TEL AVIV UNIVERSITY אוניברסיטת תל אביב

**Aug-18**

# Validation report on EcoAeon Israel vortex-ceramic balls hybrid (VCB) technology

## Introduction

A novel water treatment approach using a physical vortex-ceramic balls hybrid (VCB) technology to impact water flow dynamics, improve water quality, reduce water usage and increase food crop productivity will be examined and validated for reverse osmosis concentrate. This method does not involve use of any chemicals. The VCB system will be integrated to existing water systems, where the water passes through the vortex and then through the ceramic balls, and is further used to irrigate the crops and improve their yield and food quality.

Over fifty mineral matters make up each CB. Heated in Temperature beyond 3500 DF each CB become extremely durable and possess active energy properties. CB can activate and ionize water and generate FIR also have anti-bacterial properties Figure 1 illustrates the VCB hybrid structure.

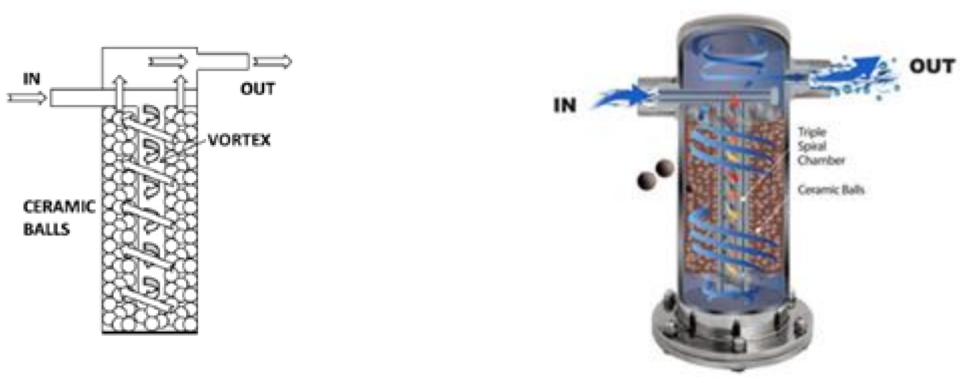


Figure 1: VCB hybrid structure

Ceramic chemistry, are viewed as composed of oxides as $SiO_2$, $Al_2O_3$, ZnO, and $Fe_2O_3$. Ceramic mineral aggregates may contain metals such as Fe and Cu that may impose a germicidal effect. Miranda-Ríos et al., (2011) showed that these mineral oxides can be used as a natural alternative for improving disinfection by inactivating *E. coli*. Ceramic materials hold visible and infrared radiative properties in the wavelength range 0.35–2 μm (Ganesan et al., 2013). Recent studies showed that far-infrared rays emitted from ceramic material can be used for pain control (Leung et al., 2013). In this study, it is hypothesized that when the ceramic balls are immersed in water, the ceramics create changes in the property of water, by "activating" the water, therefore reducing scale, red-rust formation and its reoccurrence, disinfecting the water and controlling biofilm formation as well. The second effect occurs by the vortex motion of the water. Malenkov et al., (2012) studied the collective effects in water and revealed correlations in molecular motions related the existence of extended clusters, whose molecules are linked by long-living hydrogen bonds. The water cluster theory gives a reasonable explanation for many of the anomalous properties of water (Loboda and Goncharuk, 2010). It is hypothesized that the vortex motion in water impacts water clustering and its properties. Due to the spinning motion of the water flow within the vortex, this action can inactivate bacteria in water, oxygenate the water and in the long-run may impact lime scale in water pipes. The vortex aerates the water and creates a centrifugal force, causing the water to pull away from the center axis and possibly undergo a redox (oxidation-reduction) reaction for ammonia, Fe and Mn oxidation. Whereas, Ceramic balls nestled in the VCB may replicate a natural bed rock formation, emit far infrared rays (FIR), increase surface activity and serve as a catalyst, with strong disinfection properties.

High production yield and quality depend on appropriate development of the plant. Plant development highly depends on water and nutrient availability to the plant's root. To enhance the yield (in terms of quantity and quality) it is crucial to supply water and nutrients to the plant in the most effective way. Studies showed that excessive quantities of soluble salts accumulate in the root zone and results in crop difficulty in extracting water from the salty soil solution. Bhattarai et al. (2006) examined root aeration on yield and water use efficiency of tomato in saline soils. Irrigation with aerated water (12%) stimulated above-ground growth, enhanced the reproductive performance through earliness of flowering and fruiting compared with control.

The hypothesis is that irrigation of crops with the hybrid technology by a hybrid VCB will attain the following: (1) stimulate above-ground growth and enhance the performance and yield of the tomatoes, (2) aeration of water with high salinity levels will increase plant water use and water use efficiency and (3) increase plant water use and water use efficiency.

Field on-site testing

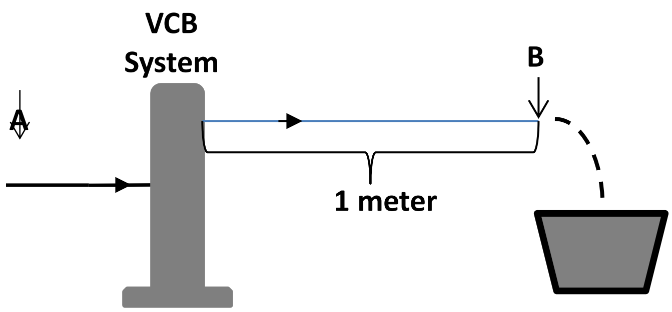


Figure 2: Schematic representation of the field on-site testing

On-site testing of the VCB apparatus in Israel showed the following case-study results:

**Case study 1: At Moshav Ein Yahav, Arava, Israel**

The village Ein yahav is the first village in the Arava center, established in 1959. Ein yahav grow mostly agriculture crop as sweet pepper, bell pepper, chilli peper, tomatoes, melons, water melon, cucumber, grape, date and some other vegetables. They grow in green house, net house and outdoor field.

**The current farmer, is one of the first farms in Ein Yahav that grow beef tomatoes using VBC (SEM 3000 water activator).**

Saline water from Moshav Ein Yahav, Arava, Israel that feeds the on-site VCB pilot system at Ein Yahav was withdrawn before and after the VCB, at a flow rate of 20L/min at points A and B according to figure 3, and immediately analyzed. Water quality parameters were examined before and after the VCB at points A and B according to figure 3.

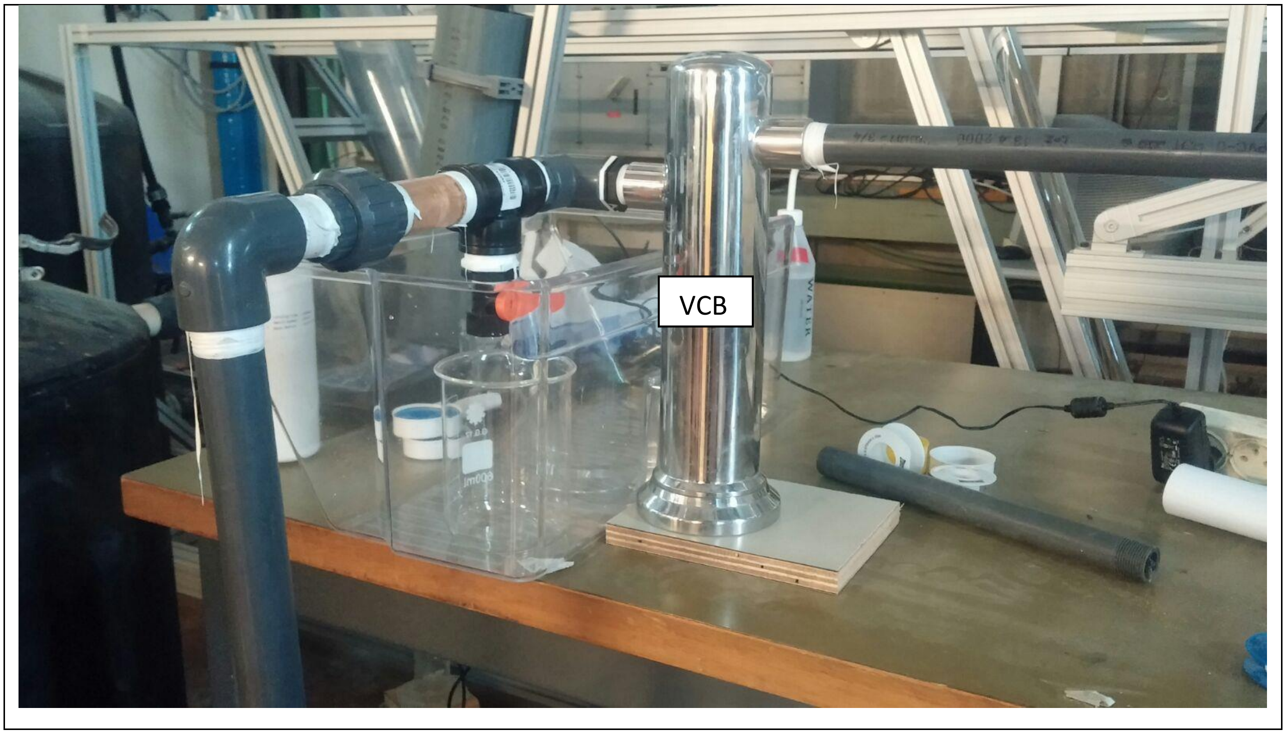


Figure 3: Photo images of the VCB

**Table 1 – Various water quality parameters at the lab before and after sampling water from the lab-scale VCB treatment**

| Parameter | Units | A (Inlet) | | | B (Outlet) | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 |
| **Nitrite** | mg/L | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| **Kjeldahl Nitrogen** | mg/L | 7 | 5.5 | 2.6 | <1 | 1.9 | 1.5 |
| **$NH_3$-N** | mg/L | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| **Alkalinity** | mg/L as $CaCO_3$ | 177 | 182 | 179 | 177 | 178 | 179 |
| **Hardness** | mg/L as $CaCO_3$ | 1240 | 1310 | | 1305 | 1307 | |
| **TSS 105$^0$C** | mg/L | <1 | <1 | <1 | <1 | <1 | 1 |
| **TDS 180$^0$C** | mg/L | 2465 | 2455 | 2460 | 2490 | 2285 | 1970 |
| **TOC** | mg/L as C | 0.7 | | | 0.6 | | |
| **Ion Chromatograph** | | | | | | | |
| **$Cl^-$** | mg/L | 538 | 546 | 536 | 530 | 526 | 524 |
| **$SO_4^{-2}$** | mg/L | 731 | 710 | 712 | 713 | 705 | 720 |
| **$NO_3^-$** | mg/L | 67 | 70 | 69 | 91 | 65 | 65 |
| **$PO_4^{-3}$** | mg/L | <1.5 | <1.5 | <1.5 | <1.5 | <1.5 | <1.5 |
| **ICP** | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Ag** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Al** | mg/L | 0.05 | 0.05 | 0.05 | 0.1 |
| **As** | mg/L | <0.02 | <0.02 | <0.02 | <0.02 |
| **B** | mg/L | 0.4 | 0.4 | 0.5 | 0.4 |
| **Ba** | mg/L | 0.02 | 0.02 | 0.02 | 0.02 |
| **Be** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Ca** | mg/L | 278 | 296 | 294 | 296 |
| **Cd** | mg/L | <0.005 | <0.005 | <0.005 | <0.005 |
| **Co** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Cr** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Cu** | mg/L | 0.01 | <0.01 | 0.01 | 0.01 |
| **Fe** | mg/L | <0.01 | <0.01 | 0.01 | <0.01 |
| **K** | mg/L | 16 | 16 | 16 | 16 |
| **Li** | mg/L | 0.04 | 0.04 | 0.04 | 0.04 |
| **Mg** | mg/L | 133 | 139 | 139 | 139 |
| **Mn** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Mo** | mg/L | 0.01 | 0.01 | 0.01 | 0.01 |
| **Na** | mg/L | 259 | 264 | 264 | 265 |
| **Ni** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **P** | mg/L | <0.1 | <0.1 | <0.1 | <0.1 |
| **Pb** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **S** | mg/L | 267 | 288 | 289 | 288 |
| **Se** | mg/L | 0.02 | 0.02 | <0.01 | <0.01 |
| **Sn** | mg/L | <0.05 | <0.05 | <0.05 | <0.05 |
| **Sr** | mg/L | 9 | 9 | 9 | 9 |
| **Ti** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **V** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| **Zn** | mg/L | 0.02 | 0.01 | 0.02 | 0.05 |

**Table 2 – Various water quality parameters before and after the lab-scale VCB treatment**

| **Analysis** | **Units** | **Inlet-A** | | **Outlet-B** | |
|---|---|---|---|---|---|
| | | 1 | 2 | 1 | 2 |
| **pH-25 $^0$C** | | 7.15 | 7.19 | 7.14 | 7.21 |
| **Conductivity** | mS/cm | 3.14 | 3.12 | 3.11 | 3.1 |
| | T$^0$C | 24.7 | 24.3 | 24.7 | 23.8 |
| **UVT** | % | 94.75 | 97.37 | 97.75 | 97.91 |
| **Turbidity** | NTU | 1.64<br>1.68 | 0.51 | 0.67 | 0.38 |

## FIELD EXPERIMENTS

Experiments were held at the Arava International Center for Agriculture. In the Arava region, the irrigation method is critical for the success in crop production. This region is not connected to the national Israeli water system and water is supplied via local drilling. On-site farm testing is the ultimate test for the farmers as it provides the necessary information for the best option of irrigation for the next season. Experiments were conducted during 2013-2014 and 2014-2105 by comparing two systems of irrigation on both tomato yield and quality, using beef tomato.

The irrigation systems chosen were the regular method (control experiment) and the VCB water activation system, while the other conditions remained the same. Experiments were conducted in green house at the field of Moshav Ein Yahav, Arava, Israel. The water flow rate through the VCB was:

The experiments were conducted in 2 fields:

- Field 1 used regular drip irrigation system whereas
- Field 2 used hybrid VCB water activator

Greenhouse dimensions were 6 dunam, 6 meters height, 120 meters long, 50 meters wide, each field comprises 40 plants in 2 rows, space between the rows is 1.2 m and between plants is 0.5 m. Parameters examined were the weight of the fruits measured one by one using a digital balance in gram unit and quality of tomato as examined by naked eye. A good yield quality refers to beef tomatoes with a minimal diameter of 72 mm exhibiting no defect or shape distortion.

**After the experiment has completed, results showed the following:**

During 2013-2014: On the same area, beef tomato using hybrid VCB water activator had a higher yield by 12% than beef tomato using regular irrigation and in addition, fruit quality using VCB was better than regular irrigation. This was an experiment on a new type of tomato without any prior knowledge on amount of water for irrigation and irrigation type.

During 2014-2015: the total yield of tomatoes for the hybrid VCB water activation system (9.54 tons/Dunam) was higher than the regular method (8.87 tons/Dunam), by 7.55%. Results so far show an average increase of about 10% in the yield of beef tomato using hybrid VCB system.

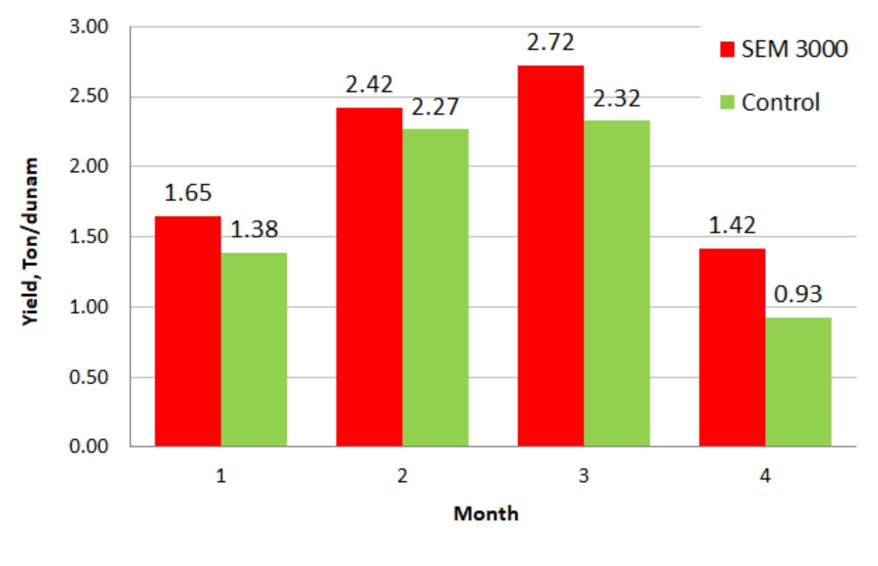


Figure 4: Yield per month

Water Quality:

| 5.9.16-aminolab-Laboratory results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Units** | **Entrance-A** | | | | **Exit-B** | | | |
| | | **1** | **3** | **5** | | **2** | **4** | **6** | |
| Nitrite | mg/L | | | | | <.5 | | | <.5 |
| Kjeldahl Nitrogen | mg/L | | 9.2 | 4.5 | 4.5 | | 4.2 | 4.5 | 4.5 |
| NH3-N | mg/L | | | | | | | | |
| Alkalinity | mg/L as $CaCO_3$ | | | | | | | | |
| Hardness | mg/L as $CaCO_3$ | | | 1066 | | | | 1041 | |
| TSS $105^0$ C | mg/L | | | | | | | | |
| TDS $180^0$ C | mg/L | | | | | | | | |
| TOC | mg/L as C | | | | | | | | |
| Ion Chromatograph | | | | | | | | | |
| $Cl^-$ | mg/L | | | 525 | | | | 520 | |
| $SO_4^{-2}$ | mg/L | | | 634 | | | | 630 | |
| $NO_3^-$ | mg/L | | | 36.5 | | | | 36 | |
| $PO_4^{-3}$ | mg/L | | | <1 | | | | <1 | |
| ICP | | | | | | | | | |
| Ag | mg/L | | | <0.01 | | | | <0.01 | |
| Al | mg/L | | | <=0.05 | | | | <=0.05 | |
| As | mg/L | | | <0.02 | | | | <0.02 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| B | mg/L | | | 0.4 | | | | 0.4 | |
| Ba | mg/L | | | 0.03 | | | | 0.03 | |
| Be | mg/L | | | <0.01 | | | | <0.01 | |
| Ca | mg/L | | | 236 | | | | 231 | |
| Cd | mg/L | | | <0.005 | | | | <0.005 | |
| Co | mg/L | | | <0.01 | | | | <0.01 | |
| Cr | mg/L | | | <0.01 | | | | <0.01 | |
| Cu | mg/L | | | <0.01 | | | | 0.01 | |
| Fe | mg/L | | | 0.01 | | | | 0.02 | |
| K | mg/L | | | 17 | | | | 17 | |
| Li | mg/L | | | 0.1 | | | | 0.1 | |
| Mg | mg/L | | | 116 | | | | 113 | |
| Mn | mg/L | | | 0.01 | | | | 0.01 | |
| Mo | mg/L | | | <0.01 | | | | 0.01 | |
| Na | mg/L | | | 260 | | | | 254 | |
| Ni | mg/L | | | <0.01 | | | | <0.01 | |
| P | mg/L | | | <0.1 | | | | <0.1 | |
| Pb | mg/L | | | <0.01 | | | | <0.01 | |
| S | mg/L | | | 220 | | | | 210 | |
| Sb | mg/L | | | <0.05 | | | | <0.05 | |
| Se | mg/L | | | <0.01 | | | | <0.01 | |
| Si | mg/L | | | 9 | | | | 9 | |
| Sn | mg/L | | | <0.05 | | | | <0.05 | |
| Sr | mg/L | | | 8 | | | | 7 | |
| Ti | mg/L | | | <0.01 | | | | <0.01 | |
| V | mg/L | | | <0.01 | | | | 0.01 | |
| Zn | mg/L | | | 0.02 | | | | 0.01 | |

| On Site-5.9.16 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Analysis | | Units | Entrance-A | | | Exit-B | | |
| | | | 1 | 3 | 5 | 2 | 4 | 6 |
| pH-25 $^{0}$ C | | pH | 7.25 | 7.23 | | 7.29 | 7.29 | |
| ORP | | mv | | 233 | 227 | | 229 | 242.1 |
| DO | | mg/L | | 4.04 | 3.97 | | 4.53 | 4.52 |
| | | T °C | | | | | | |
| Conductivity | | µs/cm | | 2.96 | 2.97 | | 3.12 | 3.12 |
| | | T °C | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| UVT | | % | 94.75 | | 97.37 | 97.75 | | 97.91 |
| Turbidity | | NTU | | 9.7 | 9.55 | | | 9.62 |
| $NO_3$-N | | mg/L | | | | | | |
| $NO_3^-$ | | mg/L | | | | | | |

**Ministry of Agriculture, R&D center in the Arava, 2017**

Ministry of Agriculture, R&D center in the Arava. Experiment was conducted by the ministry of agriculture. The control and SEM experiment were a dunam each. Results showed approximately 10% increase in the various parameters as below (Fig. 5 & 6). The fertilizer was added through the system in comparison to other 2016-2017 data where the fertilizer did not pass through the system and higher yields were obtained. The experiment took place about 3 months and numerous parameters were examined.

**Cucumbers:**

| | Control | SEM | % increase |
|---|---|---|---|
| **High quality for export, total kg** | **424.76** | **463.865** | 9.206375 |
| **Total weight of cucumbers** | **493.005** | **544.145** | 10.37312 |
| **Number of cucumbers** | **3468** | **3758** | 8.362168 |

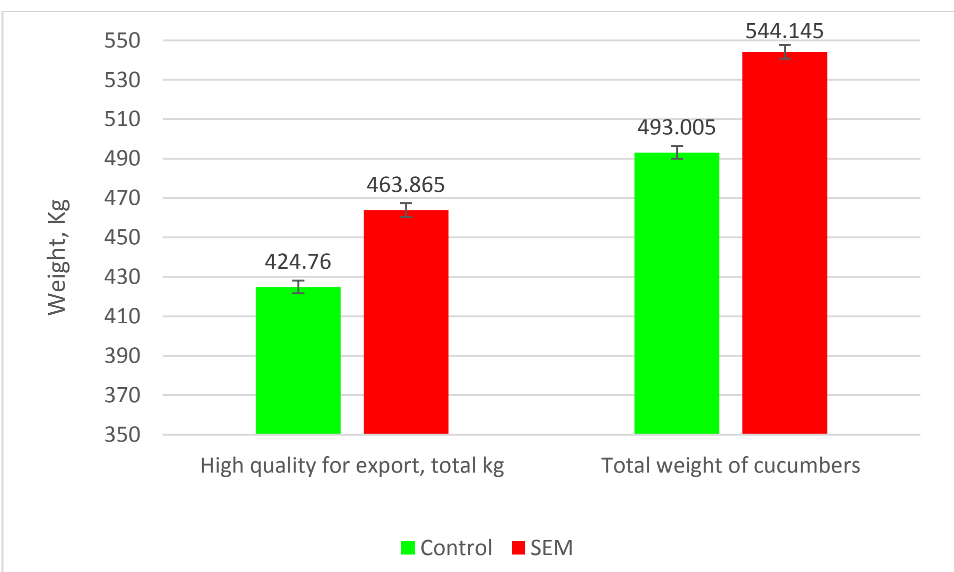


Fig 5: Total weight of cucumbers and high-quality cucumbers for export, control vs. SEM

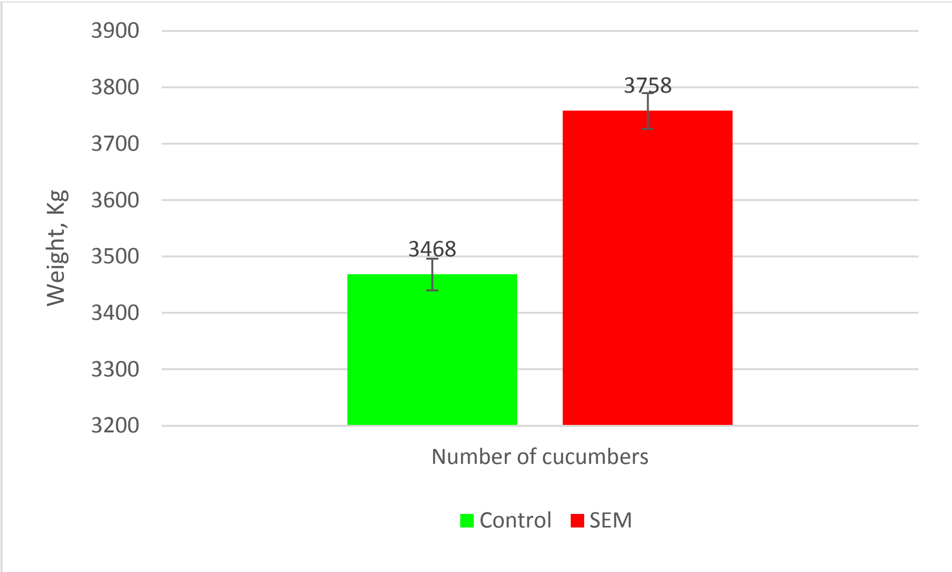


Fig. 6: Number of cucumbers, control vs. SEM

**Case study 2: Shaki Farm, Achituve, Israel**

Experiments were conducted in a 2000 m$^2$ polyethylene greenhouse situated on the Emek Hefer region, Shaki Farm, Achituve, Israel. Plants were grown under natural light conditions. The greenhouse was maintained at daily temperatures between 18 and 33°C, and day/night relative humidity of 85%. Seeds of “beit-alpha” type were grown in pots in another greenhouse located elsewhere and irrigated either with feed water termed “control seeds” or irrigated with hybrid VCB treated water and termed “VCB treated water seeds”. Pots were disposed in 16 rows for each treatment on the greenhouse floor. The space between plants within a row was 0.4 m and the distance between the centers of double rows was 1.5 m, resulting in a plant density of 3.8 plants m$^2$. These plants were transplanted in the greenhouse at Achituve when they reached a stage of four open leaves. The experiment was designed as follows: control plants transplanted in the “control site” and irrigated with feed water, whereas VCB treated water plants transplanted to the “treated site”, were irrigated with VCB treated water. Fruits were harvested on May 2013. **The total marketable number of normalized fruit weight per plant is 2.34 kg/plant for the control site and 2.9 kg/plant for the hybrid VCB treated site.** Thus, the yield of the test site was **24%** above the yield of the control site (Fig. 7 and 8). Moreover, the shelf life of the VCB treated fruits was longer than the untreated ones (control) (Fig. 9)

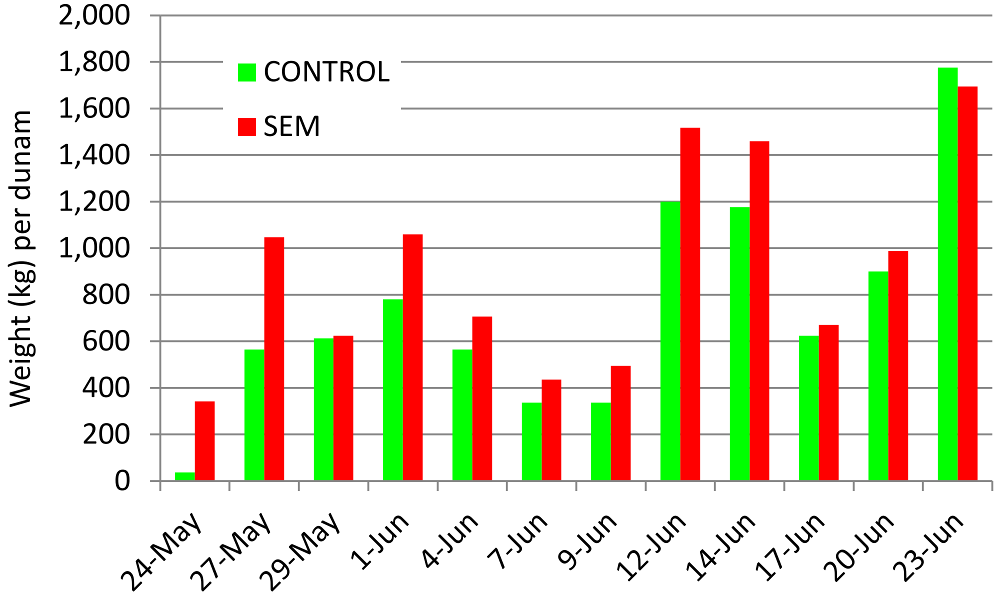


Fig. 7: Weight (kg) per dunam, control vs. SEM

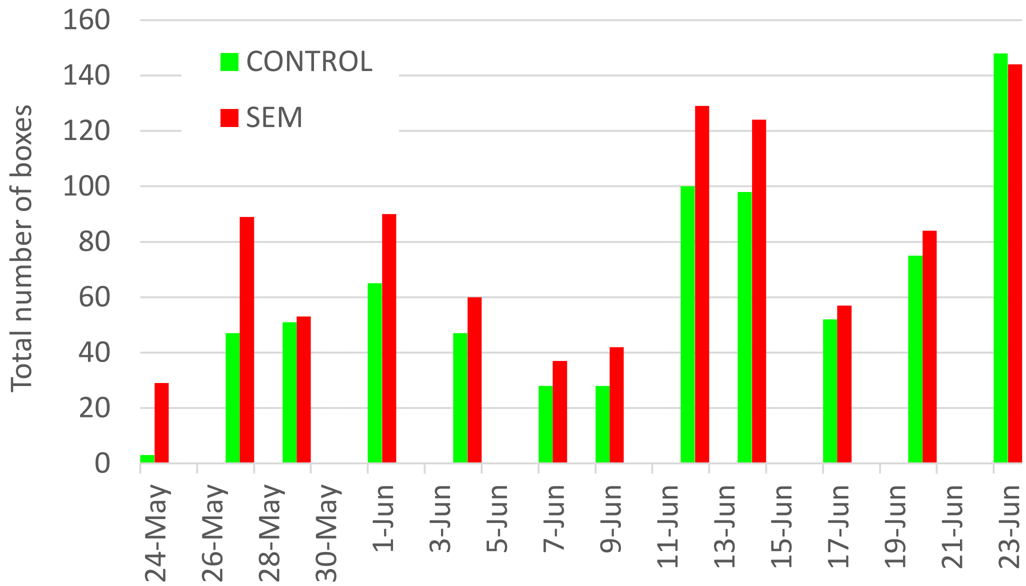


Fig. 8: Total number of boxes, control vs. SEM

Figure 9: Three weeks after transplanting, one and three weeks after post-harvest, control (right) and VCB treated water (left).

The following actions are expected:

- Improve food security and reduce water usage by increasing agriculture yield.
- The results obtained will provide the most needed knowledge for the successful implementation in food crops, currently on-going worldwide and in Israel.

**Case study 3: Bangalore Site, India 2018**

Seed name: HYBRID CHITRA.

Germinated (min) 60%, Physical Purity (Min) 98%, Genetic Purity (Min): 99%, Moisture (Max) 6%. Initially Ground was prepared with local manure. Soil Preparation: enriched with biofungicide, nimatiside with good amount of FYM neem cake and vermicompost. To avoid soil borne disease the seeds were treated before sowing at the source. Fertilizers: sprayed using bio pesticides and insecticide, mixing neem and pongamia soap, from 2nd day onwards weekly twice.

| Parameter: | **Control** | **VCB** |
|---|---|---|
| Number rows | 26 | 26 |
| The space between plants within a row | 35cm | 35cm |
| Distance between the centers of any two rows | 3' | 3' |
| Plant density = number of plants per m2 | 6 | 6 |
| Number of plant in total | 1285 | 1207 |

NOTE: Open area project test. Area: Test: 1000 $m^2$, control: 1000 $m^2$

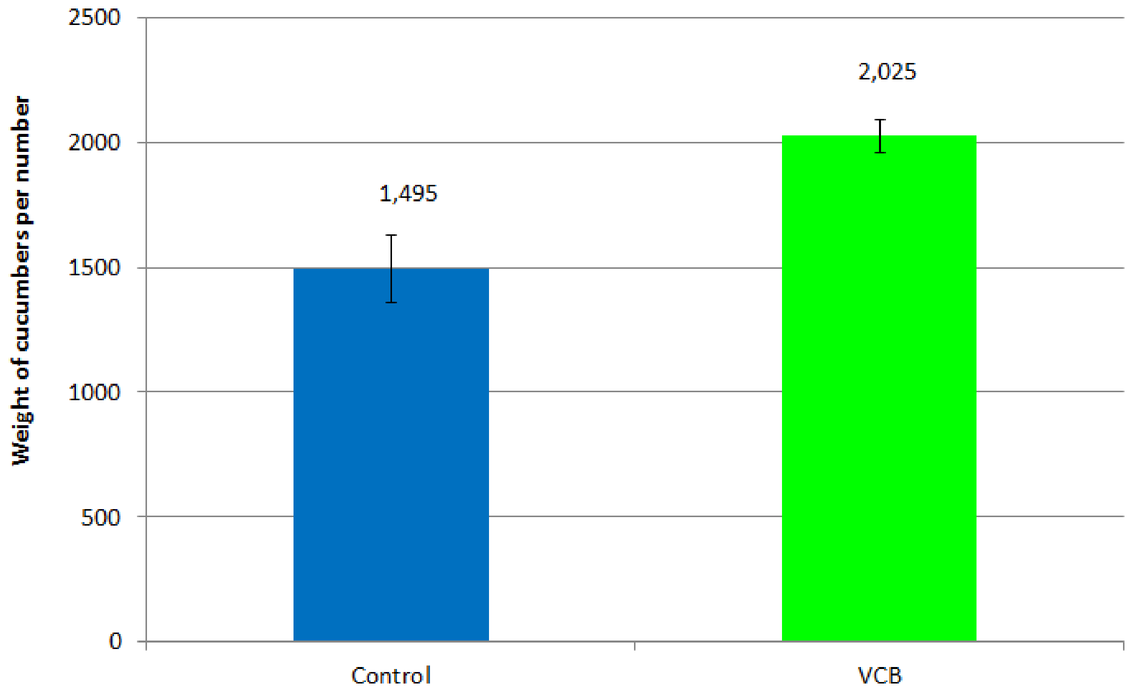


Figure 10: Weight of cucumbers per number harvested of control compared to VCB test site

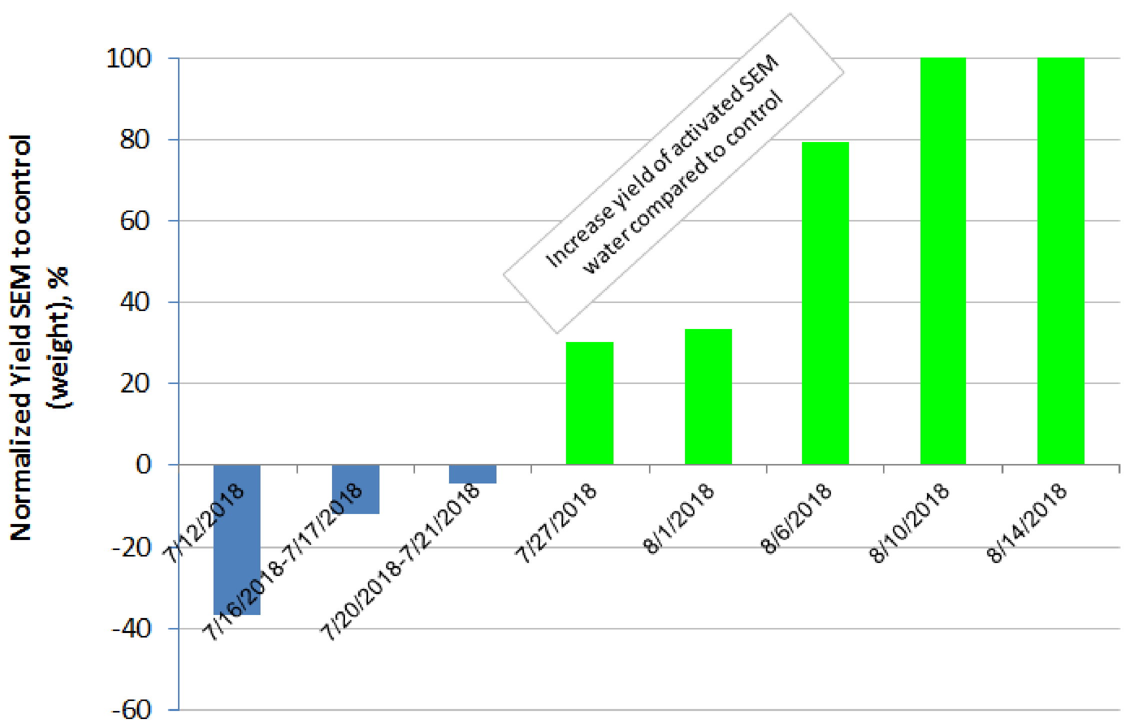

Figure 11: Normalized yield of control vs. VCB. Note: Test did not start from watering seeds with VCB water and irrigation was less than 50% than usual due to heavy rains. A surplus yield was obtained after the plant gained the activated water after three harvest sessions.

**Case study 4: At Beit Yitzhak, Emek Hefer, Israel**

Experiments were conducted in Beit Yitzhak, Emek Hefer, Israel. Water is treated by passing the water through a biofilter followed by UV disinfection for controlling pathogens proliferation. Ammonia is the main end product of nitrogen metabolism in fish in recirculation systems at high stocking densities. It may reach toxic levels (acute or chronic), unless the system is equipped with biofilters with bacteria that break down ammonia to less toxic nitrite ($NO_2^-$) and nitrate ($NO_3^-$).Water is probably the most important factor in the fish growing industry where its quality. The fish type grown at Beit Yitzhak is cichlid fish.

After biofiltration and UV, the water flowed to 2 similar tanks operated in a similar manner, with full occupancy of cichlid fish, about 10,000 each container. One is a control tank without the VCB system and in the other tank, a VCB system was installed in a recirculating line at a flow of ~40 L/min. At the end of each experiment, fish were enumerated and sized. Water quality analysis showed 4% increase in dissolved oxygen and 9% increase in nitrate, possibly indicating nitrification. More notably, the fish in the VCB treated container visibly showed 0 % mortality compared to 20% mortality on control side, with no food leftovers at the bottom of the tank and no formation of gases (ammonia).

**Yours sincerely, Prof. Hadas Mamane**

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