Productivity, Water and Energy Use Efficiency under Protected Agriculture in Marginal Environments

Cucumber cultivated in net-house consumes 25 percent of water as compared to greenhouse and saves 90 percent of energy. Under the UAE climate conditions, cucumbers can be cultivated in net-house nine months a year.

Thematic Area: Crop Productivity and Diversification

Purpose: Contribute to food security by cutting on water and energy consumption

Geographic Scope: UAE

Timeline: 2014 - 2017

Funding Agency:

- Ministry of Climate Change and Environment
- International Center Biosaline Agriculture (ICBA)

Partners:

- Ministry of Climate Change and Environment
- Food and Agriculture Organization (FAO)

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The Gulf Cooperation Council (GCC) countries are among the most water-scarce countries in the world. Scientists forecast that water scarcity will worsen due to climate change. As agriculture uses over 85 percent of the available freshwater resources, improving water management and water productivity in agricultural systems is a strategic priority for most GCC countries. Crops cultivated under protected agriculture can play a key role in ensuring water and food security. Greenhouse structures may vary from simple net-house to sophisticated glasshouse.

The GCC countries have around 14,000 ha under protected agriculture. In the United Arab Emirates (UAE), the number of greenhouses increased over the period of 2005 - 2011 by 48 percent, reaching 493 ha and contributing to the total production of vegetables to the tune of 147,000 tons in 2010.

Greenhouse production can help to achieve higher yields and quality. But it is important to study sustainability, water and energy use for different crops under different types of greenhouses.

As the GCC countries, including the UAE, are vulnerable to changing climate with a rise in temperature, droughts, growing salinity and water stress, it is necessary to come up with alternative solutions to increase agricultural production. With high dependence on international markets to feed growing populations, it is important to explore the potential of greenhouse and net-house technologies to achieve future food security.
In response to this issue, scientists at ICBA are developing greenhouse and net-house technologies suitable for the GCC region, which will help to reduce use of water and energy while increasing crop production quality and quantity.

Activities and Outcomes

Since 2014, ICBA has been operating hydroponic greenhouse and net-house facilities using technologically sophisticated and commercially proven horticultural techniques combined with unique energy-saving innovations.

The facilities include three greenhouses, two with a conventional pad and fan evaporative cooling system, and one with insect-proof net and a fogging system for cooling.

All three structures are supplied with desalinated water for irrigation which is automatically dosed with nutrients under the control of a commercial computerized system designed for this purpose. The cooled greenhouse consists of two adjoining but

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Mist and shading materials in net-house help to reduce air temperature by 6 degrees Celsius.

separately controlled compartments, while the non-cooled net-house is controlled as a single unit. The facilities will help to study different aspects, including crop productivity, energy and water balance, and the economics of production in a hot and humid arid climate such as the UAE.

Over the past years, scientists have run experiments on production of different crops and tested different substrates. During the months of April - August 2015 cherry tomato and sweet pepper were cultivated under greenhouse conditions and cucumber under net-house conditions. The research was mainly focused on water consumption patterns and crop productivity. In the greenhouse, water and energy consumption for the cooling system was 2.6 and 3.5 times higher than the required irrigation for sweet pepper and cherry tomato respectively. However, the mist system in the net-house consumed about 75 percent and 91 percent of the irrigation water used for cucumber and sweet pepper respectively. It was also found that greenhouse consumed 32 times more energy than the net house, allowing a saving of 97 percent of energy in the net house.

During the winter season (October 2015 - January 2016), two varieties of cucumber were cultivated under both greenhouse and net-house conditions using local and imported substrates. Obtained data indicates that greenhouse cooling consumed about 76 percent of the water used in irrigation while the mist system in the net-house consumed about 9 percent. The greenhouse consumed 49 times more energy and 1.5 times more water compared to the net-house. The scientists also tested several substrates, including imported (coco peat, perlite, peat) and local (sand). The results indicated that local substrates were more economically productive than imported substrates (perlite and coco peat).

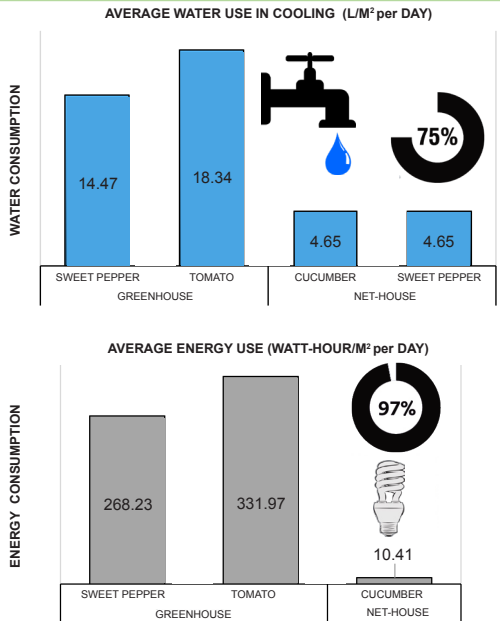
These results show that there is a need to improve energy and water use efficiency in protected agriculture in the GCC region. The economic analysis showed that cultivating cucumber under net-house conditions three cycles a year was more profitable than cherry tomato or sweet pepper under greenhouse conditions.

ICBA's research team is also carrying out experiments on a new generation greenhouse at the Agriculture Innovation Centre in Al Dhaid, Sharjah, the UAE. This research is conducted in collaboration with the Food and Agriculture Organization (FAO), the International Center for Agriculture in the Dry Areas (ICARDA), the Ministry of Climate Change and Environment of the UAE and the research group Watergy at Technical University of Berlin (TBU). This greenhouse can recycle water evaporated from plants by condensation and can help to save up to 90 percent of water and cut significantly on energy use.

Funded by the Ministry of Climate Change and Environment, the research initiative aims to promote key protected agriculture solutions adapted to desert conditions and boost protected agriculture in the UAE and GCC countries. The significant amount of water savings in this new generation greenhouse can have additional advantages such as: productivity is five times higher than that in the open; pest, diseases and weed control is considerably more effective than in the open; and zero pollution of groundwater compared with the open.

Future Directions

As climate change poses greater risks to arid and semi-arid regions like the GCC, there is a continuous need to research and invest in technologies and systems that are cost-effective and sustainable, and use less water and energy. ICBA scientists aim to work out solutions and policy options for the public- and private-sector decision-makers. Taking forward the current analysis from the field trials, scientists will continue to study water and energy consumption under greenhouse and net-house conditions. Research results will also help to develop a local low-cost substrate. The team also plans to test several varieties and species of berries under greenhouse conditions.



Encouraging results on tomato and sweet pepper grown under greenhouse and cucumber and sweet pepper grown under net-house conditions in field trials at ICBA in April-August 2015.