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Report on environmental parameters D2.2

Ecoponics

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Project website: http://aquaponics.is/ecoponics/

Environmental parameters in Breens aquaponics systems

The main tasks of WP2 include an optimal design of the commercial aquaponics plant at Breen taking into account optimal harvesting at least once a week all-year round, driven by market needs. The focus is on environmentally friendly production and total utilization of all resources, see Figure 1. The key to this is a healthy and balanced polyculture system. Thus, the production is 100% based on sustainable ingredients, non-synthetic fertilizers are used for the plant production and no effluent water or waste leave the plant.

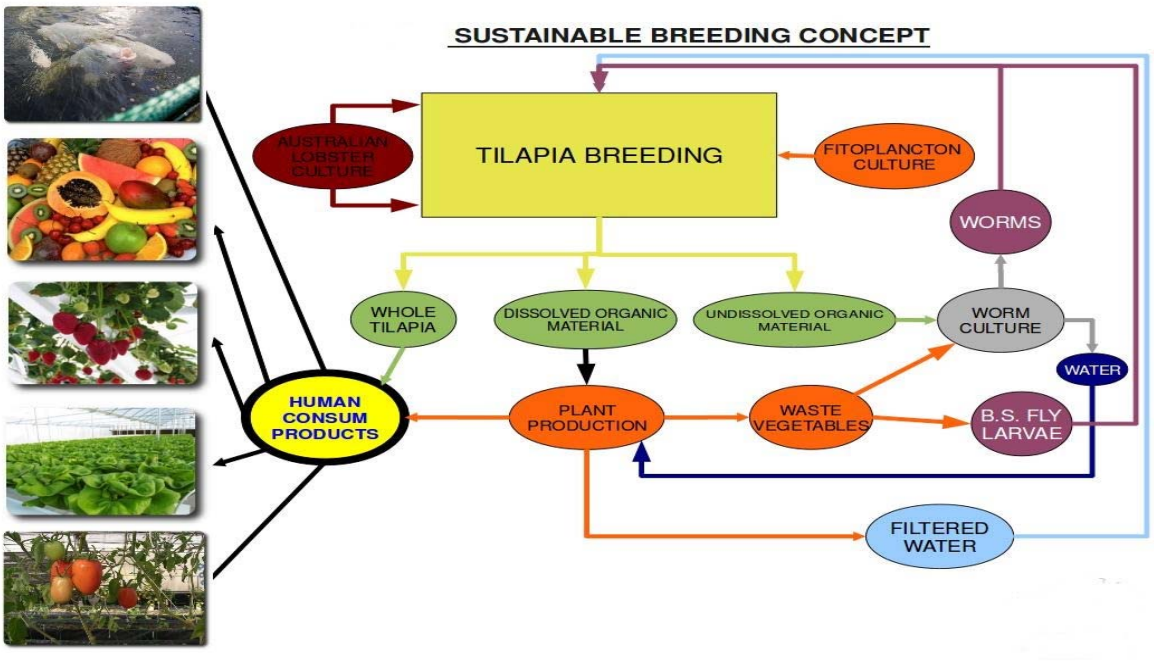


Figure 1. Breen´s sustainable breeding concept.

Pilot unit design

The data shown in this report were obtained during the period December 2013 to July 2014. The total water volume of the pilot system was 20 m^3 with an average of 225 kg of fish or an average stocking density of 11.3 kg/m^3 during the test period.

The organic waste from the fish supports 250 m^2 of vegetable production with lettuce, tomatoes, peppers, strawberries and aromatic herbs.

The fish has been fed during this period with Biomar, Efico Alfa 845F fish feed. The daily feeding is on average 3% of the fish biomass with a particle size of 1.5 mm, 3.0 mm and 4.5 mm depending on the fish size 4-15g, 15-60g, 60-400g, respectively, see Table 1 for recommendations. Figure 2 shows the measured growth rate of tilapia during the test period.

Table 1. Feeding indicative (kg feed per day for 100 kg of fish).

		Temperature (°C)								
Fish size (g)	**Feed – pellet size (mm)**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**
8 - 15	**1.9**	1.77	2.66	3.40	4.25	4.67	7.64	6.78	3.50	1.54
15 - 25	**1.9**	1.63	2.53	3.26	4.07	4.26	7.41	6.48	3.35	1.47
25 - 35	**3.0**	1.58	2.38	3.16	3.95	4.17	7.10	6.39	3.25	1.43
35 - 60	**3.0**	1.34	2.06	2.68	3.34	3.62	5.53	4.99	2.75	1.21
60 - 100	**4.5**	1.23	1.85	2.46	3.08	3.31	3.63	3.20	2.53	1.12
100 - 160	**4.5**	1.06	1.58	2.11	2.64	2.84	2.91	2.74	2.17	0.96
160 300	**4.5**	0.90	1.35	1.80	2.25	2.42	2.48	2.33	1.85	0.81
300 - 400	**4.5**	0.76	1.14	1.52	1.90	2.04	2.09	1.97	1.56	0.69

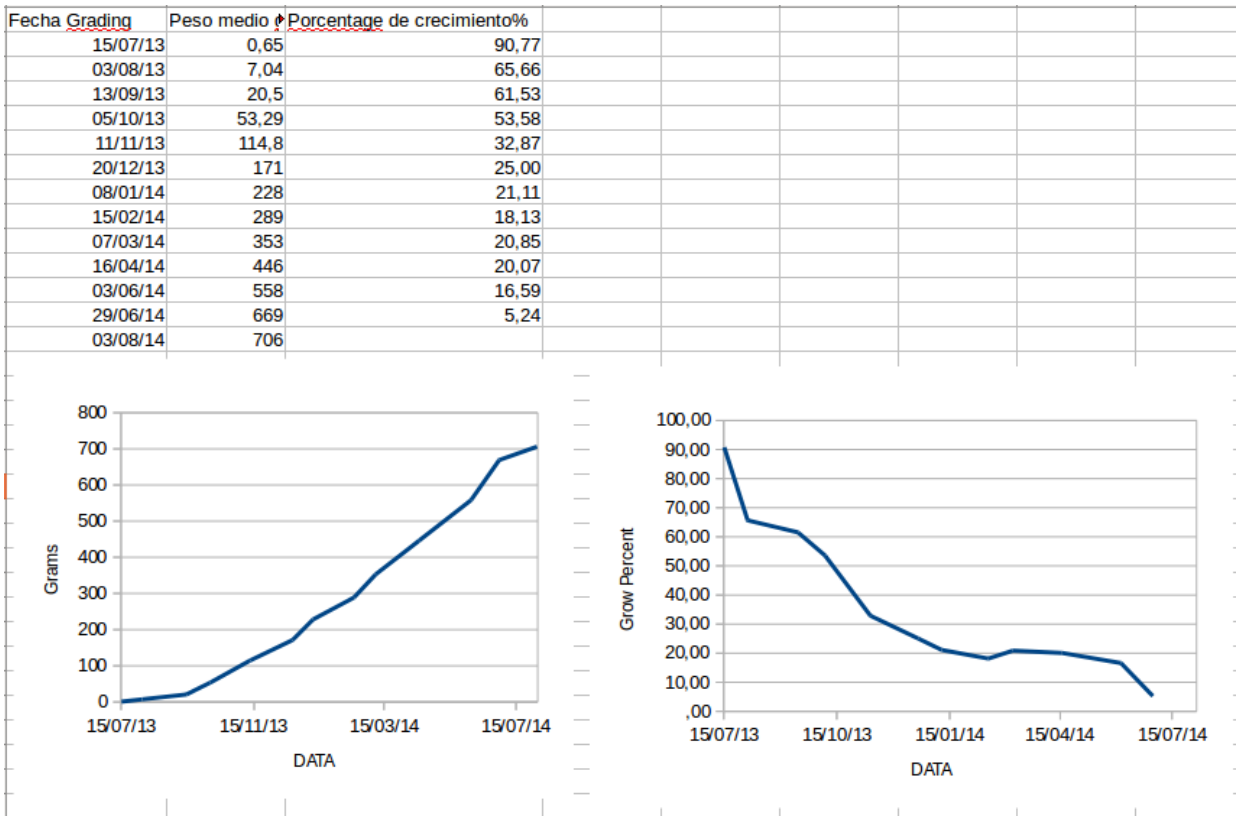


Figure 2. Measured growth of tilapia during the test period.

Filter system

The filter system includes a four compartment settling tank system and three sand filters of the type Kripsol BL640, separating the solid particles from the water. It is crucial in a large scale aquaponics system to have an effective filtering system, removing the solid organic matter, even small particles. The first compartment filters approximately 80% of the solids, the second one filters 20% and nitrification takes place in the third, eliminating the ammonia through biological filtration. When the water reach the fourth tank it is ready to be pumped through the system again.

Figure 3. A four compartment settling tank forms the filter system at Breen together with three sand filters.

Vermiculture

In the system of sustainable farming at Breen, the sludge is not treated as pollutant matter but as organic matter rich in nutrients that are used for another type of culture using a biological sewage treatment plant.

The biological treatment plant at Breen is based on a mixed culture of bacteria and earthworms. The sludge from the filter system is moved to the system and used for vermiculture. The compost from the vermiculture is a storable material that serves as fertilizer for plants and the excess of worms serves as extra protein intake for the Tilapia.

Figure 4. Vermiculture system at Breen utilising organic waste material.

Waste management

The units built at Breen are closed-loop zero waste systems and all nutrients are fully used. No synthetic fertilizers are used in Breen´s systems and no waste is coming from the system. What is generated of dissolved organic matter from the fish goes as nutrient to the plants and solid organic matter is composed by the red worms. 300 kg of production from waste organic materials (100 kg of plants and 200 kg of red worms) is generated per year and used to feed the fish. The water used in this process, once filtered, is reused by returning it to the aquaculture.

Water and CO_2 use

The water used in the system is rain water collected in a tank under the green houses. $9m^3$ of water is added per month, an average of 10% of the total water in the system every week. No CO_2 is added to the plant system and no waste water is taken out from the system.

Controlling environmental parameters

The automatic control of all the main process parameters is important, minimizing risk in the production system, controlling the water quality and obtaining optimal utilization of all resources.

In order to follow the water quality parameters, Breen has installed a Profilux surveillance system purchased from the German company GLH (https://www.aquariumcomputer.com/en-GB/products-shop/profilux-controllers). With this system the company controls all the factory automation, the feeding, the photoperiod and the volume of water in the tanks. Moreover, the most important water quality parameters are measured; pH, temperature, conductivity, Redox, the level of oxygen, humidity, and ambient temperature.

The pH is kept at 7 and it is important to maintain the oxygen level above 4 ppm. The optimum conductivity is on average 500µS and the Redox on average 45mV.

To control the quality of the water, apart from the parameters listed above, there are two other parameters that cannot be measured by the Profilux system, but needs to be followed closely. These are ammonia NH3-N and nitrate NO3-N. To measure those a spectrophotometer manufactured by Hanna Instruments is used. The ammonia is kept as low as possible and the NO3-N level is kept around 4-5 ppm and below 10 ppm. Ammonium levels should be negligible and always below 1.5 ppm. Figure 5 shows the results of the ammonia and NO3-N measurements during the test period.

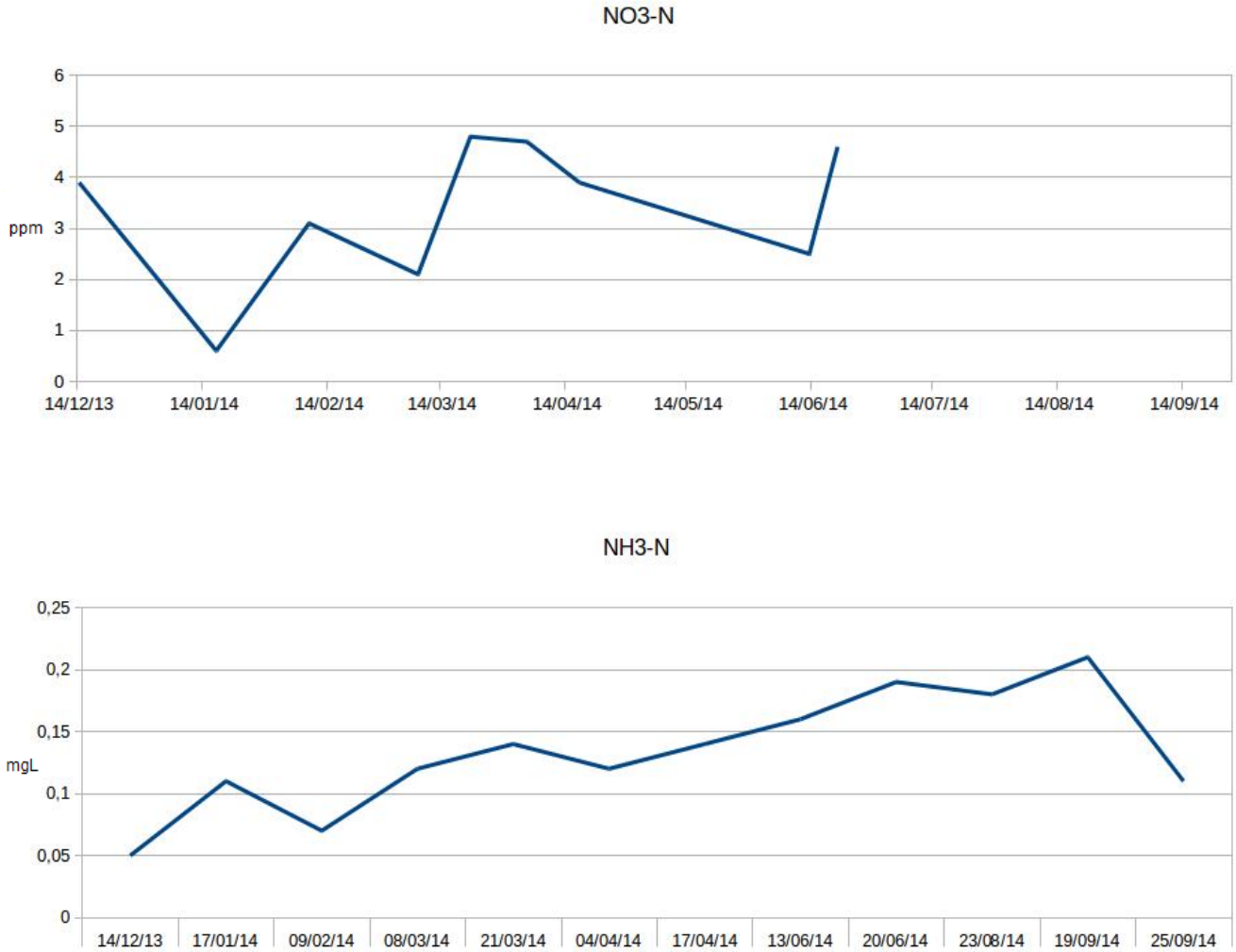


Figure 5. Measurements of ammonia and nitrate in Breen´s system during the test period.

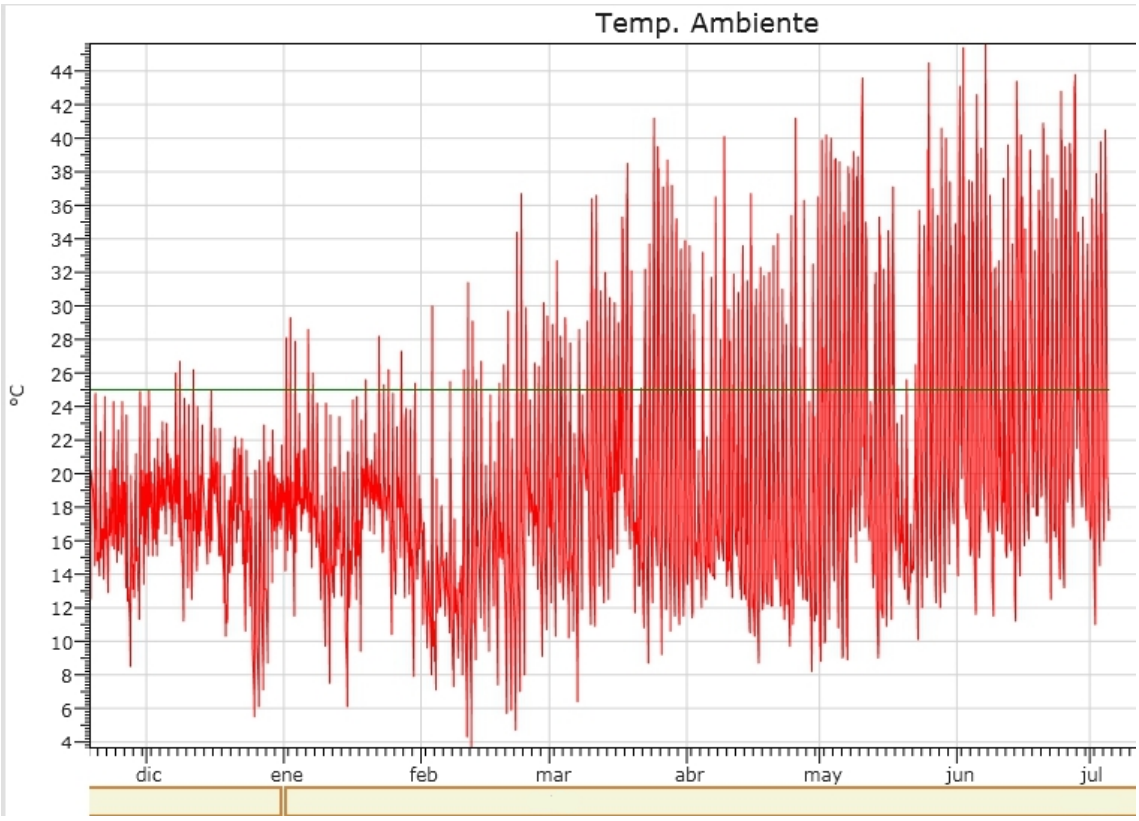


Figure 6. Ambient temperature measured during the period December 2013 to July 2014.

The ambient temperature is measured to estimate its effect (positive or negative) on the water temperature inside the tanks, so the energy consumption can be estimated. For example, temperature readings are taken to find out how much energy and expense to expect at different seasons.

The aim is to keep the warm water fish tilapia at 24-28°C in Breen´s systems. During winter time the ambient temperature sometimes drop dramatically in the nights so excess energy is needed to maintain the temperature of the fish tanks at appropriate levels. During summer no additional heat is required. The temperature that is lost overnight is recovered during the day. However, there may be need for extra cooling during the summer time.

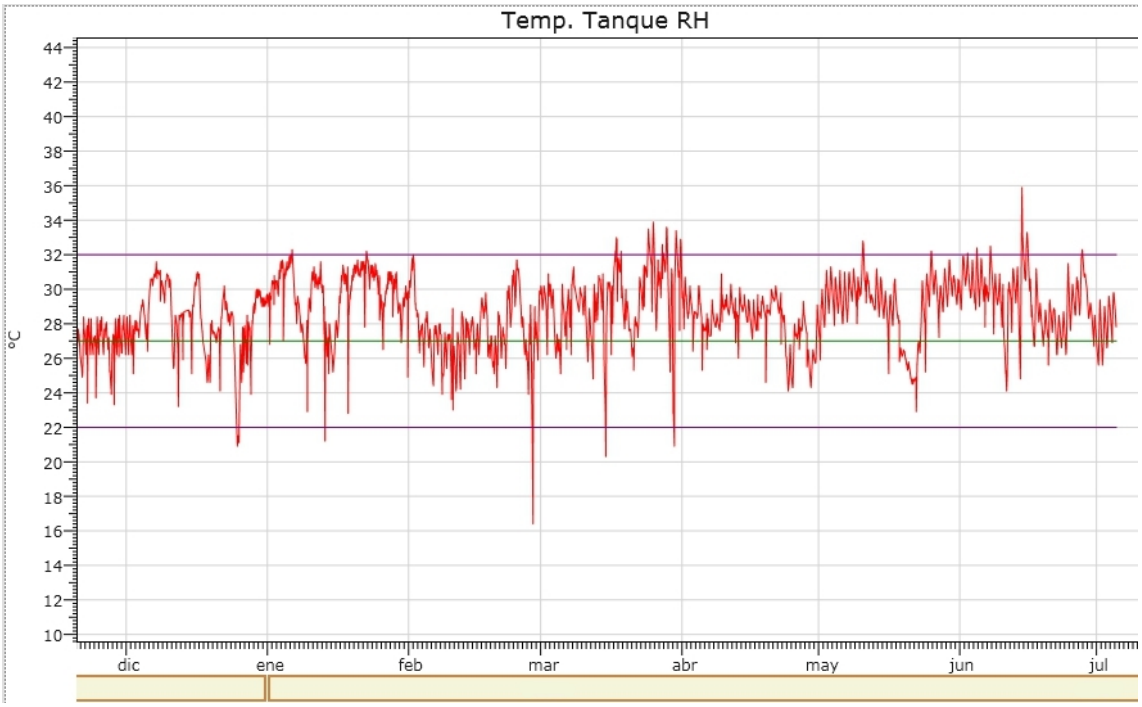


Figure 7. Temperature inside the fish tanks in the period December 2013 – July 2014.

Figures 6 and 7 reflect the temperature difference that exists between the ambient temperature and its impact on the temperature of the water inside the hatchery.

Energy use - kWh

Breen emphasis direct use of renewable energy and waste heat. The company uses waste heat from a cogeneration system for the pilot plant.

Breen seeks to maintain the water temperature in the fish tanks at 24-28°C. During winter the temperature can drop down to 20°C. To increase the temperature by 4ºC 93 kWh are needed:

Q= (m)*(C)*(T2-T1)

Q: heat required
m: Water mass (g)
C: specific heat: 1 cal/g
T2-T1: temperature difference

Q= (m)*(C)*(T2-T1)
Q= (20.000.000)*(1)*(4-0)
Q= 80.000 kcal = 93 kWh

To move the water which is totally circulated three times per hour all year round six pumps of 350 W each are used.

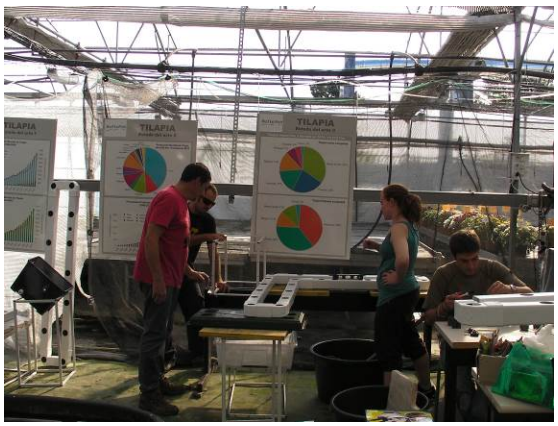
Breen uses cold white LED lights, 12 W per m^2

The lights are controlled by Profilux with the 1-10v digital input to simulate sunrise and sunset. 18 hours of light and 6 hours of darkness.

Social Parameters

Breen has offered an aquaponics training course for unemployed people – two groups of 15 people have now completed the training programme at Breen.



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Annex: Vegetable species for different periods of the year

Winter	Spring	Summer	Autumn
Cauliflower		Cauliflower	Cauliflower
Broccoli Romanesco			Broccoli
Brussels sprouts			Brussels sprouts
Collard			Collard
Garlic			Garlic
Leek		Leek	Leek
	Onion	Onion	Onion
Tomato Cherry	Tomato Cherry	Tomato Cherry	Tomato Cherry
	Tomato Apple	Tomato Apple	Tomato Apple
	Pepper	Pepper	Pepper
	Chili	Chili	Chili
	Eggplant	Eggplant	Eggplant
Lettuce Batavia	Lettuce Batavia	Lettuce Batavia	Lettuce Batavia
Endive			Endive
	Lettuce butterhead	Lettuce butterhead	
Cyclamem	Cyclamem	Cyclamem	Cyclamem
Basil	Basil	Basil	Basil
Rosemary	Rosemary	Rosemary	Rosemary
Oregano	Oregano	Oregano	Oregano
Parsley	Parsley	Parsley	Parsley
Cuncuat	Cuncuat	Cuncuat	Cuncuat
Calamondino	Calamondino	Calamondino	Calamondino
Papaya	Papaya	Papaya	Papaya
Aloe vera	Aloe vera	Aloe vera	Aloe vera
Strawberry	Strawberry	Strawberry	Strawberry
	Courgette	Courgette	
	Cucumber	Cucumber	
	Melon	Melon	