the majority of its water. It is determined by both plant and soil properties. Different varieties of plants have different potential rooting depths. Water uptake of a plant is closely related to its root distribution. About 70% of a plant's roots are found in the upper half of the plant's maximum rooting depth and with it 70% of its water uptake. This zone is the effective root depth. Deeper roots are able to extract enough moisture to keep the plant alive, but do not extract sufficient water to maintain optimum growth.
  Effective root depth is further influenced by plant development. In vegetative phase it increases while growing, until the reproductive phase is reached and effective root depth remains fairly constant.
- Crop water usage rate (CWUR) is the rate at which the plant available water is being extracted by the plant. In combination with soil water measurements it determines the irrigation schedule for optimum watering.
- Crop sensitivity to drought stress (CSDS) is the reduction of yield or quality by drought stress for a specific plant variety. It depends on the stage of crop development. With knowledge about the sensitivity in each growth phases, one can determine the least susceptible time for a plant and adjust the watering schedule accordingly.