Effect of water current on some growth performance and water quality in a closed rainbow trout (*Oncorhynchus mykiss*) culture system

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Abstract

The effects of water current increment on rainbow trout (*Oncorhynchus mykiss*) culture were investigated during a 35 day experiment. Fish weighing 5.5 g were stocked in aquarium tanks. Four different water speeds (0, 3.5, 7, 10.5 cm/s) were provided for each treatment in three replicates. These different currents water were provided by reusing outlet water of each culture unit. Length, weight, daily growth rate (DGR), specific growth rate (SGR), condition factor (CF) and survival rate (SR) were evaluated in each treatment. Also, the changes of NO2, NO3, NH3, NH4+, total hardness and pH were measured. The data variance analysis showed significant differences among all treatments during the first week (P<0.01). However, these results were not observed in following days. Based on Duncan's test results, the best survival rate (97%), daily growth rate (1), SGR (6%) and average weight (24g) were achieved in 10.5 cm/s.

Keywords: current speed, closed system, outlet water, rainbow trout, Iran.

Introduction

During the last decade, rainbow trout (*Oncorhynchus mykiss*) production has been expanded in Iran and its amount grew from 9000 mt in 2000 to 130000 mt in 2014. Aquaculture increment could be considered as one of the main reasons for water pollution in the world. Thus, water quality protection in fish culture is important and this leads industry to use modern systems such as recirculation aquaculture system (RAS) in order to get maximum production without polluting water. The possibility of outlet water refining is the main advantage of these systems and pH, temperature and control of bacterial disease are their other advantages (Willoughby 1999). However, they are very expensive. But what would be happened if some functions of RAS are eliminated and water velocity is increased through the culture unit, larger fish can stand against more water velocity (Sedgwick 1990). Therefore, this experiment was undertaken to evaluate the effect of water velocity, physical filtration and aeration in a closed rainbow trout culture system. The study was run via a randomize complete blocks design with 4 treatments in 3 replicates. Different water velocities of 0, 3.5, 7, 10.5 cm/s along with twelve plastic aquariums (200×40×15 cm) were considered.

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Materials and Methods

The experiment was carried out during a period of 35 days in Khojir Natural Resources Station, Tehran, Iran. Each plot contained 60 L of water with a Renault air pump for aerating. Rainbow trout weighing 5.5 g were provided from a private farm in Semnan province. Twelve fish were introduced to each aquarium after 48 h adaptation and feeding was started 48 h after fish transportation. Water recircu-

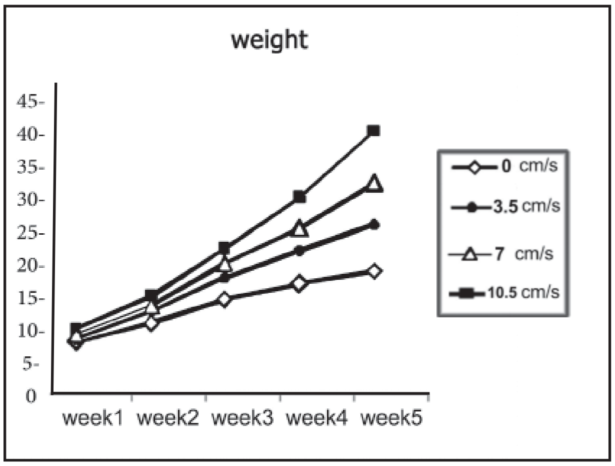

Figure 1 Changes of fry weight in different treatments during the experiment period.

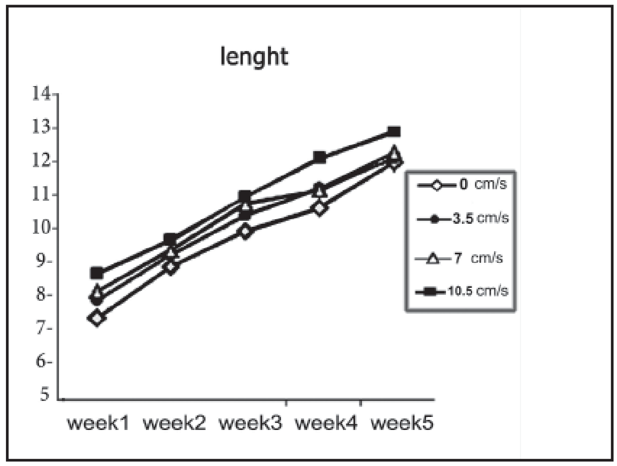

Figure 2 Changes of fry length in different treatments during the experiment period.

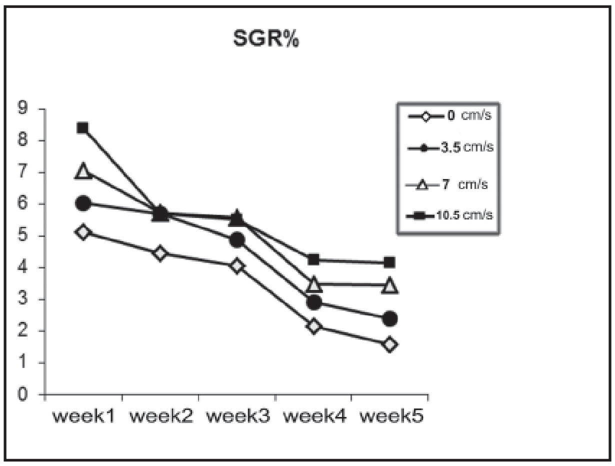

Figure 3 Changes of fry SGR% in different treatments during the experiment period.

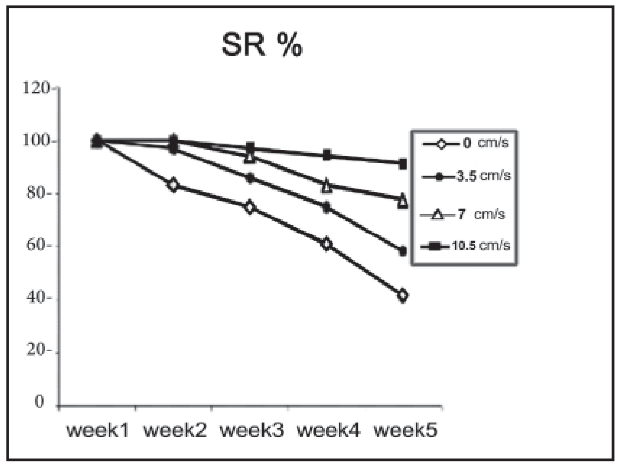

Figure 4 Changes of fry SR% in different treatments during the experiment period.

lation was performed by external electrical pumps via each plot which was connected to 30µ mesh size filter bags in order to physically filter water. These filter bags were cleaned manually daily, using fresh water. Evaporated water in each plot was replaced by isotherm fresh water. The water was gathered from the bottom of each plot by pumping and re-circulating to aquarium after filtering. Fish stocking was considered 200/m2, which was more than two fold Iranian farms average density. Fish were fed with a commercial food (Biomar Company, France) at 4% body weight (Jeffrey 1999) 5 times a day between 7 am and 7 pm. Feed comprised of 54% crude protein, 18% crude fat, 0.5% fiber, 10% ash and 1.4% phosphor. Water temperature and pH were measured daily during the experiment. Also, fry weight, length, specific growth rate (SGR) daily growth rate (DGR) survival rate (SR) and condition factor (CF) were weekly measured using below equations (Castell & Tiews 1980):

DGR: [(final weight (gr) - initial weight (gr)) ÷ experiment days]×100

SGR: [(Ln final weight- Ln initial weight) ÷ experiment days]×100

CF: (weight (g) ÷ lenght3)×100

SR: (live fry÷ total plot fry)×100

Data were analysed by SPSS software, version 14 and Duncan's averages comparing test was used to determine the best fish indexes averages among different treatments.

Results

Average oxygen demand was 7, 7.5, 8.5, 10.5 in 0, 3.5, 7 and 10 cm/s treatments, respectively. Table 1 shows significant difference for measured variables

Table1 Growth performance of trout treated in different water qualities one week post-experiment at 18±1.19 ºC

Growth factor	Treatment				
	F5	T1	T2	T3	T4
Weight (g)	**16.823	7.8731^{c}±0.30	8.3867^{bc}±0.38	9.0191^{b}±0.23	9.8938^{a}±0.42
Length (cm)	**11.173	7.4961^{c}± 0.17	8.0231^{bc}± 0.48	8.3046^{ab}±0.18	8.8276^{a}±0.18
SGR%	**16.892	5.1172^{c}±0.55	6.0173^{bc}±0.65	7.0590^{b}±0.53	8.3791^{a}±0.62
DGR%	**16.814	0.3389^{c}±0.04	0.4123^{bc}±0.05	0.5026^{b}±0.04	0.6276^{a}±0.06
CF%	**6.608	1.8666^{a}±0.10	1.6381^{b}±0.21	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

** Significant differences in P<0.01, ^{ns} non significant differences, T= Treatment.

Table 2 Growth performance of trout treated in different water qualities two week post-experiment at 18±1.19 ºC

Studied indicators	Treatment				
	F5	T1	T2	T3	T4
Weight (gr)	9.162**	10.7598^{c}±0.67	12.5396^{bc}±0.32	13.4600^{ab}±0.70	14.7584^{a}±0.98
Length (cm)	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

** Significant differences in P<0.01, ^{ns} non significant differences, T= Treatment.

Table 3 Growth performance of trout treated in different water qualities three week post-experiment at 18±1.19 ºC

Studied indicators F5	Treatment				
		T1	T2	T3	T4
Weight (gr)	6.783**	14.3287^{c}±1.71	17.7351^{bc}±2.80	19.8966^{ab}±1.87	22.2434^{a}±2.39
Length (cm)	8.033**	10.0897^{c}±0.40	10.5445^{bc}±0.21	10.9010^{ab}±0.20	11.0927^{a}±0.20
SGR%	1.852ns	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%	3.286ns	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

** Significant differences in P<0.01, ^{ns} non significant differences, T= Treatment.

Table 4 Growth performance of trout treated in different water qualities four week post-experiment at 18±1.19 ºC

Studied indicators	Treatment				
	F5	T1	T2	T3	T4
Weight (gr)	6.850**	16.7387^{c}±2.78	21.8137^{bc}±4.91	25.4217^{ab}±3.27	29.9999^{a}±4.36
Length (cm)	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.

in all treatments (P<0.01). Based on Duncan's test results, it seems the fourth and first treatments have caused maximum (a rank) and minimum (c rank) averages in week 1, respectively. The changes of fish weight, length, and specific growth rate are summarized in Figures 1-4.

Table 5 The results of fry ANOVA and Duncan's test in fifth week

Studied indicators	Treatment				
	F5	T1	T2	T3	T4
Weight (gr)	7.604**	18.7571^{c}±3.66	25.8052^{bc}±5.75	32.2331^{ab}±5.75	40.2558^{a}±7.26
Length (cm)	2.617ns	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

** Significant differences in P<0.01, ^{ns} non significant differences, T= Treatment.

Table 6 Growth performance of trout treated in different water qualities 35 days post-experiment at 18±1.19 ºC

Studied indicators	Treatment				
	F5	T1	T2	T3	T4
Weight (gr)	7.617**	13.6915^{c}±1.82	17.2561^{bc}±2.89	20.0061^{ab}±2.38	23.4302^{a}±3.08
Length (cm)	4.815*	9.9239^{b}±0.41	10.3250^{ab}±0.39	10.4920^{ab}±0.29	10.9985^{a}±0.28
SGR%	7.059**	3.4682^{c}±0.56	4.3767^{b}±0.66	5.0494^{a}±0.49	5.5881^{a}±0.64
DGR%	7.605**	0.3781^{c}±0.10	0.5800^{bc}±0.16	0.7637^{ab}±0.16	0.9929^{a}±0.20
CF%	11.336*	1.4257^{b}±0.03	1.5073^{ab}±0.04	1.6124^{a}±0.02	1.6174^{a}±0.06
SR%	10.615**	72.200^{c}±6.73	83.3066^{bc}±6.007	91.0866^{ab}±5.09	96.6533^{a}±4.42

** Significant differences in P<0.01, * significant differences in P<0.05, T= Treatment.

Discussion

Concerning high fish density in this survey, water velocity was increased till dissolved O_2 and CO_2 increased and decreased during water fell, respectively. Summerfelt, Vinci & Piedrahita (2000) showed that water oxygenation along with CO_2 elimination are necessary factors in water reuse aquaculture systems. Our results implied that water velocity increment by outlet water reuse can also moderate these two factors. Clarke (2003) suggested that oxygen injection could increase fish raceway capacity, although our results showed that this matter could be done by water velocity increment through reuse of filtered outlet water. Water velocity increment increased mixing level between air and water. This could result in better dissolved O_2 and CO_2 balance in water. CO_2 concentration could be bearable till 24 mg L^{-1} by rainbow trout in culture unit (Good, Davidson, Welsh, Snekvik & Summerfelt 2010), although we never recorded such CO_2 concentration during the experiment. At the same time, CO_2 reduction in faster treatments was more evident. According to Martins, Pistrin, Ende, Eding & Verreth (2009) studies, solved and dissolved matter concentrations could be inhibitor factors in recirculation aquaculture systems, so their high amount could result in fry mortality. The results of this experiment showed that stocking density level could be differential based on water velocity in fry bearable limitations. In our study, water velocity increment was provided by outlet water reuse after physical filtration and aeration only. Our results justify Colt's findings who introduced water speed as an effective factor on reducing water pollution (Colt 2005). It was seen that water pollution occurred gradually and is reusable after aerating and total solid sediment (TSS) elimination. This issue has been supported by the previous findings (Summerfelt, Davidson, Waidrop, Tsukuda & Williams 2004; Summerfelt & Chris 2005; Stewart, Boardman & Helfrich 2006). In this experiment, stocking density was more effective on fish growth and survival rate rather than water quality, and this matter has previously been reported (North, Ellis, Turnbull, Davis & Bromage 2006; Person-Le Ruyet, Labbé, Le Bayon, Sévère, Le Roux, Le Delliou & Quéméner 2008). These workers showed that desired 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 a considerable effect on fish growth and survival (Lefrancois, Claireaux, Mercier & Aubin 2001; North, Turnbull, Ellis, Porter, Migaud, Bron & Bromage 2006). Roque d´orbcastel, Blancheton & Belaud (2009) found that only water recirculation could supply fish survival without the necessity of 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 the 35 day experiment. Duncan's test results justify that in the first week, the fourth treatment (10 cm/s) took the best rank (a) of growth factors excluding condition factor (CF). However, the reason was not distinctive and requires further studies. The weakest results were observed in static water treatment (control) while 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 that water speed increment could affect 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 higher water speeds be examined in order to determine the limitation velocity for trout culture under laboratory condition.

References

Clarke M.L. (2003) *Comparison of water quality, rainbow trout production and economics in oxygenated and aerated raceways*. MSc thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Colt J. (2005) Water quality requirements for reuse systems. *Aquacultural Engineering* **34,** 143-158.

Castell J. D. & Tiews K. (1980) *Report of the EIFAC, IUNS and ICES working group on the standardization of methodology in fish nutrition research.* FAO, Technical Paper.

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* **42,** 51-56.

Jeffrey M. H. (1999) *Trout production: feeds and feeding methods.* SRAC publication. No. 223.

Lefrancois C., Claireaux G., Mercier C. & Aubin J. (2001) Effect of density on the routine metabolic expenditure of farmed rainbow trout (*Oncorhynchus mykiss*). *Aquaculture* **195,** 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* **291,** 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. *Aquaculture* **259,** 260-267.

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

Person-Le Ruyet J., Labbé L., Le Bayon N., Sévère A., Le Roux A., Le Delliou H. & Quéméner L. (2008) Combined effects of water quality and stocking density on welfare and growth of rainbow trout (*Oncorhynchus mykiss*). *Aquatic Living Resources* **21,** 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* **40,** 135-143.

Sedgwick S. D. (1990) *Trout farming handbook.* Fishing News Book, Oxford, UK.

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

Summerfelt S. T., Vinci B. J. & Piedrahita R. H. (2000) Oxygenation and carbone dioxide control in water reuse systems. *Aquacultural Engineering* **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* **31,** 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* **33,** 214-224.

Willoughby S. (1999) *Manual of Salmonid farming.* Fishing News Books, Blackwell Science, Oxford.

تأثیر جریان آب برروی برخی پارامترهای رشد و کیفیت آب در پرورش ماهی قزل آلای رنگین کمان (*Oncorhynchus mykiss*) در محیط بسته

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چکیده

در این مطالعه اثرات افزایش جریان سرعت آب برماهی قزل آلای انگشت قد در محیط بسته پرورشی در مدت ۳۵ روز مورد بررسی قرار گرفت. ابتدا چهار تیمار با سرعت‌های ۰، ۳/۵، ۷، ۱۰/۵ سانتی متر بر ثانیه در تکرارهای سه تایی تشکیل شده و جریانهای متفاوت سرعت آب بوسیله تنظیم کردن خروجی‌های هر آکواریوم (یک واحد پرورشی) فراهم گردید. سپس فاکتورهای طول، وزن، میزان رشد روزانه و رشد ویژه، عامل وضعیت و میزان بقاء برای هر تیمار مورد ارزیابی قرار گرفت. همچنین میزان تغیرات نیترات، نیتریت، آمونیاک، آمونیوم، سختی کل وpH برای هر واحد پرورشی اندازه‌گیری گردید. آنالیز واریانس نتایج، تفاوت معنا داری را در همه گروها در هفته اول نشان داد (P<۰/۰۱) در حالیکه در ادامه زمان پرورش تفاوت معنا داری مشاهده نشد. بر اساس نتایج تست دانکن، بالاترین میزان بقاء (۹۷%)، میزان رشد روزانه (۱)، SGR (۶٪) و میانگین وزن (۲۴ گرم) در گروه پرورشی با سرعت ۱۰/۵ سانتی متر بر ثانیه بدست آمد.

واژه‌های کلیدی: قزل الای رنگین کمان، پرامترهای رشد، آب خروجی، سیستم بسته، سرعت جریان.

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