



Hydroponic Training Visit

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Report GTB-1400

1. Wageningen UR Greenhouse Horticulture, 2. ECO Consult, Amman, Jordan



Referaat

Van 25-29 januari 2016 is in opdracht van Ecoconsult (Hydroponic Green Farming Initiative), Jordanië en met financiering van USAID aan Jordaanse onderzoekers en voorlichters een training hydroponics verzorgd door Wageningen UR Glastuinbouw. Presentatie zijn verzorgd op het gebied van teeltsystemen eigenschappen van substraten, het berekenen van voedingsoplossingen, vereiste waterkwaliteit en het interpreteren van laboratorium analyses van de voedingsoplossing. Tevens zijn bezoeken gebracht aan bedrijven via de toeleveranciers Haket en Hortimax. Na het volgen van deze training zijn deelnemers in staat om beginnende substraattellers in Jordanië een goede start te geven.

Abstract

From January 25-29 2016 Wageningen UR Greenhouse Horticulture organized a Hydroponic Training for Jordan researcher and consultants. The order was supplied by Ecoconsult (Hydroponic Green Farming Initiative) from Jordan and funded by USAID. Presentations were delivered in the field of growing systems, properties of substrates, calculations of nutrient solutions, required water quality and the interpretation of laboratory analysis of the nutrient solution. Besides visits were made to commercial companies, guided by suppliers Haket and Hortimax. After following this Hydroponic Training participants are able to give starting hydroponic farmers a good start.

Reportinfo

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1 Introduction

The Hydroponic Green Farming Initiative (HGFI), an initiative of ECO Consult in Jordan and funded by USAID, arranged a training course in cooperation with Wageningen UR Greenhouse Horticulture Group (Wageningen UR) from 25-29 January 2016 in the Netherlands. This five-day course enabled participants to discover and explore new and advanced hydroponic techniques that achieve high production of vegetables with a minimum of water and fertilizer use.



Participants from different sectors in Jordan were invited by HGFI to attend this course. Selection criteria for the most suitable candidates included whether they had an appropriate degree of exposure to hydroponics, in addition to previous experiences in extension work and dealing with farmers. HGFI's objective is to secure the knowledge and then disseminate the knowledge to Jordanian farmers after the training course.

Feedback from participants was obtained after the course through a quick evaluation. All of them were satisfied with the knowledge they received, the site visits conducted and the general set up of the course. At the end of the course, certificates of attendance were handed to each participant, while all presentations were delivered on a USB stick.

1.1 Training Course Program

Many topics were tackled during the course. The full program is shown in Annex 1. Major topics like nutrient solution, system design, water quality, salinity, etc. were covered. In addition to these topics, and during the different lectures and visits, many side topics were discussed to fulfil the needs of the participants.



The main topics tackled are:

1. Introduction, growing systems, water.
2. Basics of plant nutrition.
3. Fertilizers.
4. Nutrient solution recipe and calculations.
5. Growing media and their properties.
6. Water and media sampling, interpretation, and analysing the data.
7. Feedback from analysis and how to make adjustments.
8. Salinity and its effect on plant growth.

In addition to these lectures, several field visits were conducted to show the commercial farming systems in the Netherlands and how farmers are controlling and managing their farms. Details of the visits and photos are shown below.

1.2 Participants

Seven participants attended the course. This group represents the different sectors of Jordanian agriculture.

1. Laith Abdelsalam Khaled Al-Waked/USAID HGFI Project Manger.
2. Ala'a Ibrahim Ahmad Hasan/USAID HGFI, Responsible for Field Operations.
3. Nayel Tawfiq Metri Alkawalit/Head of Projects Section/Extension Engineer/Ministry of Agriculture.
4. Jamil Ibrahim Yousef Hirzalla/Al-Nimer Hydroponic Farm Manger/Madaba.
5. Khaled Fawzi Moh'd Obeidat/UNIFERT Agriculture Company, Fertigation and Fertilizers Specialist.
6. Nidal Mahmoud Fawzi Bader/NCARE, Extension Agent, Zarqa.
7. Bashar Hanna Ibrahim Dawoud/NCARE, Hydroponic and Aquaponic Specialist.

This diversity of participants allowed for a more fruitful discussion given the different working backgrounds: a governmental research institute, a governmental body, a commercial agricultural company, a farmer and project staff.

Another important point is the diversity of locations where the participants work: Zarqa/Azraq, Ghor Safi, Jordan Valley, and Amman/Madaba areas were represented in this course so that knowledge gained would be dispersed across a wide physical area.

Moreover, solid experiences of participants enhanced the scientific and practical discussions during the lectures and the field visits, and as a result the level of the course was conducted at a higher technical level.

2 Field Visits

2.1 Wageningen UR Greenhouse Facility (Bleiswijk)

A comprehensive visit explored the Wageningen UR greenhouse facility where different crops are grown. Tomato, cucumber, lettuce and ornamentals were the main crops cultivated during the time of the Jordanian visit. This greenhouse facility was designed for research purposes where all the needs of research are available. This research center is part of Wageningen University where higher education students are conducting research.



The cost of this research greenhouse was approximately €2000/m² which differs considerably from a commercial greenhouse of €200/m².

Different location/stops were shown:

a. *Lighting influences production.*



Artificial lighting was first introduced in commercial greenhouses in the early 1990s. Responding to the high prices of flowers in the winter, numerous growers invested in artificial lighting, making year round produce possible. It was only until the beginning of this century that lighting was used in vegetable production. The investment in artificial lighting still remains a calculated decision. However, with the recent developments of LED-lighting, it is becoming more and more economical.

b. Heating systems

The first form of heated greenhouses dates back to 1900. By extending the season, farmers can increase their revenue significantly. By using coal fired boilers, they increased production, but also the cost of it. Since the 1970s natural gas has been the main heating source. In the last decade, researchers are looking for other heating sources (wood, wind, solar, geothermal heat). Now Dutch horticulture cannot be found without the capacity for heating; however the energy consumption per m² decreased drastically -- by more than 65% -- compared to the 1980s. For Jordanian greenhouses it should be considered where advantages in greenhouse design are effective.



c. Examining different types of lettuce on raft system

Hydroponic lettuce production is still under evaluation and testing. Many varieties are not well adapted to hydroponic systems/farming. Wageningen UR researchers are working to find out the best methods/varieties that could work commercially. Here it will be emphasized which factors influence growth most: temperature of the water and the relation with air temperature, oxygen, speed of flow, nutrient composition, and microbial diversity.



d. Shelf life laboratory

Much attention is paid to the shelf life of the different products. Longer shelf life will increase selling prices and reduce the rotting risks at the retail shops. Cooling, packaging and transport are important factors.



e. Water and media laboratory

Water and media analysis are a key to success that each farmer should adopt. Analyses help farmers in decision making. Knowing the nutrient composition of the nutrient solution and around the root zone in the substrate is a key factor in hydroponic success. A special research lab for testing and determining properties of different media, water and nutrient solutions was established for better decision making. Routine analyses are executed by commercial laboratories with which Wageningen UR has close cooperation.



f. Fertigation units

Automated fertigation processes are adopted to ensure precise control of the different parameters with regard to electrical conductivity and alkalinity of water, nutrient solution and drainage. Each of the more than 50 compartments can be supplied by a different nutrient solution.



g. Plant maintenance operations

During the visit to the greenhouse, the participants explored the different operations to maintain the plants' health and productivity. Some of these operations were similar to Jordanian operations and others are really very strange and unusual. But the designs of green houses and the farming methods are totally different.



h. Control room

In this room all operations for climate control and nutrient solutions are monitored and adjusted. Here different conditions inside the greenhouses can be created. Water consumption, EC levels, drainage percentages, temperatures, relative humidity, CO₂ and many others are part of the monitoring system.



i. Rain water collection facilities

It was noticed that in many farms in the Netherlands, rain water is the main water source for irrigation, and this is due to the frequent number of rainy days during the year (uniform distribution over the year). Each farm is equipped with a facility to collect this water. Rain water quality is considered to be excellent for hydroponic farming and is recommended by Wageningen UR.



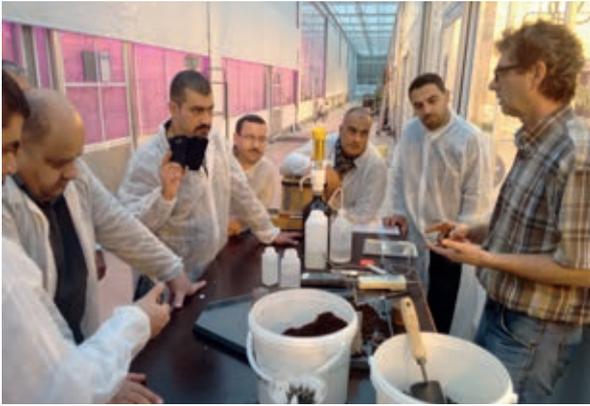
j. UV disinfection unit

The recirculation process needs a disinfection unit to ensure disease free water. The adopted disinfection technique at Wageningen UR is the UV unit that eliminates up to 99% of the different viruses, bacteria and fungi. In commercial practice UV and heat treatment are the most widely used.



k. *Practical measurements*

Special attention was paid to a practical measurement of EC and pH in water and substrate. Aat van Winkel showed the principles.



2.2 Yellow Bell Pepper Farm (Bleiswijk)

Supplier and installation firm Haket (Gerben de Jong, www.elektivonhaket.nl) took trainees to several commercial companies. This farm is a private farm for commercial production. The produce is mainly exported to Scandinavian countries. The area of the farm is 80,000 m².



The farm is equipped with all the needed tools/equipment to guarantee high quality production for ten months -- heating system, lighting system, packing house, grading machines, shading system, double glass cover, advanced fertigation units, rain water harvesting ponds, reverse osmosis plant, and electrical generator. All these items are success factors that most Dutch farmers use on their farms to ensure the highest produce quality.

General notes:

- The production is 35 kg/m² as stated by the farm manager.
- The media used was rock wool slabs.
- Planting density was 2.2 plants/m².
- Greenhouse temp ranges between 18C at night and 21C during the daytime.
- Variety planted was "Orando."
- Transplants are planted in the greenhouse when they are at the first bloom.
- 8-10 litres of water/m²/day is the peak consumption.
- Drainage percentage was 30-40% of the irrigation water.
- CO₂ for CO₂-enrichment is collected from gas heating system chimneys.

2.3 Bayer Research Center (‘s Gravenzande)

This center was designed to produce different varieties of seeds: lettuce, tomato, cucumber, eggplant, leafy crops, and others. Various farming systems are used at this center; soil systems and soilless systems. Among the soilless systems, they are adopting drip system, raft system and Nutrient Film Technique (NFT). All the advanced farming technologies are adopted, from rain water harvesting to very efficient fertigation and UV disinfection units.



General notes:

- Photography is not allowed at this site.
- Very strict hygienic procedures are to be followed before entering the farm. Even pens and note pads were not allowed.
- Production of vegetables and fruits are not the goal at this place, rather production of seed of new varieties is the goal.
- Hydroponic lettuce production still needs further research. Unlike tomato and cucumber, hydroponically produced lettuce is not satisfying producers yet.

2.4 Hortimax Fertigation Unit Factory

Hortimax (www.hortimax.com) is one of the leading companies in Europe for producing fertigation units (and climate control equipment). Several series/models of fertigation units are available from the company. Recently, they started to produce units to suit small farmers, especially in the Gulf and Middle East areas. These units are simple in design, easy to operate and manage and reasonable in price.



The product manager presented the company's profile to the participants. He also presented the different products and the ability to design and manufacture units according to user's demand.

The general manager of the company joined us while the product manager was presenting and reviewing the small unit (FertiMix-Go!). He showed the interest of his company to enter the Middle East market and how they can produce different types of fertigation units with respect to price and demand.

They also showed the group a UV disinfection unit for recirculation of hydroponic water that is widely used on farms in the Netherlands. This is the most effective method to disinfect recycled water and nutrient solution in terms of initial cost, maintenance costs and effectiveness.



2.5 Tomato Hydroponic Farm (Duijvestijn Tomaten) in Pijnacker

The last visit was to a large well established tomato farm (14.5 ha). It was high-tech, advanced and well managed -- located in Pijnacker, South-Holland. This farm is owned by four brothers and produces only tomatoes. The waste of this farm is almost zero: water is recirculated; plant residues are composted; and the fibrous material used for packing material for their own tomatoes. Three types of tomato are produced in this farm: cocktail, round and plum.

The owners decided to get benefits from high temperatures underground to reduce the cost of energy. They dig 1000 m below the ground vertically and more than 6000 m horizontally to reach a point where a hot spring was detected by satellites. This geothermal project is the first for agricultural uses in the Netherlands. The idea was to bring hot water to heat up the greenhouse. More details on geothermal energy and company Duijvestijn are available on these web sites:

- <https://youtu.be/76UximAkBAG>
- <https://www.youtube.com/watch?v=JsGiOuo2e1o>



General notes:

Total area of 14.5 ha

Packing facility

Year round supply of tomato

9,750,000 kg annual yield (about 67 kg/m²)

70-80 employees.

No entry to the glass house

<http://duijvestijntomaten.nl/>

3 Conclusions Hydroponic Training Course and Recommendations

3.1 Participants

After this training course, participants are now able to select the proper hydroponic/soilless farming system to use for different crops, water quality and nutrient solutions; they can interpret water and media analyses, irrigation and drain calculations. They know much more about management of closed hydroponic systems, trouble shooting and problem solving than when they arrived at the course. In addition, participants will be able to train beginning farmers to start their own hydroponic projects. Participants are aware of different system starting from the very basic low tech systems up to very high-tech advanced systems.

For the coming years, and as hydroponic farming is becoming vital to the Jordanian agricultural sector, those engineers will be the core of the hydroponic farming knowledge and will contribute in national plans and extension efforts regarding this type of farming. The physical dispersion of participants in Jordan will also help to better disseminate knowledge, covering four major cropping areas in the country.

3.2 HGFI

After this training course, many issues were clarified. Visiting real farmers and growers at their farms increased the level of understanding of many issues. The HGFI team is now armed with the hydroponic systems management, and is able to give advice and recommendations more deeply and scientifically than before. HGFI will disseminate the gained knowledge to farmers in different areas through field days, workshops, and printed materials. This will enhance the adoption of hydroponic farming, save more water and increase farmers' profits.

3.3 General Notes from Lectures and Visits

- The farmer/grower is the main success factor of hydroponic farming systems even with fully automated systems.
- Greenhouse design, weather control requirements, and level of complexity are determined by the growers needs and marketing strategies.
- Fertilizers quality used in hydroponics is of a great importance and greatly affects production quantity and quality. Most of fertilizers used on the Dutch farms were especially made for hydroponics and soilless culture, and sometimes special fertilizers are manufactured for systems with recirculation.



- Water quality and nutrient solutions affect the quality, quantity, and taste of the product. The farmer himself can control this with his equipment.
- Marginal water could be used for hydroponic farming with more attention to salinity problems and production threshold.

- Production of tomato in the Netherlands is higher than in Jordan for many reasons: environmentally controlled greenhouses (optimised temperatures, relative humidity, CO₂, length of season), higher technology adoption, more educated farmers, and marketing to achieve reasonable selling prices.
- Investment in greenhouse industry is very large in the Netherlands. For example, the pepper farm (80 dunums) cost was 8 million euro, 100 EU/m². But the revenue is also high due to high selling prices.
- 10,000 ha with protected cultivation, mainly glass (95%) of which 7,000 ha are grown soilless (hydroponically) and 3,000 remaining ha with soil plantations.
- Generally it appeared that there is not one fixed value or set-point for EC, pH, nutrient concentration, temperature, oxygen concentration etc., but that there is a deviation around an optimal value. Because of the weather the grower has to “play” with the set-points. It is a similar situation for substrate, growing system and variety selection.
- Record keeping of measurements during cultivation of a crop is very important: you know what you did and can improve in next crop.

3.4 Recommendations

- Jordan now is at the starting point of the hydroponic industry despite of the presence of few advanced farms (front runners). Considering the benefits that hydroponics could bring to Jordan, huge efforts should be paid to improve and support this type of farming.
- Netherlands hydroponic industry took not less than 40 years of research and trials to reach this point of excellence (comm. with Erik Van Os). Hopefully Jordan can take steps in the coming 5-10 years to improve water efficiency using protected horticulture.
- A national plan should be started to increase the adoption of hydroponics tied with continuous support from government and the donor community.
 - Improve present greenhouse/tunnel design: use better ventilation.
 - Design better low-tech tunnels and mid-tech multi-span greenhouses adapted to Jordan’s climate zones.
 - Create an investment environment that will help growers.
 - Test hydroponic growing systems for various crops with different substrates, nutrient composition, temperatures, oxygen concentrations and varieties.
 - Demonstrate to growers the progress to be achieved and teach them to use new equipment.

Summary

To save water Jordan's horticulture has to find other growing methods which are more water efficient. Hydroponics is such a method and in 2015 steps were taken to introduce hydroponics to Jordanian growers. The HGFI was started and funded by USAID. Wageningen UR Greenhouse Horticulture is helping Jordan growers with this project by supplying recommendations about hydroponic growing methods. It became clear that a more structured knowledge transfer is required.

From January 25-29, 2016 Wageningen UR Greenhouse Horticulture organized a Hydroponic Training Course for Jordanian researchers and consultants. The order was supplied by ECO Consult (HGFI) from Jordan and funded by USAID. Presentations were delivered in the field of growing systems, properties of substrates, calculations of nutrient solutions, required water quality and the interpretation of laboratory analysis of the nutrient solution. Visits were made to commercial companies, guided by suppliers Haket and Hortimax. After taking this Hydroponic Training Course participants are able to guide farmers to get a good start in hydroponic production.

In 2016, the HGFI project will be finished; however, not all growers have converted to hydroponics. A National Plan should be started to increase the adoption of hydroponics tied with continuous support from government and the donor community:

- Improve present greenhouse/tunnel design: use better ventilation.
- Design better low-tech tunnels and mid-tech multi-span greenhouses adapted to Jordan's climate zones.
- Create an investment environment that will help growers.
- Test hydroponic growing systems for various crops with different substrates, nutrient composition, temperatures, oxygen concentrations and varieties.
- Demonstrate to growers the progress to be achieved and teach them to use new equipment.

Transfer of knowledge and capacity development will be very important over the long-term. This training course is the first step in adopting the existing knowledge from the Netherlands and adapting it to the Jordan situation.

Annex 1 Full programme of the HGFI Hydroponic Training Course

Detailed programme

Date: January 24 – 29 2016

Venue: Wageningen UR Bleiswijk, Violierenweg 1 Bleiswijk

Date	Hour	Tutor	Topic
24 Jan.	Arrival Airport		
25 Jan.	09.00 – 10.30h	Erik van Os	Introduction, growing systems, water
	10.30 - 11.00		Coffee break
	11.00 – 12.30	Erik van Os	Greenhouse visit
	12.30 – 13.30		Lunch break
	13.30 – 15.00	Wim Voogt	Basics of plant nutrition
	15.00 - 15.30		Coffee break
	15.30 – 17.00	Wim Voogt	Fertilizers
26 Jan.	09.00 – 10.30h	Wim Voogt	Nutrient solution recipe and calculations
	10.30 - 11.00		Coffee break
	11.00 – 12.30	Wim Voogt, Chris Blok	Continuation
	12.30 – 13.30		Lunch break
	13.30 – 15.00	Chris Blok	Growing media and their properties
	15.00 - 15.30		Coffee break
	15.30 – 17.00	Chris Blok	Continuation
27 Jan.	09.00 – 10.30h	Geerten van der Lugt	Sampling, interpretation or analysing report, A&B container
	10.30 - 11.00		Coffee break
	11.00 – 12.30	Geerten van der Lugt	Continuation
	12.30 – 13.30		Lunch break
	13.30 – 15.00	Chris Blok	Feedback: what and how to control
	15.00 - 15.30		Coffee break
	15.30 – 17.00	Chris Blok	Continuation and measurement activities
28 Jan.	9.15 – 20.00	Erik van Os	Excursion and dinner
	9.15		Collection at hotel
	10.00	Gerben de Jong	Haket, Wateringen
	12.30 – 13.30		Lunch break
	14.00	Michiel Suurmond	Hortimax, Pijnacker
	17.00 – 20.00		Delft and dinner
29 Jan.	09.00 – 10.30h	Wim Voogt	Salinity
	10.30 - 11.00		Coffee break
	11.00 – 12.30	Wim Voogt	Salinity
	12.30 – 13.30		Lunch break
	13.30 – 15.00	Erik van Os, Chris Blok, Wim Voogt	Evaluation, other subjects, questions and discussion
	15.00 - 15.30		Coffee break
	15.30 – 17.00	Erik van Os, Chris Blok, Wim Voogt	Continuation and closure

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Annex 2 Presentations of the HGFI Hydroponic Training Course (on USB presented to participants)

The following were presented:

1. Erik van Os, growing systems and water quality
2. Chris Blok, rooting media
3. Chris Blok, hydroponic skills
4. Geerten van der Lugt, sampling and analysing
5. Wim Voogt, basic principles of plant nutrition
6. Wim Voogt, fertilizers and calculation of nutrient solution
7. Wim Voogt, EC, Na, Cl and water quality

Because of illness of Wim Voogt other teachers took over his presentations.

To explore
the potential
of nature to
improve the
quality of life



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Greenhouse Horticulture Report GTB-1400

Wageningen UR Greenhouse Horticulture initiates and stimulates innovations for a sustainable protected horticulture and a better quality of life. This is achieved by partnering with primary producers, the supply sector, plant breeding companies, the scientific community and governments in applied research.

The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 9,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach.