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Symbiotic Between *Oreochromis niloticus* Fingerlings and Some Medicinal Plants: Growth Performance and Water Quality Enhancement

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ABSTRACT

Aquacultural scholars and experts should create new plans to sustain aquaculture, with a minimum negative impact on the environment since aquaculture activity affects the environment and is further complicated by the paucity of good-quality water and land. As a result, a symbiotic experiment involving fish and plants was carried out to ascertain how the two organisms affected one another. The deep Flow Technique was created as a hydroponic system in its simplest form. Mentha spicata L. (mint) at 46 cm TL, *Ocimum basilicum* L. (basil) at 43.5 cm TL, *Origanum majorana* (marjoram) at 37 cm TL, *Salvia Rosmarinus* (rosemary) at 33 cm TL, and *Origanum syriacum* (thyme) at 34.7 cm TL were the plants utilized in this experiment. 400 fish/pond (1.3 g wet weight) of the *Oreochromis niloticus* L. species of tilapia fingerlings were stocked. A commercial feed for specific species (with a crude protein content of 25 percent) was represented as the diet in this experiment. Four plants and a control treatment comprised the five treatments, each of which had three replicates. The findings showed that using medicinal herbs improved the quality of the water, especially when compared to un-ionized ammonia (NH_3) values in both basil and marjoram. Basil and mint ponds had the greatest fish performance results without any discernible variations, while rosemary ponds had the best survival rate at 96.25%. The performance of some medicinal plants as well as the purity of the water is both benefited by symbiotic relationships with both fish and plants. In order to assess the impact of intense culture on the effectiveness of this program, more studies must be conducted.

INTRODUCTION

Aquaculture is considered one of the most effective mankind activities for it provides protein-rich food resources. Thus, to meet the demand of the present food supply, artificial commercial fish farms have been established worldwide. The key to this activity enterprise's success is creating the best conditions for quick output at the lowest possible resource and capital cost. Given that the aquatic environment is a complex ecosystem with many different water quality factors **(Ebeling & Timmons, 2012)**, fish production varies depending on pond-specific parameters such as water temperature, pH, salinity, water level, dissolved oxygen, and fish density **(Tacon, 2018; Brooks & Conkle, 2019)**. The concentration of both oxygen and ammonia in cultured ponds is of primary importance since all fishes as well as their food organisms depend on dissolved oxygen for their respiration **(Zain *et al.*, 2018)**. A sharp drop or an increase within their limits has negative effects on their biological and physiological functions **(Bhatnagar & Devi, 2013)**. Hence, good water quality is essential for the survival and growth of fish.

Several academic and applied research suggested the use of biological, bioremediation techniques and treatment to reduce fish farm impacts. One of the most successful technologies is an aquaponic system. The European Union (EU) Parliament has identified the aquaponics system as one of the "ten technologies that could change our lives" **(dos Santos, 2016)**. The biological wastes (ammonia, salts) that fish exhale are used as fertilizers by plants in aquaponics systems. As a result, this technique enables plants to filter out unwanted nutrient wastes from the water and permits the water to be used again for fish. **(Palm *et al.*, 2018b)**. In fact, in AP systems, the bulk (> 50%) of the nutrients necessary for plants to develop as healthily as possible comes from the leftovers from feeding the aquatic organisms **(Lam *et al.*, 2015; Palm *et al.*, 2018a)**.

The potential of medicinal plant application in hydroponics **(Giurgiu *et al.*, 2014)** and aquaponics **((Abdel-Rahim *et al.*, 2019)** systems has been investigated. Recently, these kinds of plants are considered economical species for supporting various industries such as pharmacological, cosmetics, herbs industry as well as healthy food **(Espinosa Moya *et al.*, 2016; Espinosa-Moya *et al.*, 2018b)**.

Therefore, this work aimed to evaluate the efficiency of using four herbaceous plants: *Salvia Rosmarinus* (rosemary), *Origanum majorana* (Marjoram), *Ocimum basilicum* L. (basil), and *Mentha spicata* L. (mint) on the Nile tilapia fingerling production, within a floating raft aquaponic system.

MATERIALS AND METHODS

1. Experimental design and cultural conditions

The experiment was held on a commercial farm in Kafr El-Shikh governorate, Egypt. When it continued for 75 days. *Oreochromis niloticus* fingerlings were obtained from a commercial Hatchery, Kafr El-Shikh governorate, Egypt. Additionally, a commercial diet was purchased containing 25% crude protein.

Twelve rectangle concrete basins (24m^2 each) stocked with tilapia fingerlings (*Oreochromis niloticus* L.) were used at a stocking density of 400 fish per each (1.3 g wet weight). The feeding diet (Table 1), 3 ml in size, specific for species was supplied at satiation and divided into two doses during the day (9:00 h and 14:00 h). At the beginning and end of the experiment, the fish were weighed on a scientific digital scale, model 21-2544-09.

Table 1. Chemical composition of the commercial diet used during the experimental period

Chemical composition	%
Crude protein	25
Crude lipids	4.5
Ash	5.1
Crude fiber	4.3
Nitrogen-free extract ([1]NFE)	61.1
Phosphorus	0.7
[2]GE	434.70

[1]NFE = 100 _ [% ash + % lipid + % protein + % fibre].
[2] GE was calculated as 5.64, 9.44, and 4.11 kcal/100 g for protein, lipids, and NFE, respectively **(NRC, 1993)**.

1.1. Aquaponic systems and water supply

The hydroponic system was designed as Deep Flow Technique (DFT) in its simplest type. Commercial foam panels were used to fix the plants on the water pond surface. Four panels were supplied to each pond (3×8×0.8 m). Each panel contained 10 plants (Fig. 1) covering about 4.38% of the total pond surface area.

1.2. Medicinal plants

The plants used in this experiment were *Mentha spicata* L. (spearmint) 46cm total length (TL), *Ocimum basilicum* L. (basil) 43.5cm TL, *Origanum majorana* (Marjoram) 37cm TL, *Salvia Rosmarinus* (rosemary) TL 33cm and *Origanum syriacum* (Oregano) obtained from a commercial plantation at age of 60 days. 10 plants were randomly placed in each HB, and one species per system was used. At the beginning and end of the experiment, all plants were weighed.

2. Measured parameters

2.1. Growth performance of fish

At the end of the experiment, final body weight (FW), weight gain (WG), average daily gain (ADG), specific growth rate (SGR) and survival rate were calculated according to the following equations:

Weight gain (WG, g/fish) = W_0-W_t

Where, W_0: initial mean weight of fish in grams, and

W_t: final mean weight of fish in grams.

Average daily gain (g/fish/day): ADG = $W_0 - W_t / n$

Where, n: experiment period (days).

Specific growth rate: (SGR %day) = 100 × (ln W_t − / ln W_0) / days

Where, ln: natural logarithm.

Survival rate (%) = 100 × (initial number of fish / final number of fish)

Fig. 1. Deep Flow Technique panels covering about 4.38% of the total surface area of the pond

2.2. Feed utilization of fish

Feed intake (FI, g): This is the amount of feed given or supplied during the experimental period.

Feed conversion ratio (FCR, g): FCR = dry matter intake (g)/body weight gain (g).

Protein efficiency ratio (PER) was calculated according to equation of **Pérez-Sánchez *et al.* (2014)**:

PER = weight gain (g)/ protein intake (g)

Protein productive value (PPV, %):

PPV % = 100 × (final body protein content – initial body protein content)/protein consumed (g)

2.3. Whole-body proximate chemical composition

Homogenized samples were analyzed in triplicate for moisture, protein, lipids, and ash. Protein analysis was conducted according to the study of **AOAC (2000)**, while moisture (fish sample) was determined by oven drying at 70°C to constant weight. Ash content was evaluated by combustion in a muffle furnace at 550°C.

2.4. Plant parameters

To determine plant variables, four out of every 10 plants in each HB were randomly selected and measured at the beginning and end of the experiment, where the length (midrib) and the width of the middle part of 6 randomly selected leaves were measured, without cutting the plant, using standard millimetric paper. The absolute growth rate (AGR) was also calculated on a wet base (WB) according to the equation used in the work of **Aristizábal (2008)** as follows:

AGR (g plant day-1) = (Final Weight (WB) - Initial Weight (WB))/day experimental period

The latter was determined according to the equation of **Ruiz *et al.* (1997)** and **Sánchez (1999)** as follows:

Specific leaves area (SLA) (cm^2) = Length × width × 0.08

2.5. Water quality measurements

Physico-chemical parameters were determined in ponds: Temperature (°C) was determined by LOVibond Sensodirect 150, while pH and dissolved oxygen (DO, mg L-1) were evaluated with HANNA equipment HI98193 BOD/OUR/SOUR Meter. On the other hand, total ammonia was determined by using HANNA HI83399 Multi-parameter photometer with COD; then, un-ionized ammonia values were calculated according to temperature and pH values.

3. Statically analysis

All data were presented as mean ± standard error. The statistical analysis was performed using SPSS V. 21 (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Analysis of variance, one-way ANOVA, was used to evaluate the effect of using some medicinal plants on water quality and growth performance of the Nile tilapia fry. The difference within each experimental treatment was evaluated using the TUKEY test at a probability level of 0.05.

RESULTS

1. Fish growth performance

The results of the Nile tilapia *Oreochromis niloticus* growth performance as a result of herbs usage characterized as FBW, Gain, ADG, SGR, RGR, and SR% are represented in Table (2) and Fig. (2).

These results indicate that there were no significant differences between treatments. Nevertheless, the symbiotic between the Nile tilapia and basil resulted in the best growth performance compared to all other herbaceous plants. FBW, Gain, ADG, SGR, and RGR values were determined as 9.02g, 7.72g, 0.11g/day, 2.59%/day, and 693.90%, respectively.

While, rosemary showed the least values of FBW, Gain, ADG, SGR, and RGR (7.34g, 6.04g, 0.08 g/day, 2.31%/day, and 564.32%, respectively). Conversely, the Nile tilapia fingerlings presented the best survival rate in the case of using rosemary (96.25%), compared to all other treatments, without any significant differences. Whereas, the control treatment and basil treatment exhibited the same least value (91%).

Table 2. The effect of using herbal plants on growth performance of the Nile tilapia *Oreochromis niloticus* fingerlings for 75 days

Treatment	IBW (g)	FBW (g)	Gain (g)	ADG (g/day)	SGR (%/day)	RGR (%)	SR (%)
Control	1.3±0.00	7.72±0.010	6.42±0.01	0.09±0.00	2.38±0.005	593.82±0.01	91.00±1.00
Mint	1.3±0.00	8.88±0.095	7.58±0.10	0.10±0.00	2.56±0.010	682.69±0.01	91.25±1.75
Basil	1.3±0.00	9.02±0.380	7.72±0.38	0.11±0.01	2.59±0.06	693.90±0.06	91.00±4.00
Marjoram	1.3±0.00	8.11±0.885	6.81±0.89	0.09±0.01	2.44±0.14	623.31±0.15	95.75±3.25
Rosemary	1.3±0.00	7.34±0.040	6.04±0.40	0.08±0.00	2.31±0.01	564.32±0.01	96.25±3.75
Oregano	1.3±0.00	8.29±0.710	6.99±0.71	0.09±0.10	2.47±0.00	637.50±0.12	94.38±5.63

*Values are means ± SEM; *n* = 3 per treatment group.
*Means in a row without a common superscript letter differ ($P< 0.05$) as analyzed by one-way ANOVA and the shuffle's test.

EG (cal.) and EU (%) exhibited different tendencies, as the least values of EG (cal.) were obtained by control and oregano treatments (9.8±1.86 cal. and 10.1±3.66 cal., respectively). While, the highest values were detected for both basil and mint treatments (11.47±1.55 cal. and 11.35±0.50 cal., respectively). Additionally, the highest value of EU% was that recorded for the control treatment, with a value of 24.07±1.86%, followed by basil and oregano (21.04±1.55% and 20.45±3.66%, respectively).

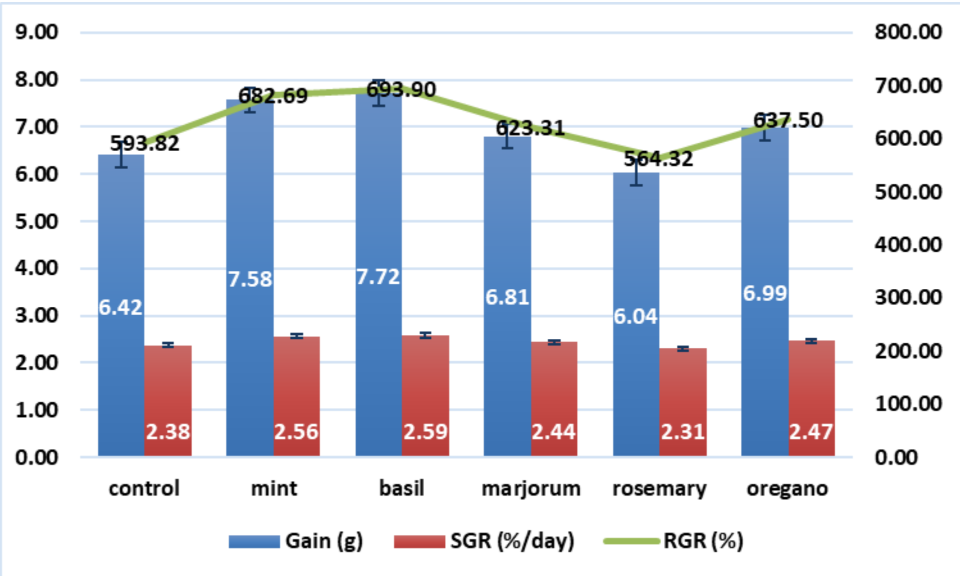

Fig. 2. Effect of using different medicinal plants on growth performance of the Nile tilapia *Oreochromis niloticus* fingerlings

2. Feed utilization of fish

The effect of using herbal plants on the feed utilization of the Nile tilapia *Oreochromis niloticus* fingerlings signified as FI, FCR, PER, PPV, EG, and EU are demonstrated in Table (3).

The results revealed that there are no significant differences between all treatments. The highest value of feed intake (FI g) was attained by basil treatment with 12.65±1.37 g, followed by mint and marjoram (12.58±0.48g and 12.44±0.82g, respectively). Whereas, the least value was obtained by control treatment, with a value of 9.4±0.36g. Subsequently, the best value of FCR was that of the control treatment, attaining a value of 1.46±0.06g. The worst values were those recorded for both marjoram and rosemary (1.84±0.12g and 1.93±0.14g, respectively), without any significant differences. Following the previous results, the control treatment attained the highest PER and PPV values (2.74±0.14 and 42.4±2.41%, respectively), followed by basil and oregano. Their PER gave the same value (2.46g) for the two plants, and PPV recorded 38.12±2.06% and 36.96±5.88% for these plants, respectively.

Table 3. The effect of using herbal plants on feed utilization of the Nile tilapia *Oreochromis niloticus* fingerlings for 75 days

Treatment	FI (g)	FCR (g)	PER (g)	PPV (%)	EG (cal.)	EU (%)
Control	9.40±0.36	1.46±0.06	2.74±0.14	42.40±2.41	9.80±1.86	24.07±1.86
Mint	12.58±0.48	1.66±0.04	2.42±0.09	36.91±1.32	11.35±0.50	20.78±0.50
Basil	12.65±1.37	1.64±0.10	2.46±0.12	38.12±2.06	11.47±1.55	21.04±1.55
Marjoram	12.44±0.82	1.84±0.12	2.19±0.17	34.46±2.16	10.39±1.07	19.14±1.07
Rosemary	11.65±0.77	1.93±0.14	2.08±0.13	31.45±1.23	8.84±0.93	17.52±0.93
Oregano	11.45±0.48	1.66±0.24	2.46±0.38	36.96±5.88	10.1±3.66	20.45±3.66

*Values are means ± SEM, *n* = 3 per treatment group.

*Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by one-way ANOVA and the shuffle's test.

3. Whole-body proximate chemical composition

The carcass composition of fish as a manifestation of a cooperative rearing system with herbaceous plants is displayed in Table (4). The chemical composition of the Nile tilapia *Oreochromis niloticus* fingerlings is equivalent to both growth performance and feed utilization parameters. Significant differences were not identified among treatments. Oregano treatment accomplished the best protein content (52.09±0.43%), followed by marjoram (51.86±0.17%), which carried out nearly the same content as well as all other treatments. Nevertheless, lipid content was at its highest in control and mint treatments (23.48±1.39% and 23.15±0.25%, respectively).

Remarkably, all other treatments offered almost the same value (about 22%). Similarly, dry matter content showed the highest values in the three treatments of marjoram, rosemary and oregano (30.04%), whereas its value was at its lowest in mint (29.27±0.23%), yet no significant differences were detected.

Table 4. The effect of using herbal plants on carcass composition of the Nile tilapia *Oreochromis niloticus* fingerlings for 75 days

Treatment	Moisture (%)	DM (%)	Ash (%)	Lipids %	Protein (%)
Control	70.45±0.16	29.55±0.17	22.95±0.46	23.48±1.39	51.72±0.04
Mint	70.73±0.23	29.27±0.23	23.52±0.50	23.15±0.25	51.78±0.44
Basil	70.34±0.28	29.67±0.28	23.66±0.14	22.11±0.31	51.70±0.30
Marjoram	69.97±0.38	30.037±0.38	24.06±0.23	22.58±0.17	51.86±0.17
Rosemary	70.79±0.65	30.037±0.65	23.86±0.18	22.50±0.23	51.31±0.19
Oregano	71.39±0.39	30.037±0.39	22.87±0.36	22.37±1.15	52.09±0.43

*Values are means ± SEM, *n* = 3 per treatment group.
*Means in a row without a common superscript letter differ (*P*< 0.05) as analyzed by one-way ANOVA and the shuffle's test.

4. Water physicochemical parameters

Mean values of physicochemical parameters of pond water during the experiment are presented in Table (5) and Fig. (3**)**. No significant differences were noticed in water temperature (°C), as it ranged from 23.33°C to 23.78°C. However, pH values significantly varied from 8.46 to 8.56. The highest value was obtained by the control pond, followed by a pond attached with rosemary trays (8.55). The least value was attained by basil Pond. Nevertheless, all pH values were among the adequate range for the Nile tilapia *Oreochromis niloticus* fingerlings.

Surface, deep, and mean DO values significantly differed among the various herbaceous treatments. These values were the highest in the control treatment (7.83±0.50 mg/l, 4.38±0.22 mg/l, and 6.11±0.36 mg/l, respectively). Ponds attached by rosemary trays came second when their values were 6.32±0.15 mg/l, 4.48±0.08 mg/l, and 5.40±0.03 mg/l, respectively, without any significant differences. However, mint (5.17±0.30 mg/l, 3.22±0.28 mg/l, and 4.19±0.01 mg/l, respectively) and basil (4.52±0.02 mg/l, 3.12±0.12 mg/l, and 3.82±0.05 mg/l, respectively) significantly recorded the least values of surface, deep and mean DO.

Regarding chemical parameters of nursing water, TAN and unionized ammonia differed significantly among various treatments. TAN and un-ionized ammonia values (mg/l) were the highest in the control pond (0.77±0.01 mg/l and 0.122±0.00 mg/l, respectively), oregano recorded the second high values (0.41±0.05 mg/l and 0.058±0.01 mg/l, respectively) with significant differences, compared to the control treatment. Nevertheless, there were no significant differences among all other four treatments. However, it was obvious that, marjoram achieved the least values of both TAN and un-ionized ammonia (0.12±0.02 mg/l and 0.016±0.00 mg/l, respectively).

Table 5. The effect of using herbal plants on water physio-chemical parameters of the Nile tilapia *Oreochromis niloticus* fingerlings for 75 days

Treatment	TAN (mg/l)	Un-ionized ammonia (mg/l)	ARRC%	Temp.	pH	Average DO
Control	0.77±0.01[a]	0.122±0.00[a]	0	23.78±0.18	8.56±0.00[a]	6.11±0.36[a]
Mint	0.20±0.01[c]	0.028±0.00[c]	74.14±0.86[a]	23.53±0.23	8.49±0.02a[b]	4.19±0.01[b]
Basil	0.18±0.00[c]	0.024±0.00[c]	76.52±0.20[a]	23.62±0.08	8.46±0.01[b]	3.82±0.05[b]
Marjoram	0.12±0.02[c]	0.016±0.00[c]	84.98±2.09[a]	23.68±0.08	8.49±0.00[ab]	4.33±0.42[b]
Rosemary	0.22±0.04[c]	0.034±0.01b[c]	71.69±5.46[a]	23.72±0.02	8.55±0.02[a]	5.40±0.03[ab]
Oregano	0.41±0.05[b]	0.058±0.01[b]	46.46±6.99[b]	23.33±0.03	8.51±0.01[ab]	4.73±0.14[ab]

*Values are means ± SEM, n = 3 per treatment group.
*Means in a row without a common superscript letter differ ($P < 0.05$) as analyzed by one-way ANOVA and the shuffle's test.

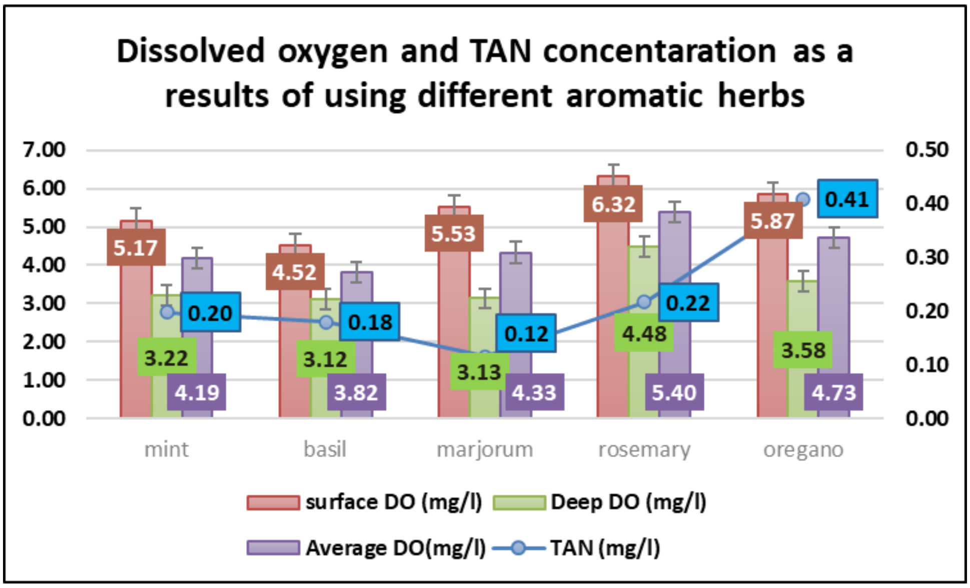

Fig. 3. Dissolved oxygen and TAN concentration as a result of using different medicinal herbs

5. Herbaceous plant growth indicators

The effect of symbiotics between plant and the Nile tilapia *Oreochromis niloticus* fingerlings on growth indicators of mint, basil, marjoram, rosemary, and oregano are listed in Table (6). The response of plants to the symbiotic system differs significantly between treatments. Specific leaves area (SLA) of mint was significantly the highest among all treatments (46.2±12.60 cm^2), followed by basil (27.66±4.26 cm^2). As a result, stem area and root area were the highest in these two treatments (577.50±157.50 and 327.50±57.5 cm^2, respectively) for mint and (369.50±5.00 cm^2 and 53.50±1.50 cm^2, respectively) for basil, with highly significant differences (Figs. 4- 6).

The relative growth rate (g/day) of plants showed significant differences; spearmint recorded the highest value (0.38 g/day), followed by basil (0.22 g/day). While, oregano recorded the worst value (-0.16g/ day).

Table 6. The effect of symbiotic between plant and the Nile tilapia fingerlings on growth indicators of mint, basil, marjoram, rosemary and oregano

Treatment	Stem area	Root area (cm^2)	SLA (cm^2)	RGR (g/day)
Mint	577.50±157.50^{a}	327.50±57.5^{a}	46.2±12.60^{a}	0.38±0.01^{a}
Basil	369.50±5.00^{ab}	53.50±1.50^{b}	27.66±4.26^{b}	0.22±0.02^{ab}
Marjoram	177.00±7.00^{ab}	47.00±7.00^{b}	22.23±1.53^{b}	0.07±0.01^{b}
Rosemary	138.50±5.50^{b}	25.50±1.5^{b}	14.25±0.47^{b}	-0.18±0.02^{c}
Oregano	349.00±11.00^{ab}	18.25±1.7^{b}	28.88±2.48^{b}	-0.16±0.07^{c}

*Values are means ± SEM, n = 3 per treatment group.
*Means in a row without a common superscript letter differ (*P*< 0.05) as analyzed by one-way ANOVA and the shuffle's test.

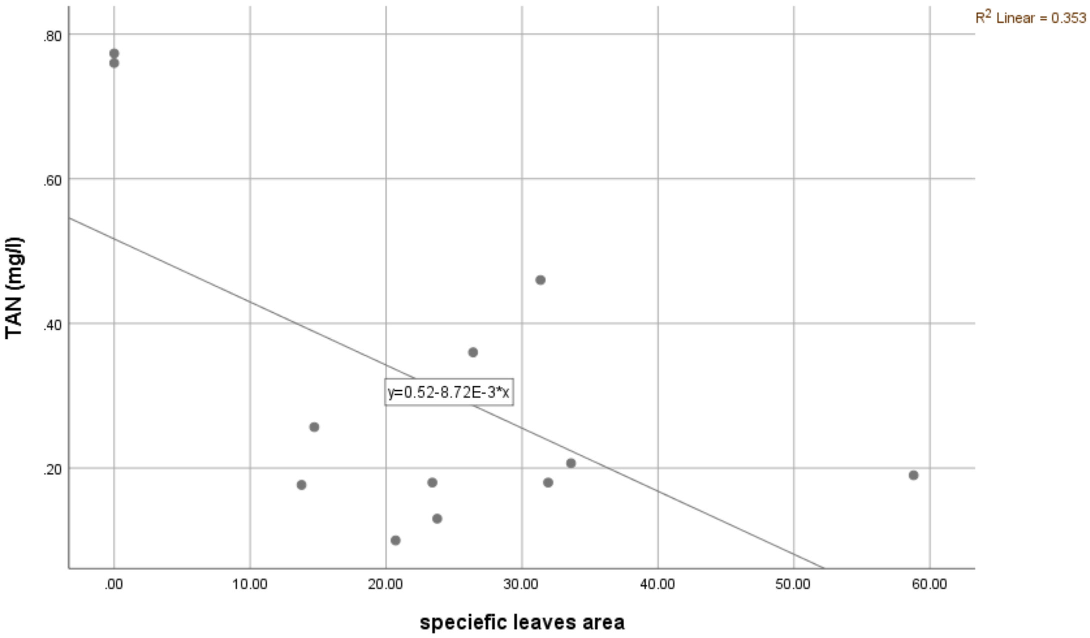

Fig. 4. Correlation between TAN (mg/l) and SLA (m2%)

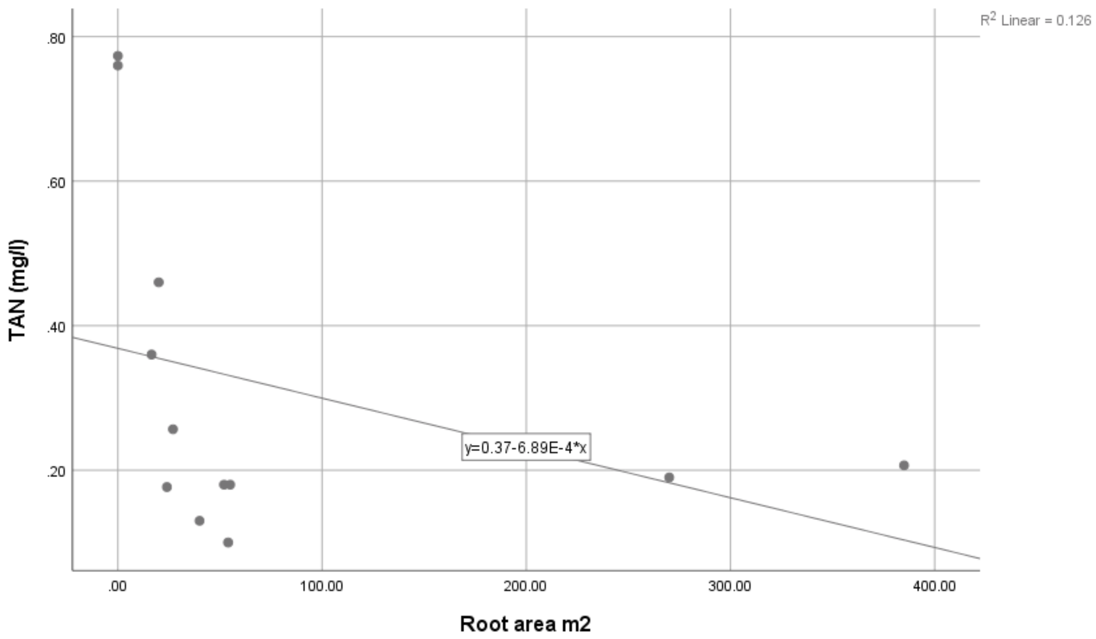

Fig. 5. Correlation between TAN (mg/l) and root area m^2

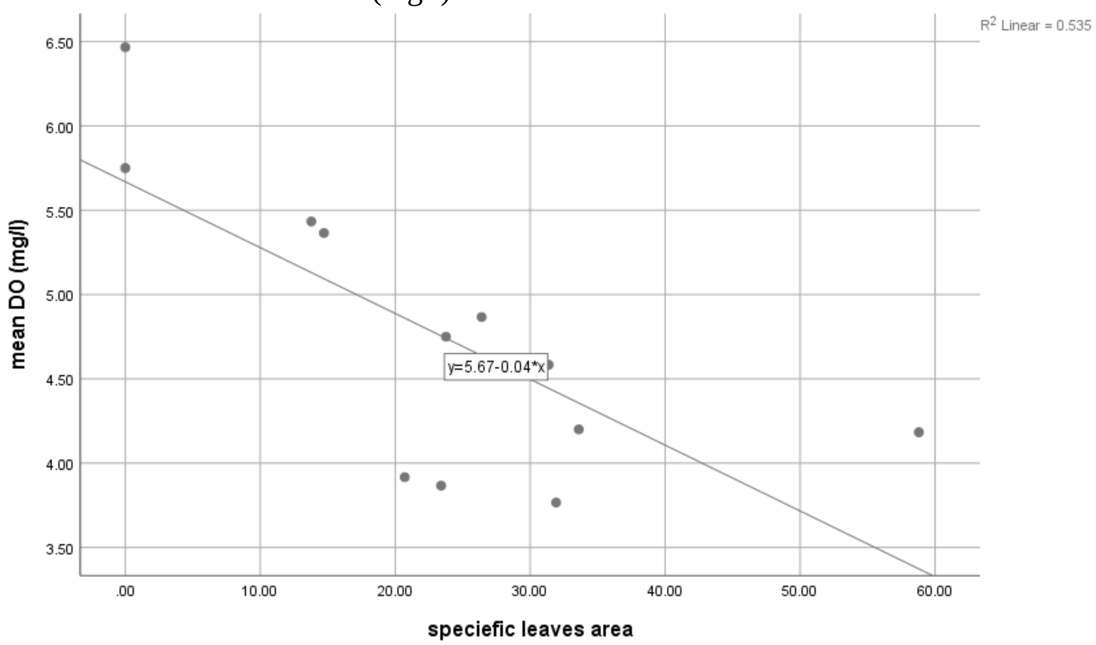

Fig. 6. Correlation between mean DO (mg/l) and SLA (m2%)

DISCUSSION

Bioremediation for fishpond’s enhancement is considered one of the cleanest, most economical, and most sustainable technologies for the aquaculture industry. Many organisms (algae, bacteria, fungi, bivalves, echinoderms and plants) and aquatic plants or hydroponic systems are several techniques that present water bioremediation. In this current study, four medicinal plants were used and had a positive effect on both fish and water, compared to the control treatment. Although there were no significant differences in all fish growth parameters, medicinal plant treatment showed slight improvement. This insignificance is due to the age stage of fish, which represents slight effects on fish gain.

The final body weight of basil and spearmint treatments was the best among all treatments. Their values were higher than the control treatment (16.84% and 15.03%, respectively). The same trend was attained for SGR and RGR, when their values were the best in both basil and spearmint, respectively. Likewise, there was insignificant mortality among all treatments, which is doubtless due to low temperature for this stage of the Nile tilapia fingerlings. These current results are well-matched with data in **Somerville *et al.* (2014)** when they stated that the Nile tilapia growth rate can reach 600g in 6- 8 months.

Feed utilizing parameters were somewhat different in comparison with growth performance. Feed intake and sequential energy gain showed higher values in basil, mint and marjoram. The better values of these three treatments were obtained as a reason for improved water quality in fishpond represented in lower total ammonia concentration. Good water quality causes lower stress on fish and higher vitality, feed intake and energy gain as well. Nonetheless, FCR values showed a different trend when it was the best in the control treatment without any significant differences, these values resulted from lower oxygen content in plant treatment together with higher feed intake, which consumes more oxygen; in addition, roots' respiration process consumes some of the dissolved oxygen in the pond. **Rakocy *et al.* (2016)** stated that, under an integration system between fish and plants, the FCR of the Nile tilapia was 1.7, while red tilapia was 1.8. In the same context, **Somerville *et al.* (2014)** revealed that in good conditions, FCR of the Nile tilapia ranges from 1.4 to 1.8, which support the current results, except in case of rosemary. Moreover, protein metabolism was affected by dissolved oxygen in the pond; this effect was noticeable in PER, PPV and protein content of fish tissue as well. These all factors led to lessening the feed utilization parameters in plant-attached ponds than in control ones. However, the Nile tilapia fingerlings reared in oregano ponds attained the highest protein content; this case may be referred to as the behavior of fingerlings in this treatment. While, the Nile tilapia fingerlings tend to feed on oregano roots. This behavior explains that the TAN content of oregano ponds gave the second highest value after the control pond.

Significant references were noticed in the physical and chemical parameters of water, where mint, basil and marjoram recorded the least dissolved oxygen concentration. Large root area and SLA of mint and basil (327.50±57.5 and 53.50±1.50 cm2 for root area and 46.2±12.60 and 27.66±4.26b cm2, for SLA, respectively) are considered the reason for the reduction in DO values. Hence, roots and leaves consume more oxygen during the respiration process, especially since the determination of the DO occurs in the morning when the photosynthesis process is at its lowest rate.

Corresponding results were obtained by **Suhla *et al.* (2019)** who stated that the oxygen concentration decreased during the day, and then increased again during night. During the whole experimental period, an increase in oxygen reduction during daytime was perceived. As there was a significant (sig. 2 tailed = 0.007) inversely relationship (r=-0.731) between mean DO and SLA (fig 6) according to the equation: (5.67-0.04*x). One of the DO reductions in ponds is the use of oxygen in NH4 oxidation. This explained the reduction in DO in ponds with low NH4 concentration.

A study by **Espinosa-Moya *et al.* (2018a)** evaluated the growth and development of three medicinal plants (paper mint, spearmint, and basil) in aquaponics systems. The authors revealed that DO in ponds ranged from 4.6 to 7.4mg/ l; while in hydroponic units, DO ranged from 2.4 to 7.4mg/ l under the same aeration conditions. These results reveal that plants consume large amounts of oxygen during their metabolism process as fish do. Thus, more aeration is required to improve the performance of the system. In 2014, FAO **Somerville *et al.* (2014)** published a technical report, the authors stated that the optimum ranges of water quality of aquaponics - which is a symbiotic relationship between fish and plants – are 18-30°C, pH 6-7, DO >5 mg/l, ammonia <1 mg/l, nitrite <1 mg/l, and nitrate 5-150mg/l. Current results showed that the marjoram treatment was the best considering the ammonia removal rate. Notably, it was the least ammonia concentration in the fishpond. These data indicate that the ability of marjoram roots to absorb ammonia is better than both spearmint and basil, which have the highest SLA values. These data are supported by ARRC% recording the highest value in the case of marjoram ponds (84.98±2.09%). Additionally, the current results of basil and spearmint ARRC% (76.52% and 74.14%, respectively) are superlative, compared to those recorded in the study of **Espinosa Moya *et al.* (2016)** who found that, basil and spearmint remove only 49.70% and 48.10%, respectively. However, the wide-ranging results revealed that there were inversely proportional (r= - 0.594 on, sig. 0.42, 2-tailed Pearson test) correlations between both SLA and TAN content in ponds, according to the equation (Y= 0.52-8.72E-3*x). These results specified that the plants used TAN in leaves production. In addition, AGR of both spearmint and basil (0.38±0.01 and 0.22±0.02, respectively) was the best among all other treatments. These results are due to the optimum DO and temperature in fish ponds which are attached by both plants **(Somerville *et al.*, 2014)**. Moreover, these indications support the SLA of both plants, elucidating that spearmint and basil were better planted for hydroponic systems than the others used in this experiment. In the same context, **Espinosa-Moya *et al.* (2018a)** argued that spearmint presented the largest number of leaves and the best AGR, whereas basil attained the largest SLA among all three investigated plants. In this system, a key benefit was that plants are not exposed to soil borne diseases. Furthermore, this system may get plants more resistant to diseases due to the presence of some organic matter in the water pond that generates a wide diversity of microorganisms, which may be antagonistic to pathogens **(Bakiu & Shehu, 2014; Rakocy *et al.*, 2016)**.

Fish production is affected by several conditions such as feeding and environmental conditions. Existing data show that various environmental conditions affect each other, with an evidence of the effect associated with the absence and presence of plants, and in turn, affecting water quality. It is worthy to mention that, the growth of the Nile tilapia fingerlings has not been affected due to the very early stage of growth.

CONCLUSION

The culture of plants together with fish led to enhancing the water quality and consuming ammonia, which ,in turn, reduced its concentration in the fishpond. Yet, plants compete with fish in consuming oxygen. This matter can be overtaken by detaching both fish and plants within separated ponds and providing each pond with oxygen. Both spearmint and basil are very suitable for floating raft aquaponic systems. Additionally, marjoram is suitable for bioremediation of water on condition of choosing the right season.

ETHICAL ISSUES

Experiment was performed in accordance with relevant institutional animal care and use committee of National Institute of Oceanography and Fisheries under the code (NIOF-AQ1-F-21-R-008).

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