المـركـز الوطنـــي لأبحـاث وتطوير الزراعة المستدامة
NATIONAL RESEARCH AND DEVELOPMENT CENTER FOR SUSTAINABLE AGRICULTURE

WAGENINGEN
UNIVERSITY & RESEARCH

Evaluation of water saving technologies at Estidamah research center in Saudi Arabia

J.B. Campen, K. Al Assaf, A. Al Harbi, M.Y. Sharaf, F. de Zwart, W. Voogt, K. Scheffers, I. Tsafaras, O.M. Babiker and M. Qaryouti

Background

In countries like Saudi Arabia water is a scarce commodity as rain fall is minimal. Water used for agriculture is usually extracted from deep water resources . This resource is depleted by the extensive use and the quality of the water decreases during this process . Several growers stopped production due to poor water quality. Alternatively, sea water can be used by applying reverse osmosis . This method to produce fresh water is used more extensively specially for domestic use. A cubic meter of water can be produced at a cost of around 1.75 dollar with %70 of the costs resulting from energy consumption . Using treated wastewater for food production is not considered as an option in this region. This water is mainly used for irrigation of parks and forests .

Objective

The purpose of this paper is to evaluate different levels of greenhouse technology, viz., low, mid and high-tech in terms of water use, energy consumption and production.

Methods

The experiments were conducted at the Estidamah research center in Riyadh. Three different levels of technology are present: low-tech, mid-tech and high-tech. The low-tech is the greenhouse design commonly used in Saudi Arabia, being a single span polyethylene greenhouse with a pad and fan system. The area is 320 m^2) with 5 planting lines. Figure 1 shows a picture of the greenhouse. The control is more advanced compared to the conventional greenhouse since the fans are individually controlled allowing the ventilation capacity to be controlled in three stages. Three fans are inserted in low-tech, each fan has a capacity of 15000 $m^3.h^{-1}$ The pad wall is made from cardboard with a thickness of 15 cm.

Figure 1. Low-tech greenhouses (left) at Estidamah research center and the inside of a mid-tech compartment (middle) and High tech. (right).

The mid-tech greenhouse compartments with a glass cover have a size of 480 m^2 and 6 m height. The fans are frequency controlled allowing the ventilation capacity to be controlled. Per compartment 6 fans are placed with a capacity of 15000 m3 h1- each. The pad wall has a height of 3 m with a thickness of 15 cm and made from plastic. The cropping is done on gutters from where the drain can be collected to be reused. In total seven mid-tech compartments are present at Estidamah (Figure 1).

The high-tech greenhouse compartments with a glass cover have a size of 400 m^2 and 6 m height. The climate control in this type of greenhouse is done by air conditioning. Heat exchangers are placed near the cover of the greenhouse to provide the cooling. Conditioned air is also distributed by air ducts placed on the growing gutter. The energy consumption for cooling for both systems is recorded by measuring the cold-water supply flow and temperature difference over the heat exchanger. The condense from the heat exchangers is collected and measured before reused by the fertigation unit. The glass roof of both the mid and high-tech compartments is regularly cleaned by a roof washer. There is no ventilation with the outside air in the high-tech greenhouse compartments.

Results

The water use for irrigation is provided for all levels of technology, the water use by the pad wall for the evaporative cooling only for the low and mid technology. The drain which is collected in the mid and high technology can be reused so it can be subtracted from the water use. The condense coming from the cooling system in the high-tech can also be reused so it is also subtracted from the water use. For those months that low-tech did not operate, the water use was stimulated according to known similar greenhouses. Clearly the water use is higher in the summer months.

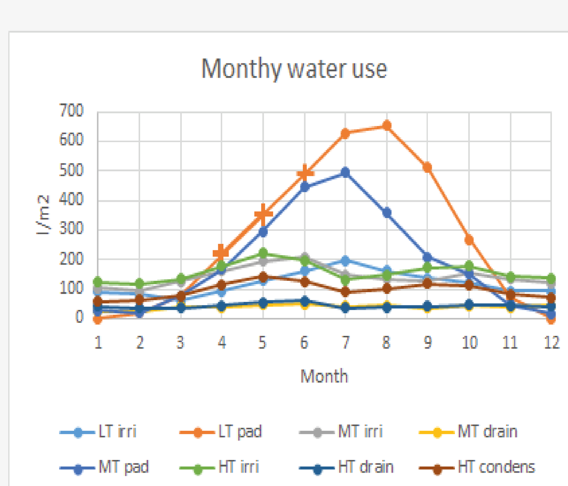

Figure 2. Monthly water uses for irrigation (irri), (pad) water and return water flows from drain and condense for the different types of technology. LT: low-tech, MT: mid-tech, HT: high-tech.

Table 2. Climatic conditions, temperature in °C, relative humidity in %, and solar radiation in MJ day1-, over the year in Riyadh based on 2018 weather data collected at Estidamah.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. temp.	28.8	34	36.7	36.9	40.8	43.8	43.9	42.5	43.9	37.9	31.5	27.8
Min. temp.	6.8	8.6	14.9	18.3	24.1	29.0	30.6	30.2	27.8	16.3	13.8	10.8
Av. temp.	17	20.4	25.7	26.5	32.5	37.1	37.6	36.8	36.5	29.7	21.4	18.6
Max. RH	89	83	84	89	45	28	20	23	34	92	97	93
Max. RH	5	5	3	7	4	4	3	5	4	6	11	18
Av. RH	30	26	20	31.4	15	9	8	10	11	27	55	48
Solar rad.	16.8	17.5	22.9	21.4	24.6	26.9	26.6	26.1	23.4	18.6	14.4	15.0

Table 3. Annual water use for the different levels of technology in $L.m^{-2}$

Low-tech		Mid-tech			High-tech		
Irrigation	Pad	Irrigation	Drain	Pad	Irrigation	Drain	Condense
1498	3192	1712	-479	2299	1889	-523	-1167
4690		**3531**			**198**		

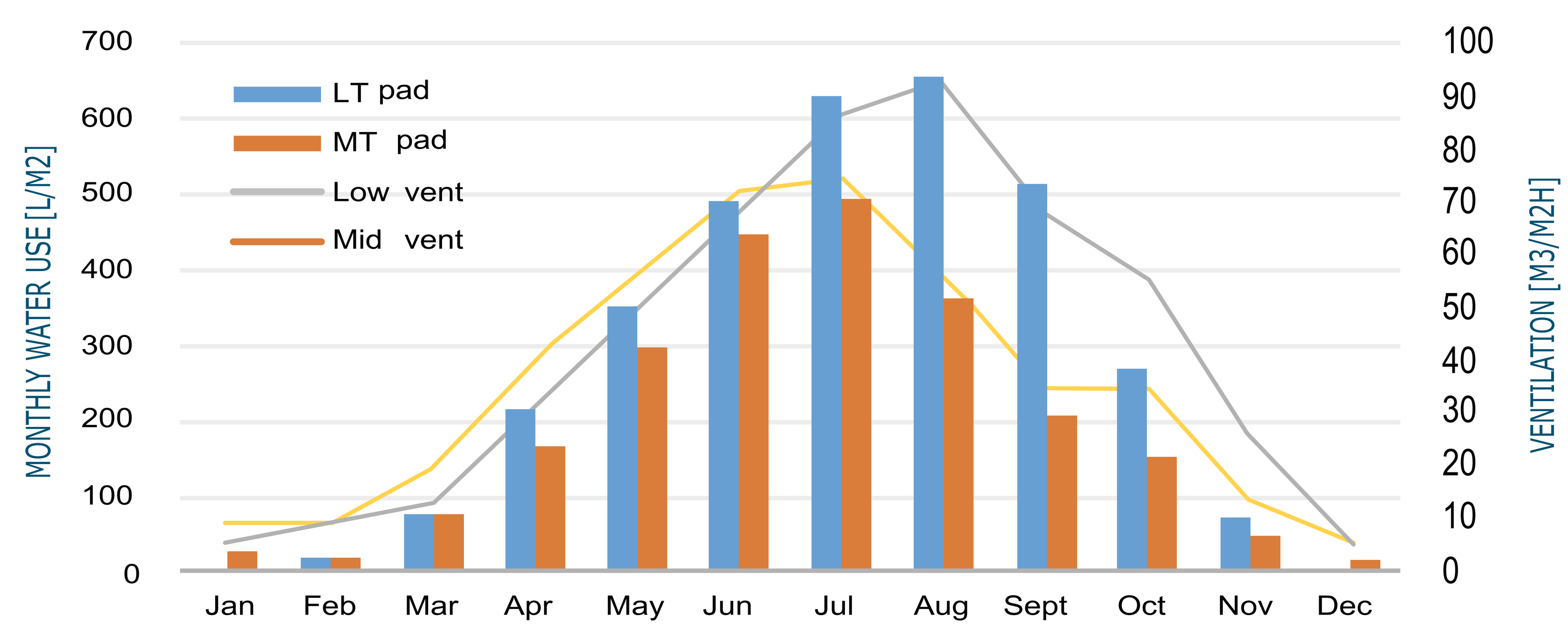

Figure 3. Monthly water use and ventilation for every month of the year for low and mid tech.

Discussion

The lower water use by the pad wall in the mid-tech can be explained partly by the placement of the fans. As can be seen in Figure 1, the fans in the mid-tech greenhouse are placed far above the crop, where in the low tech the fans are placed relatively at the top of the canopy. The placement of the fans determines the temperature profile in the greenhouse.

The temperature profile in Med-tech greenhouse. As a result, only the warm air in the greenhouse is extracted while, when the fans are placed lower, the cooler air is also extracted from the greenhouse. This results in a higher ventilation since more air needs to be exchanged in order to obtain the same cooling . This results in a higher ventilation since more air needs to be exchanged in order to obtain the same cooling as indicated by the equation below (Sase, 2006). The water consumption by the pad wall is directly related to the ventilation as was shown before, so it will also increase.

$$PP\ \text{cooling} = \Phi\ \text{ventilation}\ (TT\ \text{out} - TT\ \text{in})$$

Conclusion

Evaporative cooling is a very effective method for greenhouse climate control in arid regions. Unfortunately, water is usually scarce in these regions. The research at Estidamah shows that by proper designing of the greenhouses, the water use efficiency can be increased compared to the traditional design by reducing the water use and at the same time increasing the production. Since the mid-tech greenhouses are more transparent compared to the low-tech plastic greenhouses production levels are higher.

Wageningen University & Research
BU Greenhouse Horticulture & Flower Bulbs
P.O. Box 6700 ,123 AB Wageningen
Contact: ilias.tsafaras@wur.nl
T + 31 (0)317 48 89 10, M +31 (0)6 24 92 17 55
www.wur.nl/

National Research And Development Center For Sustainable Agriculture (Estidamah)
Riyadh Techno Valley, King Saud University, Riyadh
12373, Saudi Arabia
Contact: info@estidamah.gov.sa
https://estidamah.gov.sa