Advances in Life Science and Technology
ISSN 2224-7181 (Paper) ISSN 2225-062X (Online) DOI: 10.7176/ALST
Vol.71, 2019

Performance Evaluation of Integrated Aquaculture of Catfish, Pig and Rice

Omoike, Augustine [1*] Falaye, Augustine Eyiwunmi [2] Ajani, Emmanuel Kolawole [2]
Akande, Olubukunmi Samuel [2]
1. Department of biological Sciences, Bells University of Technology, P.M.B. 1015, Ota, Nigeria
2. Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria
Corresponding author email: dromoike@yahoo.com

Abstract
Study was carried out on the performance of fish, pig and rice integration to assess the productivity of integrated fish farming system against conventional fish, pig and rice farming, carried out in 84 days, T-test was used to compare means of the growth performance of fish and pig and water use efficiency (WUE) of rice culture under conventional and integrated farming systems. The average weight gain (167g), specific growth rate (1.2) and the feed conversion ratio (1:1) in the integrated system were better and significantly different ($p< 0.05$) from those got from conventional systems. Water use efficiency of the integrated system in terms of rice production (3.566) was 16.99 times better than that conventional system that relied on irrigation. Physico-chemical parameters of the two system studied were within tolerable range and showed no significant difference. According to the results got, integration of fish, pig and rice reduces waste and input and thus increased productivity which in turn brings about wider profit margin and contributes to food security. In the face of the greatly dwindling freshwater reserve, integrated aquaculture holds the key to sustainable food security. This study has shown that integration of catfish, pig, and rice gave more yield and profits.
Keywords: Integrated aquaculture, fish - pig –rice, performance, water use efficiency
DOI: 10.7176/ALST/71-04

1. Introduction

Nigeria offers the largest market for fisheries products in Africa, Fish production from capture fisheries in spite of its being expensive has been erratic and on the decline in recent years, resulting in increase in poverty and nutritional deficiency. Aquaculture production remains the best option to bridge the gap between the total fish demand and total domestic production in the face of high cost of production and unstable government policies. Rosen *et al*. (2016) reported that an estimated 840 million people lack adequate access to food; and about 25% of these are in sub-Saharan Africa. The most reliable source of protein for many is fish, yet millions of people who depend on fish are faced daily with the fear of food shortage (Prithwiraj *et al.,* (2010). One of the main challenges facing aquaculture today is sustaining a continued increase in fish production while minimizing the impact on the environment (Sugiura *et al*., 2006). This therefore requires an intervention to maintain a surplus that is sustainable. Given this situation, it is therefore pertinent to provide the poor and hungry with a low cost and readily available strategy to increase food production using less land area and less water without further damage to the environment (Ayinla, 2003). Sahoo and Singh (2015) concluded that integrated fish-pig farming is profitable for getting higher growth of fish, net income and optimum utilization of the given resources. Integrated rice-fish production can optimize resource utilization through the complementary use of land and water (Frei and Becker, 2005). Integration of fish with rice farming improves diversification, intensification, productivity, profitability, and sustainability (Ahmed *et al*., 2007; Nhan *et al.,* 2007). This study is conducted to assess the performance indices of the integration of catfish, pig and rice so as to compare the production against the conventional methods of farming.

2. Materials and Methods

2.1 *Study Area, Duration and Organisms*

This research project was conducted in the Department of Aquaculture and Fisheries Management's Fish Farm, University of Ibadan (latitude 7.4412333 and longitude 3.900545). This study was carried out in 84 days with the Rice, Pigs and Catfish purchased from the Department of Agronomy, Department of Animal Production and Department of Aquaculture and Fisheries Management respectively, Faculty of Agriculture and Forestry in University of Ibadan, Ibadan, Nigeria.

2.2 *Study Facilities and Feeding*

The research comprises of an earthen pond (inside which was a rice paddy), a pig sty of three rooms, a maggottery and a reservoir. The pig sty consisting of three rooms (3.65m by 3.5m each) was constructed of blocks and concrete floors with enough openings for cross ventilation. The drinking trough was 0.45m x 0.55m and feeding trough was 1.05m x 0.6m. 10 pig growers (cross between large white and landrace) of average weight 14.1kg were put in the sty. An earthen pond size of 20m by 13m was used for fish culture for 14

weeks.1120 pieces of *Clarias gariepinus* juveniles (each weighing 10gramme) were stocked in the pond. A rice paddy of 14m by 5m was constructed right at the middle of the pond. Productivity in terms of weight gain of fish and pig was monitored throughout the period of production. Yield and water use efficiency of rice was also monitored.

2.3 *Maggot production*
Maggot production unit was constructed with wood and netting materials to prevent the escape of fly. Maggot was produced in 3 bowls of diameter 0.85m and depth of 0.35m. Fecal depth of 10cm was maintained. Continuous maggot production was achieved by the addition of fresh manure.

2.4 *Feeding*
The fish were fed with floating pellet (Vital Feed) 2mm size for 4weeks period while compounded feed of 4mm size (27.3 crude protein) was given for 10 weeks. Feeding was done between 8.00am and 8.30am then 4.30pm and 5.00pm at 5% body weight of the stocked fish. This was done on weekly basis to adjust for the constantly changing weight of fish. Pigs were fed twice a day at 3% body weight between 8.00am and 8.30am and between 4.30pm and 5.00pm. Quantity fed was also adjusted weekly. 150-250g of maggots of *Hermetia illucens* was fed to the fish under integrated system daily to supplement the compounded feed.

2.5 *Rice culture*
Low land rice (4 varieties) was used in the study. The spacing of the rice was 20cm x 10cm. 1000 stands were transplanted after spending three weeks in the nursery plots. The growth performance was monitored. Mean of yield and water use efficiency under both systems were taken and compared.

2.6 *Concept of integration*
The concept of integration in this study is demonstrated in (1) Planting of rice on a paddy in the fish pond such that the fish culture water irrigates the rice and the fact that the waste of fish and their uneaten feed fertilizes the rice. Pig excreta is used in producing maggot which was used to feed fish.

2.7 *Physico-chemical parameters:* Dissolved oxygen was measured with DO meter. pH, Nitrite, and ammonia levels were measured weekly using water quality test kit.

2.8 *Statistical Analysis*
All data collected were subjected to one way analysis of variance (ANOVA) using SPSS window software at a 95% probability level. T-test was used to compare the means of the growth performance of fish and pig under both farming systems. Water use efficiency (WUE) of rice and physico-chemical parameters of fish culture water under both systems were also compared using T-test.

3. Results
The research has shown the performance of fish in the 5 conventional ponds in Table 1. This shows that the total weight gained by conventional was 133.342kg with FCR 1.3 against integrated with 150.995kg with FCR of 1.1. In Table 2; the pig had better production with integrated than the conventional in the area of weight gain of 27.7g with FCR 3.6 against 25.98g with FCR 4.2. The comparative performance of pig showed better results in the integrated. Table 3 indicates the physico-chemical parameters in the research, the temperature, ph and Dissolved Oxygen showed no significant difference except in the case of ammonia. Table 4 showed that the integrated production used less volume of water with higher yield of 3.569 kg/m^3(rice) against conventional production of 0.2075 kg/m^3.

Table 1: Performance of fish in integrated pond compared with the average of production in 5 conventional ponds

Performance indicators	A-E(conventional)	F(Integrated)	t	df	Sig.(2-tiled)
Initial avg. wt (g)	11.4	11.2	0.423	6	0.687
Final avg weight (g)	182	178.6	0.041	6	0.968
Total feed given (kg)	173.5	166.1	1.549	6	0.172
Total weight gain (kg)	133.342	150.995	5.538	6	0.001
FCR	1.3	1.1	4.183	6	0.006
% survivability	75	82.0	2.281	6	0.063

*FCR: Feed Conversion Ratio

Table 2: Comparative performance of pig in integrated farming compared with production in 5 pig farms

Parameter	Conventional	Integrated	t	df	Sig. (2-tailed)
Final weight (g)	41.24	41.8	0.561	6	0.595
Initial weight (g)	18.08	14.1	1.131	6	0.301
Weight gain (g)	25.98	27.7	2.227	6	0.068
SGR	1.11	1.2	1.283	6	0.247
FCR	4.2	3.6	2.271	6	0.064

*SGR: Specific Growth Rate
*FCR: Feed Conversion Ratio

Table 3: Comparative physico-chemical parameters of manured pond and ponds in 5 fish farms in Ibadan.

Systems	Conventional	Integrated	t	df	sig. (2-tailed)
Temperature (^{0}C)	29.04	29.74	0.893	6	0.406
pH	8	7.46	1.312	6	0.237
Ammonia (mg/l)	0.015	0.018	9.263	6	0.000
Dissolved Oxygen	4.66	3.72	2.942	6	0.026

Table 4: Comparative Water use efficiency between integrated farming and conventional farms

Indicators	Conventional	Integrated	t	df	Sig. (2-tailed)
Paddy area (m^2)	70	70	2.362	5	0.605
Vol. of water used (m^3)	60.75	6.445	4.531	5	0.006
Yield (kg/60m^2)	12.665	23	4.566	5	0.006
WUE (kg/m^3)	0.2075	3.569	56.188	5	0.000

4. Discussion

The results in this research has shown that the combination of Catfish, Pig and Rice, yielded more compare to the conventional production of these livestock, there was a great improvement in the FCR, which was lower as an indication of good performance indices.

The lower feed conversion ratio and higher weight gain of fish in the integrated system can be attributed to the maggot generated from pig excreta which was used as supplementary feed for fish. Nitrogenous waste of fish and continuous availability of water supported the growth of rice as evident in the higher yield without the use of fertilizer. Findings of this study supports that of Gabriel et al. (2007) who wrote "in any integrated system, the interrelationships are many, crop by-product are fed to animals, while fish and animal manure are returned to the crops and fish in the pond, the fish may feed on insects and weed in the rice field planted inside the pond and this in turn can increase the available nutrients to the crop". Also, in the statement of Sahoo and Singh (2015), states that the production yields from integrated fish farming vary depending on the livestock (either pig or poultry) and the management system practiced. Nevertheless, it has proved to be more profitable than unitary system of farming and ensures the spread of financial risk, reduced wastes and thus is ecologically more sustainable. In this study, water use efficiency was mostly enhanced in rice production compared to single irrigation system because the water in the pond serves dual purpose: supports fish and rice. The water use efficiency is greatly enhanced because the rice paddy is right inside the fish pond. This ensures minimal water loss as water seepage and water run off like in the case of irrigation is reduced drastically. Surprisingly, there was no significant difference between the physico-chemical parameters of both systems. This was in full agreement with the findings of Mlejnková and Sovová (2012) who reported that heavy organic loading through pig excreta did not reduce the dissolved oxygen content of water and had no direct negative effect on water quality. Fishes are predators of insect pests of rice making the purchase of pesticide unnecessary. Rice husk served as a good feed ingredient for both fish and pig.

Conclusion

As global population grows, the need for more food production grows but the expanse of land for agriculture even reduces making it a double fold disadvantage. This has given rise to intensive culture systems in agriculture generally. However, with increase in intensification comes the generation of more waste which if not managed will make the planet uninhabitable for upcoming generations. The integration of fish, pig and rice has the potential to provide adequate solution to issues of protein supply, productive and profitable land use and most importantly efficient use of water and productive use of "waste" than conventional system of farming.

Significance Statements

This study discovers that the integration of Catfish-pig-rice has the tendency to produce a higher yield compared to production of catfish or pig or rice in a conventional method, this will help to reduce cost of production and

reduce wastage and more economical in terms of cost. The environmental pollution will be greatly minimal as this supports organic agriculture.

Recommendation

Based on this study, the following recommendations are made to bring about improvement in fish, pig and rice integration. Research into zoonotic diseases of pigs that can be contracted through the consumption of fish raised under fish, pig and rice integration should be carried out. Research into the organoleptic quality of fish under fish, pig and rice integration should also be carried out. Herbivorous fishes and nest builders like *Oreochromis niloticus* should not be cultured under fish, pig and rice integration with the rice paddy inside the fish pond because they tend to uproot rice while building nest.

Acknowledgement

The authors wish to gratefully acknowledge the grant support from West and Central African Council for Agricultural Research and Development (Coraf/Wecard) for funding this study and Head, Department of Aquaculture and Fisheries for facilities support.

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