
**E-ISSN: 2347-5129**
**P-ISSN: 2394-0506**
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(4): 288-293

www.fisheriesjournal.com
Received: 25-06-2020
Accepted: 27-07-2020

**Ahmad Daud Om**
Fisheries Research Institute, Tanjong Demong, 22200 Besut, Terengganu, Malaysia

**Nik Haiha Nik Yusoff**
Fisheries Research Institute, Tanjong Demong, 22200 Besut, Terengganu, Malaysia

**Zainoddin Jamari**
Fisheries Research Institute, Batu Maung, 18100 Pulau Pinang, Malaysia

**Corresponding Author:**
**Ahmad Daud Om**
Fisheries Research Institute, Tanjong Demong, 22200 Besut, Terengganu, Malaysia

# Evaluation of economics feasibility on marine fish seeds nursed in local backyard recirculating aquaculture system (RAS)

**Ahmad Daud Om, Nik Haiha Nik Yusoff and Zainoddin Jamari**

**Abstract**
The use of recirculating aquaculture systems (RAS) is an alternative to the marine fish hatchery system in the country. However, the technology originated from overseas are relatively high cost and is found to be unsuitable for use to certain extent. It requires modifications in accordance with local requirements. To date, there is no fully developed RAS system using local technology that can be applied in marine fish nurseries. Therefore, RAS system with a concept of backyard technology, its believed more reliable to be developed for the use of local operators, as it is less expensive compared to technology purchased from abroad. Study was undertaken to improve marine fry nursing system by using recirculating aquaculture system technology for practical advantages. This RAS system is named as CENTS-RAS 2.0 system that consists with installation on 20 units of 300 liters concrete tank each for a total capacity of 6000 liters per module. System was testing using hybrid grouper with the stocking rate at 1000 pieces / tank which is in total of 20,000 seeds for the complete set of the module. Fish with Initial size 5.0±0.68 cm of total length were reared for 50 days. The survival rate was 91.5% with total length was 10.25±2.5 cm and 25.5±2.18 g. A separate flow-through system was used as a control with same module size. The total production or biomass production (kg/ton) is 70.07 kg per $m^3$ compare to CENTS-FT which is only 18.75 kg per $m^3$. The optimum return on the density of 20,000 seeds with 49% IRR indicator, ROI 64%, and break-even point of 139,650 tails at production cost of RM 3.44 per tails. This finding study defines what is requirement for optimum condition of marine seeds nursing system in RAS.

**Keywords:** RAS, flow through system, nursing system, hybrid grouper

## 1. Introduction
Quality and quantity of seeds are frequently a major issue in the development of the marine aquaculture industry. It is estimated that a total of 250 million marine fish seeds from various species are needed by year 2025 [1]. The high demand cannot be fulfilled by local farmers resulting in almost 80% of the seeds imported from abroad. The methods currently used are not productive and need to be enhanced to make it more innovative and effective. Therefore, a new method should be designed so that the fish seed can be produced with more quality and quantity.

The use of recycling system (RAS) is an alternative to the marine fish hatchery system in the country [2]. However, the technology imported from overseas is relatively high cost and is found to be unsuitable for use in local environments. It requires modifications in accordance with local requirements. To date, there is no RAS system using local technology that can be developed in marine fish nursery. It is the intention of the Department of Fisheries (DOF) that a local technology could be developed to meet this need.

It is believed to develop our local hatchery with backyard concept, as it is less expensive compared to technology purchased from abroad. Although small-scale hatcheries make a substantial contribution to livings and food security at a regional level. The key features of small-scale hatcheries are that they are inexpensive to construct and relatively simple to operate [3].

This study was designed to investigate the fish performance nursed in RAS facilities focusing on the effect of stocking density on growth in marine fish seeds cultured by farmers in Malaysia. Increased number of stocking could affect the survival performance and profit. Moreover, the optimum density number should be identified, for a successful RAS design and better growth performance.

## 2. Materials and Methods

The pilot recirculating nursing system at Fisheries Research Institute, FRI Tanjong Demong, CENTS-RAS 2.0 was used for the research. Experiments were conducted for several series, between May 2016 and September 2019, in nursery tanks rearing units. The configuration of the pilot CENTS-RAS 2.0 was designed and water treatment equipment (physical, mechanical and biological filters) (see figure 1) were integrated in the system.

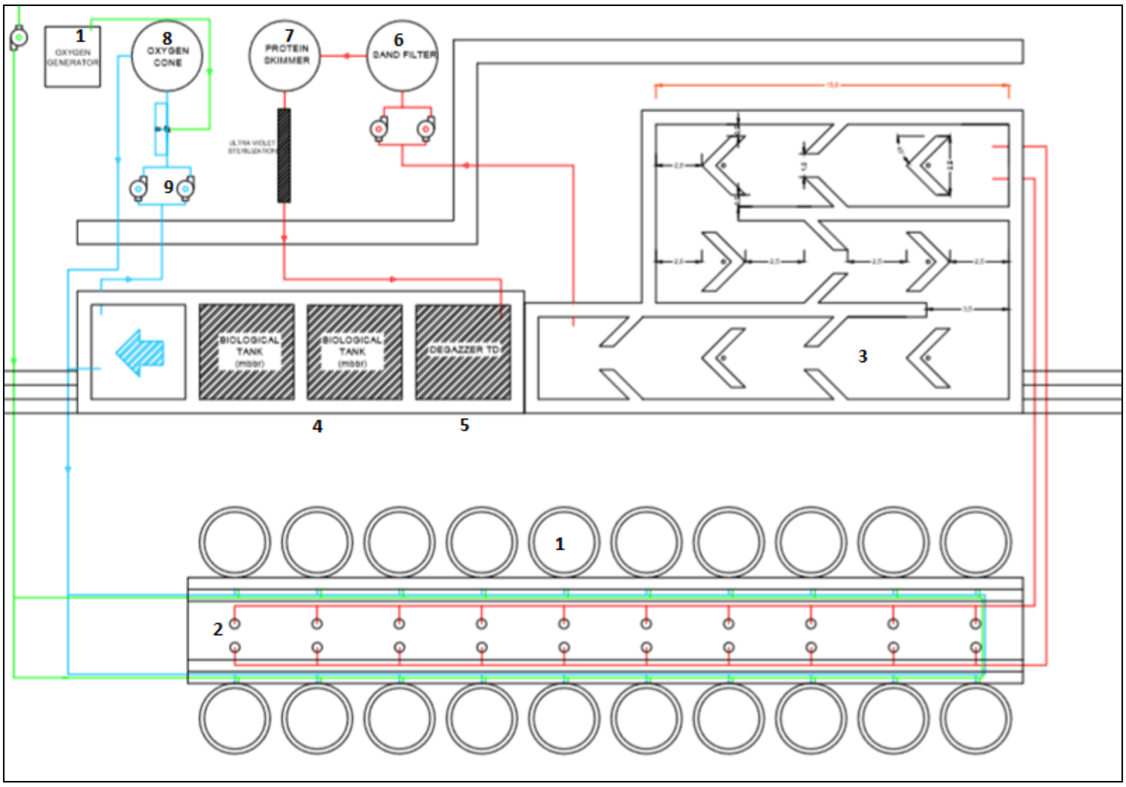


**Fig 1:** CENTS-RAS 2.0 system layout: 1. Nursery tank, 2. Waste Trap, 3. Sedimentation Tank, 4. Biological Tank, 5. Degassing Tank, 6. Sand Filter, 7. Protein Skimmer, 8. Oxygen Cone, 9. Oxygen generator, 10. Centrifugal pump.

Conditioned by the role played in RAS, the integrated components of the pilot are group in two categories. Essential component including, nursery tank, waste trap, sedimentation tank and biological with 6 tons' capacity, sand filter, pumps, component for the management of dissolved gases (oxygen and carbon dioxide), air conditioning equipment (Oxygenator), independent electrical generator. Secondary component; monitoring equipment for water quality, automatic feeder and storage facilities. All of these systems are able to control the water quality optimally and are in a safe range.

The RAS system consists of 20-cements concrete wrap with fiberglass for seeds nursery tank units with capacity of 300 L/unit, round shape and were design in two row connected with waste trap for remove suspended solids (unfed and feces). The effluent of the nursery tanks is collected and by gravity ally transported to sedimentation tanks, retaining solid particles and removing them regularly. The processes of suspended solid removal continue in the next stage of mechanical filtration by sand filter. The route of the water treatment between the mechanical and the biological filters is treated with protein skimmer and degassing unit, which are detrimental to the fish, must be removed. The degassing and protein skimmer process is carried out by aeration of the water, and the method is often referred to as stripping. The water contains carbon dioxide ($CO_2$) from fish respiration and from the bacteria in the bio filter is extremely toxic to fish and need to remove.

The CENTS-RAS 2.0 (Figure 2) system relies on bio filter convert ammonia (NH4 + and NH3) released by fish to nitrates. Ammonia is a product of fish metabolic waste and high concentration (> 0.02 mg / L) is toxic to most fish. Nitrifying bacteria will alter ammonia to nitrite and nitrate. Bio filter provides a substrate for the bacterial community, which produces a growing biofilm in the filter. Water is pumped through a sieve, and ammonia is used by bacteria for energy. Nitrate is less toxic than ammonia (> 100 mg / L), and may be produced by denitrifying bio filter or water replacement. Stable environmental conditions and maintenance are required to ensure bio filter operates efficiently

During the period (May 2016 until September 2019) five nursery trials were carried out by using a 2-inch (5.0 cm total length) fry. This study was conducted for 50 days, body weight and total length fish were measured every 10 days. Data on survival and amount of feed was recorded.

Meanwhile, for flow-through system were reared in FT system owned by farmer at Kampong Air Tawar, Mukim Pengkalan Nyireh, 22200 Besut, Terengganu (Figure 2). The set-up of FT system during trial was simple setting, with 2hp pump seawater, blower 1hp and 20 tanks with 300 liters each tank or total capacity 6 $m^3$. The fish were reared with the same duration time (50 days) and fed with commercial diet with 1-4 mm pellet sizes throughout the study.

(A) (B)

**Fig 2:** (A) CENTS-RAS 2.0 and, (B) Cents Flow-through system during trial nursed hybrid grouper.

## 3. Results

The objective of this study was to determine the efficiency of local pilot RAS for nursing marine fish fry. Three different species that is Hybrid grouper, Tiger grouper and Asian Seabass were tested and nursed in CENTS-RAS 2.0 facilities. The number of density varies from 5,000 seeds or 250 pcs/tank until maximum 27,000 or 1350 pcs/tank seeds per module compare with control in flow-through system, 5,000 seeds or 250 pcs/tank per module.

The growth of hybrid grouper reared in RAS was found to be affected by stocking density. Growth was reduced at high stocking density. Productivity biomass curve slope for 20,000 pcs were slowly inclined compare to 10,000 pcs (Figure 3). The different on biomass production between FT system and RAS system, shows almost more than triple increments biomass achieve in 20,000pcs at RAS facilities. Sampling at day 40 and day 50 showed a narrow slope occurred to batch 20,000 pcs compare with 10,000 pcs. Thus suggesting that the optimal stocking density equivalent to the highest productivity should be between 10,000 to 20,000 fry.

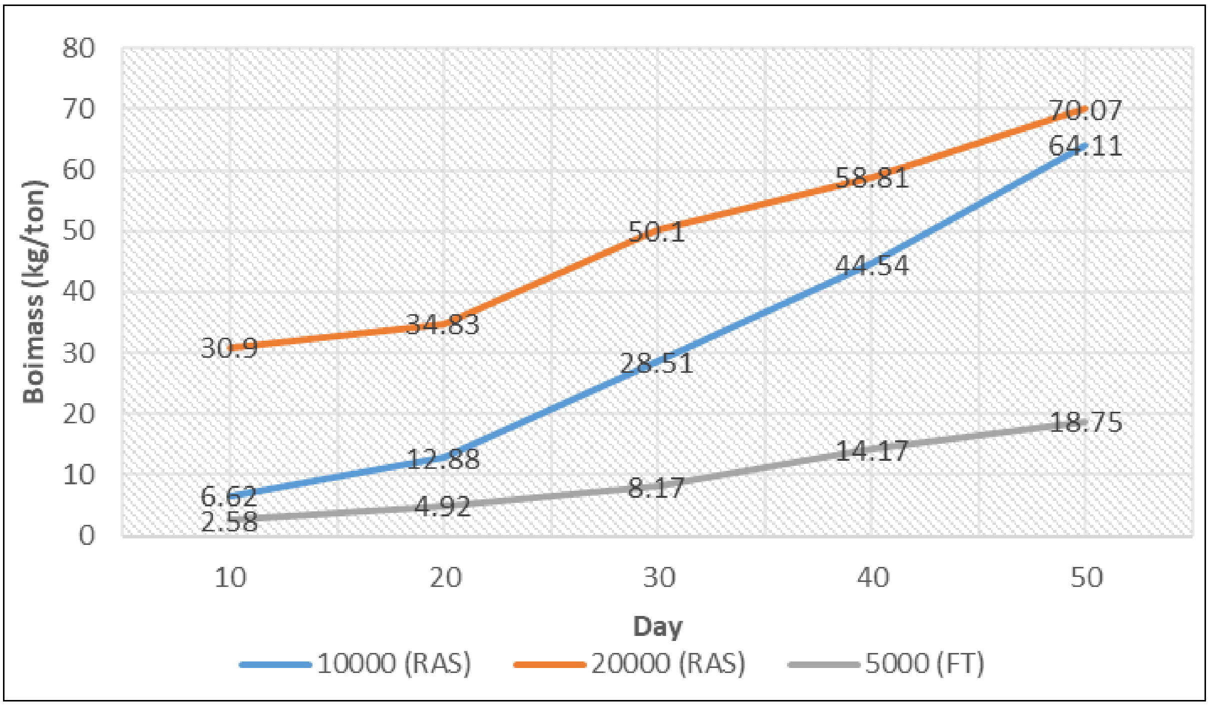


**Fig 3:** Comparative biomass productivity (kg/m$^3$) between 20,000 pcs (RAS), 10,000 pcs (RAS) and 5,000 pcs (Flow-through) per module on hybrid grouper nursed in CENTS-RAS 2.0

On the other hand, analysis cost and profit show in table 1 were different. High density gave better gross profit. The grouper hybrid nursed showed better achievement in 20,000 seeds compared to 10,000 seeds per cycle. Although, the productivity biomass (kg/m$^3$) of 20,000 pcs (70 kg/m$^3$) was slightly different compare to 10,000 pcs nursed (64.11 kg/m$^3$).

**Table 1**: Comparative economic analysis on cost and revenue nursed of different species of marine fish fry in CENTS-RAS 2.0 and CENTS Flow-through (control).

| Species | Stocking Density | Survival Rate (%) | Value of Fry (RM) after harvest | Others Cost | Gross Profit | Productivity Biomass (Kg/ m$^3$) |
|---|---|---|---|---|---|---|
| Grouper Hybrid Exp 1 Sept – November 2019 RAS Method | 20,000 pcs | 91.5% | 18,300 x RM5.50 = RM 100,650 | Fry = RM 3.12 x 20,000 = RM 62,400<br>Feed cost = 240 kg x RM 7.50 = RM 1,800<br>Electrical Cost = RM 2,500<br>Other Cost = RM 1000<br>Labor Cost = RM2,400<br>Total Cost Expend = RM 70,100 | RM 30,550 | 70.07 |
| Grouper Hybrid Exp 2 January - March 2018 RAS Method | 10,000 pcs | 92% | 9,200 X RM5.50 = RM 50,500 | Fry = RM 2.50 x 10,000 = RM 25,000<br>Feed Cost = 235 kg x RM20 = RM 4,700<br>Electrical cost = RM 2,500<br>Other Cost = RM 1,000<br>Labour Cost = RM 2,400<br>Total Cost Expend = RM35,600 | RM 14,900 | 64.11 |
| Asian Seabass Exp 1 Feb – April 2017 RAS Method | 20,000 pcs | 96% | 19,200 X RM 1.00 = RM 19,200 | Fry= RM 0.5 x 20,000 = RM 10,000<br>Feed Cost = 140 kg x RM7.50 = RM 1,850<br>Electrical Cost = RM 2,500<br>Labour Cost = RM 2,400<br>Other Cost= RM 1,000<br>Total Cost Expend = RM 17,750 | RM 1,450 | 42.0 |
| Asian Seabass Exp 2 Mac-May 2019 RAS Method | 27,000 pcs | 65.61% | 16,904 x RM 1.00 = RM 16,904 | Fry= RM 0.5 x 27,000 = RM 13,500<br>Feed Cost = 236 kg x RM 7.50 = RM 1,770<br>Electrical Cost = RM 2,500<br>Labour Cost = RM 2,400<br>Other Cost= RM 1,000<br>Total Cost Expend = RM 21,170 | (-RM 4266) | 57.6 |
| Tiger Grouper July – Sept 2017 Exp 1 RAS Method | 5,000 pcs | 94% | 4,700 X RM 5.00 = RM 23,500 | Fry = RM 2.50 x 5,000 = RM 10,000<br>Feed Cost = 125 kg x RM20 = RM 2,500<br>Electrical Cost = RM 2,500<br>Labour Cost = RM 2,400<br>Other Cost = RM 1,000<br>Total Cost expend = RM 18,400 | RM 5,100 | 45.38 |
| Hybrid Grouper July – Sept 2018 Control Flow through Method | 5,000 pcs | 90% | 4500 X RM 5.50 = RM 24,750 | Fry = RM 2.50 x 5,000 = RM 12,500<br>Feed Cost = 130 kg x RM7.50 = RM 975<br>Electrical Cost = RM 1,500<br>Other Cost = RM 750<br>Labour Cost = RM 2,400<br>Total Cost expend = RM 18,125 | RM 6625 | 18.75 |

*Foreign money exchange of 1 USD is equals to RM 4.20

Economic analysis showed that grouper hybrid nursed in RAS is more profitable than seabass. The value was more than 5 times better than Asian seabass. In fact, seabass could effect on minus gross profit (-RM 4266), when the survival was low (65%). This happened, when the market value is very low, almost 5 times cheaper than grouper hybrid. So it is suggested that the best species for this pilot RAS nursing for marine fish seeds is grouper hybrid.

For commercial purposes, grouper hybrid seeds are a high priority species that can produce high yields when raised in this system. From the 20,000 seed of initial size 5.0 cm (initial price is RM3.12), it can give a net revenue return of more than RM 70,100 after a 50-day care period. Nevertheless, to provide consistent yield returns, from the analysis of net cash charts, this system must provide optimum return on the density of 20,000 seeds with 49% IRR indicator, ROI 64%, and break-even point of 139,650 tails at production cost of RM 3.51 (Table 2)

**Table 2**: Cash flow analysis on nursing of grouper hybrid fry in CENTS-RAS 2.0

| Number of Hybrid grouper | IRR * (%) | ROI * (%) | Break-even point (Year) | Break-even point (number of fry) | Production cost (RM) per tail |
|---|---|---|---|---|---|
| 20,000 | 49 | 64 | 1.55 | 139,650 | 3.44 |
| 15,000 | 26 | 39 | 2.48 | 167,628 | 3.54 |
| 10,000 | 5 | 19 | 4.96 | 223,735 | 3.77 |

***** IRR means, Internal rate of return and ROI means, Revenue of investment

The results also showed that the increasing in productivity between species was not only related to the number of fry survived but also on the fish behavioral. Asian seabass, which has cannibalistic characteristics makes them less susceptible to dense quantities. Also Asian seabass which its more scattered behavior is needed more space compared to grouper. This makes hybrid grouper more tolerance to high stocking density.

## 4. Discussion

The basic principle of RAS is the necessity to treat the water continuously to remove the waste products excreted by the fish, and to add oxygen to keep the fish alive and well. A recirculation system is in fact quite simple. From the outlet of the fish tanks the water flows to mechanical filter and further on to a biological filter before it is aerated and stripped of carbon dioxide and returned to the fish tank. RAS production system must provide a suitable environment to promote the growth of the fish.

The CENTS-RAS 2.0, is a unique efficient system based on back-yard concept, which combines local technologies for land-based recirculating system with simple knowledge technique at medium price. The idea of building RAS and equipment is based on very different views on what is important and what is interesting.

In general, the production of commercial scale recirculating system for nursery culture in Europe especially at Mediterranean fish are presented at about 50-80 kg/m$^3$ [4]. This performance is similar to our finding, when our CENTS-RAS 2.0 system has the same ability to produce 70 kg /m$^3$ compared to 18.75 kg /m$^3$ of conventional method (CENTS-FT). This study also verified the survival rate of seeds was above 90% for grouper hybrid. Three tested species, hybrid groupers, tiger grouper and seabass seeds proved that the rate of productivity was more than 3 times the normal method. Data also, verified suitable species for nursed in CENTS-RAS was hybrid grouper and not Asian seabass due to low price seeds to nursed in RAS facilities.

Stocking density did influence the behavioral response to the fish. It's could effects stressing the fish both performance and physiological indicators gave indication of impaired fish welfare within the range of densities. Several studies have investigated on growth performances of fishes in relation to stocking density. High stocking density have been reported to inhibit the growth of juvenile *E. malabaricus* [5], turbot *Scophthalmus maximus* (L. 1958) [6], and European sea bass *Dicentrarchus labrax* (L.1758) [7] cultured in RAS, as well as other fish species culture in various no-recirculating production system [8 & 9]

High stocking density has been reported to cause decreased growth of hybrid grouper in RAS system [10] due to different factors such as decreased food consumption and social interactions [11] or decreased water quality [12]. Moreover, high stocking density produces both hormonal and metabolic alterations [13] including a reduction in thyroid hormone activity [14]. However, fish in recirculating system must be reared in tanks at high densities to make the production system cost effective. In CENTS flow-through (CENTS-FT) nursery system, the stocking rate was low at 0.5 fry per liter but in CENTS-RAS 2.0, the stocking rate was 3.5 fry per liter. An increase in stocking density will in general cause a deterioration of water quality due to a reduction in dissolved oxygen, build-up of fish metabolites and carbon dioxide followed by a reduction of pH level. However, by use of oxygenation, to increase the carrying capacity of the water [15], and high water flow, higher densities can be maintained [16].

It is believed, the CENTS RAS 2.0 system could help farmers to increase their income and reduce the import of seed from abroad. Ultimately, this innovation will benefit the country by driving the aquaculture sector to a more excellent level. The system is also designed to facilitate the management of fry care and to reduce cannibalism in order to provide a high standard of living at the nursing level.

## 5. Conclusion

CENTS-RAS 2.0 has achieved the targeted production and the technology are ready for transfer to the local farmers. It is expecting that the CENTS RAS 2.0 system will give an impact to marine fish fry aquaculture industry in Malaysia.

## 6. Recommendation

It is recommended that stocking rate must be taken into consideration due to its impact on effectiveness on nursing of fish seed in Cents-RAS 2.0 system for achieving productivity and profitability.


## 7. Acknowledgments

We thank the members of the Fisheries Research Institute of Malaysia for providing materials used in this work. Also, we would like to thank the anonymous referees for their helpful comments on the manuscript.


## 8. References


1. Department of Fisheries Malaysia, 2019. Malaysian Statistical Fisheries, 2018.
2. Ahmad Daud Om, Asuhan Benih Ikan Marin. Sistem CENTS-RAS, Dewan Bahasa dan Pustaka, Kuala Lumpur. 2012, 90.
3. Mardiana EF, Ketut S, Michael AR. The role of small-holder seed supply in commercial mariculture in Southeast Asia. Aquaculture. 2018, 912-918.
4. Liu S, W, Liu ZP, Yu Y. Effect of density stress on growth and metabolism of juveniles *Epinephelus malabaricus*. Journal of Fishery Sciences of China. 2011; 18:322-328.
5. Blancheton JP. Development in recirculation system for Mediterranean fish species. Aquacultural Engineering. 2000; 22:17-31.
6. Liu BL, Jia R, Han C, Huang B, Lei JL. Effect of stocking density on antioxidant status, metabolism and immune response in juvenile turbot (*Scophthalmus maximus*). Comparative Biochemistry and Physiology C.,

2016; 190:1-8.
7. Sammouth S, Orbcastel D, Gasset ER, Lemerie G, Breull G, Marino G *et al*. The effect of density on sea bass (*Dicentrachus labrax*) performance in a tank-based recirculating system Aquaculture Engineering. 2009; 40:72-78.
8. Bolasina S, Tagawa M, Yamashita Y, Tanaka M. Effect of stocking density on growth, digestive enzyme activity and cortisol level in larvae and juveniles of Japanese flounder, *Paralichthys olivaceus*, Aquaculture. 2006; 258:432-443.
9. Mackenzie DJ, Hoglund E, Dupont-Prinet A, Larsen BK, Skov PV, Pedersen PB *et al*, Effect of stocking density and sustained aerobic exercise on growth, energetics and welfare of rainbow trout. Aquaculture. 2012; 338:216-222.
10. Shao T, Chen X, Zhai D, Wang T, Long X, Liu Z. Evaluation of the effects of different stocking densities on growth and stress responses of juvenile hybrid grouper *Epinephelus fuscoguttatus* x *Epinephelus lanceolatus* in recirculating aquaculture systems. J Fish Biol. 2019; 95:1022-1029.
11. Wedemeyer GA. Effects of rearing conditions on the health and physiological quality of fish in intensive culture. In Fish stress and Health in Aquaculture Edited by G.K. Iwama, A.D. Pickering, J.P. Sumpter, and C.B. Schreck. Cambridge University Press, Cambridge, 1997, 35-71.
12. Blancheton JP. Development in recirculation system for Mediterranean fish species. Aquacultural Engineering. 2000; 22:17-31.
13. Leatherland JF, Cho CY. Effect of rearing density on thyroid and internal gland activity and plasma and hepatic metabolite levels in rainbow trout, *Salmo gaidneri* Richardson. J Fish Biol. 1985; 27:583-592.
14. Vijayan MM, Leatherland JF. Effect of stocking density on the growth and stress-response in brook charr. *Salvelinus fontinalis*. Aquaculture. 1988; 75:159-170.
15. Person-Le Ruyet J, Labble L, Le Bayon N, Severe A, Le Roux A, Le Delliou H, Quemener L. Combined effects of water quality and stocking density on welfare and growth of rainbow trout (*Oncorhynchus mykiss*). Aquat. Living Resour. 2008; 21:185-195.
16. Ellis T, North B, Scott AP, Bromage NR, Porter M, Gadd D. Review paper: the relationships between stocking density and welfare in farmed rainbow trout. J Fish Biol. 2002; 61:493-531.