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Cucumis sativus in an Anthroponics system under different aged urine dosages

Henrique Junior Aiveca Sánchez

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Abstract

Anthroponics is a recirculating soilless agriculture system that uses natural bacterial cycles to convert human biowaste such as urine into plant fertilizer.

A small experiment was conducted in Malmö, Sweden. The method involved building three anthroponic systems (System 1, System 2 and System 3) and collecting and aging urine samples from one healthy individual. The objective was to cultivate *Cucumis sativus* in the anthroponic systems under different dosages of aged urine to observe the different growths in the plants. Each system received two seedlings, and all the systems were tested for Nitrate (NO_3^-), Electrical Conductivity (EC), pH on a weekly basis, while diagnosed for defficiencies and tested for Potassium (K), Iron (Fe) and Magnesium (Mg) once suspected of having defficiencies. All plants were also measured in length at the end of the experiment.

System 1 received 109 mL of aged urine per week during one month and produced two plants with a length of 109 cm and 144 cm, System 2 received 54,5 mL of aged urine per week during one month and produced two plants with a length of 97 cm and 94 cm, and System 3 received 218 mL of aged urine per week during one month and produced two plants with a length of 84 cm and 149 cm. All of the plants in all systems presented some signs of Iron defficiency and possible Potassium defficiency, and plants in System 1 and System 2 showed signs of Magnesium defficiency.

In conclusion, while the experiment was too short to observe fruit growth, System 1 and System 3 each produced the longest vegetative growth in one of the system's cucumber plants, at the expense of the second plant of the system, which displayed increased defficiency signs. It is possible that a dosage amount between the amounts used for System 1 (109 mL/week) and System 2 (218 mL/week), as well as additional Potassium, Magnesium and Iron supplementation, can provide sufficient nutrients for a healthy production of one cucumber plant of in an anthroponics system.

Keywords: Anthroponics, aquaponics, human urine, hydroponics, nutrient recovery, wastewater treatment.

1. Introduction

Anthroponics can be defined as a recirculating soilless agriculture system that uses natural bacterial cycles to convert human biowaste such as urine into plant fertilizer. As stated in the author's report *Lactuca sativa production in an Anthroponics system* (Sanchez, 2015), the main processes behind anthroponics include ammonia volatilization from urea and the aerobic nitrification of ammonia to nitrate. This report is a continuation of such report, as the original objective of the report on lettuce was to test different urine dosages.

As such, the present report has the goal to test different aged urine dosages and observe their effect in the development of the cucumber plants, both by analyzing water chemistry as well as observing deficiency signs. The results will enable a greater understanding in the nutrient requirements of cucumber plants in an anthroponics system as well as understanding the ideal aged urine dosage range, both for individual plants as well as for scaled systems.

2. Materials & Methods

Three cycled anthroponic systems used in the author's report *Lactuca sativa production in an Anthroponics system* (Sanchez, 2015) were used to plant the *Cucumis sativus* seedlings (Figure 1). The overall materials such as containers, pumps, hoses and lights as well as the construction os detailed in the mentioned report. The seedlings were started in ROOT!T ® cubes using General Hydroponics™ Flora series.

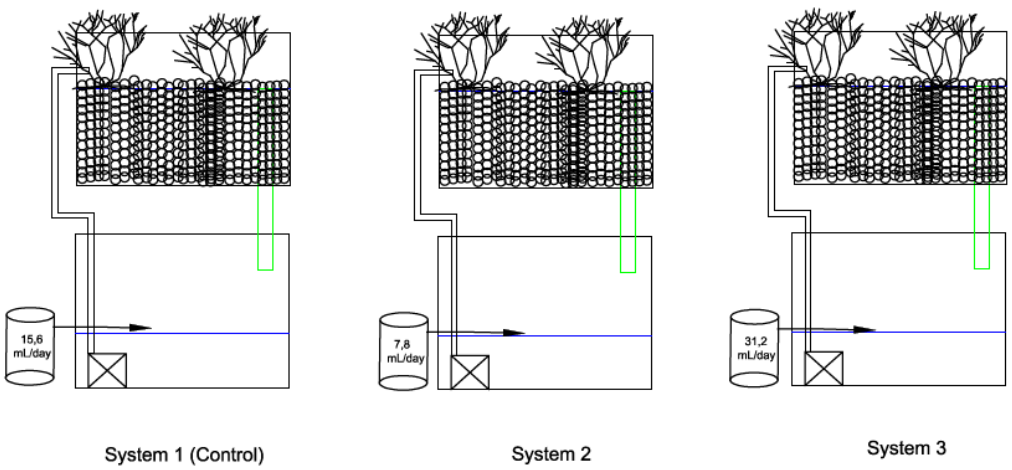

Figure 1: Experiment overview with the different systems.

The systems were built at Hemmaodlat's office. Hemmaodlat is a Swedish NGO organization located in Malmö, Sweden, with the goal of teaching hydroponic and aquaponic concepts. More detailed information about the systems can be seen in Table 1. The urine was collected from a healthy individual and under no type of medication. The urine was stored in several jars and its pH monitored until it reached a value of 9, rendering it safe for use (Sanchez, 2015).

Table 1. Main parameters and results of production in the experimental anthroponic systems.

System	1	2	3
Total Water volume (L)	20-25	20-25	20-25
Pump flow rate (L/h)	650	650	650
SSA media (m^2/m^3)	250	250	250
Biofilter volume (L)	19,5	19,5	19,5
BSA (m^2)	4,875	4,875	4,875
Aged urine (mL/week)	109	54,5	218
Experiment duration (days)	42	42	42
Plant growing area (m^2)	0,11	0,11	0,11
Number of plants in grow box	2	2	2
Plant species	*Cucumis sativus*	*Cucumis sativus*	*Cucumis sativus*

Parameters such as pH and Electrical Conductivity (EC) were measured with calibrated HM Digital waterproof PH-200 and calibrated HM Digital waterproof COM-100, respectively. Other parameters such as Nitrate, Potassium, Magnesium and Iron were measured with a HI Multiparameter Photometer (Figure 2) and the respective test kits.

Figure 2: Hanna Instruments HI Multiparameter Photometer. 26th August 2015.

3. Results

All cucumber plants experienced vegetative growth during the duration of the experiment (Figure 3), with all plants producing male flowers and at least one plant in each system producing at least one female flower.

Figure 3: Evolution of cucumber plants in the anthroponics experiment units. From left to right, the dates are: 22nd July 2015, 5th August 2015, 19th August 2015, and 26th August 2015.

The analysis of pH (Figure 4), EC (Figure 5) and Nitrate (Figure 6) levels were expected with the different aged urine dosages, though in the case of Nitrate the test kit was limited in its range to 30 mg/L N-NO_3 (or 132,8 mg/L NO_3).

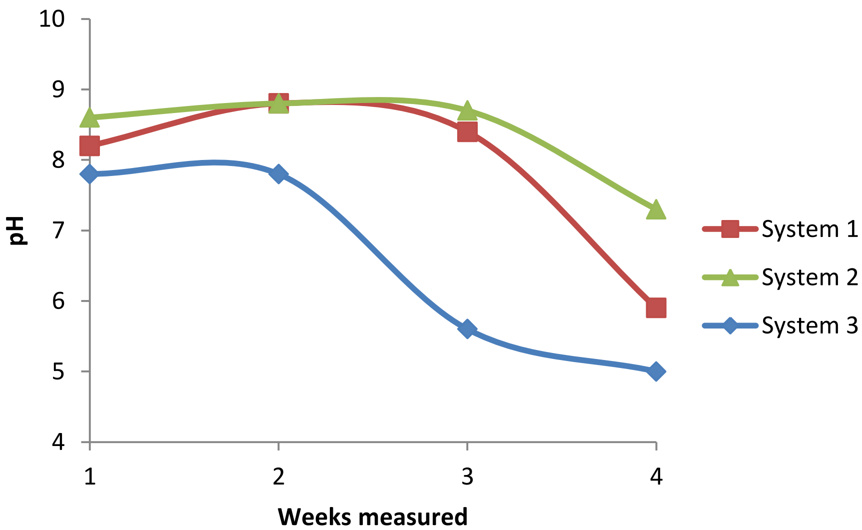

Figure 4: Evolution of pH levels over a period of 1 month in all three anthroponic systems.

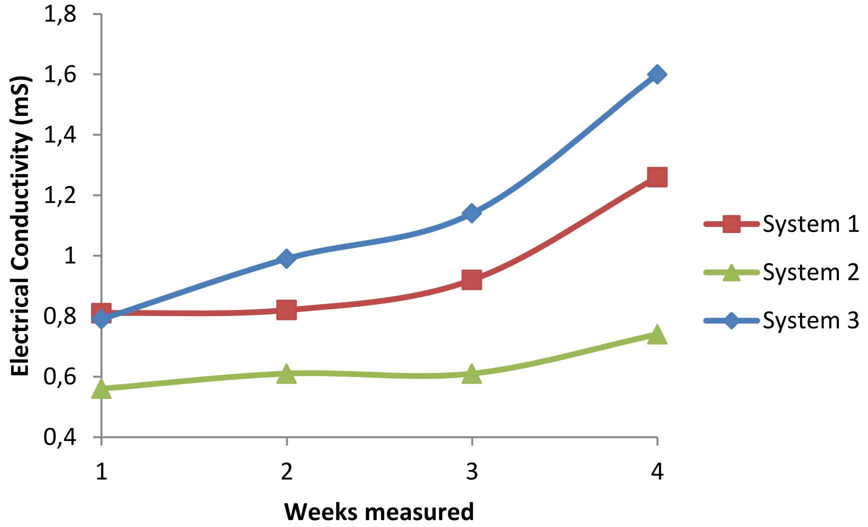

Figure 5: Evolution of EC levels over a period of 1 month in all three anthroponic systems.

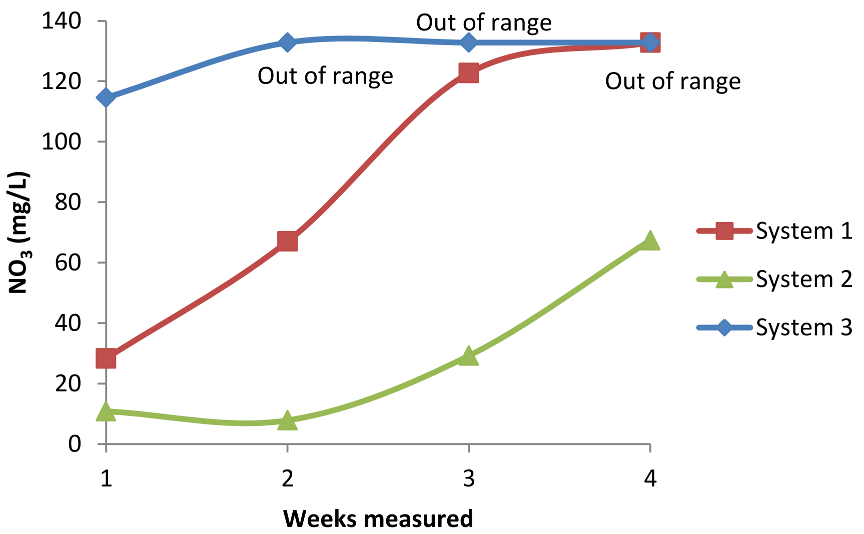

Figure 6: Evolution of Nitrate levels over a period of 1 month in all three anthroponic systems.

The cucumber plant length also correlated with what was expected from different aged urine dosages. System 1 produced plants with an estimated length of 109 cm and 144cm, System 2 produced plants with an estimated length of 97 cm and 94 cm, and System 3 produced plants with an estimated length of 83 cm and 149 cm (Figure 7).

Figure 7: Different cucumber plant lengths. From left to right: Two plants from System 3, two plants from System 2, and two plants from System 1. 2nd September 2015.

In Figure 7 it is also visible how in the more successful systems (System 1 and System 3), one of the plants thrived while the other showed struggling signs, either by its reduced length (System 3) or by its reduced leaf health and amount (System 1).

Perhaps more importantly, several defficiency signs were observed during the experiment (Figure 8), particularly in plants from System 2, but also in at least one plant of System 1 and System 3.

Figure 8: Different defficiency signs in cucumber plants from all systems. 26th August 2015.

To confirm a correct defficiency diagnosis, the water chemistry of each system was tested for Potassium (K), Iron (Fe) and Magnesium (Mg). The obtained results are presented in Table 2.

Table 2: Potassium, Iron and Magnesium concentration in the anthroponic systems.

Date	System	Urine to add (mL)	pH	EC (mS)	K (mg/L)	Fe (mg/L)	Mg (mg/L)
19-08-2015	1	109	8,4	0,92	>100	-	-
19-08-2015	2	54,5	8,7	0,61	6	-	-
19-08-2015	3	218	5,6	1,14	82	-	-
26-08-2015	1	0	5,9	1,26	>100	-	-
26-08-2015	2	0	7,3	0,74	8	-	-
26-08-2015	3	0	5,0	1,6	>100	-	-
02-09-2015	1	0	7,5	1,25	-	0,03	35
02-09-2015	2	0	8,0	0,73	-	0,00	15
02-09-2015	3	0	5,0	1,68	-	0,05	50

4. Discussion and conclusions

The diagnosis of the observed defficiencies was possible by comparing the symptoms with Table 2.6 of the book *Hydroponic Food Production* (Resh, 2013), which presents a summary of the mineral defficiencies in tomatoes and cucumbers.

The observed symptoms in the anthroponic systems included:

- Discolored yellowish green at margins, later turning brown and drying, in older leaves (Indicating Potassium defficiency);
- Interveinal chlorosis from leaf margins inward, with the development of necrotic spots, in older leaves (Indicating Magnesium defficiency);
- Fine pattern of green veins with yellow interveinal tissue and a later chlorosis spreading to veins, turning entire leaves to a lemon-yellow color, in younger leaves (Indicating Iron defficiency).

After testing these nutrients in the anthroponic systems, the results were compared with literature values of recommended minimum concentrations for cucumber plants.

Table 3: Comparison between literature values and observed values for Potassium, Iron and Magnesium concentrations.

Concentration of parameters	Resh (2005)	HydroponEast Magazine (2013)	System 1	System 2	System 3
K (mg/L)	350	190	>100	8	>100
Mg (mg/L)	50	15	35	15	50
Fe (mg/L)	3	0,4	0,03	0,00	0,05

It can be concluded that all systems had Iron defficiency, while System 1 and System 2 also had Magnesium defficiency, and System 2 had Potassium defficiency. In regards to Potassium, it is also possible that System 1 and System 2 were defficient in Potassium, since the test kit did not have the required range.

While the experiment was too short to observe fruit growth, System 1 and System 3 each produced the longest vegetative growth in one of the system's cucumber plants, at the expense of the second plant of each system, which displayed increased defficiency signs. It is possible that a dosage amount between the amounts used for System 1 (109 mL/week) and System 2 (218 mL/week), as well as additional Potassium, Magnesium and Iron supplementation, can provide sufficient nutrients for a healthy production of one cucumber plant of in an anthroponics system.

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