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BEST PRACTICES

Management and control of hydroponic systems in greenhouses in Mediterranean area

Institutional information

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Summary

Explain your case in one or two sentences

This text aims to propose techniques to manage and control soilless greenhouse production systems.

Background information: How was the situation previous to your actions?

Traditionally, greenhouse crops were grown in the soil but in the last decades switching over to soilless production systems is observed due to the benefits offered by the hydroponic systems. Today, soilless culture systems are one of the most intensive production methods recognized globally for its ability to support efficient and intensive plant production and at the same time applying environmentally friendly technology and implementing computational intelligence. Irrigation and fertigation are considered to be the two critical inputs which enables farmers to control plant development, yield, and quality. The application of precision irrigation and fertigation methods in hydroponic systems is required, considering also water scarcity, climate change, and several environmental issues that exert pressure on agricultural producers.

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What were the needs you identified?

Irrigation and fertigation scheduling has to take into account the effects of climatic parameters on crop water uptake (e.g., transpiration rate), water stress threshold values, systems' energy consumption, efficient nutrient crop uptake, environmental concerns regarding fertilizer leaching and substrates disposal.

What solution you found to cover those needs?

Application of irrigation and fertigation methods to soilless culture systems by exploiting sensing, smart and sustainable methods

What actions did you take to reach the solution?

- Application of transpiration models based on the originally proposed Penman–Monteith approach.
- Exploitation of plant monitoring systems to optimize the irrigation efficiency.
- Nutrients were supplied along with water (i.e. nutrient solution) simultaneously to the crop. The whole preparation process of the fresh nutrient solution was automatically controlled through hydroponic fertigation head units.
- Drainage water was reused without discarded irrigation solution in the surroundings. The benefit of recycling the nutrient solution without adversely affecting yields presupposes that it was replenished with appropriate amounts of nutrients before reuse.
- Semi-closed soilless culture systems were exploited
- Mathematical and empirical models simulating specific ions accumulation in the root zone environment were applied.
- The nutrient solution in recirculation systems was periodically partly replaced during the crop growth.
- Micro-irrigation substrate was used as it is probably the most commonly used, high efficient, water delivery method.
- The direct estimation of the irrigation amount was performed according to the substrate's unique characteristics, using a relevant equation and following appropriate processes to obtain the required input data.
- The quality of source water was evaluated based on the type of the soilless culture system.
- The salinity of the nutrient solution was quantified based on electrical conductivity measurements, which correspond to the total amount of dissolved ions in the solution.
- A web-based irrigation scheduling algorithm was applied in order to determine the irrigation interval rate and the amount of nutrient solution in each irrigation event.

If any, which partners or other organisations did you involve during the process?

- Department of Agriculture, Cyprus
- Agricultural Research Institute, Cyprus

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What were the main problems or difficulties you had to face?

- Any attempt to transfer a certain approach to a different climatic environment or geographical location is bound to run into peculiar difficulties. Therefore, hydroponic control techniques have to be matched to local growing conditions.
- Model validation under different climatic conditions does not always successfully fit calibration data.
- In closed recycling systems, some nutrients and non-nutrients are accumulated in excess in the root zone, causing an increase of total salinity above a threshold value of acceptable salt accumulation. Semi-closed soilless culture systems efficiently control salt accumulation in the root zone.
- There is a difficulty of individual real-time corrections to each nutrient in response to actual crop nutritional demands. That is the reason why the nutrient solution in recirculation systems may be periodically rejected during the crop growth or at least partially replaced.
- The design of the trickle irrigation system has to be correctly sized in order to deliver water at the desired pressure and flow rate.
- Special attention should be given to the substrate water holding capacity and the restricted root of crops in soilless culture systems in order to avoid plant water deficiency.
- Different types of soilless culture systems require different irrigation scheduling approaches, which in turn need modification according to the microclimate inside the greenhouse

What is the situation now, after your actions?

- Water and nutrient use efficiency was higher in closed soilless culture systems compared with open systems.
- In recirculation soilless system, fertilizer losses and water consumption were respectively by 15-65% and by 15-35% lower, compared to a free drainage system.
- The application of a web-based irrigation scheduling algorithm to determine the irrigation interval rate and the amount of nutrient solution in each irrigation event resulted in 100% increase in water and fertilizers use efficiency as opposed to common irrigation practices.

Main lessons learned along the way? *

Methods are available to manage and control irrigation and fertigation efficiently in hydroponic greenhouse systems. However, the problem of applying nutrients and water to crops is more complicated, as it involves a multistage decision pattern for determination of optimal decision. There is a need for the development of a commercial irrigation controller unit, in order to model and monitor the soil-plant-atmosphere utilizing artificial intelligence analyses. In addition, the implementation of mathematical and empirical models, in combination with decision support systems, may be a useful tool for the better management of the nutrient solution in soilless culture system crops.

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Source:

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