

EFFECT OF STOCKING DENSITY IN INTENSIVE FISH CULTURE SYSTEM ON GROWTH PERFORMANCE, FEED UTILIZATION AND ECONOMIC PRODUCTIVITY OF NILE TILAPIA (*Oreochromis niloticus* L.) REARED IN HAPAS

Ramadan M. Abou-Zied¹ and Ahmed A. AbdEl-Rahman².

¹ Anim. Prod. Dept. Faculty of Agriculture, Fayoum University, Egypt

² Central Laboratory for Aquaculture Research, Agriculture Research Center, Egypt.

Received 13/ 11/ 2012

Accepted 28/ 12/ 2012

Abstract

This study was carried out to evaluate the effect of varying stocking densities in intensive Nile tilapia culture system on the growth performance, feed utilization, and economic productivity of Nile tilapia (*Oreochromis niloticus* Linnaeus 1757) reared in Brackish water ponds (average depth, 1.7 m) of Rayyan region, Fayoum Governorate, Egypt, for a period of 6 months. Tilapia fingerlings with a mean initial weight of 20 ± 2.4 g were randomly stocked at 100, 200, 300 and 400 fingerling/m³ and fed on a commercial diet (27% Crude Protein). Each treatment was carried out in 3 hapas representing 4 treatment.

Results revealed that there were significant differences ($P > 0.05$) in final weight, weight gain, daily gain, specific growth rate, feed conversion ratio (FCR) among all treatments studied. However there were insignificant differences ($P < 0.05$) in survival rate. Results show also that as stocking density increased, the growth performance values decreased indicating an inverse relationship between stocking density and growth parameters. The stocking density of 200 fingerling /m³ with a final weight of 315 g per fish, feed conversion ratio of 1.74, survival of 92.90% and fish production of 58.49 kg/m³ was considered best on the basis of the profit index of 1.35 compared with the range of 1.26 to 1.32 for the other three treatments.

Under the experimental conditions Nile tilapia reared at 200 fish/m³ was the best regarding to profit index and relatively high growth parameters

Key words: Nile tilapia, stocking density, growth performance, feed utilization and economic evaluation

INTRODUCTION

Tilapia has become popular for farmers as it is easy to culture and there is a good demand for this fish in the market. Moreover, tilapias (*Oreochromis spp.*) adapt well to the local environment and local feed, and have high productivity (Sorphea *et al.*, 2010). For many years, tilapia has drawn attention of the farmers for their better growth performance. It rank high in global aquaculture production after carps (FAO, 2012). Tilapias are a hardy species produced by several culture methods under a wide range of environmental conditions in tropical and subtropical regions in developing countries and can be cultured in mesh cages that maintain free circulation of water. It ensures flexibility in management practices with easy and low cost of harvesting.

Egypt fish production from aquaculture activities contributed by 70.48% of the total fish production which amounted 1.305 million metric tons, where tilapia acts as 52.68 % of them (GAFRD, 2011).

Fish farmers were interested in recent years to increase production per water unit by stocking density of fish as a one of the solutions to increase production.

Stocking density is one of the most important variables in aquaculture because it directly influences survival, growth, behavior, health, water quality, feeding and production. The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. Fish intensification by increasing stocking density is also found suitable to overcome the problem of land shortage (Khatab *et al.*, 2004).

Growth, survival and yield effects of stocking density on aquaculture are well known for a diversity of species (Garr *et al.*, 2011; Khatune-Jannat *et al.*, 2012; Zhu *et al.*, 2011) and seem to impact production differently. Both growth performance and survival rate which

tended to be higher at lower stocking densities in the African catfish, *C. gariepinus* (Hecht *et al.*, 1996), in Thai climbing perch, *Anabas testudineus* (Khatune-Jannat *et al.*, 2012), in Amur sturgeon *Acipenser schrenckii* (Zhu *et al.*, 2011), in silver catfish *Rhamdia quelen* (Pouey *et al.*, 2011) and in *Oreochromis* spp. (Sorphea *et al.*, 2010), but only survival is higher under same conditions in *Oreochromis* spp. (Ridha, 2005). In some cases advantage of lower stocking densities is either non-existent, as in channel catfish (Southworth *et al.*, 2009), in *Oreochromis niloticus* (Osofero *et al.*, 2009) or existent temporary and wanes after sometime so that generally no differences occur across different stocking densities, as in apple snail, *Pomacea paludosa* aquaculture (Garr *et al.*, 2011). Although they may promote competition for food and negatively influence reproductive success via reduced fecundity and egg quality (Tave, 1986), high stocking densities may sometimes have no effect on mortality rates and may actually enhance total fish yield (Khatune-Jannat *et al.*, 2012; Pouey *et al.*, 2011; Sorphea *et al.*, 2010) and lead to higher gross and net return at a lower cost of production (Abou *et al.*, 2007). Where land costs, fresh water, manpower and other facilities are limiting it may be more profitable to adopt higher stocking densities in fish culture (Ridha, 2005).

Generally high density is considered as a potential source of stress, with a negative effect on fish growth rate (Lefrançois *et al.*, 2001) and survival and feeding rates (Rowland *et al.*, 2006).

The object of the present study was to investigate the influence of different stocking densities of Nile tilapia reared in hapas on growth performance and total yield.

MATERIALS AND METHODS

This study was carried out to investigate the effect of stocking density on growth performance and feed utilization of Nile tilapia reared in hapas under natural water condition. The study started on beginning

April 2012 till 6/10/2012 for a proximally 189 days in Rayyan region Fayoum Governorate.

Nile tilapia fingerlings were obtained from a private farm from on July 2011. A total of 12000 Nile tilapia fingerlings with an average initial body weight of 20 ± 2.4 g were distributed in 12 hapa $2 \times 2 \times 1$ m suspended in a big natural pond of agricultural drainage water supplied continually from neighboring and the area of this pond exceed 30 feddan.

The experimental fish were divided into four stocking densities (100, 200, 300 and 400 fish/m³) and each density was performed in three hapas replicates. Fish were fed on an artificial diet containing 27% CP at a feeding rate of 3% of body weight twice a day. The proximate analysis of the diet including DM; CP; EE; ash; CF; NFE and gross energy is given in Table 1.

Table (1). Proximate analysis of diet used.

Items	%
DM	11.15
Crude protein, CP	27.31
Ether extract, EE	7.24
Ash	7.69
Crude fiber, CF	6.26
Nitrogen free extract. NFE¹	51.50
GE, kcal/g*	4.598

1, Calculated by differences

* Calculated according to NRC, 1993.

Some fish were weighed every two week in order to adjust the feed amount in the hapa according to the new weight obtained.

Statistical analyses were performed using SPSS (1997), one way analysis of variance were used and significantly between treatments was evaluated at the 5 % probability level.

RESULTS AND DISCUSSION

Water quality recorded during the experimental period was 7 – 9 ‰ for salinity, the temperature was stable around 27-28°C oxygen concentration was suitable (6.2-7.0) and pH water was around 7.8 (Table 2), all water quality were within the acceptable levels for best growth of Nile tilapia (Khalfalla *et al.*, 2008)

Table (2). Water quality parameters.

Month	Temperature	pH	Dissolved oxygen	NH ₄
May	27	7.8	6.3	0.019
June	28	7.7	6.2	0.020
July	29	7.6	5.8	0.020
August	30	7.6	5.2	0.019
September	29	7.8	6.8	0.018

Growth performance:

The effect of stocking density on growth performance parameters is illustrated in Table 3. Significant differences ($P < 0.05$) on final fish weight, weight gain, daily gain and specific growth rate were observed between groups. Final mean weight showed a decreasing tendency with increasing stocking density. The differences between the lowest and highest density were 25% in final weight. Fish reared at the highest densities (400 fish/m³) had the lowest mean growth performance parameters while those of the lowest densities (100 fish/m³) showed the highest means while the densities of 200 and 300 fish/m³ were in between. These results may be due to the presence and abundance of oxygen and large areas for fish movement in low densities and increased competition of food and/or space can negatively affect fish growth. These results are agreement with results obtained by Chakraborty *et al.* (2010) and Yi and Lin (2001) who stated that increased fish biomass of Nile tilapia in cages had a significant negative effect on the final mean

body weight. Diana *et al.* (2004) reported that sex reversed Nile tilapia stocked in ponds at a low density showed better growth than at a higher density. The lower growth performance of tilapia at higher stocking density may due to voluntary appetite suppression, more expenditure of energy because of intense antagonistic behavioural interaction, competition for food and living space effects (Diana *et al.*, 2004) and increased stress (Ouattara *et al.*, 2003). For there more Dambo and Rana (1992) reported that increasing stocking density of Nile tilapia fry might have lead to diminishing social dominance, resulting in lower individual growth rates.

Table (3). Effect of stocking density on growth performance parameters of Nile tilapia reared in hapas.

Parameters	Stocking density/ m ³				SED
	100	200	300	400	
Initial mean body weight, g	18.67	20.67	18.67	22.00	0.900
Final mean body weight, g	361.67 ^a	315.00 ^b	271.67 ^c	268.33 ^c	11.73
Total gain, g ⁽¹⁾	343.00 ^a	294.33 ^b	253.00 ^c	246.33 ^c	0.062
Daily gain, g ⁽²⁾	1.81 ^a	1.56 ^b	1.34 ^c	1.30 ^c	0.031
SGR, % ⁽³⁾	1.57 ^a	1.44 ^b	1.42 ^b	1.32 ^c	0.073

* Average in the same row having different superscripts differ significantly $P \leq 0.05$.

* SED is the standard error of difference

Experimental period = 189 days

(1) = Final weight - Initial weight

(2) = Total gain, g /period in days.

(3) = $100 (\ln \text{ Final weight} - \ln \text{ Initial weight}) / \text{period in days}$, where \ln is the natural log.

Feed utilization:

Results of the effect of stocking density on feed utilization are presented in Table (3). Significant differences in feed conversion ratio (FCR) were observed between groups. Results of this Table indicated that The FCR improved at stocking density (100 fish/m³) (1.55) than high socking density (400 fish/m³) (2.02) and the difference among both groups was 23% but other densities were in between. These results was

near to that obtained by Alhassan *et al.* (2012). Explanation for this can be drawn from Aksungur *et al.* (2007) who indicated that social interactions through competition for food and/or space can negatively affect fish growth. Moreover, Aksungur *et al.* (2007) explained that, higher stocking densities leads to increased stress and that resulting increase in energy requirements causing a reduction in growth rates and food utilization.

Results of Table (4) show that the survival rate was insignificantly ($P \leq 0.05$) affected with stocking density. It was between 95 – 89.25% independently of the density and the period. Part of the mortalities observed was due to fish crowding and other part after sampling. These results agreement with El-Sayed (2002).

Table (4). Effect of stocking density on feed utilization of Nile tilapia reared in hapas.

Parameters	Stocking density/ m ³				SED
	100	200	300	400	
Feed intake, g/fish	531.67	511.67	486.67	498.33	20.55
FCR	1.55 ^c	1.74 ^b	1.92 ^a	2.02 ^a	0.228
Survival rate%	95.00	92.90	90.39	89.25	4.99
Feed intake, kg/hapa	201.93	380.43	528.1	711.46	

* Average in the same row having different superscripts differ significantly $P \leq 0.05$.

* SED is the standard error of difference

Economic evaluation:

The effect of stocking density on economic evaluation was shown in Table (5). Although increasing final body weight of the lowest density, the net returns of hapa improved with increasing density and the best net returns were observed with the density 400 fish/m³ followed by densities 300, 200 and 100 fish/m³ respectively.

In conclusion regarding to returns and costs (profit index) the best density was 200 fish/m³ than the lowest density (100 fish/m³) and the highest density (400 fish/m³).

Table (5). Effect of stocking density on economic efficiency of Nile tilapia reared in hapas.

Parameters	Stocking density/ m ³			
	100	200	300	400
Costs, L.E. /hapa				
Feed	707	1,331	1,848	2,490
Fish	140	280	420	560
Other costs	300	300	300	300
Total costs, L.E.	1147	1911	2568	3350
Hapa biomass, kg	137.47	233.96	294.78	383.19
Selling, L.E/ hapa	1512.17	2573.56	3242.58	4215.09
Net returns	365.17	662.56	674.58	865.09
Profit index	1.32	1.35	1.26	1.26

Price of one kg selling fish = 11

Price of kg feed = 3.5 L.E

REFERENCES

- Abou, Y.; E.D. Fiogbe and J.C. Micha. 2007. Effects of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed Azolla diet, in earthen ponds. *Aquac. Res.*, 38: 595–604.
- Aksungur N.; M. Aksungur; B. Akbulut and I. Kutlu. 2007. Effects of stocking density on growth performance, survival and food conversion ratio of Turbot (*Psetta maxima*) in the net cages on the southeastern coast of the Black Sea. *Turkish J. Fish. Aquat. Sci.*, 7: 147-152.
- Alhassan, E.H.; E.D. Abarike and Ayisi, C.L. 2012. Effects of stocking density on the growth and survival of *Oreochromis niloticus* cultured in hapas in a concrete tank. *African Journal of Agricultural Research*, 7 (15): 2405-2411.
- Chakraborty, S.B.; D. Mazumdar and S. Banerjee. 2010. Determination of Ideal Stocking Density for Cage Culture of Monosex Nile Tilapia (*Oreochromis niloticus*) in India. *Proc. zool. Soc.*, 63 (1): 53–59.
- Dambo, W.B. and K.J. Rana. 1992. Effects of stocking density on growth and survival of Nile tilapia *Oreochromis niloticus* (L.) fry in the hatchery. *Aquacult. Fisher. Manage.*, 23: 71-80.
- Diana, J.S.; Y. Yi and C.K. Lin. 2004. Stocking densities and fertilization regimes for Nile tilapia (*Oreochromis niloticus*) production in ponds with supplemental feeding In: Bolivar, R, Mair, G. and Fitzsimmons, K. (eds) *Proceedings of the Sixth International Symposium on Tilapia in Aquaculture*, Manila, Philippines, BFAR, Philippines, pp. 487-499.

- El- Sayed, A.M. 2002. Effect of stocking density and feeding levels on growth and feed efficiency of Nile tilapia (*Oreochromis niloticus* L.) fry. *Aquacult. Res.* 33: 621- 626.
- FAO. 2012. Food and Agriculture Organization of the United Nations. Statistics and Information Service Fisheries and Aquaculture Department. The State of World Fisheries and Aquaculture part 1
- GAFRD, 2011. General authority for fish resources development. Fishery statistic. Egyptian Ministry of Agriculture.
- Garr, A.L.; H. Lopez; R. Pierce and M. Davis. 2011. The effect of stocking density and diet on the growth and survival of cultured Florida apple snails, *Pomacea paludosa*. *Aquaculture* 311: 139–145.
- Hecht, T.; L. Oellermann and L. Verheust. 1996. Perspectives on clariid catfish culture in Africa. *Aquat. Living Resour.*, 9: 197–206.
- Khalfalla, M.M.; Y.A. Hammouda; A.M. Tahoun and H.A.M. Abo-State. 2008. Effect of Brood stock sex ratio on growth and Reproductive performance of Blue tilapia *Oreochromis aureus* (Steindachner) reared in hapas. 8th International Symposium on Tilapia in Aquaculture (CICC) Egypt, 1: 115-125.
- Khattab, Y.A.R.; M. Abdel-Tawwab and M.H. Ahmad. 2004. Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry (*Oreochromis niloticus* L.). In: Bolivar, R, Mair, G. and Fitzsimmons, K. (eds) Proceedings of the Sixth International Symposium on Tilapia in Aquaculture, Manila, Philippines, BFAR, Philippines, pp. 264-276.

- Khatune-Jannat, M.; M.M. Rahman; M.A. Bashar; M.N. Hasan and F. Ahamed. 2012. Effects of stocking density on survival, growth and production of Thai Climbing Perch (*Anabas testudineus*) under fed ponds. *Sains Malaysiana*, 41: 1205–1210.
- Lefrançois, C.; G. Claireaux; C. Mercier and J. Aubin. 2001. Effect of density on the routine metabolic expenditure of farmed rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, 195: 269–277.
- NRC. 1993. Nutrient requirement of fish. National Academy Press, Washington DC.
- Osofero, S.A.; S.O. Otubusin and J.A. Daramola. 2009. Effect of stocking density on tilapia (*Oreochromis niloticus* Linnaeus 1757) growth and survival in bamboo – net cages trial. *Afr. J. Biotechnol.* 8: 1322–1325.
- Ouattara, N.I.; G.G. Teugels; V.N. Douba and J.C. Philippart. 2003. Aquaculture potential of the black-chinned tilapia, *Sarotherodon melanotheron* (Chiclidæ). Comparative study of the effect of stocking density on growth performance of landlocked and natural populations under cage culture conditions in Lake Ayame (Cote d'Ivoire). *Aquacult. Res.*, 34: 1223-1229.
- Pouey, J.L.; S.R. Piedras; C.B. Rocha; R.A. Tavares and J.D. Santos. 2011. Productive performance of silver catfish, *Rhamdia quelen*, juveniles stocked at different densities. *Ars Veterinaria*, 27: 241–245.
- Ridha, M.T. 2005. Comparative study of growth performance of three strains of Nile tilapia, *Oreochromis niloticus*, L. at two stocking densities. *Aquac. Res.*, 37: 172–179.

- Rowland, S.J.; C. Mifsud; M. Nixon and P. Boyd. 2006. Effects of stocking density on the performance of the Australian freshwater silver perch (*Bidyanus bidyanus*) in cages. *Aquaculture*, 253: 301-308.
- Sorphea, S.; T. Lundh; T.R. Preston and K. Borin. 2010. Effect of stocking densities and feed supplements on the growth performance of tilapia (*Oreochromis* spp.) raised in ponds and in the paddy field. *Livest. Res. Rural Dev.*, 22; 227.
- Southworth, B.E.; C.R. Engle and K. Ruebush. 2009. The effect of understocking density of channel catfish stockers in multiple-batch production. *J. Appl. Aquacult.*, 21: 21–30.
- SPSS. 1997. Statistical Package For Social Science (for Windows). Release 8.0 Copyright (C), SPSS Inc., Chicago, USA.
- Tave, D. 1986. Genetics for Fish Hatchery Managers. AVI Publishing Co., Westport, Connecticut.
- Yi, Y. and Lin, C.K. 2001. Effect of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system. *Aquaculture*, 195: 253-267.
- Zhu, Y.J.; D.G. Yang; J.W. Chen; J.F. Yi and W.C. Liu. 2011. An evaluation of stocking density in the cage culture efficiency of Amur sturgeon *Acipenser schrenckii*. *J. Appl. Ichthyol.*, 27: 545–549.

تأثير كثافة التخزين فى نظام استزراع الاسماك المكثف على مظاهر النمو والاستفادة من الغذاء والانتاجية الاقتصادية للبلطى النىلى المربى فى هابات

رمضان محمد أبوزيد^١ و أحمد عبد الله عبد الرحمن على^٢

^١ قسم الإنتاج الحيوانى - كلية الزراعة - جامعة الفيوم - مصر

^٢ المعمل المركزى لبحوث الثروة السمكية بالعباسة - مركز البحوث الزراعية - وزارة الزراعة

الملخص العربى

أجريت هذه الدراسة لتقييم تأثير كثافة التخزين المختلفة فى النظام المكثف على مظاهر النمو والاستفادة من الغذاء والانتاجية الاقتصادية للبلطى النىلى فى حوض مياة شروب (متوسط العمق ١.٧ م) بمنطقة الريان - محافظة الفيوم لمدة ٦ اشهر. وزعت اصبعيات البلطى بمتوسط وزن 20 ± 2.4 جم عشوائيا بمعدل ١٠٠، ٢٠٠، ٣٠٠ و ٤٠٠ اصبعية/م^٣ وغذيت بعليقة تجارية ٢٧% بروتين. تم تمثيل كل معاملة فى اربع مكررات.

وجدت اختلافات معنوية فى الوزن النهائى والزيادة فى الوزن والزيادة اليومية ومعدل النمو النوعى ومعدل الاستفادة من الغذاء فى جميع المعاملات اما معدل الاعاشة لم يتأثر معنويا. بزيادة كثافة التخزين انخفضت قيم مظاهر النمو مشيرة الى علاقة عكسية. كثافة التخزين ٢٠٠ سمكة/م^٣ بمعدل وزن نهائى ٣١٥ جم ومعدل تحويل غذائى ١.٧٤ واعاشة ٩٢.٩ وانتاج ٥٨.٤٩ كجم/م^٣ تعتبر احسن الكثافات على اساس مؤشر الربح ١.٣٥ بالمقارنة ١.٢٦-١.٣٢ لباقي المعاملات.

تحت ظروف التجربة يعتبر تربية البلطى النىلى بمعدل كثافة ٢٠٠ سمكة/م^٣ افضل نظرا لمؤشرات الربح العالية ومعدلات النمو العالية نسبيا.