Substrate growing: Irrigation Regime based on radiation

Jordan Hydroponic Agriculture and Employment Development Project: Experiences 2018 - 2019 no. 4-1

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Introduction

Due to the small volume occupied by the root system and small water holding capacity, irrigation management of crops grown in substrate requires a much more precise control than for similar crops in soil. This fact sheet aims to explain the basic concept of irrigation based on radiation.

The root zone

The root zone is a reservoir where nutrients and water are stored. Once one of these becomes depleted, irrigation needs to occur to re-supply this resource. It is also possible that a particular element becomes excessive, in this case irrigation is needed to flush out or dilute this element.

Figure 1 : The root zone.

Irrigation regime

Irrigation regime is based on the following 3 parameters:

1. Radiation
2. Drain percentage
3. Time

We prefer the radiation to be the leading parameter on deciding how frequent irrigation should be activated. The drain percentage is used to check whether the applied volume is sufficient and time should preferably be used only as a safety blanket in case the other parameters do not work correctly.

Radiation

An accumulated radiation threshold value is used to activate irrigation. For example, at every 100J/m^2 an irrigation cycle will start. You have to continuously finetune this threshold to adjust for the crops stage needs as well as the changing weather. Setting a small radiation threshold will result in very frequent irrigation, setting a high radiation threshold will result in a low frequency. You need to find a balance between frequency and volume so that slabs have the right moisture content. Observing the drain percentage will help you with this.

Drain percentage

The drain percentage should be between 20-30% so the slabs always have enough water but water is not stagnating. If the drain percentage gets too high or too low, the supply volume and radiation threshold should be adjusted. For example: If you observe that on a sunny day the drain percentage stays very low, you might want to decrease the radiation threshold to give your plants more water. If your greenhouse is equipped with a drain counter, the computer can adjust the irrigation regime based on drain automatically.

Time

A maximum time interval is set so that if after this period none of the other thresholds have been reached, for example because of a wrong measurement or a very cloudy day, the plants will still be supplied with water. In the beginning it is advisable to have a small time slot, once you become more experienced you can choose a larger time slot and thereby decrease its importance.

Figure 2: Pressure compensated drippers are used to precisely supply the plants with its irrigation requirements (nozzles in blue below the trough).

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Start and end time

Obviously, on a sunny day your plants transpire more and therefore need more frequent irrigation. Frequency can therefore be determined and based on radiation. At hot and sunny days, sometimes as many as 30 irrigation cycles have to be supplied in order to keep healthy slabs and plants. On cloudy days, it can be as little as 8 cycles.

The volume applied in each irrigation must compensate for the crop water uptake between irrigations. A too large supply volume results in flushing of your slabs, which means it is difficult for plants to take up nutrients, also it is a waste of resources. Too small volumes can result in accumulation of salts and drying out of slabs.

Transpiration

Transpiration is the process of water movement through a plant and its evaporation mainly from its leaves. The volume transpired per Joule of radiation should be stable year round. Wherever in the world, it's ratio should be between 2 and 3. Note that in substrate growing, the difference between supplied volume and drained volume is the amount of water that the plants use for transpiration.

Frequency & cycle size

The first irrigation cycle should start more than one hour after sunrise and the last cycle should be an hour before sunset in case of bright weather. In dull weather, irrigation should start 2 hours after dawn and stop 2 hours before sunset. At night, it is better not to irrigate as your plants hardly transpire at night and irrigation at night could lead to fruit bursting. Only in very warm periods you should supply one irrigation cycle at night. This means in the morning you will start with a slightly drier substrate where salts have accumulated. In the first 2-3 irrigations in the morning there will be no drain, the slabs will saturate again. To compensate for this, choose larger supply volumes in the morning (cycle size period 1) to flush out the accumulated salts. In the afternoon you want smaller volumes (cycle size period 2) and a higher frequency (smaller interval between cycles) to precisely supply your plant with what it requires. The table below will help you determine how many cycles are needed at different radiation sums.

Parameter	Unit	Value sunny day	Value cloudy day	Given / Calculated	
Radiation	J/cm^2	2000	500	A	
Transpiration target	ml/J	2	2	B	
Drain target	%	30%	30%	C	
Supply	L/m^2/day	5.2	1.3	D	(A*B)*(1+C)/1000
Dripper / plant density	nr/m^2	2.5	2.5	E	
Cycle size period1	mL/m^2/cycle	120	100	F	
Cycle size period2	mL/m^2/cycle	70	75	G	
Cycles period1	nr/d	2	2	H	fixed number
Cycles period2	nr/d	26.3	4.267	I	(D*1000-E*F*H)/(E*G)
Start time	h:m	9:00	9:00	J	
Stop time	h:m	16:00	16:00	K	
Day length	min	420	420	L	(K-J)*60
Min interval set	min	15	15	M	
Interval check	min	16.0	98.4	N	L/(H+I)
Max Interval	min	120	120	O	

Table 1: This table can help you decide how to set your irrigation settings. Its shows 2 examples, one of a sunny day and one of a cloudy day. Note that the amount of radiation, drain and transpiration target determine the supply volume.

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