Ann. Bangladesh Agric. (2018) 22 (1) : 119-124
ISSN 1025-482X (Print)
2521-5477 (Online)

Short Communication

ASSESSMENT OF LETTUCE (*Lactuca sativa*) GROWTH AND YIELD IN TWO DIFFERENT AQUAPONIE SYSTEMS

U. K. Fatema* and M. A. Hossain

Abstract

In different types of aquaponic system, the choice of proper planting scheme provides sustainable and vigorous food production. An experiment was conducted for a period of 60 days to evaluate raft system (T_1) and bricklets medium (T_2) in recirculatory aquaponic system to grow lettuce (*Lactuca sativa*). Each treatment was replicated thrice. In this study, climbing perch (*Anabas testudineus*) was used as experimental fish measuring average 8.47±1.26 cm and 12.35±3.79 g in both treatments as length and weight initially. Commercial floating pellet feed was fed to the fish up to satiation twice a day. Bricklets medium (T_2) resulted higher number of plant leaves (25.27), plant height (25.37 cm) and leaf area (89.16 cm^2) as compared to raft system (T_1) where number of plant leaves (22.40), plant height (19.98 cm) and leaf area (72.80 cm^2) were found. Moreover, higher lettuce production (kg/m^2) was found in T_2 (1.60) than T_1 (1.18). The findings of the study indicated that in recirculatory aquaponic system, bricklets medium is more potential for growth of lettuce compared to raft system.

Keywords: Aquaponic system, lettuce, climbing perch, yield.

Aquaculture is being intensified in Bangladesh hence, creating environmental problems. Aquaculture operation solely depends on ground water which depleting the water level day by day. Agriculture and aquaculture sustainability that require water can only be succeeded through proper management practices (Postel, 2000). In this situation we need such an environmental friendly and sustainable technology for food production which can handle current problems efficiently. Aquaponics is that type of technology which can produce relatively safe food (fish and vegetables) with reduced environmental hazards (Salam *et al.,* 2013; Fatema *et al.,* 2017). In the system, fish wastes provide nutrients to plants and recycled water return to fish tank. Aquaponic systems have been designed to mitigate aquacultural fish waste product by converting it to nutrient rich effluent to produce healthy food (Lam *et al.,* 2015). Lettuce is considered to be one of the healthiest green leafy vegetables.

On the other hand, climbing perch is one of the most popular fish used in aquaponics, because this fish is well adapted to aquaponic set up. They have good taste, growth, nutrients value and a high market price (Alam *et al.,* 2006). The use of less water than conventional agriculture provides an option for nutrient recycling and reuse in aquaponic system (Fragozo *et al.,* 2015). There are mainly three types of aquaponics system practiced in the world, such as media based which is

Department of Aquaculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh. *Corresponding author: ukfatema@bsmrau.edu.bd

the simplest type. In this type, small rocks, clay pebbles, gravels and bricklets are used as plants growing medium. Another type is nutrient film technique (NFT) that is usually set up in a separate tank through which the water passes before going through the plant pipes. Latter type is raft system which involves the use of foam that floats on top of the water. A container is used to hold the water as it is pumped through from the fish tank, better suited to growing herbs and leafy green vegetables varieties. The present study was conducted to evaluate raft system and bricklets medium in re-circulatory aquaponics system to grow lancet.

Two different treatments in triplicates as raft system (T_1) and bricklets medium bed (T_2) were used in the experiment to assess the growth of lettuce in aquaponics system. Three trays of each of the treatments attached with a fish holding tank. Locally purchased two 300 L fish tanks were prepared before starting the experiment. Preparation of tank included cutting of upper end, washing, plumbing pipes, and setting bricklets and filled up the tank with water. The pipes were set to make an inlet and outlet. One air pump with two air stones was set to maintain proper dissolve oxygen in each of the fish tank. The tank was then filled with bricklets of 2-5 cm diameter up to six inches at the bottom of the tank. Before placing the bricklets they were washed with clean water and finally the tank was filled with underground water. Lettuce was grown in trays made of galvanized iron (GI) sheets. The rectangular size trays were of 30 L capacity. In T_1, vegetable trays were covered by styrofoam sheet with five holes of 2.5 inches diameter each so that there was six inches between each hole and both ways. Then each of the holes was attached with thin bottom cut plastic pot filled with coconut coir which was used to support the lettuce plant in raft system. The trays were filled with 20 L of water as a growing medium. On the other hand in $T_{2,}$ the vegetable trays were filled with bricklets up to 2/3rd from the bottom. Here PVC plastic made bell siphon was attached at the middle of the trays towards the fish tank. Healthy, diseased free and good quality climbing perch were collected from the previously stocked fish tank and used as experimental fish. A total of 50 fish were released in each of the tank after taking their initial length and weight. Fresh grown lettuce saplings were collected from local nursery, and then transplanted to vegetable trays. Each of the vegetable trays contained five lettuce saplings. So that total six vegetable trays hold thirty lettuces (each contains five lettuce saplings) from which first fifteen lettuces were allowed to grow in raft system and another fifteen lettuces in bricklets medium. Fish was fed with commercially available pellet feed containing 30% protein. The fish was fed up to satiation level twice daily (9 am and 5 pm) for six days in a week. The water supply pipe was cleaned regularly to avoid congestion with algae and microbes. Length and weight of 10 fish from each tank were sampled randomly to monitor the growth performance fortnightly. Growth of fish in length (cm) and weight (g) was measured and the following parameters were used to evaluate fish growth. At the end of the rearing period, all fish in a tank was counted for survival rate and total production. The lettuce sampling was carried out after one month of growing period. Lettuce growth was monitored on the basis of number of leaf, plant height (cm), leaf area (cm^2), and fresh vegetable production (kg/m^2). The physico-chemical parameters of fish tank water were measured to consider the water quality before arriving to vegetables grow bed (influent) and returning to fish tank (effluent). Dissolved oxygen (DO), temperature and pH were measured every 15 days interval using HQ 40D Portable Multi Meter and total ammonia nitrogen (NH_3-N), nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N) and total phosphorus (TP) were measured at one month interval using DR 5000™ UV-Vis Spectrophotometer. Preliminary data were transferred into Microsoft Excel 10 and subjected to one-way analysis of variance (ANOVA). Standard deviation in each parameter and treatment was calculated and expressed as mean ± S.D. The level for significance was set at 0.05%. Using the statistical software package (Statistics 10) all statistical analyses was performed.

In the experiment water temperature varied from 24.1 to 27.5°C in fish tanks and 23.1 to 24.2°C in vegetable trays. The suitable water temperature for fish culture ranged from 26.06 to 31.97 °C (Boyd, 1982). On the other hand, temperatures ranged from 7 to 24°C, were best suited for lettuce growth (Maynard and Hochmuth, 2007). pH values of fish tank water under two treatments were found to be alkaline ranged from 6.9 to 7.2 (Table 1). Depending on species and temperature the optimum pH for nitrifying bacterial growth is 7.8 (Tyson *et al.,* 2007). Optimal growth of lettuce required pH of 5.5 to 6 (Resh, 2012). The mean values of dissolved oxygen concentration in two different fish tanks ranged from 5.54±0.21 to 5.7±0.12 mg/l whereas 3.80 to 6.12 mg/l were within the suitable level of climbing perch (Chakraborty and Nur, 2012).

At the end of the experiment, mean length gain and mean weight gain of climbing perch were found 1.85±0.23 cm and 5.95±0.06 g in T_1 and 2.15±0.41 cm and 6.65±1.25 g in T_2, respectively. Those were significantly differing in two treatments ($P \leq 0.05$). In this experiment, FCR value was observed 1.92 in T_1 (raft system) and 1.87 in T_2 (bricklets medium). Rearing fish in winter season at relatively lower temperature might be the reason behind that higher FCR. The final production of climbing perch was found 3.18 kg/m^3 in bricklets medium compared with 3.03 kg/m^3 in raft system. In six months culture period of climbing perch obtained 4.8 to 5.5 kg/m^3 production in monoculture management with supplementary feed (Rahman *et al.,* 2013). Generally climbing perch attained 80-100 g size within 90-120 culture days (Saha *et al.,* 2009). At the end of the experiment, climbing perch attained average 18.2±4.10 g in T_1 and 19.1±4.78 g in T_2 indicated that highest fish growth was found in T_2 (bricklets medium). Overall fish production was low in both the treatments due to winter season because it reduced fish metabolic rate and slowed feed consumption and growth performance.

The number of leaves/plant, plant height (cm), leaf area (cm^2) was recorded for all the two treatments, where T_1 was raft system and T_2 was bricklets medium. At the time of planting the average number of leaves/plant was 7.27 in T_1 and 7.40 in T_2 which was similar but different started at the 30 days after planting (12.47 in T_1 and 15.07 in T_2); and after 60 days (22.40 in T_1 and 25.27 in T_2) (Fig.1). The average plant height (cm) was 10.47 in T_1 and 10.71 in T_2 at the time of planting. Significantly different plant height was observed in both at the 30 days (14.75 cm in T_1 and 17.16 cm in

Table 1. Average water quality parameters in two aquaponic systems

Parameters	Raft System (T_1)		Bricklets Medium (T_2)	
	Influent	Effluent	Influent	Effluent
Temperature (°C) pH DO (mg/l)	26.13±1.59[a] 7.04±0.11[a] 5.54±0.21[a]	23.78±0.45[b] 5.5±0.07[b] 2.28±0.18[b]	26.22±1.19[a] 7.1±0.12[a] 5.7±0.12[a]	23.66±0.47[b] 5.46±0.11[b] 2.22±0.20[b]
TAN (mg/l)	0.08±0.0[a]	0.04±0.01[b]	0.07±0.02[a]	0.03±0.01[b]
NO_2-N (mg/l)	0.04±0.02[a]	0.03±0.01[b]	0.04±0.01[a]	0.02±0.01[b]
NO_3-N (mg/l)	1.39±0.28[a]	1.0±0.12[b]	1.38±0.28[a]	0.8±0.09[b]
TP (mg/l)	3.17±0.34[a]	1.25±0.21[b]	3.15±0.27[a]	1.10±0.19[b]

* Means with different superscript in a row are significantly different *($P \leq 0.05$);* values in the parenthesis indicate the standard deviation

T_2) and 60 days (19.98 cm in T_1 and 25.37 cm in T_2) after planting (Fig.1). At the time of planting, average leaf area (cm^2) was 24.13 in raft system (T_1) and 24.51 in bricklets medium (T_2). But at the 30 days after planting, it was found 50.61 cm^2 (T_1) and 62.75 cm^2 (T_2). On the other hand, at the 60 days after planting, the average leaf area (cm^2) was found 72.80 in T_1 and 89.16 in T_2; were significantly ($P \leq 0.05$) different in both treatments (Fig. 1). In this experiment, lettuce was grown upto 100 g in T_1 and 132 g in T_2. On an average 150 g of lettuce

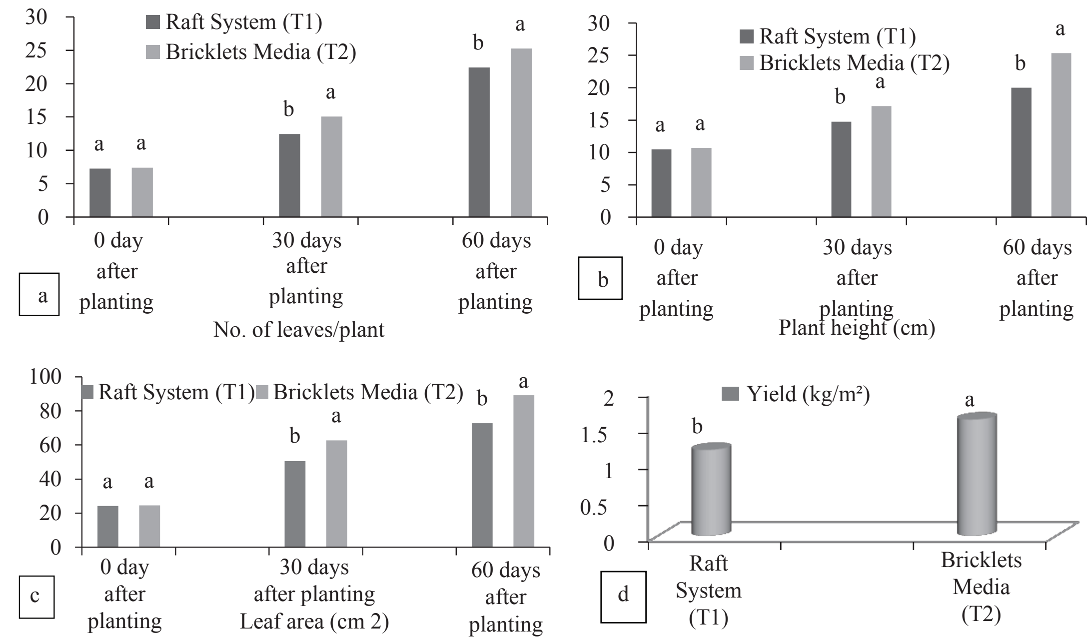

Fig. 1. Lettuce growth and yield in two different media (data in same sampling day bearing different letters are significantly different at *$P \leq 0.05$*). a) number of leaves/plant at different days after planting; b) plant height at different days after planting; c) leaf area at different days after planting; and d) yield at the end of the experiment.

can be achieved in 3-4 weeks after transplant under optimal growing conditions (Both *et al.,* 1994) that was more or less similar with the present study.

The total yield of lettuce in T_1 (1.18 kg/m^2) was significantly lower than T_2 (1.60 kg/m^2) that might be due to higher amount of nutrient availability to the lettuce plants in T_2 than T_1. Because, T_2 (bricklets medium) had large surface area for bacterial growth to perform nitrification but in T_1 (raft system) there was used groundwater and fish tank water for lettuce production, but no addition of chelate ion or any other nutrients solution. Therefore, due to less minerals and nutrient contents, comparatively low production occurred in raft system (T_1). Yields of lettuce were found from 1.5 to 2.2 kg/m^2 at different planting density in 60 days of culture period (Kawser *et al.,* 2016) which were more or less similar to the present study. For the cool-season crops like lettuce, chelate ion or other nutrient solution plays significant role in oxygen transport that enhance the plants growth (Campbell *et al.,* 1999). According to above discussion, it may be concluded that bricklets have great potentialities as medium for lettuce production in aquaponic systems.

References

Alam, M. K., L. Rahman, M. M. R. Khan and S. M. Z. Rahman. 2006. Allozyme marker for the analysis of genetic variation of cross koi (♀ local ×♂ Thai) *Anabas testudineus* with their parents. *Mole. Biol. Biotec. J. 4*: 9-12.

Both, A. J., L. D. Albright, R. W. Langhans, R. A. Reiser and B. G. Vinzant. 1994. Hydroponic lettuce production influenced by integrated supplemental light levels in a controlled environment agriculture facility: experimental results. *Acta. Hortic.* 418: 45-52.

Boyd, C. E. 1982. Water Quality Management for Pond Fish Culture. Elsevier Sci. Publ. CO. Amsterdam, Netherlands. 381 P.

Campbell, N. A., J. B. Reece and L. G. Mitchell. 1999. Plant Nutrition. Biology 5th ed. Menlo Park, California. 714-17 P.

Chakraborty, B. K. and N. N. Nur. 2012. Growth and yield performance of Shinghi, *Heteropneustes fossilis* and Koi, *Anabas testudineus* in Bangladesh under semi-intensive culture systems. *Int. J. Agril. Res. Innov. Tech.* 2(2): 15-24.

Fatema, U. K., M. A. Salam and K. M. S. Rana. 2017. Feasibility of coconut coir and water hyacinth roots as media in vertiponics system to grow mint. *Int. J. Agric. Envr. Res.* 3(3): 3229-3241.

Fragozo, P. M., O. A. Jacome, E. R. Garcia, I. T. Pacheco, A. C. Hernandez, R. V. O. Velazquez, J. F. G. Trejo and R. G. G. Gonzalez. 2015. Perspective for aquaponic systems: "omic" technologies for microbial community analysis. *Biomed. Res. Int.* 2015: 1-10.

Kawser, A. Q. M. R., M. A. Hossain and M. F. Yeasmin. 2016. Optimizing the planting density of lettuce (*Lactuca Sativa*) with tilapia (*Oreochromis Niloticus*) in a recirculation aquaponic system. *Amer. J. Agric. Sci. Eng. and Tech.* 3(4): 1-11.

Lam, S. S., N. L. Ma, A. Jusoh and M. A. Ambak. 2015. Biological nutrient removal by recirculating aquaponic system: Optimization of the dimension ratio between the hydroponic and rearing tank components. *Int. Biodeter. Biodegr.* 102: 107-15.

Maynard, D. N. and G. J. Hochmuth. 2007. Knott's Handbook for Vegetable Growers 5th ed.

John Wiley and Sons. Inc. New Jersey, USA. 621 P.

Postel, S. L. 2000. Entering an era of water scarcity: The challenges ahead. *Ecol. Appl.* 10: 941-48.

Rahman, S., M. S. Monir and M. H. Khan. 2013. Culture potentials of climbing perch, Thai Koi, *Anabas testudineus* (Bloch) under different stocking densities in northern regions of Bangladesh. *J. Expt. Biol. Agric. Sci*. 1(3): 203-08.

Resh, H. M. 2012. Hydroponic food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower 7th ed. CRC Press, Boca Raton, USA. 560 P.

Roosta, H. R. and M. Hamidpour. 2011. Effects of foliar application of some macro and micro nutrients on tomato plants in aquaponic and hydroponic systems. *Sci. Hortic.* 129: 396-402.

Saha, A., M. R. Kabir and M. M. Ali. 2009. Breeding performances of Thai *Koi*, *Anabas testudineus* (Bloch, 1792) in different months of the different season under two sex ratios. *Bangladesh. Res. Publ. J.* 2: 667-73.

Salam, M. A., M. Asadujjaman and M. S. Rahman. 2013. Aquaponics for improving high density fish pond water quality through raft and rack vegetable production. *World J. Fish. Marine. Sci.* 5(3): 251-56.

Tyson, R. V., E. H. Simonne, M. Davis, E. M. Lamb, J. M. White, D. D. Treadwell. 2007. Effect of nutrient solution, nitrate nitrogen concentration, and pH on nitrification rate in perlite medium. *J. Plant. Nutrition*. 30: 901-13.

Guidelines to Author
(Ann. Bangladesh Agric.)

Annals of Bangladesh Agriculture is published biannually in June and December by Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). Annals of Bangladesh Agriculture publishes original unpublished articles on all disciplines of research and education in agriculture including rural development. However, emphasis is given on the aspects of crop science in Bangladesh. In addition to original articles, review articles are considered for publication.

Manuscript Submission: Double-spaced manuscripts should be written in English, printed on one side of A4-size paper with 2.5 cm margins all around using the font Times New Roman, 12 point. Text of a full paper should not exceed 12 typed pages excluding photographs, tables and figures. Short communication should not exceed six typed pages. Manuscript submitted for the first time should be in duplicate and sent to Executive Editor, Annals of Bangladesh Agriculture, BSMRAU, Gazipur 1706, Bangladesh. Manuscript is subjected to go through the peer review process. Manuscripts not complying with the format and style of the Journal or of unacceptable quality will be notified to the author(s). Author(s) of the articles accepted for publication have to submit the original manuscript along with the revised one on a CD together with a hard copy signed by the principal/corresponding author. Articles reporting research findings of five years old or more are not considered for publication in Ann. Bangladesh Agric.

Contents

Page 1: Title of the article and name(s) of the author(s) with address should be typed. **Page 2 :** Title, Abstract and Keywords should be typed. **Page 3 onward:** Introduction, Materials and Methods, Results and Discussion, Acknowledgement (if any) and References should follow in an unbroken sequences.

Short Communication should not have sectional headings except abstract.

Title: Title should represent the text in minimum possible words without verbs/auxiliary verbs. It should be indicative rather than narrative.

Abstract: An abstract is not a part of the text, it has single entity, which is self explanatory and comprehensive with minimum words not exceeding 200. It contains purpose of the study, location, gist of the findings with relevant treatments and concluding remarks.

Text: The text of the article should be clear, precise and comprehensive.

Tables and Figures: Same data must not be presented in both table(s) and figure(s).

Table(s) and figure(s) must be numbered and should be referred to as Table 1 or Fig. 1, etc. Each Table should be self explanatory and typed on a separate sheet and be headed by a brief legend. All original figures should be in finished form ready for reproduction. Photographs should be glossy print with strong contrasts. Colour photographs will be printed in color only at the author's expense. For both tables and figures, the desired point of insertion should be marked in the right margin of the text. Tables and Figures should be printed in A_4-size paper.

References

In the text

For single author: Ahmed (2000) or Ahmed, 2000; for two authors: Ahmed and Hamid (2000) or (Ahmed and Hamid, 2000); for more than two authors: Ahmed *et al.* (2000) or (Ahmed *et al.,* 2000); for more than one publication of the same author appeared in the same year: Ahmed (2000a, 2000b) or (Ahmed, 2000a & 2000b); for more than one citation at a time: (Karim *et al.,*1976; Ahmed and Hamid, 2000).

In the reference/citation section

References must be included and arranged alphabetically according to surname of first author and it should be as follows:

Ayub, A., T. K. Dey, M. Jahan and M. Z. Rahman. 1996. Assessment of yield loss due to powdery mildew of blackgram. *Bangladesh J. Plant Pathol.* 12: 9-11

Bonnardot, J. P., J. Marsac, P. Richard, R. Bonvoisin, M. Brulé, S. Bouchoucha and P. Deligné. 1978. The effect of surgical incisions on ventilatory function. *Ann. Anesthesiol. Fr.* 199: 795-801.

Elin, R. J. 2010. Assessment of magnesium status for diagnosis and therapy. *Magnes. Res.* 23: 194-98.

Hill, D. S. 1787. Agricultural Insect Pests of the Tropics and Their Control 2nd ed. Cambridge Univ. Press, New York, USA. 746 P.

Troughton, J. H. 1975. Phytoshynthetic Mechanisms in Higher Plants, Pp. 357-91. In Cooper J.P. (ed.) Photosynthesis and Productivity in Different Environments. Cambridge Univ. Press, Cambridge, UK.

Reprints

Contributors are entitled to get 20 copies of reprints free of cost for each article.