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Observation of Aqua-Bio fertilizer nutrients influence of *Trigonella foenum- graecum L.* growth in mediated Aquaponics system for food security.

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Abstract- The conception of Aquaponics is a synergistic combination of aquaculture and hydroponics that nurture plants with aquaculture water. It is the internationally improved agricultural practices, are needed to assuage rural poverty and enhance food security. Aquaponics is a soil-less combined approach to proficient and sustainable intensification of agriculture that meets the needs of water scarcity inventiveness and generated modern farming practices in agriculture. The nutrient-rich fish water from the fish tanks is used to fertigate hydroponic production beds. To improve the production efficiency can be used bio fertilizers (Aquaponic water and *Gracilaria corticata* extract) as a liquid it contains organic macro, micronutrient and growth hormones. Tilapia fish produced the nutrient that is utilized by the plant *Trigonella foenum- graecum L.* The Physico-chemical parameter of both bio fertilizers should be assessed by using the standard procedures. The fish effluent water is compared with the *Gracilaria corticata* red seaweed extract by foliar spray and combining with both liquid bio fertilizers (Aquaponic water and seaweed extracts). Morphological growths of the plants were assessed. The combination of Aquaponic water and *Gracilaria corticata* seaweed extract was given the good result, but the estimation (15.26± 0.29, 24.06± 0.27, 30± 0.64, 35.94 ±0.28 cm plant height at 7, 14, 21 and 28 DAS) (2.6± 0.1 branches at 30, DAS) (533.67 ±11and 51 ± 1 mg shoot and root fresh weight per plant) leaf area (46.62±0.89cm2) at 28 DAS was related to the Aquaponic water in the plant *Trigonella foenum- graecum L.* Thus, the present result revealed that the integrated aquaponic system is the new agricultural farming systems with liquid bio fertilizers are eco- friendly practice for food security.

Keywords: Aquaponics, Tilapia fish, *Trigonella foenum- graecum L., Gracilaria corticata* seaweed and liquid biofertilizer, eco-friendly

I. INTRODUCTION

Aquaponics is an integrated method that combines recirculating aquaculture and hydroponics [34], in which the water from the fish tanks that is enriched in nutrients is used for plant growth. Lehman *et al*., (1993) deliberated a sustainable agriculture as a process that does not exhaust any non-renewable resources that are fundamental to agriculture in order to endure the farming practices. Francis *et al.,* (2003) append that sustainable agricultural production can be achieved by resembling natural ecosystems and "designing systems that close nutrient cycles", which is the main characteristics of Aquaponics. The absolute product of bacterial conversion is a nitrate, which the main nitrogen source for plant growth in an Aquaponic system [12, 15, 35]. The lower nutrient concentrations are acceptable for an Aquaponics system because the nutrients are produced daily with the fish metabolic activities as well as mineralization of organic matter [36,16]. Conventional hydroponics necessitate mineral fertilizers in order to supply the plants with necessary nutrients, but the Aquaponics systems use the obtainable fish water that is rich in fish waste as nutrients for plant growth. The synergistic interaction of aquaculture and hydroponics are converted into strengths. This combination significantly minimizes the need for input of nutrients and output of waste, unlike when running as separate systems. Minerals transfer from aquaculture to hydroponics support efficient nutrient recycling and relatively safe food (fish and vegetables) [49]. Media-filled grows bed is the most popular intention of small-scale Aquaponics. This method is strongly recommended for most developing areas. This type has well-organized with space, low cost and are suitable for beginners because of their simplicity [30]. It was filled with coco peat because it has a pH neutral, low-cost, lightweight, high-water retention; support the plant in the medium level, easy to work but short lifespan [18]. The *Trigonella foenum-graecum* L. (Fenugreek) plants are grown in the media bed. It is the medicinal plant from the Fabaceae family originated in central Asia [1]. Its green leaves containing β-carotene (19 mg/100 g), ascorbate (220 mg/100 g) [48], fiber, iron, calcium and zinc even more than the regular food items [27]. The leaves and seedling of fenugreek are eaten as greens. The leaves have a bitter taste and a unique odour [44]. Moreover, the Tilapia (*Oreochromis niloticus*) fish has many favorable characteristics like poor water quality, wide salinity ranges, water temperature ranges, low dissolved oxygen levels, and elevated ammonia concentrations adopt in Aquaponic production [31]. Therefore, we have conducted experiments on Tilapia fish in this system.

***Gracilaria corticata* is used as a liquid fertilizer**

Gracilaria corticata Seaweed (marine macroalgae) has been used as fertilizer help to promote plant growth. The extract of this seaweed signs successful seed germination, saplings development, increase plant tolerance to environmental pressures [52,53] and improve plant growth and yield [17,55,20,21,6]. Foliar application of seaweed liquid gives many beneficial effects on the plant growth as they contain growth-promoting hormones (IAA, IBA and Cytokinins) [5,10,19]. Seaweed liquid is available in the market as liquid bio-fertilizer. Therefore, in this present study aimed to prove the Aquaponic water and seaweed liquid is the Aqua-biofertilizer with the growth performance of *Trigonella foenum- graecum L.* plants in the *Oreochromis niloticus* (Tilapia) mediated Aquaponic system.

Aquaponic System. a denotes Media Filled Aquaponic system; b represents plants grown in the Aquaponic System.

II. MATERIALS AND METHODS

The Aquaponic system was designed according to Bernstein (2014) model. The Aquaponic system was comprised of two fish tanks about 142 litres. The fish tanks were covered with aluminum net, it prevents fish from jumping out and prevent leaves, debris from entering and prevent predators such as cats and birds from attacking the fish. The tap water was located near the rearing tanks, supplied water for a short distance to the fish rearing tank. The conformity of nitrification and nutrient availability in the Aquaponics system was acquired pH= 7. The fish tanks were aerated with 10-watt motor to avoid insufficient oxygen level. The water from the fish tanks were flowed by the gravity and then it was entering the hydroponic grow bed. The pipes were plumped to join media- filled grow bed with the fish tank having inlet and outlet of water. An overflow pipe was set at 10 cm for maintaining a constant water level in the plant bed. The hydroponics media- filled grow bed was filled with Aquaponic water; it was drained and entered into the sump tank. The capacity of the sump tanks were 20 liters. It was the lowest part of the system. The submersible pump was fitted inside the sump tank that was returned the treated culture water to the rearing tank. The procedure was followed in both the tanks. About 20 nos of 2.5cm length and 4-6 gm Tilapia fingerlings were bought from the Ukkadam Periyakulam, Coimbatore, Tamil Nadu. Further, they were fed with floating feed three times a day with 12.0 gms, fish food containing 32% protein.

2.1 Media filled grow bed

Trigonella foenum- graecum L. plant was grown in the coconut peat as a medium. The four media filled grow beds were chosen for plant cultivation [3], the wooden frame with watertight polyethylene sheeting on the base and inside the walls. The beds were filled with coco peat. The size of the media beds was 50 cm x 30 cm x 40 cm in the rectangular shape. The water holding capacity or volume of the four beds was 45 litres. Beds are designed to flood-and-drain. The first tank was connected with the T_2 grow bed and another tank was connected with the T_4 grow bed.

2.2 Collection of the seed

The *Trigonella foenum- graecum L* plant seeds were bought in the Tamil Nadu Agricultural University (TNAU), Coimbatore. The seeds with uniform size, color and weight were chosen for the experimental purpose. A hundred seeds were soaked in the water overnight for germination. The four grow beds were directly sown with seeds. In each media-filled grow bed 25 seeds were sown because it was helped to measure the seed germination days. The procedure was followed in each grow bed.

2.3 Collection of seaweed

The seaweed was collected in Ramanathapuram district, Tamil Nadu in the latitude of 9° 17'N and longitude of 80°10'. The extract was prepared from the red seaweed *Gracilaria corticata.* About 1 kg of fresh and healthy seaweed was collected. The sample was washed thoroughly in seawater followed by tap water to remove the extraneous materials and sand particles.

2.4 Preparation of seaweed liquid fertilizer

The freshly collected seaweed was shade dried for ten days that dried material was finely powdered. From the dried powder, 50 grams of powder were extracted with 500 ml of boiling water for 60 min and then filtered. The resulting extract was cooled and taken as a 100 % concentration of the SLF [37]. The seaweed liquid fertilizer was refrigerated between 0°C and 4 °C.

2.5 Experimental design and treatments

The effect of Aquaponic fish effluent water and seaweed extracts on the growth of fenugreek was evaluated using various treatments applied as coco peat used media filled grow beds. The treatment dose was 20% seaweed liquid fertilizer. [54,33]. Low concentration is effective for greens. The seaweed liquid fertilizer was given weekly once.

T_1 grow bed was a control, T_2 was Aquaponic water, T_3 was seaweed liquid fertilizer (20%) and T_4 was Aquaponic water and 20% seaweed liquid fertilizer.

Figure 1. Seaweed, *Gracilaria corticata*

Table 1 Experimental design with different treatments.

S.No	*Experiment*	*Component of Experiment*
1	T1	Cocopeat+Tapwater
2	T2	Cocopeat+Aquaponic fish effluent water
3	T3	Cocopeat+Gracilaria corticata seaweed liquid extract
4	T4	Cocopeat+ Aquaponic fish effluent water+Gracilaria seaweed extract.

2.6 Physico-chemical properties of Aquaponic water and *Gracilaria corticata* seaweed

The physico-chemical parameter such as pH (Hanna, HI98107), Calcium, and Magnesium, Sodium, and Potassium (Varian spectra-220AA atomic absorption spectrophotometer) of Aquaponic water and seaweed extract were recorded.
The growth parameter of *Trigonella foenum- graecum L* plant was observed at 7days interval that included average height (by meter rule), seed germination, and the leaf area was calculated (LA=0.5*L*W, Where: LA=Leaf area) [32]. The average number of plant branches was counted and measured in biomass. The results were performed by using Microsoft Excel, 2010.

III. RESULTS AND DISCUSSION

3.1 Macro and micronutrients present in the aquaponic water:

Macro and Micronutrients of the Aquaponic water values were shown in the Tables 2 and 3. The results showed that Ammonium concentration level in the Aquaponic water and Nitrate levels were 0.35±.02 mg/l and 37±1.2 mg/l respectively, nitrate level was higher in Aquaponic water. Phosphate is an important ingredient nutrient. This value of phosphate found in Aquaponic water was marked as 11±1.15 mg/l. The potassium level was recorded as 26±1.15 mg/l. Calcium and Magnesium levels were 30±.6 mg/l and 16.2±.8 mg/l. The micronutrients of the Iron level was recorded as 0.2±.06 mg/l. Zinc and manganese content were at the scale 0.4±.0601mg/l, 0.08±.01mg/l (Table 2).

Aquaponic water as noted by Licamele (2009) observed higher growth (50 mg/l N-Nitrate) in *Lactuca sativa* in an aquaponic integrated system. Similarly, the present result indicated that higher plant growth (***Trigonella foenum- graecum L)*** as observed in Aquaponic water was 37 mg/l. Endut *et al*., (2011) observed that the phosphorus (P) concentration of aquaponic water was within the above limit.The present result also indicated a similar aquaponics system. The minimal concentration of aquaponic water was acceptable to the plants in the form of continuous aquaponic fish effluent. This concentration has been found to be sufficient for the plant growth because the available nutrient was often enriched by the aquaponic water. It helped the root formation along with the growth. Villarroel *et al.,* (2011) reported that the growth of strawberry was higher with potassium concentration at 9-15mg/l, while using aquaponic water (*Oreochromis niloticus*). The present result also indicated that the concentration at the level 26±1.15 mg/l, has been solely responsible for the higher plant growth with enhanced photosynthetic efficiency. Tomasi *et al*., (2009); De Vleesschauwer *et al*., (2008); Schalk *et al*., (2011) reported that the concentration of Iron, Zinc and manganese could be delivered to the plants, especially the shoot system, leaves has been prevented pathogen attack for a long time and also reported that the ability of these molecules to induce systemic resistance in the tomato cultivation.

Table 2 Macronutrients in the Aquaponic water and *Gracilaria corticata* liquid seaweed

S.No	*Macronutrients*	*Aquaponic water* (mg/L)	*Gracilaria corticata* seaweed liquid (mg/L)
1	Ammonium	0.4±0.02	-
2	Nitrate	37±1.2	56±0.4
3	Phosphate	11±1.15	15±0.3
4	Magnesium	16±0.8	49±0.7
5	Calcium	30±0.6	72±0.6
6	Potassium	26±1.15	10 ±1.8

Mean±SE

3.2 Macro and micronutrients present in the *Gracilaria corticata* seaweed

Nitrate level in the *Gracilaria corticata* seaweed was 56±0.4 mg/l. Calcium, Magnesium, Potassium and Phosphorus level were 72±0.6, 49±0.7, 10.11±1.8 and 15±0.3 mg/l (Table 2**)**. Iron, Manganese, and Zinc present in the seaweed were 0.44±0.9, 0.32±0.3, 0.75±0.3 mg/l (Table 3). Macro and micronutrients and growth hormones found in the seaweed were supporting the plant growth [13,54,33]. It was reported that the presence of plant growth regulators and nutrients in the low concentration of SLF enhanced the growth of root and shoot [28]. Growth hormones Auxin, Cytokinin and Gibberellin levels in the *Gracilaria corticata* were 3.1, 9.3 and 5.2mg/l respectively (Table 4). They play a pivotal role in the growth of plants. Auxin increases the production and let water enter into the cells, activating H-ATPase pumps. This procedures lead to the growth of cells and simultaneously helps the growth of plants [46]. The findings reported the presence of auxin in the extracts of *Ascophyllum nodosum* [39] and *Ulva sp.*, in the extracts of cytokinins [41]. The present study showed that extracts from the *Gracilaria corticata* has been instrumental in promoting the growth characteristics of fenugreek plants.

Table 3 Micronutrients in the Aquaponic water and liquid of *Gracilaria corticata*

S. No	Micro nutrients	Aquaponic water (mg/L)	*Gracilaria corticata* seaweed liquid (mg/L)
1	Iron	0.2±.1	0.44±0.9
2	Mn	0.4±.06	0.32±0.3
3	Zn	0.08±.01	0.75±0.5

Mean±SE

Table 4 Growth Hormone (GH) in the liquid seaweed of *Gracilaria corticata*

S.No	*Growth Hormones*	*Gracilaria corticata* (mg/l)
1	Auxin	3.1
2	Cytokinin	9.3
3	Gibberellin	5.2

3.3 Morphological Analysis

3.4 Seed germination of *Trigonella foenum- graecum l.* Plant

The seed germination was observed in the *Trigonella foenum- graecum L.* (Fig.1) seed, which was used in the different substratum. A hundred seeds were selected for germination. The seeds were soaked in the distilled water overnight, then 25 seeds were being sown in each grows bed. In the Aquaponic water mixed with foliar sprays of *Gracilaria* seaweed, seeds germinated within 2 days.The similar result was observed and followed by the *Gracilaria corticata* seaweed used in the media bed, the seeds germinated in 3 days and in control media bed it took 4 days. This result indicated that the aquaponic water used with seaweed extract seeds has a higher growth rate while compared to the *Gracilaria* seaweed and the control**.**

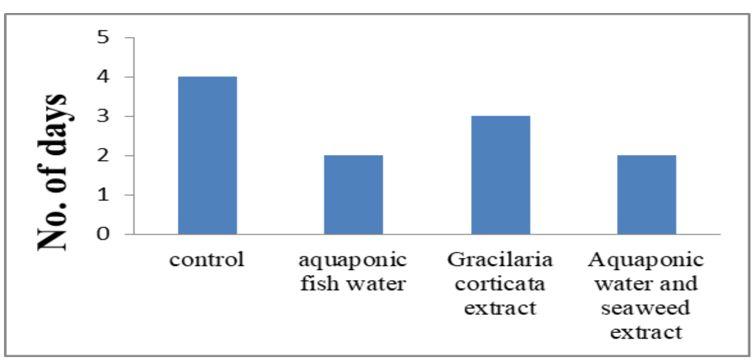

Figure 2. Seed germination of *Trigonella foenum-graecum*

3.5 Plant height (cm)

The plant height was recorded at 7,14,21, and 28 days after sown (DAS). The average fenugreek plant height was depicted in the Table5, as clearly indicated in different treatments. Treatment T4 (Aquaponic fish water+ seaweed liquid fertilizer) was found significantly superior plant height (15.26± 0.29, 24.06± 0.27, 30± 0.64, 35.94 ±0. 28 cm plant height of 7, 14, 21and 28 DAS) followed by T2 (Aquaponic water) (14.14 ±0.99, 21.42± 1.08, 28.14± 1.39 and 34.28 ±0.54 cm plant height) and T3 (seaweed liquid fertilizer) (9.46 ±1.02, 17.68±1.17, 23.9±1.42 and 30.22±0.80 cm plant height). The lowest growth was observed under the treatment T1 (control) (7.02 ±3. 89 12.2 0±.29 17.6 0±.63 and 25.58 ±0.64 cm plant height) at 7, 14, 21 and 28 DAS respectively. This may be due to the application of major and minor nutrient level through liquid bio-fertilizer that helped to increase the photosynthetic activity, Chlorophyll formation, Nitrogen metabolism and Auxin contents in the plants ultimately improving the plant height. These findings are also comparable with the findings of Subramanian and Vijayakumar (2001) Malhotra *et al.* (2006) in fenugreek.

Table 5 plant height of fenugreek at 7, 14, 21, 28 days

Treatment	No of days (cm) N=5			
	7	14	21	28
Control	7.02 ±3.89	12.2 0±.29	17.6 0±0.63	25.58 ±0.64
Aquaponic water	14.14 ±0.99	21.42± 1.08	28.14± 1.39	34.28 ±0.54
Seaweed liquid	9.46 ±1.02	17.68± 1.17	23.9± 1.42	30.22± 0.80
Aquaponic +seaweed liquid	15.26± 0.29	24.06± 0.27	30± 0.64	35.94 ±0.28

Mean±SD

3.6 Number of branches per

The number of branches per plant was recorded at 28DAS present in Table 6. Treatment T4 (Aquaponic fish effluent water+ seaweed liquid fertilizer) was found higher (2.6±0.1 branches in 28, DAS) followed by T2 (Aquaponic fish effluent water) (2.2±0.18 branches), T3 (seaweed liquid fertilizer, 2.06 ±0.08 branches). While the lowest branches noted in the treatment T1 (control) (1.28 ±0.23branches) at 30 DAS. Similar results have been reported by Datta *et al.*, 2005), and Nehara *et al*., (2002). These findings relate to the findings of Malhotra *et al.* (2006) reported that the *Azospirillum* sp. The number of branches was increased by greater nitrogen levels.The probable reason for the increased number of branches due to the improved rates of photosynthesis, supplied essential nutrients for maximum branch growth or change in auxin apical dominance.

3.7 Shoot and Root weight per plant (mg.)

The shoot and root weight of the fenugreek plant increased within the different treatments were given in Table 6. The maximum 533.67 ±11and 51 ± 1 mg shoot and root fresh weight per plant was recorded in treatment T4 (Aquaponic fish effluent water+ seaweed liquid fertilizer), followed by T2 (Aquaponic fish effluent water) (481± 5.5, 51±1mg), T3 (seaweed liquid fertilizer) (450. 67±7.09, 46±1mg) and While the lowest shoot and root weight was found inT1 (control) (410.67 ±11, 43.3 ±1.5mg). This may be due to the application of major and minor nutrients, through both liquid bio-fertilizer. Ultimately, improve the plant growth fresh weight and dry weight of the plant. These results were concurred with the findings of Sharma (2006), Subramanian and Vijayakumar (2001), Mehta *et al.* (2012) in fenugreek.

Table 6. Number of branches per plant, shoot and root fresh weight of fenugreek at 28 days

Attributes	Treatment after the 28 days			
	Control	Aquaponic	Seaweed	Aquaponic+seaweed
Shoot fresh weight (mg/plant)	410.67 ±11	481± 5.5	450. 67±7.09	533.67 ±11
Root fresh Weight (mg/plant)	43.3 ±1.5	51 ± 1	46± 1	51 ± 1
Branches	1.28 ±0.23	2.2 ±0.18	2.06 ±0.08	2.6± 0.1

Mean±SD

3.8 Leaf area

The data (Table 7) revealed that the difference among treatments with the leaf area at different stages of plant growth. The mean leaf area increased from 1.14±0.13 cm^2 at 7 DAS to 46.62±0.89cm^2 at 28 DAS. The aquaponic water showed a maximum leaf area (46.62±0.89cm^2) at 28 DAS, whereas, the control showed the minimum leaf area (24.04±0.61cm^2) at 28 DAS. The number of leaves is dependent largely upon the number of nodes and also on the number of branches both primaries and secondaries arising on the main shoot of the plant. The findings were harmony with the results of Nehara *et al.*, (2002).

Table 5 plant height of fenugreek at 7, 14, 21, 28 days

Treatment	No of days (Cm^2/plant)			
	7	14	21	28
Control	1.14±0.13	2.12± 0.13	11.32±0.19	24.04±0.61
Aquaponic	2.24±0.25	5.36±0.27	24.64±0.47	43.34±0.24
Seaweed	2.2±0.25	4.74±0.11	22.62±0.40	38.12±0.13
Aqua+seaweed	2.66±0.27	5.44±0.23	27.2±0.83	46.62±0.89

Mean±SD

IV. **CONCLUSION**

This study concludes that Aquaponic water and seaweed liquid fertilizers are Aqua bio-fertilizers and eco-friendly products which has given different effects on the growth of *Trigonella foenum- graecum L* cultivation indeed improves the yield and quality of the plant while physical growth is also enhanced. The lower concentration of aquaponic water was acceptable to the plants *Trigonella foenum- graecum L* because continuous supply of aquaponic water. Hence, this simple practice of application is an eco-friendly and sustainable food production system.This soil-less culture system is modern farming practices in agriculture for food security.

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