



Comparison of Growth for Cultivated Common carp, *Cyprinus carpio* Larvae between Earthen Ponds and Recirculation Aquaculture System

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Abstract: A comparison was conducted for growth criteria of common carp, *Cyprinus carpio* larvae cultivated in earthen ponds and recirculation aquaculture system (RAS) depending on live foods (phytoplankton and zooplankton stimulated by buffalo fertilizers in earthen ponds, while the larvae cultivated in RAS were feed on *Artemia* larvae reproduced *in vitro*, in addition to manufactured pellets (38% crude protein) for common carp in both systems. Three 2500 m² earthen ponds were cultivated for 90 days with larvae of initial weight 0.002 g at different numbers (40800 larvae for pond 1, 55600 larvae for pond 2 and 36400 larvae for pond 3). These larvae depend on natural food for 19 days, then fed on manufactured feed. Fishes were weighed every 19 days to change daily feed. Three replicates of RAS plastic tanks (100 liter capacity) cultivated for 90 days with 0.002 g larvae at a density of 2 larvae per one liter (160 larvae at each plastic tank). These larvae fed for 15 days to saturation (4 meals daily) with *Artemia* larvae and small *Artemia*, then fed on manufactured feed. Subsequently, fishes were weighed every 15 days to change daily feed. Larvae cultivated in earthen ponds recorded weight gain of 26.90 g, daily growth of 0.30 gday⁻¹, relative growth of 1345000%, specific growth of 10.56 %day⁻¹, feed conversion of 1.25 and survival rate of 13.16%. Larvae cultivated in RAS system recorded weight gain of 1.53 g, daily growth of 0.02 gday⁻¹, relative growth of 76200%, specific growth of 7.37 %day⁻¹, feed conversion of 2.82 and survival rate of 72.32%. Statistical analysis of results revealed significant differences (p<0.05) in all growth criteria for larvae cultivated in both systems. Final conclusion that earthen pond was better than RAS systems in producing fingerlings of common carp.

Keywords: Common carp, RAS, Weight gain, Growth rate, Survival rate.

Introduction

Fishes consider as one of an important highly value protein resources that comprise 20% of world protein (FAO, 2016). Fish culture production in 1918 comprise 46% of total world fish production, and it must be

increased five times to face the increasing demand of fish during next two decades (FAO, 2020).

Expansion of fish culture projects lead to increase of negative environmental effects

because of pollution that lead to reduce the capacity of traditional fish culture projects (Martins *et al.*, 2010). For this reason new production systems must be proved which depend on little amount of water to reduce pollution such as recirculating aquaculture systems (RAS) (Zachritz *et al.*, 2008; Martins *et al.*, 2010; Zhang *et al.*, 2011).

Schneider *et al.* (2006) showed RAS projects need more treasury funds than traditional projects (Martin *et al.*, 2010). For this reason fish density must be too high to increase fish production in small area to achieve benefits quickly (Martins *et al.*, 2005). Rawlinson & Foster (2001) stated that in RAS systems more than 90% of water will be returned after cleaning by biological and mechanical filtrations. Extra water will be added from stocking tanks to compensate water lost by evaporation and treating wastes, and water purified by removing organic wastes and residual feeds in mechanical filters, while ammonia and nitrite were oxidized to nitrate in biological filters (Applah-Kubi, 2012). The aim of current study is to investigate the validity of producing common carp fingerlings in RAS system comparing with earthen ponds.

Materials & Methods

Current study conducted within field and laboratory experiments. Field experiment consists of three earthen ponds (2500 m² each) belonging to Aquaculture Unit, Agriculture College, Basrah University in Hartha District, north Basrah. Laboratory experiment represented by recirculation aquaculture system RAS and conducted in Abu-Mughira agricultural area four km of

Abu Al-Khaseeb District. Pellets feed (38% crude protein) used in current experiment was manufactured from different ingredients (Table, 1). Field experiment was conducted in three earthen ponds that fertilized by 1000 kg of buffalo fertilizer for each one. These ponds were cultivated with different larvae numbers (40800 for pond 1, 55600 for pond 2 and 36400 for pond 3). These larvae brought from Fish Hatcheries of Marine Science Center. Larvae were feeding on natural food in ponds for 19 days, then fed on powdered manufactured feed (38% crude protein) at feeding ratio of 10% with two meals (morning and afternoon) until age 30 days. From age 30 to 60 days fishes fed on pellets at ratio of 7%, then decreased to 4% to the end of experiment. Fishes were weighed every 19 days to change daily feed and some environmental parameters (Water temperature, salinity, dissolved O₂ and pH) were recorded.

Laboratory experiment conducted in RAS system (plastic tanks of 100 litres capacity). The system operated before three days of bringing larvae stocking, and nitrogen bacteria (*Nitromonas* and *nitrobacteria*) were added to biological filter. Larvae (0.002 g) were bring from Fish Hatchery belong to Marine Science Center at 6 May, 2018. After one day larvae put in plastic ponds at density of 2 larvae. l⁻¹, and fed for 15 days to satiation (four meals daily) on laboratory reproduced *Artemia* larvae. Powdered manufactured feed (38% crude protein) used at feeding ratio of 10% until age 30 days. From age 30 to 60 days larvae fed on pellets at ratio of 7%, then decreased to 4% to the

end of experiment. Fishes were weighed every 15 days to change daily feed. Some environmental factors recorded daily such as water temperature, salinity, dissolved O₂, pH and concentration of ammonia. At the end of experiment numbers of fishes and growth criteria were calculated according to the following formulas:

$$\text{Weight increment (WI, g)} = FW - IW$$

$$\text{Daily growth rate (DGR, gday}^{-1}\text{)} = (FW - IW) \text{ days}^{-1}$$

$$\text{Specific growth rate (SGR, \%day}^{-1}\text{)} = 100 \times [(\ln FW) - (\ln IW)] \text{ days}^{-1}$$

$$\begin{aligned} \text{Relative growth rate (RGR, \%)} \\ &= (FW - IW) \\ &\div (IW \times 100) \end{aligned}$$

$$\begin{aligned} \text{FCR} &= \text{feed consumed} \\ &\div \text{fish weight increment} \end{aligned}$$

Where: FW = Final fish weight (g);
IW = Initial fish weight (g)

By application of SPSS (version 23), the data were subjected to one-way analysis of variance (ANOVA) to determine the difference between the means and the significant differences which were tested by LSD test.

Table (1): Ingredients of fish pellets with their chemical decomposition.

Feed ingredient		Chemical analysis	
Ingredients	%	Component	%
Local fish meal	30.21	Crude protein	38.00±1.08
Soybean meal	30.21	Oil	6.91±0.47
Yellow corn meal	18.79	Ash	6.47±0.78
Wheat meal	18.79	Moisture	4.52±0.31
Vitamins and minerals	2.00	Carbohydrates	44.10±2.35
		Energy (kcal.kg ⁻¹)	4487.9±39.1

Results

Table (2) showed measurements of some environmental parameters for earthen ponds during the experiment. These parameters had little fluctuations except salinity. Water temperature ranged between 25.0-29.0 °C, pH value ranged between 7.5-7.9, dissolved O₂ ranged between 6.8-8.2 mg/l and salinity

ranged between 3.2-8.2 PSU due to the effects of marine tide water.

Table (3) revealed growth criteria of common carp larvae cultivated in earthen ponds. Final average weight reached by these larvae was 26.90 g. lowest average weight increments (2.87 g) reached after 19

Table (2): Environmental parameters for earthen ponds water during the experiment.

Date	Water temperature (°C)	pH	Dissolved O ₂ (mg.l ⁻¹)	Salinity PSU
3/5/ 2018	26.0	7.8	7.5	3.2
22/5	26.5	7.7	7.5	3.7
10/6	25.0	7.9	8.2	4.5
29/6	27.0	7.6	7.2	5.7
22/7	28.0	7.5	6.8	7.3
1/8	29.0	7.5	6.5	8.2

Table (3): Growth criteria of common carp larvae cultivated in earthen ponds.

Period (Days)	Average weight (g)	Weight increment (g)	Daily growth Rate (g.day ⁻¹)	Relative growth rate (%)	Specific growth rate (%day ⁻¹)	Feed conversion ratio
0	0.002					
19	2.88 ± 0.51	2.87 ± 0.51	0.15 ± 0.03	143900.00 ± 25370.52	38.27 ± 0.89	
38	6.26 ± 2.08	3.38 ± 2.29	0.18 ± 0.12	117.36 ± 97.11	4.09 ± 2.11	1.13 ± 0.18
57	13.57± 3.69	7.31 ± 2.50	0.39 ± 0.13	116.77 ± 58.08	4.07 ± 1.31	1.14 ± 0.49
80	22.76 ± 7.68	9.19 ± 4.13	0.40 ± 0.18	67.72 ± 18.27	2.25 ± 0.49	1.36 ± 0.48
90	26.90 ± 7.70	4.14 ± 0.22	0.41 ± 0.02	18.19 ± 7.17	1.67 ± 0.59	2.20 ± 0.76

days, while highest average weight increments (9.19 g) reached after 80 days. The lowest average daily growth (0.15 gday⁻¹) reached after 19 days, while highest

average daily growth (0.41 gday⁻¹) reached after 90 days. Lowest average relative growth (18.19%) reached after 90 days, while highest average relative growth

(143900.00%) reached after 19 days. Lowest average specific growth was 1.67 %day⁻¹ after 90 days, while highest average specific growth was 38.27% after 19 days. Fishes revealed worst average feed conversion (2.20) after 90 days, while best average feed conversion (1.13) after 38 days.

Table (4) showed measurements of some environmental parameters of RAS plastic

tanks during the experiment. These parameters were similar in all replications. Water temperature ranged between 23.5-25.5 °c, pH value ranged between 8.0-8.2, dissolved O₂ ranged between 10.8-11.8 mg⁻¹, salinity ranged between 0.60-0.67 PSU, while ammonia concentrate don't exceed 0.1 mg.l⁻¹.

Table (4): Environmental parameters for plastic RAS tanks water during the experiment.

Date	Water temperature (°C)	pH	Dissolved O ₂ (mg ⁻¹)	Salinity PSU	Ammonia (mg ⁻¹)
7/5/2018	23.5± 0.80	8.1± 0.10	11.8± 0.40	0.64± 0.05	Less than 0.1
22/5	24.9± 1.10	8.1± 0.20	11.6± 0.60	0.62± 0.07	
6/6	24.7± 0.78	8.1± 0.18	11.7± 0.57	0.60± 0.05	
21/6	25.5± 0.70	8.2± 0.10	11.6± 0.60	0.67± 0.02	
6/7	24.0± 0.70	8.1± 0.20	11.4± 0.60	0.63± 0.05	
21/7	25.3± 0.70	8.0± 0.20	10.8± 0.40	0.67± 0.03	
5/8	25.5± 0.73	8.0± 0.21	10.7± 0.41	0.67± 0.03	

Table (5) showed growth criteria of common carp larvae cultivated in RAS system. Final averaged weight reached by these larvae was 1.35 g. lowest average weight increments (0.06 g) reached after 15 days, while the highest (0.45 g) reached after 30 days. Lowest average daily growth rate (0.004 gday⁻¹) reached after 15 days, while the highest (0.030 gday⁻¹) reached after 30 days. Fishes recorded 18.20% as lowest average relative growth rate after 90 days and the highest (3250.00%) after 15 days.

Lowest average specific growth rate was 1.67 %day⁻¹ after 90 days, while the highest was 23.39 % day after 15 days. Fishes revealed worst average feed conversion ratio (4.13) after 60 days, while best average feed conversion (1.57) after 45 days.

Table (6) pointed out comparison between growth criteria of common carp larvae cultivated in earthen ponds and RAS system for a period of 90 days. There were significant differences (P<0.05) in all studied growth criteria between both system.

Table (5): Growth criteria of common carp larvae cultivated in RAS system.

Period (Days)	Average weight (g)	Weight increment (g)	Daily growth rate(gday ⁻¹)	Relative growth rate (%)	Specific growth rate (%day ⁻¹)	Feed conversion ratio
0	0.002					
15	0.067 ±0.001	0.06 ±0.001	0.004 ± 0.00	3250.00 ±57.74	23.39 ± 0.115	
30	0.513 ±0.041	0.45 ±0.042	0.030 ±0.003	665.67 ±73.35	13.59 ± 0.649	
45	0.857 ±0.081	0.34 ± 0.04	0.023 ± 0.003	67.06 ±2.50	3.42 ± 0.10	1.57 ±0.06
60	1.074 ±0.071	0.22 ±0.014	0.015 ± 0.001	25.32 ±3.93	1.51 ± 0.212	4.13 ± 0.59
75	1.291 ±0.120	0.22 ±0.065	0.014 ± 0.005	20.20 ±5.27	1.22 ± 0.296	2.98 ± 0.91
90	1.530 ±0.099	0.24 ±0.027	0.016 ± 0.002	18.20 ±3.42	1.12 ± 0.195	3.29 ±0.673

Table (6) Comparison between growth criteria of common carp larvae cultivated in earthen ponds and RAS system.

Cultivation system	Final weight (g)	Weight increment (g)	Daily growth rate (g.day ⁻¹)	Relative growth rate (%)	Specific growth rate (%.day ⁻¹)	Feed conversion ratio
Earthen ponds	26.90 ±2.74 a	26.90 ±2.74 a	0.30 ±0.13 a	134500 ±64318.27 a	10.56 ±15.80 a	1.25 ±0.51 a
RAS	1.532 ±0.10 b	1.53 ±0.10 b	0.02 ±0.00 b	76200 ±1280.35 b	7.37 ±0.07 b	2.82 ±0.13 b

Different letters in one column are significantly different ($P \leq 0.05$)

Table (7) showed survival ratio of common carp larvae cultivated in earthen ponds at the end of experiment and survival ratio in RAS system during the experiment in addition to the end of experiment. It was observed that there were high fluctuations in the survival rate of earthen ponds (5.67% for pond 2 and 20.64% for pond 1), while in

RAS system the fluctuation was extremely low. It was noticed that there were high decrease in survival rate of larvae in the RAS system during the last 30 days of experiment. At these days, many cannibalisms were noticed between cultivated fishes.

Table (7): Survival ratio of common carp larvae cultivated in two systems.

Period (Days)	Larval survival in RAS system (%)			Average
	RAS 1	RAS 2	RAS 3	
30	91.78	89.37	91.78	90.98
60	81.87	73.37	78.62	77.95
90	51.25	46.25	46.46	47.99
Average				72.32 ±2.85 a
	Larval survival in earthen ponds (%)			
(Days)	P1	P2	P3	Average
90	20.64	5.67	13.18	13.16±7.49 b

Different letters in one column are significantly different ($P \leq 0.05$)

Discussion

Fishes, like other organisms affected by many environmental factors, such as water temperature, dissolved O₂, salinity, pH and ammonia concentration, whether in an open environment or in RAS systems (Stickney, 2000). Mocanu *et al.* (2015) stated that suitable water temperatures for cultivation common carp ranged between 20-30°C. In

current experiment most environmental factors of RAS system were as optimum factors for growth, while in earthen ponds salinity increased at the end of experiment to 8.2 g.l⁻¹. This high salinity may be responsible for reducing the growth at this time. Laiz-Carrión *et al.* (2005) pointed out that salinity increasing lead to increase

metabolism for osmoregulation and then lead to negative effects on fish growth and feed conversion.

Fish feeding requirements differ greatly with species, fish size and other factors such as water temperature, physiological situation, stress, balance feed and environmental parameters (Piska & Naik, 2013). Taher, *et al.*, (2021) was pointed out that there was positive relationship between growth of juvenile common carp and total number of zooplankton, so these juveniles fed on zooplankton rather than phytoplankton that consider as main food of zooplankton.

Results of current experiment proved that fishes cultivated in earthen ponds had growth criteria as follow: final weight of 26.90 g, daily growth rate of 0.30 g.day⁻¹, relative growth rate of 1345000%, specific growth rate of 10.56 %day⁻¹, survival ratio of 13.10% and feed conversion rate of 1.25. Shingare *et al.* (2006) showed that common carp cultivated in rain ponds recorded weight increment of 5.26 g and feed conversion of 1.54. Coroian *et al.* (2015) pointed out that common carp fingerlings recorded weight increment of 0.54 and 7.68 when fed on two different feeds. Nyadjeu *et al.* (2018) mentioned that common carp juvenile recorded growth criteria as follow: weight increments of 6.47 g, relative growth rate of 11%, specific growth rate of 2.51 %day⁻¹ and feed conversion rate of 0.71. Feed conversion rates recorded were 2.70, 2.27 and 3.01 by common carp fed with pellets of (25, 30 and 35% crude protein) respectively (Al-Jader & Al-Sulevany,

2012). Rumpa *et al.* (2016) stated that common carp juvenile cultivated for 150 days in earthen ponds reached final weigh of 430 g. Mirror carp (*C. carpio*) recorded specific growth rate of 4.95 and 4.80 %day⁻¹ in different two densities during 90 days (Hossain *et al.*, 2014). Al-Noor *et al.* mentioned that common carp (0.68 g) cultivated for 70 days on manufactured diet (42% crude protein) recorded 3.19 %day⁻¹ specific growth rate and 2.13 feed conversion rate. Taher & Al-Dubakel (2020) stated that final weights reached by common carp cultivated in earthen pond was 42.10, 31.63 and 21.30 g depending on stocking density. The differences between the results of current study and other studies may be due to differences in initial weights and period of cultivation, or due to the differences in feeds especially at early life stage.

Lopiz *et al.* (2014) stated that survival rate of larvae was low in all conditions because of the difficulty of getting food after absorbing yolk sack. This may be explain the low survival rate of larvae (0.002 g) cultivating in earthen ponds comparing with other studies. Shingare *et al.* (2006) pointed that survival ratio of common carp cultivated in rain ponds was 80.59%, while Oprea *et al.* (2015) recorded 44 and 58% survival ratio for common carp cultivated in two different densities. Common carp cultivated in earthen ponds for 150 days recorded 67 and 70% survival ratios depending on type of feeds (Mocanu *et al.*, 2015).

Results of current experiment proved that fishes cultivated in RAS system had growth criteria as follow: weight increment of 1.53 g, daily growth rate of 0.02 gday⁻¹, relative growth rate of 76200%, specific growth rate of 7.37 %day⁻¹, survival ratio of 72.32% and feed conversion rate of 2.82. Enache *et al.* (2011) recorded 1.07 %day⁻¹ as specific growth rate and 1.49 as feed conversion rate of common carp cultivated in RAS for 30 days. Common carp showed specific growth rate of 2.44 %day⁻¹ and feed conversion rate of 2.12 when reared in semi-closed system for 52 days (Taher *et al.*, 2018). Coroian *et al.* (2015) stated that live food had positive effects for growth of common carp fingerlings comparing with traditional feeds. Jafaryan *et al.* (2011) pointed that common carp larvae can be fed on different species of *Artemia*, so it achieved better feeding and growth when fed on *A. parthenogenetica*, *A. franciscana* and *A. urmiana*. koi carp, *C. carpio* recorded weight increments between 0.02-0.06 g and specific growth rate of 11.13 %day⁻¹ when cultivated for 30 days in concrete reservoirs (Usandi *et al.*, 2019). Dhont *et al.* (2013) stated that *Artemia* was the most famous feed for fish larvae in hatcheries. The movement of small zooplankton such as *Brachionus* sp. and *Artemia salina* give optical stimulation for common carp larvae to predate them (Rønnestad *et al.*, 1999; Kolkovski, 2001). The reason of good growth results at the beginning of current study comparing with other studies may be due to use *Artemia* as feed for these larvae.

Zarski *et al.* (2011) recorded nearly same specific growth of current experiment for crucian carp (*Carassius carassius*) cultivated for 21 days in RAS system. Abdul-Kadhar *et al.* (2014) recorded specific growth rate between 0.082-0.125 %day⁻¹ when *Catla catla* fed on live feeds. Nile tilapia, *Oreochromis niloticus* cultivated in RAS for 70 days recorded weight increment of 60.77 g, daily growth rate of 0.86 gday⁻¹, specific growth rate of 4.92 %day⁻¹ and feed conversion rate of 1.48 (Gullian-Klanian & Arámburu-Adame, 2013).

Results of the current experiment showed reducing in growth of common carp after larval stage comparing with other studies, may be due to differences in species or in initial weight, that caused reduction in feed intake or differences in stocking density that lead in current experiment to cannibalism situations. Many researchers recorded negative effects for stocking density on growth of fishes (Alvarez-Gonzalez *et al.*, 2001; King *et al.*, 2007; Zarski *et al.*, 2008).

Survival ratio of common carp larvae cultivated in RAS was highest than other studies, however some researchers obtain higher survival ratio than current study. Haque *et al.* (1994) stated that survival ratio of common carp reduced in high stocking densities, may be due to competition on feed and space. Usandi *et al.* (2019) recorded 47% survival ratio for koi carp. Weight gain, daily growth rate and specific growth rate of common carp cultivated in earthen ponds were decreased significantly (P < 0.05) with increased stocking density (Taher & Al-

Dubakel, 2020). Gullian-Klanian & Arámburu-Adame (2013) pointed out that Nile tilapia cultivated for 70 days in RAS at high densities revealed survival ratios between 89.50-93.60. There were mostly negative relationships between stocking densities and survival ratio in addition to growth and conversion for larval stage (Irwin *et al.*, 1999; Usandi *et al.*, 2019).

Conclusions

From the results of current experiment, it concluded that earthen pond was better than RAS systems in producing fingerlings of common carp.

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مقارنة بعض معايير النمو ليرقات أسماك الكارب الشائع (*Cyprinus carpio*) المستزرعة في الأحواض الترابية ونظام إعادة تدوير المياه

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المستخلص: أجريت مقارنة لبعض معايير النمو ليرقات أسماك الكارب الشائع (*Cyprinus carpio*) المستزرعة في الأحواض الترابية وأخرى مستزرعة في نظام إعادة تدوير المياه، وبالاعتماد على الأغذية الحية (الهائمات النباتية والحيوانية المتوفرة في مياه الإستزراع والمحفزة بالسماد الحيواني في الدراسة الحقلية وبيرقات الأرتيميا المكثرة مختبرياً لليرقات المستزرعة في المختبر، فضلاً عن العليقة المصنعة بنسبة بروتين 38% لتغذية صغار الأسماك في كلا النظامين. تمثلت الدراسة الحقلية باستزراع يرقات أسماك الكارب الشائع بمعدل وزن ابتدائي (0.002) غم/يرقة في ثلاثة مكررات (دوم واحد/ مكرر)، وبكثافة إستزراع بلغت 40800 يرقة للمكرر الأول و 55600 يرقة للمكرر الثاني و 36400 يرقة للمكرر الثالث ولمدة 90 يوماً. وغذيت الأسماك لمدة 19 يوماً على الغذاء الطبيعي فقط، فيما أدخل الغذاء المصنوع بعد ذلك. وزنت عينة من الأسماك كل 19 يوماً لغرض تغيير كمية العلف المقدم بالتوازي مع الزيادة بالوزن للأسماك المرباة. سجلت الأسماك معدلات زيادة وزنية 26.90 غم ونمو يومي 0.30 غم/يوم ونمو نسبي 1345000% ونمو نوعي 10.56% غم/يوم وتحويل الغذائي 1.25 فيما بلغت نسبة البقاء 13.16%. سجلت يرقات وصغار أسماك الكارب الشائع المستزرعة في نظام إعادة تدوير المياه بمعدل وزن (0.002) غم/يرقة في ثلاثة مكررات وبواقع 160 يرقة/ مكرر وبكثافة إستزراع 2 يرقة/ لتر ماء ولمدة (90) يوماً وبالتغذية على الغذاء الحي المتمثل ببيرقات وصغار الأرتيميا المكثرة مختبرياً لحد الإشباع لمدة 15 يوماً وبمعدل أربعة وجبات يومياً، فيما أستعمل بعدها الغذاء المصنوع. وزنت الأسماك كل 15 يوماً لغرض تغيير كمية العلف المقدم بالتوازي مع الزيادة بالوزن. سجلت الأسماك المستزرعة معدلات زيادة وزنية 1.53 غم ونمو يومي 0.02 غم/يوم ونمو نسبي 76200% ونمو نوعي 7.37% غم/يوم وتحويل غذائي 2.82 ونسبة البقاء 72.32%. أظهرت النتائج إن الأسماك المستزرعة في الأحواض الترابية سجلت فروقاً معنوية ($p < 0.05$) في جميع معايير النمو المحسوبة مقارنة مع يرقات وصغار الأسماك المستزرعة في نظام إعادة تدوير المياه. الاستنتاج النهائي هو ان نظام التربية في الاحواض الترابية افضل من النظام الدوار في انتاج اصبيات الكارب الشائع.

الكلمات المفتاحية: الكارب الشائع، نظام إعادة تدوير المياه، الزيادة الوزنية، معدل النمو، معدل البقاء.