EFFECTS OF WATER CURRENT ON SOME GROWTH FACTORS AND WATER QUALITY IN A CLOSED TROUT CULTURE SYSTEM

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EFEKTI PROTOKA VODE NA NEKE FAKTORE RASTA PASTRMKE I KVALITET VODE U ZATVORENIM SISTEMIMA GAJENJA

Apstrakt

Efekti nivoa protoka vode na uzgoj pastrmke ispitani su u toku 35 dana eksperimenta. U tankove su naseljene ribe mase 5,5 g i dužine 6,7 cm. Četiri različite brzine vode (0; 3,5; 7; 10,5 cm/s) ispitane su kroz tri ponavljanja. Ovi različiti protoci obezbeđeni su ponovnim korišćenjem izlazne vode iz svake uzgojne jedinice. Kod oglednih riba ocenjena je dužina, težina, dnevni prirast (DGR), specifična stopa rasta (SGR), factor kondicije (CF) i stopa preživljavanja (SR). Takođe, istovremeno su ispitane promene NO_2, NO_3, NH_3, NH_4^+, ukupne tvrdoće i pH vode u svakom tretmanu. Analiza varijanse podataka o kvalitetu vode pokazala je veoma značajne razlike između svih tretmana u toku prve nedelje ($p<0,01$). Međutim, ovi rezultati nisu zabeleženi u toku nastavka eksperimenta. Krajnji rezultati pokazali su veoma značajne razlike ($p<0,01$) u svim tretmanima u pogledu faktora koji su ispitivani kod mlađi. Na osnovu rezultata Dankanovog testa, najbolja stopa preživljavanja (97%), dnevni prirast (1), SGR (6%) i prosečna težina (24 g) postignuti su pri brzini protoka od 10,5 cm/s.

*Ključne reči**:** brzina protoka, zatvoren sistem, kalifornijska pastrmka, Iran*
Keywords: water current, closed system, rainbow trout, Iran

INTRODUCTION

Rainbow trout production has been expanded in Iran through last ten years so that its amount grew from 9000 mt in 2000 to 62630 mt in 2008. Aquaculture increment could be one of the main reasons for water pollution in the world. So water quality protection in fish culture is important and this leads industry to use modern systems such as Recirculation Aquaculture System in order to get maximum production without water polluting. The possibility of outlet water refining is the main advantage of these systems and pH, temperature and bacterial disease controlling are their other advantages (Willoughby, 1999). However they are very expensive. But what happens if some functions of RAS (Recirculating Aquaculture System) were been eliminated and water velocity through the culture unit is increased? Larger fishes can stand against more water velocity (Sedgwick, 1990). Therefore an experiment was conducted to assess the effects of water velocity, physical filtration and aeration in a closed rainbow trout culture system. This experiment was done through Randomize Complete Blocks design with 4 treatments and 3 repeats. Different water velocities (0, 3.5, 7, 10.5 cm/s) along with twelve plastic aquariums (200×40×15 cm) formed treatments and plots respectively.

MATERIALS AND METHODS

The experiment was carried out during 35 days in Khojir Natural Resources Station of Tehran-Iran. Each plot was contained 60 liters water with a Renault air pump for aerating. Fry were provided from a private farm in Semnan province and transferred to the station in oxygenated plastic bags. 48 hours before transferring, fry feeding had been stopped. After adaptation 12 fry were introduced to each aquarium. New feeding started 48 hours after fry introduction to the new environment. Initial fry weight and length were 5.5±0.32gr and 6.7±2.41cm respectively. Water recirculation has been done by external electrical pumps through the each plot which was connected to 30µ mesh size filter bags in order to physicaly filtrate the water. These filter bags were cleaned daily by fresh water and manually. Evaporated water in the each plot was replaced by isotherm fresh water. The water was gathered from the bottom of each plot by pump and recirculate to aquarium after filtering. Fry stocking density in this experiment was 200 fish/m^2, which is more than two fold of average density at Iranian farms. 48 hours after introducing fishes to plots, feeding operation was started with commercial food. Feeding was conducted 5 times a day among 7 am and19 pm. Food was provided from Biomar Company in France and was combined from 54% crude protein, 18% crude fat, 0.5% fiber, 10% ash and 1.4% phosphor. Feeding amount had been considered to 4% (Jeffrey, 1999) of fry weight so that all foods were used by fry. Water temperature and pH were measured daily during the experiment. At the same time, fry weight, length, specific growth rate (SGR), daily growth rate (DGR), survival rate (SR), and condition factor (CF) were weekly measured as follows (EIFAC, 1980):

DGR: [(final weight (gr) - initial weight (g)) ÷ experiment days]×100
SGR: [(Ln final weight- Ln initial weight) ÷ experiment days]×100
CF: (weight (gr) ÷ lenght^3)×100
SR: (live fry÷ total plot fry)×100

Fry length and weight were measured by an ordinary ruler (1mm accuracy) and a Sartorious digital scale, Ek-120A model (0.01gr accuracy), respectively. pH of the water was also determined by waterproof pH-meter pen model YTH 10 that was made in the United States of America.

Data analysisiswas done by SPSS software, version 14 and Duncan’s averages comparing test was used to determine the best fishes indexes averages among different treatments.

RESULTS

Water temperature average was 18±1.19°C during experimental period. Average oxygen demand was 7, 7.5, 8.5, and 10.5 in 0, 3.5, 7 and 10 cm/s treatments respectively.

Table 1. Results of ANOVA and Duncan’s test through the first week

Factors	F_s	Treatment			
		1T	2T	3T	4T
(g) Weight	**16.823	7.8731^{c}±0.30	0.38±8.3867^{bc}	9.0191^{b}±0.23	9.8938^{a}±0.42
(cm) Length	**11.173	0.17± 7.4961^{c}	0.48±8.0231^{bc}	8.3046^{ab}±0.18	8.8276^{a}±0.18
SGR%	**16.892	0.55±5.1172^{c}	0.65±6.0173^{bc}	7.0590^{b}±0.53	8.3791^{a}±0.62
DGR%	**16.814	0.04±0.3389^{c}	0.05± 0.4123^{bc}	0.5026^{b}±0.04	0.6276^{a}±0.06
CF%	**6.608	0.10±1.8666^{a}	0.21±1.6381^{b}	1.5751^{b}±0.04	1.4381^{b}±0.02
SR%	3.27^{ns}	100.000^{a}±0	100.000^{a}±0	100.000^{a}±0	100.000^{a}±0

** Very significant differences in $p<0.01$; ^{ns} not significant differences

Table 1 shows very significant differences about studied fry factors among all treatments ($p<0.01$) except survival rate. Based on Duncan’s test results, it seems the fourth and the first treatments have been caused maximum (a rank) and minimum (c rank) averages in week 1, respectively. The changes of fry weight, length, and specific growth rate are summarized in figs. 1-4.

Table 2. Results of ANOVA and Duncan’s test through the second week

Studied indicators	F_s	Treatment			
		1T	2T	3T	4T
(g) Weight	9.162**	10.7598^{c}±0.67	12.5396^{bc}±0.32	13.4600^{ab}±0.70	14.7584^{a}±0.98
(cm) Length	1.531^{ns}	9.0186^{a}±0.75	9.3664^{a}±0.46	9.5305^{a}±0.28	9.8107^{a}±0.17
SGR%	3.884*	4.4502^{b}±0.55	5.7005^{a}±0.86	5.7027^{a}±0.22	5.7131^{a}±0.33
DGR%	5.600*	0.4095^{b}±0.07	0.5932^{a}±0.13	0.6341^{a}±0.05	0.6949^{a}±0.07
CF%	0.115^{ns}	1.4943^{a}±0.29	1.5242^{a}±0.06	1.5558^{a}±0.06	1.5616^{a}±0.05
SR%	8.296**	83.300^{b}±8.3	97.200^{a}±4.84	100.000^{a}±0	100.000^{a}±0

Table 3. Results of ANOVA and Duncan’s test in the third week Studied indicators

	F_s	Treatment			
		1T	2T	3T	4T
(g)Weight	**6.783	14.3287^{c}±1.71	17.7351^{bc}±2.80	19.8966^{ab}±1.87	22.2434^{a}±2.39
(cm) Length	8.033**	10.0897^{c}±0.40	10.5445^{bc}±0.21	10.9010^{ab}±0.20	11.0927^{a}±0.20
SGR%	1.852^{ns}	4.0416^{a}±0.82	4.8838^{a}±0.83	5.4926^{a}±0.59	5.5548^{a}±1.20
DGR%	*5.057	0.5097^{b}±0.14	0.7421^{ab}±0.21	0.9194^{a}±0.16	1.0692^{a}±0.20
CF%	3.286^{ns}	1.3903^{b}±0.009	1.5054^{ab}±0.14	1.5329^{ab}±0.06	1.6252^{a}±0.08
SR%	5.735*	74.967^{b}±8.35	86.067^{ab}±9.58	94.400^{a}±4.84	97.200^{a}±4.84

** Very significant differences in $p<0.01$; * significant differences in $p<0.05$; ^{ns} not significant differences

Table 4. Results of ANOVA and Duncan’s test indexes in the fourth week

Studied indicators	F_s	Treatment			
		1T	2T	3T	4T
(g) Weight	**6.850	16.7387^{c}±2.78	21.8137^{bc}±4.91	25.4217^{ab}±3.27	29.9999^{a}±4.36
(cm) Length	6.636**	10.7669^{b}±0.33	11.3195^{b}±0.48	11.3698^{b}± 0.32	12.2400^{a}±0.46
SGR%	6.922**	2.1568^{c}±0.67	2.8973^{bc} ±0.51	3.4641^{ab}±0.49	4.2246^{a}±0.60
DGR%	6.808**	0.3442^{c}±0.15	0.5826^{bc}±0.19	0.7892^{ab}±0.20	1.1080^{a}±0.28
CF%	9.790**	1.3323^{c}±0.10	1.4724^{bc}±0.13	1.6270^{ab}±0.08	1.7460^{a}±0.05
SR%	6.016**	61.100^{c}±12.73	74.967^{bc}±8.35	83.300^{ab}±8.3	94.433^{a}±9.64

** Very significant differences in $p<0.01$

Table 5. Results of ANOVA and Duncan’s test in the fifth week

Studied indicators	F_s	Treatment			
		1T	2T	3T	4T
(g)Weight	**7.604	18.7571^{c}±3.66	25.8052^{bc}±5.75	32.2331^{ab}±5.75	40.2558^{a}±7.26
(cm) Length	2.617^{ns}	12.1281^{b}±0.43	12.2315^{ab}±0.48	12.4044^{ab}±0.54	13.0214^{a}±0.38
SGR%	12.696**	1.5753^{b}±0.42	2.3826^{ab}±0.52	3.4561^{a}±0.69	4.1440^{a}±0.52
DGR%	8.594**	0.2883^{c}±0.12	0.5701^{bc}±0.22	0.9730^{ab}±0.35	1.4651^{a}±0.41
CF%	13.811**	1.0449^{c}±0.14	1.3964^{b}±0.17	1.6773^{ab}±0.11	1.8103^{a}±0.18
SR%	15.568**	41.633^{b}±8.35	58.300^{b}±8.3	77.773^{a}±12.72	91.633^{a}±8.35

** Very significant differences in $p<0.01$; ^{ns}not significant differences

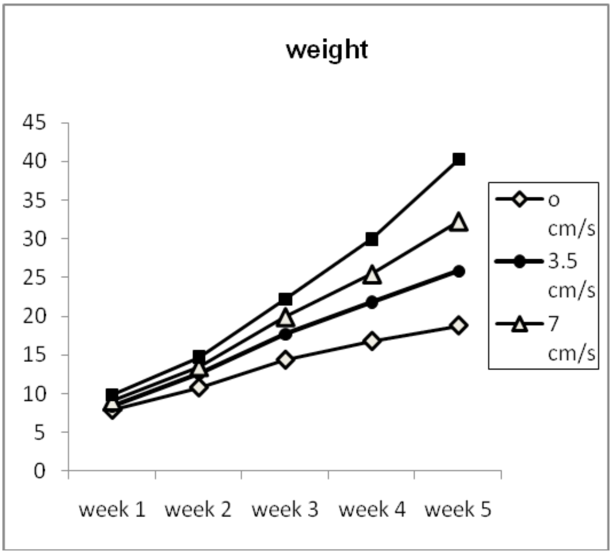

Figure 1. Changes of fry weight in different treatments during the experiment’s period

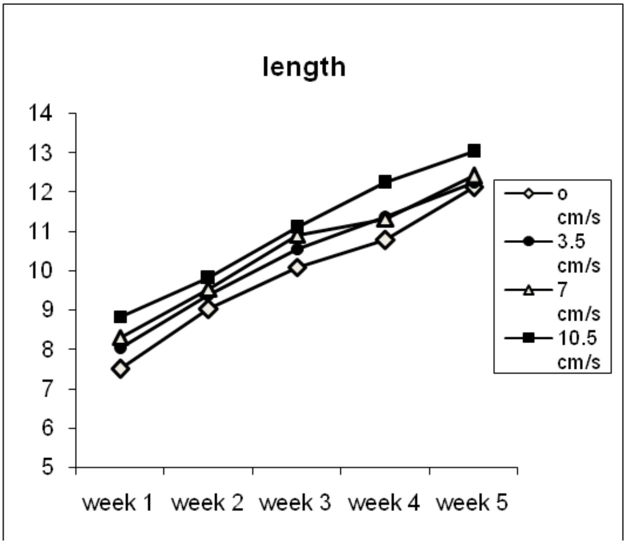

Figure 2. Changes of fry length in different treatments during the experiment’s period

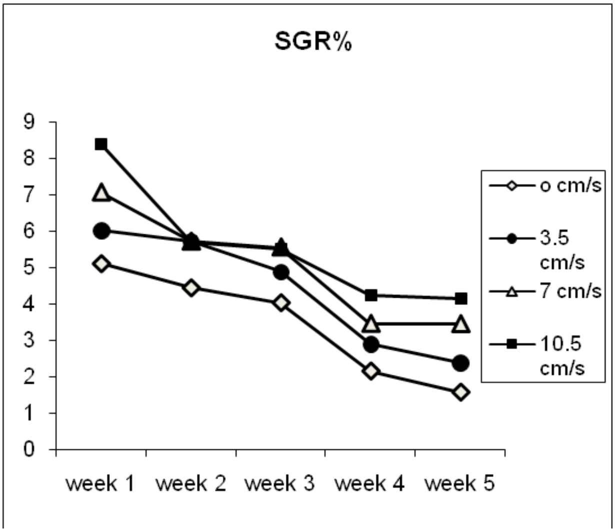

Figure 3. Changes of fry SGR% in different treatments during the experiment's period

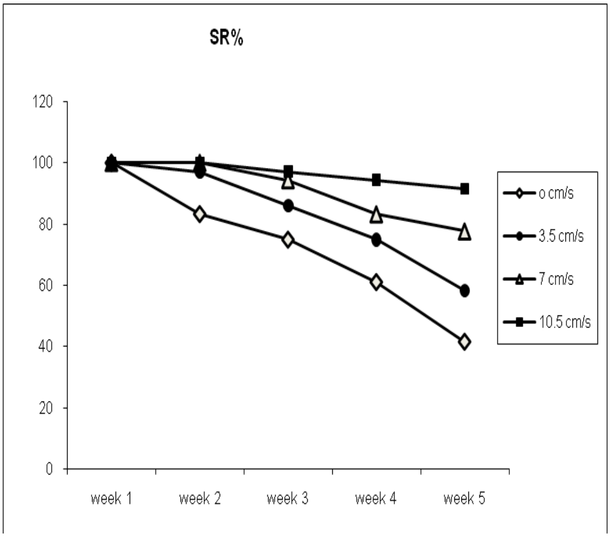

Figure 4. Changes of fry SR% in different treatments during the experiment's periodTable6.Results of ANOVA and Duncan's test indexes during 35 days of the experiment

Table 6.

Studied indicators	F_s	Treatment			
		1T	2T	3T	4T
(g) Weight	$^{**}7.617$	$13.6915^{c}\pm1.82$	$17.2561^{bc}\pm2.89$	$20.0061^{ab}\pm2.38$	$23.4302^{a}\pm3.08$
(cm) Length	4.815^{*}	$9.9239^{b}\pm0.41$	$10.3250^{ab}\pm0.39$	$10.4920^{ab}\pm0.29$	$10.9985^{a}\pm0.28$
SGR%	7.059^{**}	$3.4682^{c}\pm0.56$	$4.3767^{b}\pm0.66$	$5.0494^{a}\pm0.49$	$5.5881^{a}\pm0.64$
DGR%	7.605^{**}	$0.3781^{c}\pm0.10$	$0.5800^{bc}\pm0.16$	$0.7637^{ab}\pm0.16$	$0.9929^{a}\pm0.20$
CF%	11.336^{*}	$1.4257^{b}\pm0.03$	$1.5073^{ab}\pm0.04$	$1.6124^{a}\pm0.02$	$1.6174^{a}\pm0.06$
SR%	10.615^{**}	$72.200^{c}\pm6.73$	$83.3066^{bc}\pm6.007$	$91.0866^{ab}\pm5.09$	$96.6533^{a}\pm4.42$

** Very significant differences in $p<0.01$; * significant differences in $p<0.05$

DISCUSSION

Concerning high fry density in this survey water velocity had been increased till dissolved O_2 and CO_2 increases and decreases during water fall respectively. Summerfelt et al. (2000) showed that water oxygenation along with CO_2 elimination are necessary factors in water reused aquaculture systems. Our results implied that water velocity increment by outlet water reuse can also moderate these two factors. Clark (2003) suggested that oxygen injection could increase fish raceway capacity, although our results showed this matter could be done by water velocity increment through reuse filtered outlet water. Water velocity increment increases mixing level of air and water. This could result in better balance of dissolved O_2 and CO_2 in the water. CO_2 concentration could be bearable till 24 mg/lit by rainbow trout in culture unit (Good et al., 2010), but we have never record such CO_2 concentration during the experiment. At the same time, CO_2 reduction in the faster treatments was more evident. Based on the Martins et al. (2009), insoluble and dissolved matter concentration could be inhibitor factor in recirculation aquaculture systems so their high amount could been resulted in fry mortality. Results of this experiment showed that stocking density level could be different based on water velocity in fry bearable limitation. In our project, water velocity increment is provided by outlet water reuse after physical filtration and aeration only. Our results justify Colt (2005) findings who has introduced water speed as an effective factor on reducing water pollution. It was seen that water pollution accursed gradually and it is reusable after aerating and Total Solid Sediment (TSS) elimination. This matter implies previous findings (Summerfelt et al., 2004; Summerfelt et al., 2006; Stewart et al., 2006). In this experiment stocking density was more effective on fish growth and survival rate rather than water quality and this matter have reported already (North et al., 2006; Person et al., 2008). They showed that desire water quality covers stocking density problems. In spite of stocking density increment, our results showed that water speed increment could reduce the stocking rate problems.

At the same time, previous findings imply that fish density does not lead to considerable effect on fish growth and survival (Lefrancois et al., 2001; North et al., 2006). Roque d’orbcastel et al. (2009) found that only water recirculation could supply fish survival without necessity to water exchange. These results were justified by our findings in current water treatments, although this result was not observed in control treatment (0 cm/s).

In this experiment, weekly biometry showed some differences which could not be seen during all 35 days period. The reason for this matter can be seen by comparing tables 1-5 to table 6 . Duncan’s test results justify that in the first week the fourth treatment (10 cm/s) took the best rank (a) in assessed fry factors, excluding Condition Factor (CF), which its reason was not distinctive and needs more studies. At the same time, such result was not recorded in other weeks (table 2-5). However, the weakest results were observed in static water treatment (control).

Concerning the information in tables 1-5, the fourth treatment (10 cm/s) provided better results than the other treatments. It seems water velocity in our experiment was more important than water resource and its quality, so water speed increment could effect on water quality and adjust it to some extent.

This survey was done in laboratory condition, so its examination in farm condition could be a good point for future studies. It is recommended that other more water speeds are been examined in order to determine limitation velocity for trout culture under laboratory condition.

REFERENCES

Clark, M.L. (2003): Comparison of water quality, rainbow trout production, and economics in oxygenated and aerated raceways. Fisheries and wildlife sciences department. Etd 12172003-113917.

Colt, J. (2005): Water quality requirements for reuse systems. Aquaculture Engineering. Volume 34, Issue 3, 143-158.

EIFAC, IUNS And ICES. (1980): Report of working group on standardization of methodology in fish nutrition research.

Good, C., Davidson, J., Welsh, C., Snekvik, K., Summerfelt, S. (2010): The effects of carbon dioxide on performance and histopathology of rainbow trout *Oncorhynchus mykiss* in water recirculation aquaculture systems. Aquacultural Engineering. Volume 42, Issue 2, 51-56.

Jeffrey, M.H. (1999). Trout production feed and feeding methods. SRAC publication. No. 223.Lefrançois, C., Claireaux, G., Mercier, C., Aubin, J. (2001): Effect of density on the routine metabolic expenditure of farmed rainbow trout (*Oncorhynchus mykiss*). Aquaculture. Volume 195, Issue 3-4, 269- 277.

Martins, C.I.M., Pistrin, M.G., Ende , S.S.W., Eding , E.H., Verreth, J.A.J. (2009): The accumulation of substances in Recirculating Aquaculture Systems (RAS) affects embryonic and larval development in common carp *Cyprinus carpio*. Aquaculture. Volume 291, Issue1-2, 65-73.

North, B.P., Ellis, T., Turnbull, J.F., Davis, J., Bromage, N.R. (2006):Stocking density practices of commercial UK rainbow trout farms. The centre for environment, fisheries and aquaculture science, Weymouth laboratory, the Nothe, Weymouth, Dorset, UK, Elsevier. 10(3):141-142.

North, B. P., Turnbull, J.F., Ellis, T., Porter, M.J., Migaud, H., Bron, J., Bromage, N.R. (2006a): The impact of stocking density on the welfare of rainbow trout (*Oncorhynchus mykiss*). Aquaculture. Volume 255, Issue 1-4, 466- 479.

Person, J., Labbe, L., Le Bayon, N. (2008): Combined effects of water quality and stocking density on welfare and growth of rainbow trour(*Oncorhynchusmykiss*). Ifremer, Archimer, Aquatic living resources (EDP sciences), 2008/04,Volume 21, Issue 2 ,185-195.

Roque d´orbcastel, E., Blancheton, J.P., Belaud, A. (2009): Water quality and rainbow trout performance in a Danish Model Farm recirculating system: Comparison with a flow through system. Aquacultural Engineering. Volume 40, Issue 3, 135-143.

Sedgwick, S.D. (1990): Trout farming handbook. Fishing news book. England.208p.

Stewart, N.T., Boardman, G.D., Helfrich, L.A. (2006): Treatment of rainbow trout (*Oncorhynchusmykiss*) raceway effluent using baffled sedimentation and artificial substrates. Aquacultural Engineering. Volume 35, Issue 2, 166-178.

Summerfelt, S.T., Vinci, B. J., Piedrahita, R.H. (2000): Oxygenation and carbone dioxide control in water reuse systems. Aquacultural Engineering. Volume 22, 87-108.

Summerfelt, S.T., Davidson, J.W., Waidrop, T.B., Tsukuda, S.M., Williams, J.B., (2004): A partial-reuse system for cold water aquaculture.Aquacultural Engineering. Volume 31, Issue 3-4, 157-181.

Summerfelt, R.C., Chris, R.P. (2005): Solids removal in a recirculating aquaculture system where the majority of flow bypasses the microscreen filter. Aquacultural Engineering. Volume 33, Issue 3, 214-224.

Willoughby, S. (1999): Salmonid farming.Fishing news books.329 p.