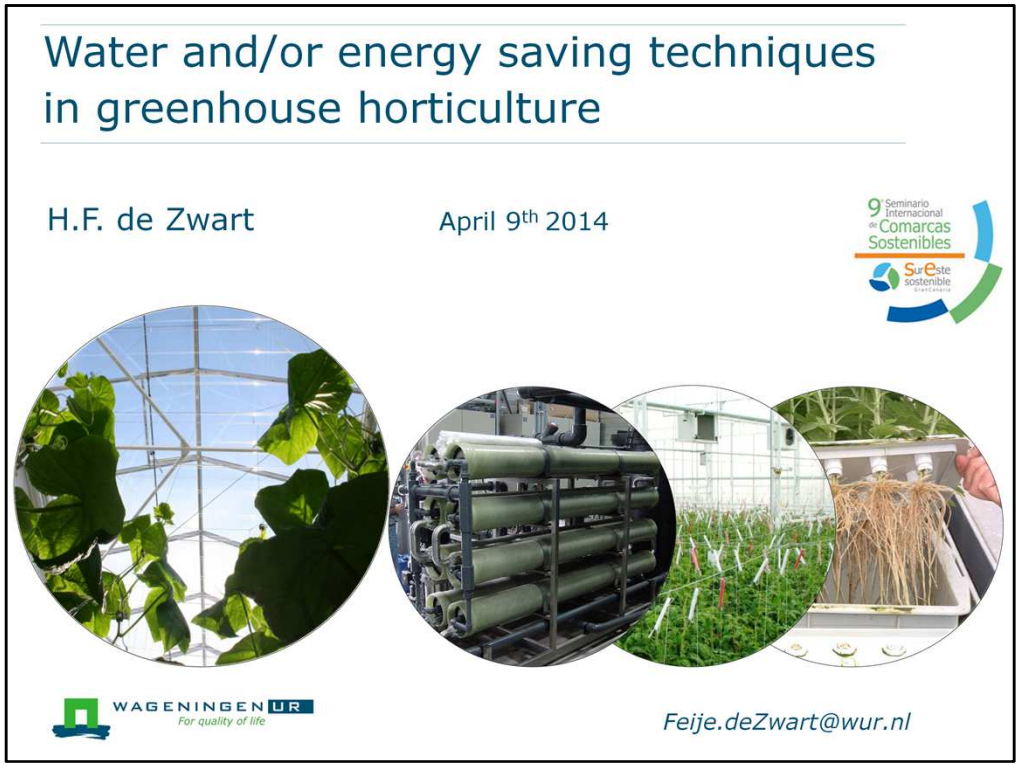

Good morning,

I am Feije de Zwart and this month I am working for 25 years on modelling and experiments in greenhouse horticulture. In the past, our research department was mainly focussed on the Netherlands, but in the last 10 years we are doing more and more research and consultancy in foreign countries as well.

Today I was asked to tell something about the developments in water and energy saving techniques.

Wageningen/Bleiswijk, The Netherlands

- 120 employees
- 1 ha of research facilities
- 2000 visitors per year

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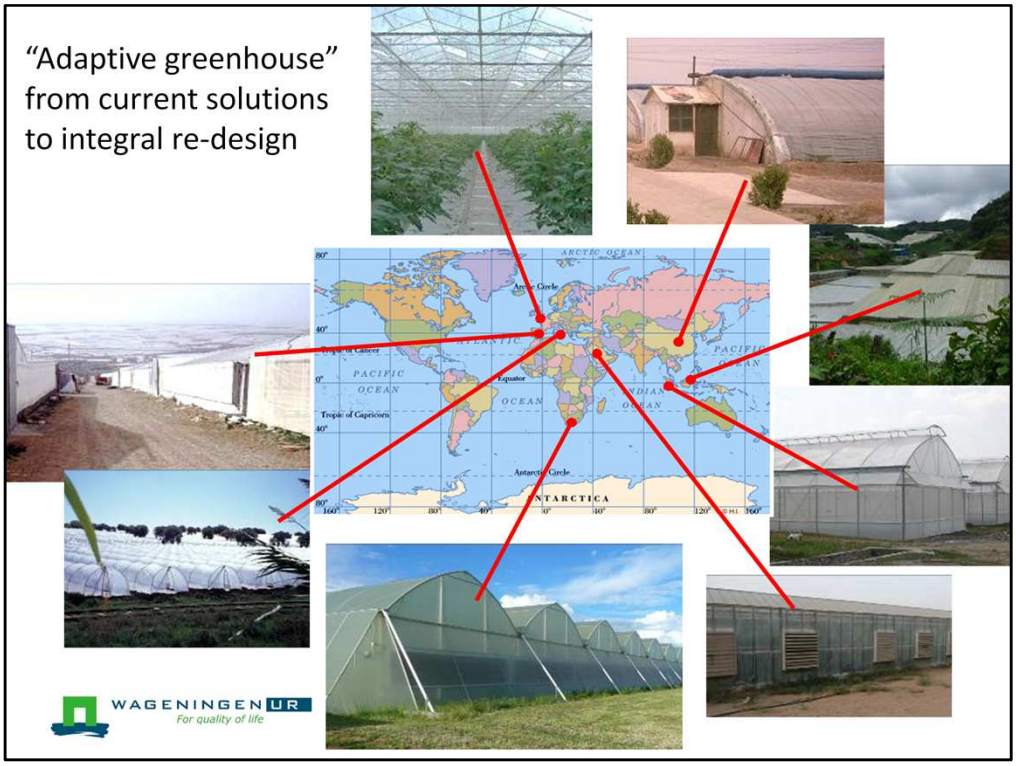
For quality of life

My research group is located in Wageningen and in Bleiswijk. Wageningen is the home city of the Wageningen Agricultural University and that's why the theoretical collegues are housed in Wageningen. Our other location is Bleiswijk and this is at the corner of the most important greenhouse area in the Netherlands, the Westland. Maybe this is even the most important greenhouse area of the world, since most modern greenhouse techniques have their origin in this area. For horticulture, the Westland is the same as silicon valley for computer industry.

The people working in Bleiswijk are working more close to the day to day practical horticulture. I divide my time about Wageningen and Bleiswijk, exactly because I always try to bridge between theory and practice.

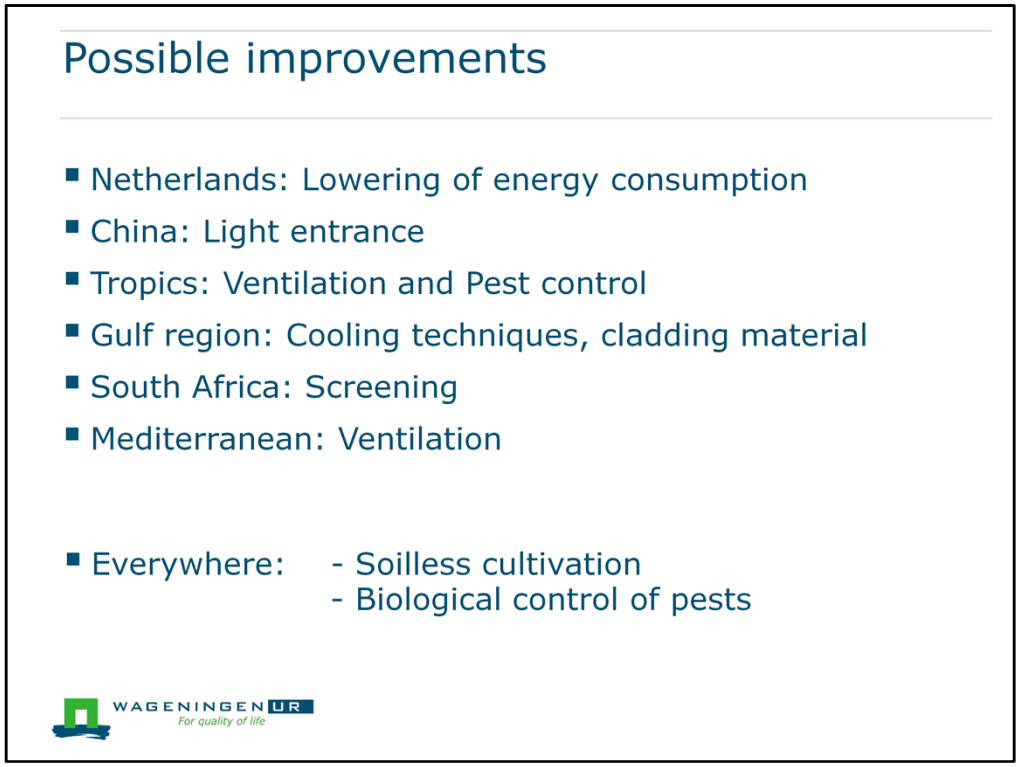
Dutch horticulture is known from its high quality and high efficiency and this is predominantly caused by the strong interaction between growers, research, policy makers and the public.
Every year we host some 2000 visitors with whom we share knowledge and views in order to stay on track.



The biggest challenge for horticulture is to adapt the techniques to local conditions.
For the Netherlands it has been shown that high tech suits the local conditions best. There a highly automated processes, just in time delivery and large greenhouse complexes are essential for a profitable business.

In other parts of the world, investments have to be smaller and therefore greenhouses have to cheaper, smaller and less complex. Low costs for labour lead to less automation.

Also the climatic conditions result in different focuses.



In the Netherlands we do a lot of work on new greenhouse systems that result on a lower energy consumption. Our cold winters require heating and supplementary lighting to achieve a year round production.
In China we advice and contribute to developments that increase the light entrance in greenhouses. Most people there are simply not aware enough of the benefits of a high light transmitting greenhouse, predominantly due to a lack of techniques to cope with the high radiation intensities in summer.
In the tropics the growing conditions are very good, unfortunately also for pests and diseases. Therefore netted greenhouses are important, but they should combine a good ventilation with a good protection to the heavy rain falls.
In the Gulf region we work on cooling, of course
In South Africa, focus is on greenhouses that preserve the daytime insolation of the winter days for the cold winter nights. Thermal screens help a lot with that.
In the mediterranean the ventilation characteristics are of major importance.

However, everywhere my collegues are working on enthomology, phytopatology and nutrition since there is a lot to learn and to achieve on the field of soilless cultivation and biological control of pests and diseases

And, worldwide there is a growing demand for fruits and vegetables since people are becomeing more and more aware of the health promoting quality of fruits and vegetables.

Issues in the Canary islands

- Demand for fresh products (local and export)
- Food safety
- Sustainability

fresh water consumption

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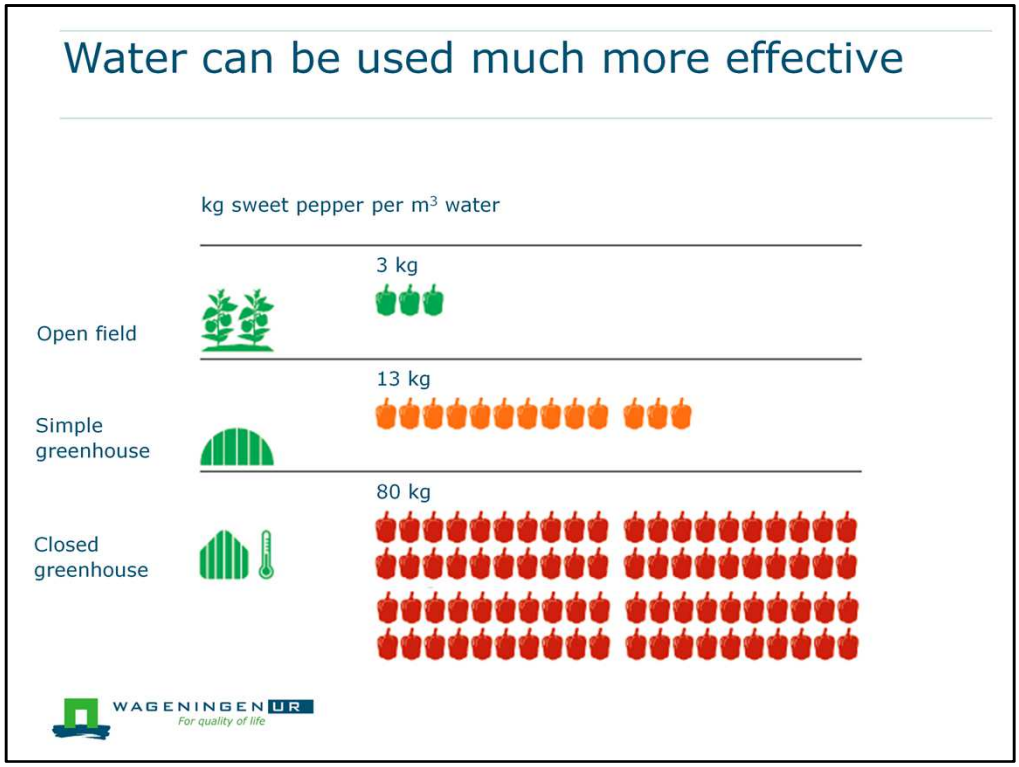
For the Canary Islands, horticulture is facing questions on the development of this growing market.
Of course Food safety and sustainability are big issues.

But, overhere, the fresh water consumption is the most important issue.



As can be seen in this slide, a simple greenhouse like the ones that you might have seen when you enter theIsland by airplane gives already a big improvement compared to open field production. The protected enviroment raises the production and loweres the evaporation, leading to an improved water use efficiency.

However, a far much higher water use efficiency can be reached when a crop is grown in an almost completely closed environment, known as the closed (or confined) greenhouse.

Closed greenhouse

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In a closed greenhouse cooling is performed by an air conditioning system. Allmost all the water evaporated by the plants is condensed on the cooling surface of the coolers. This is high quality fresh water, which can be used for the watering of the crop. In fact, water is recirculated over and over.
We, and also reasearchers of other institutes, have shown that these greenhouses are very productive and well manageable

Very water efficient but electricity consuming

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However, we do not see them everywhere around an that is predominantly because the cooling of the greenhouses requires a lot of electricity to make the cold water. For a closed greenhouse in the canaries this will be some 250 kWh/m^2 per year.
Also, since, the greenhouse has only a very limited air exchange with the outside, the inside CO_2-concentration tends to be very low. Therefore, the high production levels of 80 kg of product per m^3 of water can only be achieved when additinal CO_2 is supplied. This will take some 20 kg/m^2 greenhouse per year

What weighs most

Requirements for 1 kg of sweet pepper

- 12.5 liter water
- 6 kWh electricity
- 0.5 kg CO2
- 0.025 m2 greenhouse

- 80 liter water
- 0.5 kWh electricity
- 0.08 m2 greenhouse

→ 5.5 kWh and 0.5 kg CO_2 saves 67.5 liters of water

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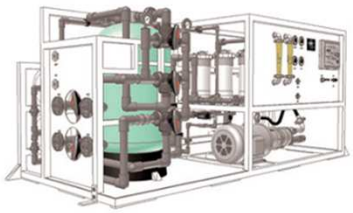
Rough figure: 1 kWh per 10 liters

With this figures sketch out the main characteristics in terms of input for both the greenhouse options.

This leads to a rough order-of-magnitude figure of 1 kWh of electricity needed for saving of 10 liters of water

Reverse Osmosis: 200 liter/kWh

Marine Reverse Osmosis Seawater Purification



model	m3 (h/d)	gpd	gph	hp	kw
T42463S	2 / 42	11000	458	40	30.53
T72463S	3 / 72	19000	792	40	30.53
T91463S	4 / 91	24000	1000	40	30.53
T114463S	5 / 114	30000	1250	40	30.53
T131463S	5 / 131	34500	1438	40	30.53
T146463S	6 / 146	38500	1604	40	30.53
T163463S	7 / 163	43000	1792	40	30.53

58 liter/ kWh

200 liter/ kWh

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A reverse osmosis device shows to provide some 200 liters of fresh water from a kWh of electricity

In Canaries:
High WUE = productive ordinary greenhouse

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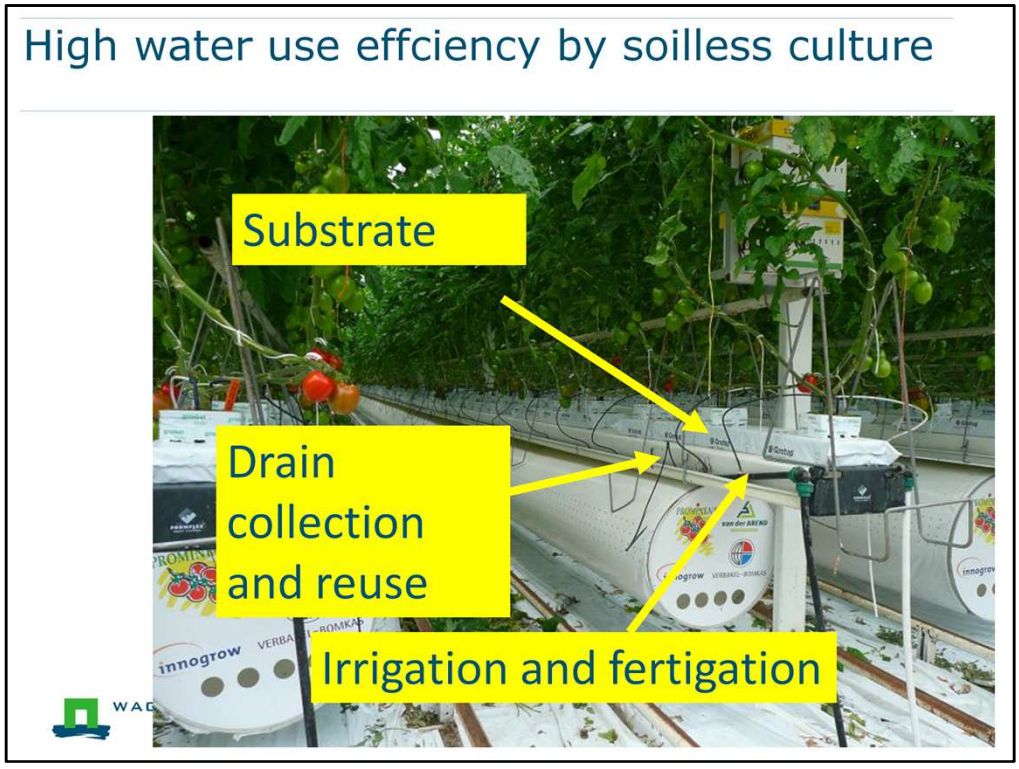
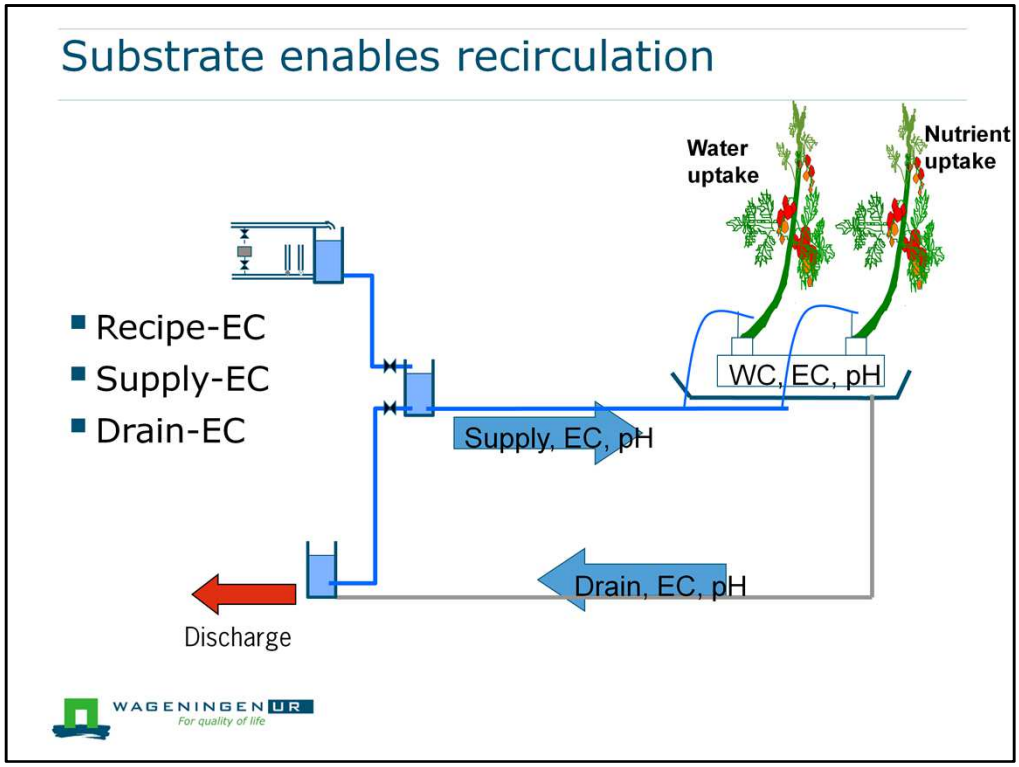
Therefore, I conclude that for a region like the Canaries, a closed greenhouse is very water efficient, but not energy efficient. Since sea water is nearby all around the island, it makes more sense to put electricity in desalination of sea water to water the plants and cool the greenhouse by evaporative cooling, than to put electricity into a closed greenhouse.



Then, still an improvement of water use efficiency can be achieved by switching to soilless culture.
A soilless substrate cultivation system enables to provide the crop the exact nutrition and water needed. In theory, no drain would run off from the substrate, but for certainty, just like in the soil bound drip irrigation, an about 30% over-irrigation is practice.
However, in a soilless cultivation system, this 30% extra water can be reused



In the development of horticultural skills, for most of the crops the optimal nutrient composition is known, even for the different growth stages of the crop. By watering the crop with the right composition, there is no accumulation of nutrients in the drain and there is no need for a discharge.
Of course this system is dependent on high quality supply water. Therefore, in the Netherlands, every greenhouse has it's rain water collection system. Here, in the canaries, it will have to be Reverse Osmosis-water.

Substrate to control water and nutrition

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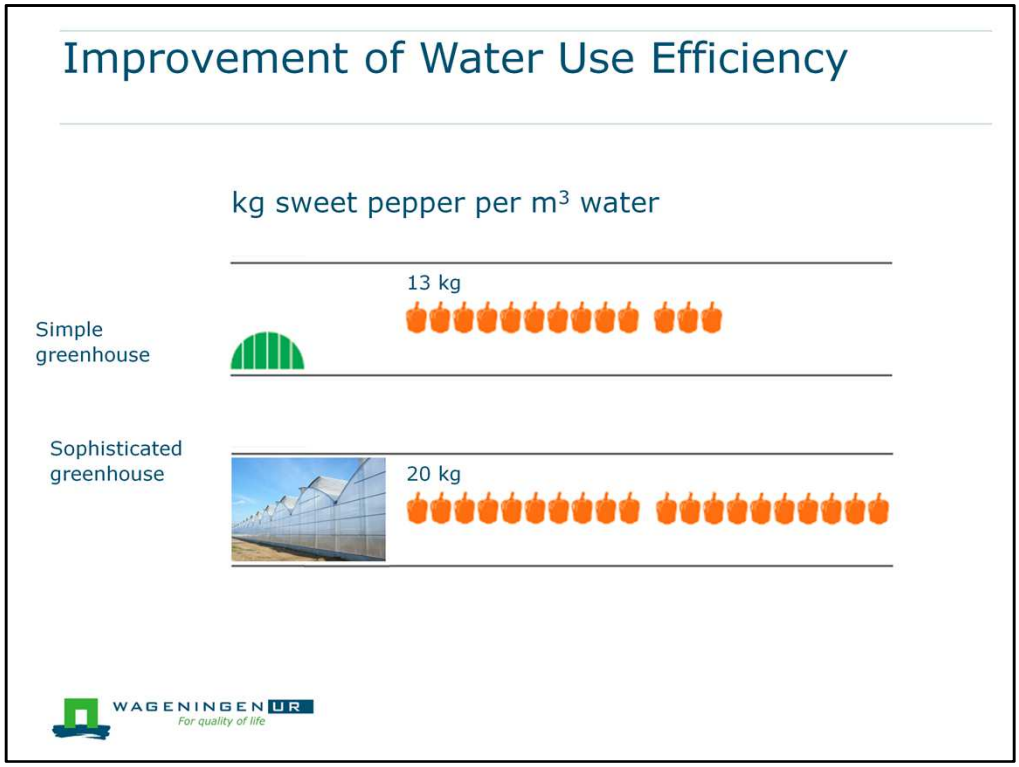
Simpeler systems for soilles culture may do as well.
The key quality parameters of a substrate are the particle size distribution the water retention characteristics and the air fraction after drainage.

For a large number of materials these qualities have been sorted out, meaning that all over the world different types of substrates are used, whichever is locally the most economic type to use.

My collegues have gathered a whole cupboard full of substrate samples.
All these types have their pro's and con's. Rockwool is the easiest substrate to use, but may be expensive. Also its disposal may be problem.
Organic alternatives, such as coco coir or peat work as well, but give variation between batches and over years and therefore need more skills to handle this variation.

You can even grow without any substrate at all, but this system has it's vulnerability as a disadvantage.



Anyhow,
I hope I haven't been to disappointing after my comments on the ultimate water saving greenhouse, which is the closed greenhouse.
Nevertheless, also in a sophisticated non closed greenhouse, I am sure large steps in the improvement of the water use efficiency by applying control on the air exchange rate, maximizing the entrance of light and, most of all, accurate tuning of fertigation stragegy.

Finally I want to thank you all for your attention and the organizing comittee for giving me the possibility to share our scientific views.