Efficacy of Swift Grow Liquid Fertilizer on Cucumber Yield Response Under UAE Condition

Final Report

September 2021

Executive summary

Reducing fertilizer and water use in crop production is an overarching goal to ensure more sustainable and responsible use of resources. One way to achieve this goal is to use organic fertilizers which have limited availability and options. Therefore, it is important to develop and test organic fertilizers in the market for their effects on yield and water saving potential.

Cucumber was chosen as the trial representative crop commonly grown and consumed in the UAE. This final report comprises the results from experiment evaluating the efficacy of Swift Grow (SG) liquid, organic fertilizer on cucumber yield in comparison with mineral fertilizer under UAE growing condition. SG trademark is produced by River Stone Fish Farm, Australia and in the UAE is marketed as Ocean Bio Fert by Desert Group LLC. The two fertilizers effect on cucumber yield were tested in two substrates (peatmoss and sand mixed with compost). The study was conducted in partnership between River Stone Fish Farm, Australia; Desert Group LLC, and ICBA.

The key findings from the trials are:

- Yield from Swift Grow Liquid Fertilizer was similar as yield from control mineral fertilizer. However, although not statistically significant, slightly higher cucumbers were harvested from plants receiving SG fertilizer than control in peatmoss substrate (6% higher). In sand substrate, the yield increase due to SG was even higher (20%) than control fertilizer application.
- SG liquid fertilizer slightly increased the number of fruits harvested in both substrates. SG increased number of cucumbers harvested in peatmoss substrate by 2% whereas it increased in sand substrate by 30%
- In a taste panel evaluating the quality of the cucumbers based on color, taste, smell and firmness, there was no statistically significant difference between cucumbers harvested from SGLF and mineral fertilizer applied crops.
- Degrees Brix of cucumbers, the sugar level measurement of fruits and vegetables, was also similar between the treatments.
- The plants growth speed (plant height, internode development) was similar between treatments
- Chlorophyll content of the leaves which indicates leaf N level was not affected by the fertilizer type. However, the substrate type affected leaf chlorophyll content which was higher (10%) in peatmoss substrate compared to mixture of sand and compost
- Substrate moisture level was not significantly affected by the fertilizer type. Soil moisture was different for the two substrates, where peatmoss has always higher moisture level than mix of sand and compost substrate. Although not significant, in general, SG fertilized soils had 11-14% higher soil moisture levels than control fertilized soils in peat moss substrate, whereas in the sand mixed with compost substrate, SG fertilizer increased (14 - 20% higher) soil moisture level compared to control fertilizer. This higher soil moisture level is partly as a result of a higher soil water holding capacity of the SG fertilized substrates as demonstrated by lower runoff (drainage) volume as in these substrates.

- The soil analysis result generally shows that the two-fertilizer types provided comparable nutrient level to the plants as shown with no statistically significant difference in ECe level (a measure of overall nutrient level).
- The similar yield and quality of harvested cucumber could be translated to higher income to farmers due to higher price of organically produced produces in the market. From environment conservation perspective SG provide alternative solution to standard farming practice which has relatively higher nutrient runoff and is harmful to beneficial microorganism within the soil.

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1. Introduction

Greenhouses are a form of controlled agriculture (CA) that is increasingly prevalent in the UAE and other countries with marginal environments. The ability to control conditions for plant production is necessary in areas with high temperatures, low water availability and poor soils. Most greenhouses in the region are low- tech and use soil as a growing media for plant cultivation. Water and nutrient management are the most important factors affecting crop yield; amendments to soils through fertilizers can optimize nutrient management.

The goal of nutrient management is to efficiently deliver the essential elements (macro elements: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and micro elements: sulfur (S), chlorine (Cl), iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu) and molybdenum (Mo)) to plants in a manner that optimizes crop health and quality and postharvest life (Mattson, 2019). Greenhouse crops such as tomato and cucumber require intensive management, and therefore high water and nutrient demand. For instance, year-round tomato production consumes about 1185 kg ha^{-1} and 284 kg ha^{-1} of N and P, respectively (Sonneveld and Voogt, 2009).

The most common method of fertilizing greenhouse grown crops is through the use of synthetic fertilizers. There are several advantages associated with synthetic fertilizers including their low cost, fast-acting nature, and precision of application. However, long-term negative effects include the elimination of beneficial microorganisms within soil, soil moisture retention, nutrient runoff which affect human and environmental health, and an increased need for pesticide use.

However, increasingly alternative form of fertilizers such as fish waste are being tested and used in some instances. These fertilizers are organic solutions rich in macro- as well as micro-nutrients and are suitable for organic farming. In a market with increased demand for organic produce, this provides an alternative for greenhouse cultivation that creates competitive products while ensuring environmental integrity.

1.1. Research Justification

Reducing fertilizer and water use in crop production is an overarching goal to ensure more sustainable and responsible use of resources. One way to achieve this goal is to use organic fertilizers which have limited availability and options. Therefore, it is important to develop and test organic fertilizers in the market for their effects on important parameters include such as yield and water use productivity.

In this research, we tested the efficacy of a fish waste organic, liquid fertilizer with the Swift Grow trademark, produced by River Stone Fish Farm, Australia (known in the UAE as Ocean Bio Fert), on cucumber crop cultivation.

2. Goal and Objectives

The goal of the research is to evaluate the potential of SG, organic liquid fertilizer, product as an alternative source of fertilizer in greenhouse vegetable production.

The objective of this experiment is to test the efficacy of SG liquid fertilizer on cucumber crop yield and quality, within greenhouse production, under UAE agro-climatic conditions. The findings of the study could provide more insight into the potential of OBF to contribute to organic food production in the UAE and help meet the UAE government's mandate of achieving food autonomy.

This research will contribute to improving food security by enabling the production of organic produce which is known to be higher in nutrients and lower in pesticide residue when compared with conventional produce. Further, it will contribute to improving water quality and the environmental integrity of ecosystems affected by greenhouse drainage water.

3. Materials and Methods

3.1. Plant material and growth condition

Cucumber cv River sun F1 plants were sown (Figure 1 photo of the greenhouse and seedlings) in a conventional greenhouse (pad and fan cooled greenhouse) (Figure 2). The treatment was SG liquid fertilizer and synthetic fertilizers (control) in two substrates (Peatmoss and sand mixed with compost[3:1 ratio by volume]).

Figure 1. Photo of cucumber seedlings on 14 June 2021.

Figure 2. Photo of the greenhouse compartment before transplanting on 14 June 2021

The cucumber seedlings were transplanted on 17 June 2021 into four rows of greenhouse (Figure 3). SG liquid fertilizer was prepared fresh every day at a rate of 43 ml per 50 l water. The control fertilization was prepared in stock solution of A and B as shown in figure 6. EC and pH were monitored daily, and adjustment was done when required. The fertigation mixture tanks were outside of the greenhouse at the start of the experiment (Figure 4). However, because of the extremely higher temperature in the summer months in UAE, a new mixing tanks were installed in the greenhouse to protect the bacteria from the intense sun light and extreme high temperature (Figure 5).

Figure 3. Photo of seedlings at transplanting 17 June 2021.

Figure 4. Fertilizer mixing tanks outside the greenhouse.

Figure 5. Fertilizer mixing tank inside the greenhouse

REPORT

STOCK NS PRECIPITATION TEST ?

Quick start guide | Unit converter (ppm> mM) | Calculation | Fertilizers and acids | Stock NS precipitation test | Input

Salt concentration of stock A	97.0	g/L
Salt concentration of stock B	97.0	g/L

NO precipitation in the stock nutrients solution tanks

Insert a new dilution ratio
1: 100

NUTRIENT SOLUTION COMPOSITION

Crop and stage: **Cucumber. Stage: Single**

Volume of stock tanks (L):	100	Ionic ratios (expressed in milliequivalent)	
Dilution ratio	1: 100	N/K	1.88
Set-point pH:	5.7	NH_4/NO_3	0.07
Target EC (dS/m):	2.15	K:Ca: Mg	0.42 0.42 0.16
Expected EC (dS/m)	**2.25**		

Irrigation water ? (uM for Fe, B, Cu, Zn, Mn, Mo; mM for other ions)

EC (mS/cm)	HCO^{3-}	$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Ca	Mg	Na	$S\text{-}SO_4$	Cl	Fe	B	Cu	Zn	Mn	Mo
0.48	0.80	0.04	0.00	0.00	0.05	0.50	0.17	1.68	0.11	2.03	0.0	8.3	0.0	0.0	0.0	0.0
ppm	*49*	*1*	*0*	*0*	*2*	*20*	*4*	*39*	*3*	*72*	*0.00*	*0.09*	*0.00*	*0.00*	*0.00*	*0.00*
OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

Selected recipe (uM for Fe, B, Cu, Zn, Mn, Mo; mM for other ions)

EC (mS/cm)		$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Ca	Mg	Na	$S\text{-}SO_4$	Cl	Fe	B	Cu	Zn	Mn	Mo
2.00	mM /mM	15.00	1.00	1.20	7.00	4.00	1.50	0.00	1.60	0.00	15.0	30.0	1.0	5.0	10.0	1.0
	ppm	*210.1*	*14.0*	*37.2*	*273.7*	*160.3*	*36.5*	*0.0*	*51.2*	*0.0*	*0.84*	*0.32*	*0.06*	*0.33*	*0.55*	*0.10*

Nutrient solution (uM for Fe, B, Cu, Zn, Mn, Mo; mM for other ions)

EC (mS/cm)		$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Ca	Mg	Na	$S\text{-}SO_4$	Cl	Fe	B	Cu	Zn	Mn	Mo
2.25	mM /mM	14.00	1.00	1.00	8.00	4.00	1.50	1.69	2.27	2.03	15.0	20.0	1.0	5.0	10.0	1.0
	ppm	*196.1*	*14.0*	*31.0*	*312.8*	*160.3*	*36.5*	*38.8*	*72.6*	*72.0*	*0.84*	*0.22*	*0.06*	*0.33*	*0.55*	*0.10*

Amount of fertilizers to dissolve in the stock nutrient solution tanks.

Stock A:

Calcium nitrate	7.55	Kg
Potassium nitrate	2.00	Kg
Iron EDDHA	139.46	g
Phosphoric acid	0.45	L

Stock B:

Magnesium sulphate	3.39	Kg
Mono-ammonium phosphate	0.34	Kg
Mono-potassium phosphate	0.06	Kg
Potassium nitrate	4.34	Kg
Potassium sulphate	1.49	Kg
Borax	11.17	g
Copper chelate (EDTA)	4.17	g
Zinc chelate (EDTA)	21.59	g
Manganese chelate	36.56	g
Sodium molybdate	2.37	g

Figure 6. Standard cucumber nutrient solution preparation sheet. Please see nutrient solution row for individual nutrient concentration used.

3.2. Plant and soil parameters

Several plant and soil parameters were recorded during the experiment period. Plant characteristics recording include plant height, internode number, flowering (bud) appearance, leaf chlorophyll content, yield, fruit number and quality (sugar level and taste panel evaluation). Soil samples were collected before, halfway and at the end of the experimental period. Soil subsamples were collected from each pot in every row and composited to create representative samples representing each planting medium and the treatment per row. Two replicates of each combination for each round were taken to the lab and analyzed for pH, EC, Ca, Mg, CO_3, HCO_3, Cl, Na, K and moisture.

In addition, soil moisture recording, regulated soil drying was recorded for 10 days to better understand how the treatments influence soil water holding capacity of the substrates used.

Cucumber taste test was carried out in four characteristics: (A) color: the color was evaluated in three categories (1: light green; 2: green; 3: dark green); (B) Taste; (C) smell and (D) Firmness: were all evaluated in three categories (1-4: not good; 5-7: average (normal); 8-10: very good. Ten ICBA colleagues participated in the evaluation panel.

3.3. Statistical analysis

Data analysis was performed using Statistical Tools for Agricultural Research (STAR) program. The experimental layout was Split-Plot Randomized Complete Block Design (See Figure 7). The main plot factor was Fertilizer type (Swift Grow [SG] and Control [C]). The sub plot factor was the substrate types (peatmoss [PM] and mixture of sand and compost [S]). 10 Cucumber plants were grown per plot and each treatment was repeated two times (Block 1 and 2). Treatment effects were tested at 5% probability level and the mean separation was done using least significant differences.

Block 1		Block 2	
Row 1	**Row 2**	**Row 3**	**Row 4**
SG PM	C PM	SG S	C S
SG S	C S	SG PM	C PM

Figure 7. Experimental layout. Swift Grow (SG) and standard mineral fertilizer (Control [C]) were used in two substrate types (peatmoss [PM] and sand mixed with compost in 3:1 ratio by volume [S]).

4. Result

4.1. Yield

Although not statistically significant, slightly higher cucumbers were harvested from plants receiving SG fertilizer than control in peatmoss substrate (6% higher). In sand substrate, the yield increase due to SG was even higher (20%) than control fertilizer application (Figure 8).

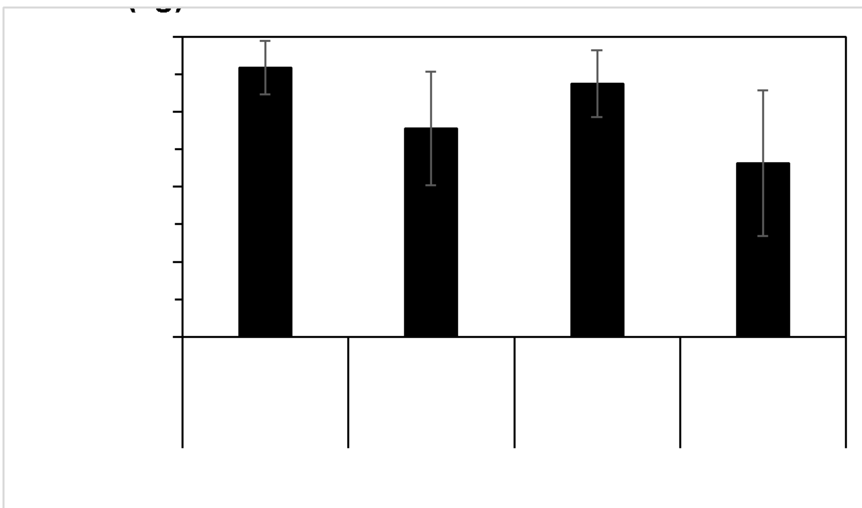


Figure 8. Harvested cucumber yield (kg) from 10 plants. SG: Swift Grow; C: is control standard chemical fertilizer; PM: peatmoss substrate whereas S: sand and compost mixture substrate

Similarly, the number of cucumbers harvested was not significantly affected by either fertilizer or substrate type (Figure 9). However, although not significant, more cucumbers were harvested from plants which received SG than control fertilizer in sand substrate (30% more).

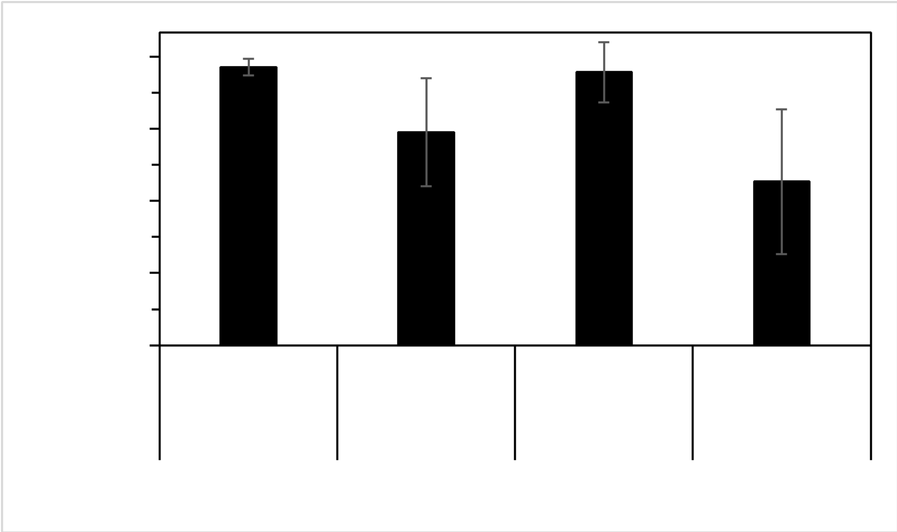


Figure 9. Harvested cucumber number from 10 plants. SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate.

4.2. Plant characteristics

Chlorophyll content of the leaves which indicates leaf N level was measured using a Soil Plant Analysis Development (SPAD) instrument (Figure 10). The result indicates that the fertilizer type did not affect chlorophyll level, whereas there was significant difference between the substrate types (P = 0.0314). Leaf chlorophyll content was higher (10%) in peatmoss substrate compared to mixture of sand and compost (Figure 11).

Figure 10. Leaf chlorophyll content measuring SPAD meter.

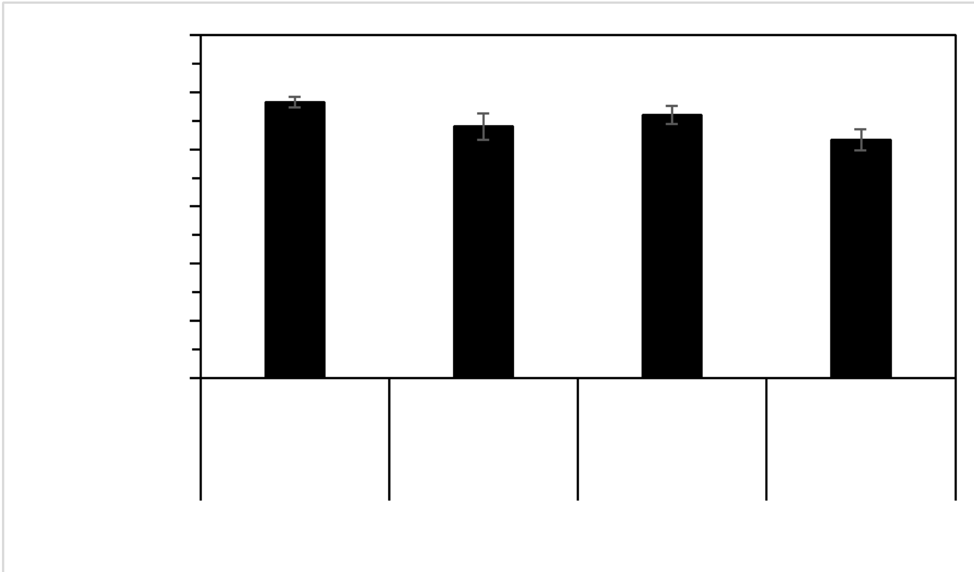


Figure 11. Effect of fertilizer and substrate on leaf chlorophyll level. SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate

Similarly, plant height as a measure of how the plants are growing was recorded five times from June 21 to 18 July 2021. The plant height increased similarly in both fertilizer types, however there was a significant increase in height in plants grown in peatmoss substrate (14%) compared to plants grown in sand substrate (Figure 12).

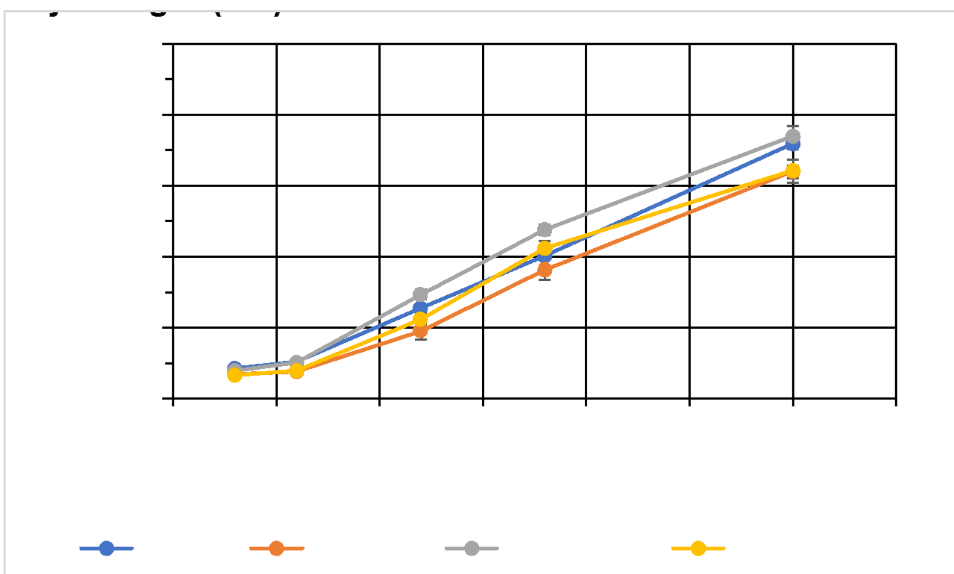


Figure 12. Effect of fertilizer and substrate type on plant height increase. SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate

There was no significant difference in the number of internodes count (data not shown).

4.3. Cucumber quality characteristics

Cucumber sugar level was measured using a brix meter (Figure 13). Brix (sugar) levels were similar in both fertilizer and substrate types (Figure 14). In addition to measurement of sugar level, ten-person taste panel evaluated the harvested cucumbers for color, taste, smell, and firmness attributes. Cucumber color was evaluated in three categories (1: light green; 2: green; 3: dark green); taste, smell and firmness were all evaluated in three categories (1-4: not good; 5-7: average (normal); 8-10: very good.

All cucumber were evaluated to be similar quality level. The panelists could not differentiate the cucumbers among the different treatments (Figure 15).

Figure 13. Sugar measuring device from Mettler Toledo.

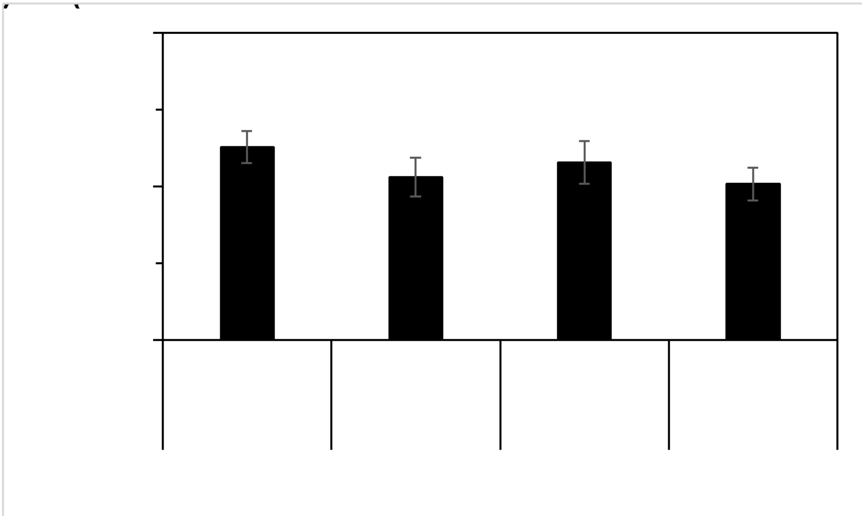


Figure 14. Effect of fertilizer and substrate types on sugar level of cucumbers. SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate

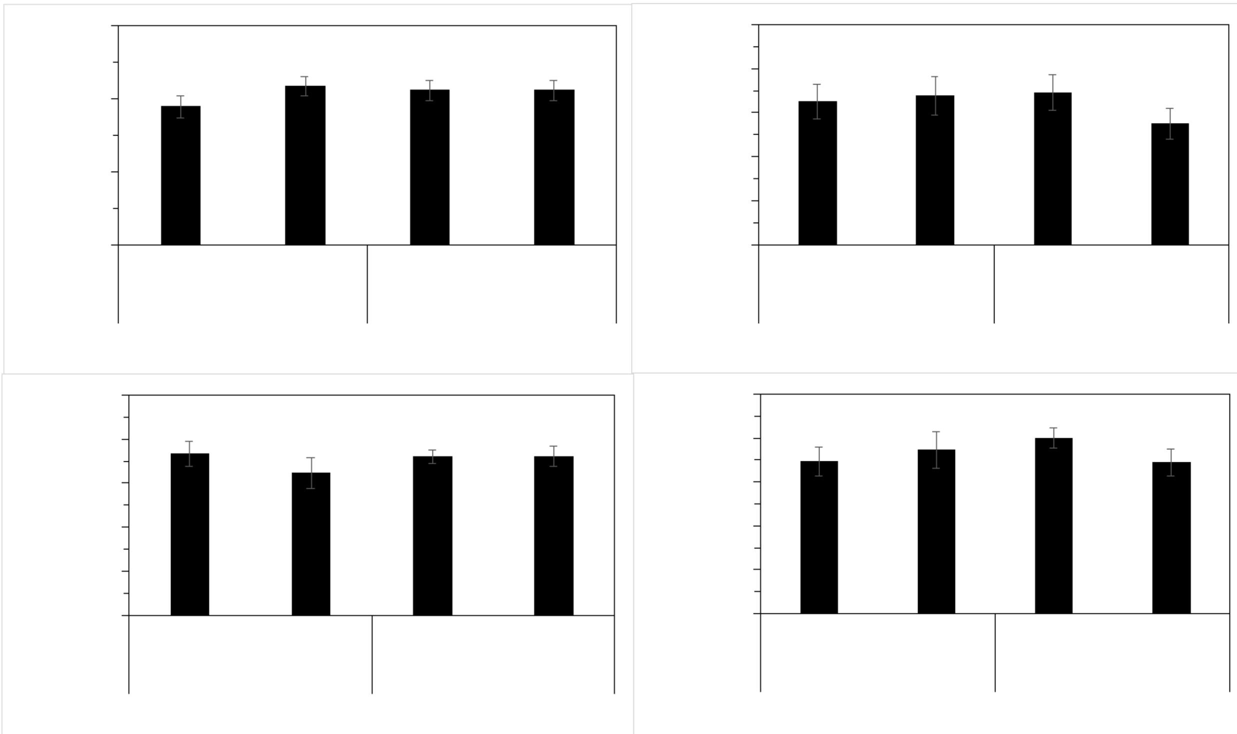


Figure 15. Effect of fertilizer and substrate types on color, taste, smell, and firmness of cucumbers. SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate

4.4. Soil properties analysis

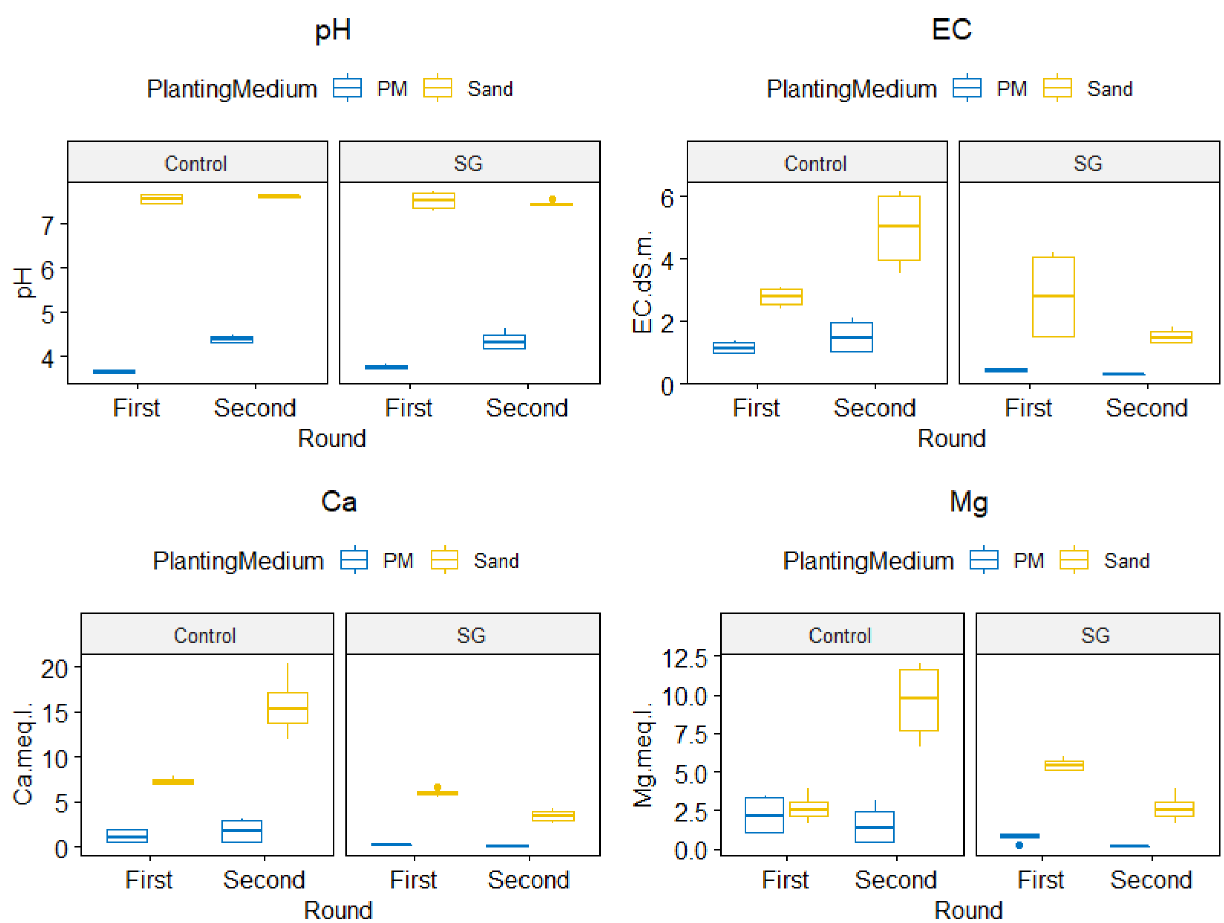
Two rounds of soil sampling for routine soil analyses were performed during the experiment – the first on June 22nd 2021, and the second on July 26th 2021. Subsamples were collected from each pot in every row and composited to create representative samples representing each planting medium and the treatment per row. Two replicates of each combination for each round were taken to the lab and analyzed for pH, EC, Ca, Mg, CO_3, HCO_3, Cl, Na, K and moisture.

As expected in the first round of sampling, there was no significant difference in all parameters due to the fertilizer type, whereas there were significant differences in most soil properties (parameters) between the two substrate types (PM vs sand) (Figure 16). In general, mixture of sand and compost had higher pH, Ca, Mg, CO3, HCO3 levels compared to peatmoss substrate. There was no difference in Na, Cl, and K levels between the two substrates.

In the second round, fertilizer type did significantly affected pH, ECe, CO3, HCO3, Cl and K levels in both substrates. Fertilizer type significantly affected Ca, Mg, and Na levels. All these three nutrients were higher in control fertilizer supplied soils than SG supplied soils (Figure 16). This may be explained by the additional microbial consumption of these nutrients in the SG samples relative to the control samples thereby diminishing their respective nutrient pools.

Substrate type significantly affected pH, Ca, CO3, HCO3, levels where higher levels of all were found in sand mixed with compost soil compared to peatmoss soil. ECe, Mg, Cl, and K levels were affected by substrate type (Figure 16).

The soil analysis result generally shows that the two-fertilizer types provided comparable nutrient level to the plants as shown with no statistically significant difference in ECe level (a measure of overall nutrient level). One interesting result is that Na level accumulated more (2.5 times) in control fertilizer supplied soils than SG supplied soils. This means that control fertilizer supplied plants would have to deal with more soluble Na levels which leads to stress.



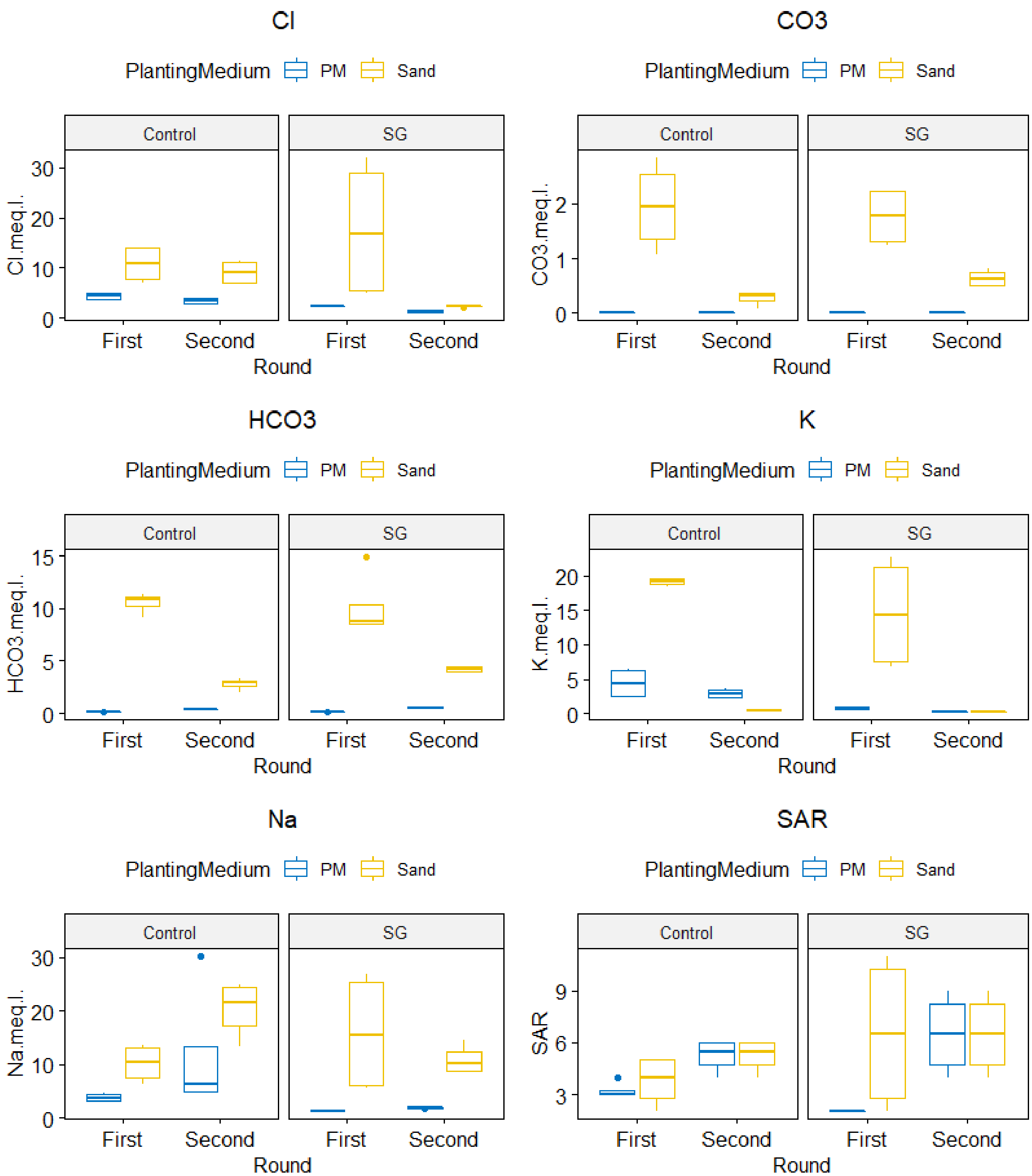


Figure 16: Soil analysis of key parameters in SG and Control soil samples in both sampling rounds. pH was measured in saturated paste for sandy samples and in 1:10 dilution in PM samples. EC of saturated paste extract was measured for sandy samples and 1:10 dilution for PM samples.

4.5. Drought stress tolerance

4.5.1. Irrigation and runoff volume

In order to assess the effect of the fertilizer and substrate type on water holding characteristics, a regulated deficit irrigation was applied. Irrigation was reduced 15% every other day from a full irrigation (1.8 L per plant per day) for 10 days. Figure 17 shows the gradual reduction of irrigation volume in the evaluation period. During this period irrigation volume as well as runoff (drainage) volume were recorded.

The runoff volume decreased as irrigation volume decreased in all the treatments (Figure 18). However, the runoff volume was always higher in pots irrigated with control fertilizer. The runoff volume from pots with peatmoss substrate and fertilized with SG decreased by 41%, 50%, 67% and 6% when the irrigation volume decreased to 85%, 70%, 55%, and 40% of initial levels respectively, compared to pots which received control fertilizer. Similarly, the runoff volume from pots with sand and compost mixture substrate and fertilized with SG, decreased by 17%, 50%, 43%, and 22% when the irrigation volume decreased to 85%, 70%, 55% and 40% respectively, compared to pots which received control fertilizer.

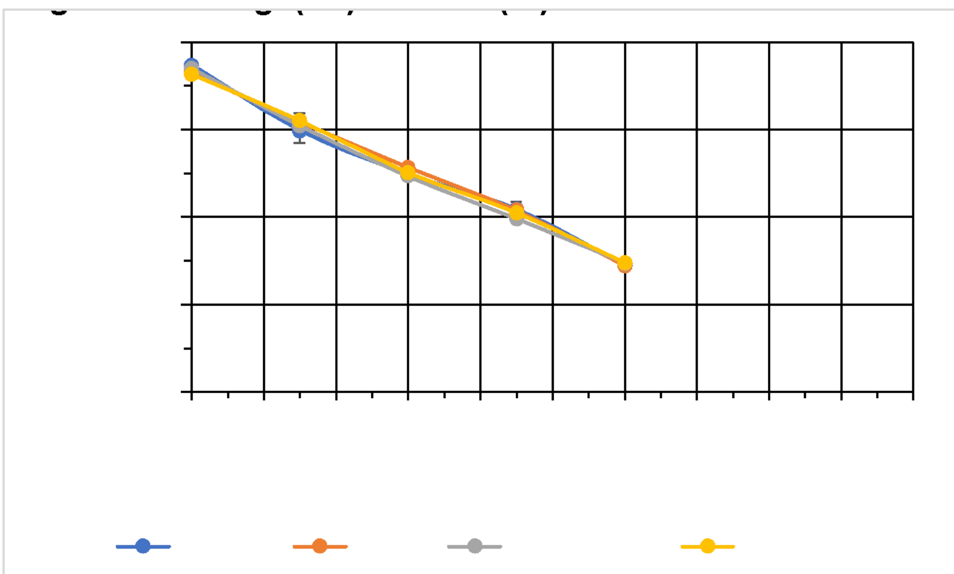


Figure 17. Irrigation volume reduction during the drought stress evaluation period. Irrigation decreased in a step of 15% every other day for 10 days.

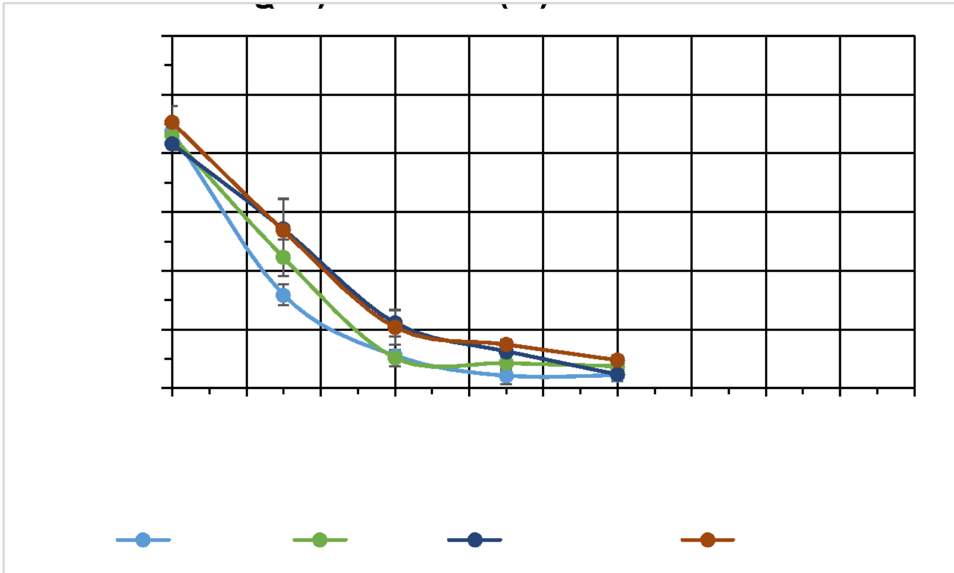


Figure 18. Runoff volume reduction as a function of irrigation volume reduction during the drought stress evaluation period. Irrigation decreased in a step of 15% every other day for 10 days.

4.5.2. Soil moisture

In addition to recoding the irrigation and runoff volume, soil moisture (Figure 19) was also recorded to understand the effect of the fertilizer regime on soil moisture retention properties of the substrates. As expected, the soil moisture level decreased as irrigation volume decreased in all the treatments (Figure 20). Fertilizer type did not significantly affect soil moisture level, however the soil moisture level in the two substrates were significantly different at two lowest drought levels (55% and 40%) (P = 0.0136). Peatmoss substrate retained higher soil moisture level than sand mixed with compost. The soil moisture levels in peatmoss fertilized with SG were 14% and 20% higher than that of soil moisture levels fertilized with control fertilizer at 55% and 40% deficit irrigation level respectively. Similarly, in sandy soil the soil moisture level of SG fertilized pots were 11% and 14% higher than control fertilized pots at 55% and 40% deficit irrigation level respectively.

Figure 19. Soil moisture measuring instrument.

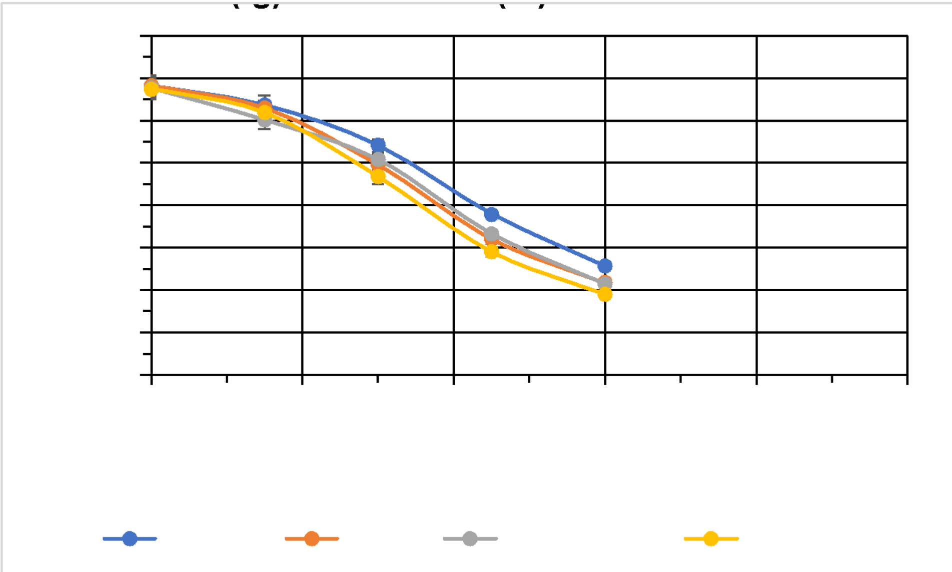


Figure 20. Soil moisture decrease (%) as a function of a decrease in irrigation volume from initial volume (%). SG: is Swift Grow liquid fertilizer; C: is control standard chemical fertilizer; PM: is peatmoss substrate whereas S: is sand and compost mixture substrate

4.5.3. Available Water Capacity

Available water capacity (AWC) is a soil health indicator that estimates a soil's holding capacity of plant-available water. The upper end of the range is referred to as 'field capacity' or the condition where saturated soil ceases to drain freely from gravity after wetting. The lower end of the range is called the 'permanent wilting point', when only water unavailable to plants is left after free drainage. AWC is determined from measuring water content at field capacity and permanent wilting point in the lab using 10 kPa and 1500 kPa pressure chambers for water extraction and calculating the difference. AWC was measured for the soil samples collected at the end of the experiment (n= 16). The results showed that there is no significant difference in AWC between SG and the control samples ($p = 0.82$) and that the only significant difference observed in the model is attributed to the difference in planting medium i.e. Sand versus Peat Moss ($p = 0.06$; Figure 21). This laboratory analysis result fits with field observation of soil moisture level.

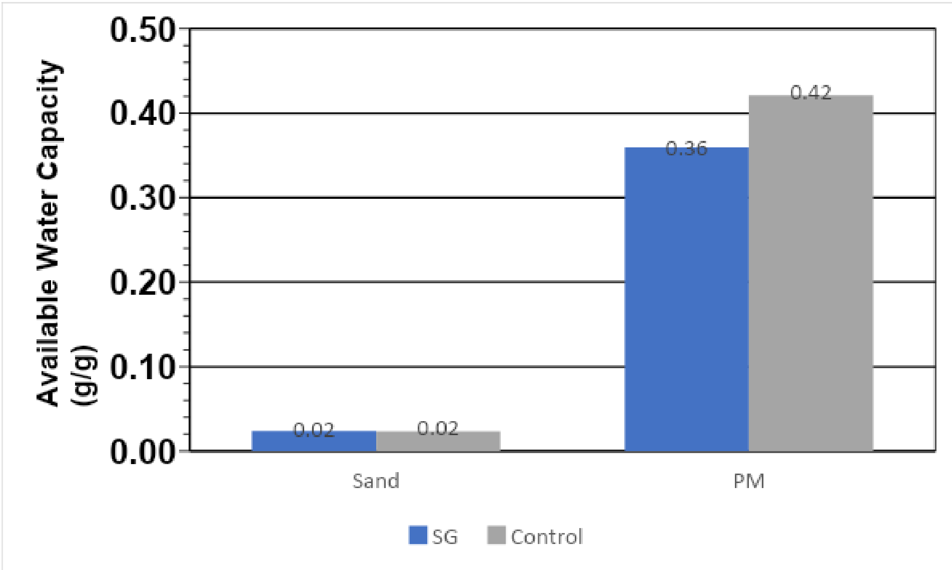


Figure 21. Available water capacity (g/g) for peatmoss (PM) and sand soil (sand) fertilized either with Swift Grow (SG) or control chemical fertilizer (Control).

The results from the soil analyses corroborate that SG as soil amendment has a relatively comparable effect on soil parameters to that of synthetic fertilizer, thus may be a good alternative for organic farmers. However, it must be noted that the addition of SG to soil may further deplete the soil's available nutrient reservoirs in favor of microbial consumption, thereby potentially effecting their relative availability to plants.

5. Discussion and Recommendations

Reducing fertilizer and water use in crop production is an overarching goal to ensure more sustainable and responsible use of resources. One way to achieve this goal is to use organic fertilizers which have limited availability and options. Therefore, it is important to develop and test organic fertilizers in the market for their effects on important parameters include such as yield and water use productivity.

In this research, we tested the efficacy of a fish waste organic, liquid fertilizer with the Swift Grow trademark, produced by River Stone Fish Farm, Australia (known in the UAE as Ocean Bio Fert), on cucumber crop cultivation.

The result indicate that SG liquid fertilizer can be used as alternative to chemical fertilizer as demonstrated by the similar yield and number of cucumbers harvested and similar speed of growth (plant height, internode number), as well as similar taste scored cucumber harvest.

The analysis of the effect of the fertilizer regime on soil moisture retention properties of the substrates was measured both in field and laboratory. The result showed no significant difference in soil moisture level as a result of the fertilizer choice. Although not significant, in general, SG fertilized soils had 11-14% higher soil moisture levels than control fertilized soils in peat moss substrate, whereas in the sand mixed with compost substrate, SG fertilizer increased (14 - 20% higher) soil moisture level compared to control fertilizer. This higher soil moisture level is partly as a result of a higher soil water holding capacity of the SG fertilized substrates as demonstrated by lower runoff (drainage) volume as in these substrates.

The similar yield and quality of harvested cucumber could be translated to higher income to farmers due to higher price of organically produced produces in the market. From environment conservation perspective SG provide alternative solution to standard farming practice which has relatively higher nutrient runoff and is harmful to beneficial microorganism within the soil.

6. Appendix

Photo of plants

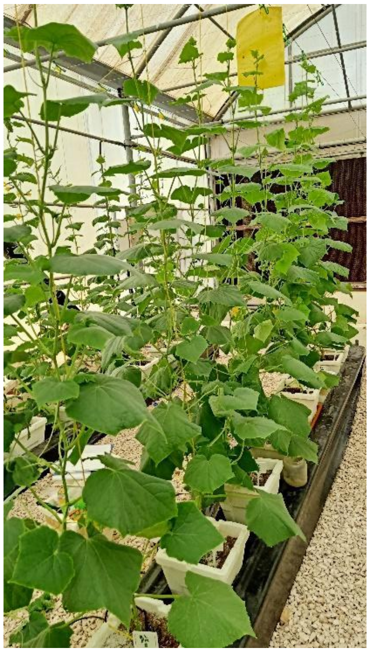
<table>
<tr><td>Row 1 (SG)</td><td>Row 2 (Control)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Row 3 (SG)</td><td>Row 4 (Control)</td></tr>
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Figure 22. Photo of plants on 18 July 2021.

Figure 23. View of the greenhouse on 14 July 2021.

Figure 24. View of plants in row 1 (SG) on 14 July 2021.

Figure 25. View of plants on 06 July 2021.