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Comparative Study of the Productivity and Some Economical Aspects of the Conventional Rice and Rice-Fish Farmings Systems in Agonlin-Lowé Village, Adjohoun, Bénin

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The main idea of this work was to compare the productivities of rice farming systems and rice rice-fish polyculture in the same fish ponds. The experiment was conducted in six (06) different compartments with a total area of 300 m² between March and August 2022. The test was carried out with 600 fry including 400 fingerlings of *Oreochromis niloticus* and seedlings of rice (Variety IR 841). The initial average weights of fish in rice-fish culture without food supply and with food supply were respectively 9.7 g and 9.8 g. After 72 days, the variations of the physico-chemical parameters showed no significant difference between the compartments. In rice-fish farming, in the compartments without food supply, the average yield was 2.17 t/ha and in the compartments with food supply this average was 2.33 t/ha against 2.04 t/ha in the rice fields. In the associated culture, food intake was favorable with a mass gain of 6.9 g compared to 1.4 g obtained in the second pound. Also, the rice yields and the growth performance of fish *O. niloticus* were significantly ($p > 0.05$) higher than those obtained in conventional rice cultivation. Also monitoring the growth of farmed fish must continue in order to assess the performance achieved as well as the financial benefits for good promotion of the sector.

Keywords: Tilapia; production; polyculture; Benin.

1. INTRODUCTION

In Benin, agricultural production is dominated by cereal crops, which make up the bulk of the population's diet. To this end, rice has become a strategic commodity [1] benefiting from particular attention through the promotion of rice cultivation with ambitions to reach one million tons in order to increase current production in Benin which is estimated at 519 667 tons during the 2021 – 2022 campaign against 411 578 tons during the previous campaign [2]. The factors that may explain these low yields obtained in each campaign are partly due to climate variability prevails, poor mastery of the technical itineraries of new seeds adopted by producers, low level of equipment, insufficient investment and unfair competition from imported rice. Equally, another important factor is the adoption of intensification techniques that are inefficient or not adapted to the different existing agro-ecological zones.

Indeed, the rice growing systems adopted in Benin not only do not allow taking most of the potential of the different agro-ecological zones but also providing the consumption needs; hence, the urgency of questioning their efficiency. Faced to the population growth, it is important that various production systems should be adopted for increasing productivity and sources of income in order to ensure food security. This is why we considered it relevant to focus our study on rice-fish farming, also called “Rice-Fish Culture”, which is an integrated rice production system (rice and fish polycultures in the same ecosystem) [3,1]. This rice-fish farming association has flourished in many countries around the world, such as in Asia (particularly in China), in Africa (Burkina Faso, Niger, Guinea, Côte d'Ivoire) and especially in Madagascar. It is a system which, in addition to the principles of the Rice Intensification System (RIS), is an attractive practice because of the many services it could provide as the joint production of rice and fish (source of protein), the securing household income, improving rice yields and many others and so on [4]. But what should be the necessary conditions for adopting this technology in the current agro-ecological and climatic context in Benin? Hence, the theme of our reflection, entitled: "Comparative study of the productivity and economic profitability of conventional rice farming and rice-fish farming systems in the village of Agonlin - Lowé (Lower Ouémé Valley). Through this work, we’d like to bring our modest contribution to the development of the "rice" sector in the lower valley of Ouémé, an agro-ecological zone producing short-cycle rice and having populations with proven experience in fish farming. So, our general objective was to make a comparative analysis of the productivity and profitability of rice farming and rice-fish farming systems (with and without feed input) and more specifically, to (i) assess the impact of fish on the production of rice produced in Agonlin-Lowé; to (ii) compare the rice yields of the systems and finally (iii) the economic profitability of the systems.

2. METHODOLOGY

2.1 Presentation of the Experimental Device

2.1.1 Study Environment and Station

The experimental protocol was implemented on a plot of an indigenous producer, located in the Adjohoun City at 2.5 km of Azowlissè (Gangban District) precisely in the village of Agonlin (Agonlin – Lowe) (Latitude: 6°39'05.5'' N and Longitude: 2°28'33.6'' E) (Fig. 1). The choice of this village was based on the fact that villagers are excellent fishermen and rice producers who desire implanting rice-fish farming systems in their village [1]. This village belongs to the lower delta of the most important river of the country, the Ouémé (560 km long) which constitutes the lower valley of the Ouémé covering the communes of Dangbo, Adjohoun, and Aguégués [5]. According to [6], in the Ouémé delta, the climate is of the subequatorial type with a succession of four seasons, namely two rainy seasons of unequal importance alternated by two dry seasons.

The main farming environments encountered are traditional. These are "whedos" and "ahlos" which are real holes used seasonally because of the hydrological regime of the river [7]. Thanks to the activities of the NGO AquaDeD (Aquaculture and Sustainable Development) which, since 2008, has accompanied fishermen and their respective associations in the delta, to promote the breeding of catfish (*Clarias* and *Heterobranchus* currently) in these holes. In addition, more modern forms of fish farming in ponds, floating cages, or in above-ground tanks or tarpaulins were popularized by various structures such as MAEP and different projects (PADPPA, PADFA, and PROVAC) and the NGO AquaDeD [8].

The study began on February 27, 2022 with the rice seed, following the preliminary work and ended on August 17, 2022 with the final harvest of paddy rice and fish, i.e. a period of 6 months. The site and its geographical position were presented in the Fig. 1.

2.1.2 Experimental device and technical route of the test

Six experimental rice plots were implemented on a total area of 300 m². Two systems have been tested (Fig. 2): the conventional rice system with two repetitions and the rice-fish farming system characterized by the cultivation of rice associated with fish in the same rice fields. Two treatments were used: Rice racks + fish stocking (without food supply; two repetitions) and Rice racks + fish stocking (with food supply; two repetitions). All the six rice fields constituted have the same dimensions : length : 10 m ; width (included refuge channel) : 5 m ; profounder : 25 cm. The biological material used were constituted of the variety IR 841 of rice already used by the producers in the village and 400 monosex fingerlings of tilapia (*Oreochromis niloticus*) of average weight of 10 g. The four fiels, 3, 4, 5 and 6 were covered by mosquito nets for their protection against birds and other fish predators.

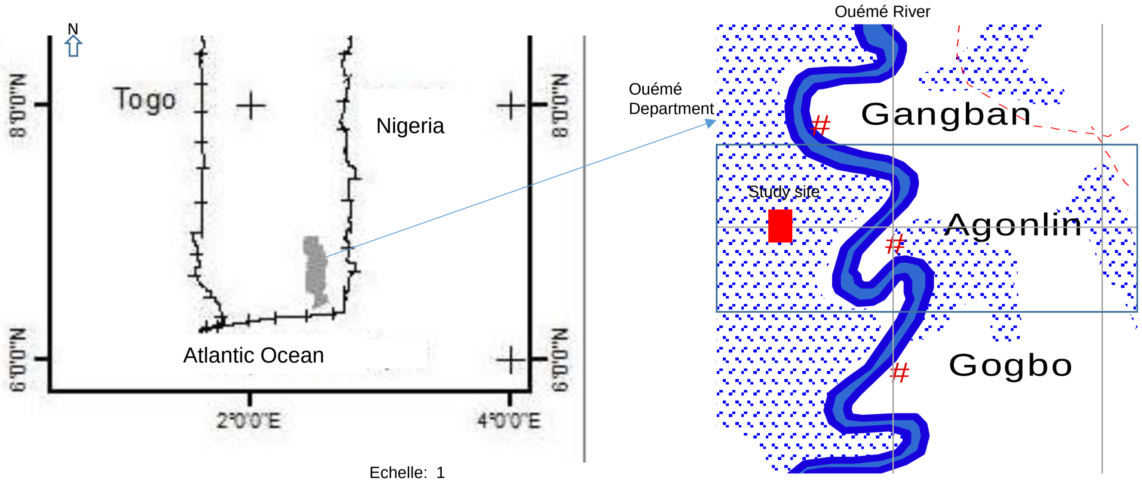

Fig. 1. Study environment and experiment site

Experimental Field 1 Conventionnal rice system (RC) L = 10 m; l = 5 m; p = 25 cm	***Experimental Field 3*** Rice –Fish system without food intake (RFWF) L = 10 m; l = 5 m; p = 25 cm	***Experimental Field 5*** Rice - Fish system with food intake (RFF) L = 10 m; l = 5 m; p = 25 cm
Experimental Field 2 Conventionnal rice system (CR) L = 10 m; l = 5 m; p = 25 cm	***Experimental Field 4*** Rice –Fish system without food intake (RFWF) L = 10 m; l = 5 m; p = 25 cm	***Experimental Field 6*** Rice - Fish system with food intake (RFF) L = 10 m; l = 5 m; p = 25 cm

Fig. 2. Experimental fields

2.2 Methods

2.2.1 Implementation of the production systems

The first activities made concerned the sowing of the rice. Rice production began with the rice nursery carried out on February 27, 2022 in a space equipped for this purpose and which was near the experimental plots. This activity was followed by the ground work that consisted in setting up of the six fields of 50 m² of surface, the drainage system. These canals were delimited using wheels in the periphery of plots No. 3, 4, 5 and 6 and represented 10% of the total area of the rice plots according to the FAO recommendations [9]. Referring to the FAO recommendations, the bunds delimiting each of the stocked plots were raised by about 30 cm (more than conventional rice plots) in order to reach a final height of 50 cm from the bottom of the rice field.

During the trial, water was added to the rice and rice-fish plots using a motor pump from two “Whédos” (small ancestral pounds) located upstream of the plots. A water column of 20 cm was maintained throughout the test due to the presence of fish.

Transplanting took place on April 24 and 25, 2022. The “line method” was used for all the plots with spacings of 25 cm between rows and 25 cm between pockets, i.e. an average density of 16 pockets per m².

Weeding was done mainly once, manually for plots N°1 and N°2. There was no weeding in plots N°3, 4, 5 and 6, however, the edges of the bunds as well as the surroundings of the plots were weeded.

The stocking of the rice-fish plots was done with the *O. niloticus* fry on July 05 2022, i.e. 40 days after transplanting because of the unavailability of the juveniles of tilapia. In accordance with FAO recommendations, the stocking density was 2.5 individuals per m²; then we used 100 juveniles per plot. For a total number of 400 fingerlings of *O. niloticus* introduced, The cost of stocking amounted to 24,000 FCFA. The fry were purchased from a fisherman locating near the village named “key fisherman” recognized in the production of it located 7 km in the northwest of the testing area.

At the end of the rice production cycle (i.e. at the rice harvest), fish were collected in each rice field previously stocked, counted, and weighed using an electronic scale. It was carried out in the afternoon of August 04, 2022 and then the fry were transferred to the Whédos until market size was reached. The rice harvest was done to estimate 4 months production into each plot.

2.2.2 Environmental parameters

Three water parameters were measured and concerned water temperature, pH and depth. For each parameter, four (04) measurements were taken per experimental plot and per month (March, April, May and June).

2.2.3 Data treatments

2.2.3.1 Assessment of the impact of fish on rice production

The agricultural yield assessment consisted of evaluating the rice production on the surface. To do this, it was a matter of first observing the experimental plots, then setting up yield squares, estimating the production per hectare for each system and finally measuring biometric parameters on rice plants.

- ✓ **Implementation of Yield Squares:** The aligned quadrat point method was chosen to evaluate the density. A quadrat for 1 m^2 was placed at randomly in the cultivated surface. In our present test, we counted the number N of the rice feet found in a unit of surface (1 m^2). We repeated this counting three times in each plot. The density (D) was the mean number of the rice feet counted per unity of surface S: **D = N / 3S.**
- ✓ **Rice Biometric Parameters:** The measurement of the following biometric variables were carried out on 10 random rice plants per experimental plot: These were the size of the rice plants, the number of tillers per plant, the number of panicles per tiller and the fresh weight.
- ✓ **Determination of the Rice Yield of the Two Systems:** The grain yield (actual) was obtained from the weighing after drying of the Paddy of the plants contained in each quadrat. The dry biomass yield of the stems was obtained in the same way from all the rice plants included in these same quadrats, excluding the grains from the measurement.

The number of panicles per plant and the number of grains per panicle were obtained from a sample of 10 rice plants per experimental plot. A weight measurement of 500 grains was also carried out for each quadrat using a precision digital scale (Sensitivity 40 g). The yield was calculated by the following formula: **Yield (r) = Production (tonne) / Area (Hectare).**

2.2.3.2 Evaluation of the economic profitability of the two systems

The evaluation of the economic profitability was based on the comparison of the financial returns of the conventional rice farming and rice-fish farming systems. Two indicators have been determined in particular:

- The net margin (MN): It is obtained by deducting from the gross product in value (PB) per hectare the total costs per hectare (CT). Expressed in FCFA (the current currency of Benin), the net margin is determined by the following formula:

Net Margin = Gross Product (GP) – Total Costs (TC), with The Gross Product (GP), the value of the total production after harvest calculated and the Total Costs, all the costs required for production, whether they are variable. The Gross Product (GP) and the Total Costs (TC) were calculated using respectively the following formula:

- **GP = Quantity harvested (production)** × **Unit price.** The price of paddy rice is estimated at 170 FCFA/kg based on market selling costs in Benin (CPA, 2019).
- **TC = Variable Costs (CV) + Fixed Costs (CF)**
- Financial Return (FR): or Profit/Cost Ratio is determined by the following formula:

RF = PB/CT

To analyze the economic profitability, we were based ourselves mainly on the Financial Yield, which is done by comparing it to the value 1. In the case where the financial yield is greater than 1, we could conclude that 1 FCFA invested in the activity or production can generate more than one (1) FCFA as profit and therefore say that the activity or production is economically profitable; otherwise, the activity is not profitable.

- ✓ **Analysis of Fish Growth by System:** Fish were weighed at the time of stocking. The average initial weight was 9.8 g in RFF system and 9.6 g in the RFWF system. During the final fishing (at the rice harvest), all the fish in the four plots were captured and counted in order to determine the survival rate of the total production and a sample of 30 specimens was also weighed.

The data collected were listed in the Microsoft Excel spreadsheet and have been processed using R software, version 4.2.1. This software was used to perform variance analyzes (ANOVA) at the 5% threshold.

3. RESULTS

3.1 Environmental Parameters

Three water parameters were measured, the water temperature, the pH and the profounder of the plots. The Table 1 below has presented the extreme and mean values of these parameters during the study. No significant difference between parameters was noticed.

Table 1. Water parameters in the plots during the study

Variables	Minimum Values	Mean Values	Maximum Values	Comparison test ANOVA	
				P-value	**Signification**
Water temperature (°C)	27.6	32.1	29.42 ±1.9	0.133	NS
pH	6.8	7.9	7.35 ±0.58	1.21	NS
Profounder (m)	23	25	24.45 ±0.97	0.078	NS

Legend: NS: Non significative (p >.05)

3.2 Comparative Study of Rice Yields and Yield Components of Production Systems

- ✓ **Number of Tillers and Straw Weight:** Table 1 below presented the yields of the different tests and their components. The analysis showed the yield performance of the rice-fish culture system with feed (RFF) compared to conventional rice cultivation (RC) and rice-fish culture without feed (RFWF) (Table 2). There was a significant difference between the numbers of tillers at harvest. RFF (18 tillers (b) promote better tillering compared to conventional rice cultivation (RC) (12 (a) and RFWF (13 (a) (Fig. 3 (a)).

The results revealed significantly higher tiller fertility in RPA (Table 3), which induces a higher number of panicles (p= .034*). However, the straw weights (Fig. 3b) as well as the 500 full grain weight (Fig. 4) do not vary significantly from one system to another. In other words, the introduction of fish in the rice production does not affect the stem biomass yield at harvest.

At harvest, the rice plants in RFF (140 cm) had a significantly higher height (Table 3) (p = .027) than the RC (121 cm) and the RFWF (118 cm). The significantly better harvest index values in RFF (0.50) led to the conclusion that RFF induced better rice yields, i.e. 2.33 t/ha (Fig. 4). Thus, the RFF allowed to obtain an added value in rice of 0.29 t/ha compared to the RC and of 0.16 t/ha compared to the RFWF, i.e. an average added value of 0.23 t/ha.

3.3 Analysis of Fish Growth by Production System

During the experiment, only 5 and 8 individuals of the fish were found dead respectively in RFF and RFWF systems. The results showed that the survival rates of fish in rice-fish farming (RFF) and in RFWF were 97.5 and 96% respectively without a significant difference (P >0.05).

Also, the average initial weights (at stocking) were 9.80 and 9.70 g respectively in the RFF and RFWF systems (Table 3). After one month, the average final weight in the RFF system was 16.70 g against 11.05 g in the RFWF system. Respectively, the weight gain was of 6.9 g in RFF and of 1.35 g in RFWF. In other words, the RFF system promoted better fish growth.

3.4 Estimation of the Economic Profitability of the Two Systems

The results below compared the economic profitability of the rice farming (RC) and of rice-fish farming (RFF and RFWF). Here, we wanted to remind that the duration of the fish culture is only two months. It remains 4 months before the fingerlings could reach the market size. The results revealed that the profit margin of the rice

Table 2. Mean values of yield and yield components per system

Treatments	Tillers Number	Number of panicles	Straw weight (g)	full grain weight (g)	Yield (t/ha)	Fertile tiller (%)	Harvest index	Height (cm)
RC	11.55 a	10.50 a	485 a	15.00 a	2.04 a	91.17 a	0.34 a	121 a
RFWF	12.70 a	11.50 a	475 a	15.25 a	2.17 a	90.99 a	0.36 a	118 a
RFF	18.05 b	17.50 b	480 a	15.25 a	2.33 b	96.95 b	0.50 b	140 b
Average	14.10	13.17	480	15.17	2.18	93.04	0.40	126
p-Value	***.012 ****	***.034 ****	***.448***	***.989***	***.020 ****	***.018 ****	***.032 ****	***.027 ****

Legend : RC = Conventional Riziculture, RFWF = Rizipisciculture without food supply ; RFF = Rizipisciculture with food supply. ; the mean values with the same letter a or b were not significantly different

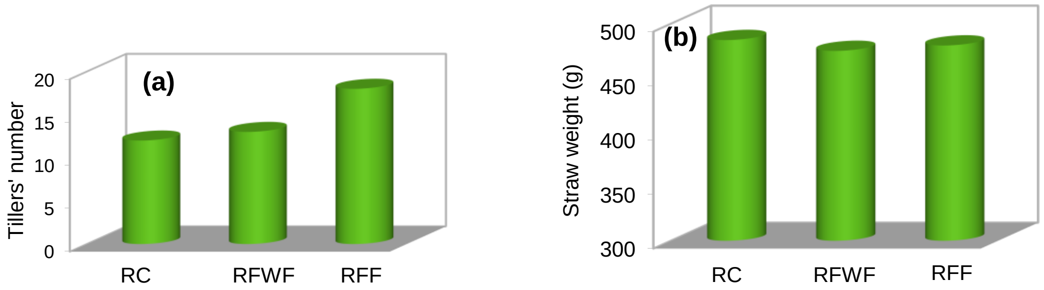

Fig. 3. Variation in the number of tillers per system (a) and of the straw weight (b)

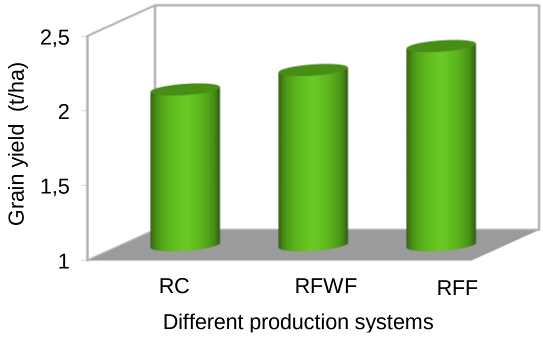

Fig. 4. Grains' yields (in tons per hectare) of each system

farming system (RC) was lower than those obtained in of rice-fish farming (RFF and RFWF) (Table 4). And the RFF system provided the best gain, better than the one obtained with the RFWF system (Tables 5 and 6).

Table 3. Average weights of fish from fish systems

Treatments	Average initial weight (g)	Average final weight (g)
RFF	9.80	16.70
RFWF	9.70	11.05
Average	**9.96**	**16.96**

Table 4. Operating account of the three systems (per hectare)

	RC	RFWF	RFF
Rice cultivation load	292 000.00	292 000.00	292 000.00
Rice recipe (F CFA)	346 800.00	368 900.00	396 100.00
Fish stock	0.00	466 666.67	2 171 111.00
Fish recipe (F CFA)	0.00	1 081 877.50	3 697 500.00
Rice margin	54 800.00	76 900.00	104 100.00
Fish margin (F CFA)	0	615 211.00	1526 380.00
Rice-fish margin	0	692 110.83	1 630 480.00
Profitability	0.16	0.26	0.36

Table 5. Operating account of the three systems (experimental area)

Variables	Simple rice	Rice + fish without feed	Rice + fish with feed
Area (m²)	50	50	50
Yield t/ha	2.04	2.17	2.33
Variable costs	4100	4100	4100
Fixed costs	1000	1000	1000
Total Costs	5100	5100	5100

Table 6. Table of financial profitability indicators

Indicators	Simple rice	Rice + fish without feed	Rice + fish with feed
Yield kg/ha	2.04	2.17	2.33
Net margin	54 800	692 110	1 630 480
Rice financial return	1.18	1.91	1.66

4. DISCUSSION

4.1 Impact of the Presence of Fish on Rice Production

4.1.1 Rice yield parameters

The number of tillers is an important yield determining parameter on which most rice yield studies are based. The results of our study showed that the number of tillers was higher in the rice-fish plots (RFF and RFWF) (with or without food supply) than in the conventional rice plots. Various comparative studies between rice farming and rice-fish farming have shown similar cases in the difference in tiller production [4]. This could be justified by the presence of fish which would have favored a good development of the tillers after their introduction into the rice plots as reported by [10]. This good tillering could be closely linked to high nitrogen availability [11].

The number of spikelets is taken from a sample of 10 panicles per yield square in each plot of each system to allow the comparison of the performance of the two systems of production. Our study showed that Rice plants in rice-fish plots were more productive in spikelets with a highly significant difference ($p=0.989$) at the 5% threshold in the number of spikelets filled between the two systems. These results corroborate the work of [12] who found a difference in the average number of filled grains per panicle in rice-fish plots. In our study, the number of grains per panicle at harvest was indeed higher for the associated systems compared to the rice system without fish (respectively 15.25 and 15) although not significant ($p>0.05$). Probably, this yield parameter would have contributed to the better performance of the integrated fish-rice systems compared to the conventional rice-growing system (respectively 2.17 t/ha and 2.33 t/ha for the stocked systems) against 2.04 t/ha for the unstocked system).

According to [2], in Benin, rice yields of 4.75 t/ha were obtained in conventional rice cultivation. However, in our study, the rice yields obtained were lower than these references in the systems tested: respectively 2.04 t/ha for the conventional system (plots n°1 and 2), 2.17 t/ha for the system stocked without food supply (plot no. 3 and 6) and 2.23 t/ha for the stocked system with food supply. Several reasons could explain these low yields of rice production. Firstly, the quality of the seeds used, according to the suppliers, are those of the previous campaigns; this confirms the poor performance of the seeds, which gave an average rice yields close to those obtained during the 2019-2020 campaign in the same commune of Adjohoun, which was around 2.7 t/ha. Secondly, no fertilization was used for this trial mainly due to its unavailability. Thus, it is likely that the natural nutrient compounds were present in low doses. But also, we must promote organic cultivation.

According to [13], the water layer influences rice yield via the number of panicles per m² and the percentage of full grains per panicle. Among several water levels, [13] observed an increase in grain yield in rice-fish culture with increasing water depth up to 15 cm, probably attributed to a number of panicles per m² and a higher number of full grains per panicle. Concerning our study, rice straw yield also has increased with the rise in water level between 10 and 15 cm. [14] observed a reduction in the number of panicles per m² in rice-fish farming resulting from water stress (lack or excess) occurring during the active tillering phase of the rice. Indeed, the maintenance of a high water depth (> 15 cm) allowing the movement of fish in the rice field, can significantly reduce the number of panicles per m² probably by inhibiting the tillering process [14]. The same author confirmed that tillering is negatively affected by permanent high water levels (>15 cm) and cause rice yield losses. In our study, the water level was maintained at a threshold below 15 cm throughout the experiment for the conventional rice farming system and at a threshold of 15 cm for the rice-fish farming systems.

Water being one of the important elements entering both rice and fish production, its availability, quality and variation could influence their production and also the abundance of weeds. During the test, a variation of the water layer present in the traps of the systems stocked or not was noted. While the rice plants can be tolerant of a significant drop in water level in the traps, the fish could not. According to [15], shallow waters (< 7 cm) constitute a favorable environment for benthic and epiphytic organisms where weeds develop easily, but in this environment the fish contribute to inhibiting the growth of these weeds because the food is more abundant there. For illustration, we refer to [16] who reported that the abundance of grasses decreases significantly for a water depth of 5 cm and that the sedge genus of the sedge family is usually absent from 15 cm, better when the fish were present in the traps. In the same perspective, [16] showed that the growth of dicotyledonous weeds such as *Jussiaea repens* (L.) (one of the weeds listed in our experimental plots is inhibited for a blade of water between 5 and 7 cm but that, conversely, the development of these weeds is favored by a water level between 9 and 11 cm. Similarly, the growth of species of the genus *Eleocharis i*s increased for water levels exceeding 10 cm. In our study, most of the identified weeds proliferated in the rice fields of the two systems whose water depth was kept below, in particular for the *Cyperus difformis* (L) species.

Also, the water temperature and the pH are important factors controlling the rice farming and the fish growth [17]. Indeed, as shown by [16], high temperatures can lead, in upland rice, to an increase in the need for water, increased water and heat stress, reduced tillering, white panicles, reduced number of spikelets during flower initiation, increased sterility. Rice does best in soils with good water-holding capacities, e.g. clay soils with high organic matter content. And the geo-morphological area we used corresponds better to this activity. The water température values measured during the experiments were betwwen 26 °C and 29 °C obtained early in the morning (6 to 10 o'clock in the morning). The optimum pH is about 6-8 corresponding to the lowland growth rice [17,18].

4.1.2 Effect of stocking on rice

According to the results, the best yields are obtained in RFF with an observation of similar yields in RC and RFWF. Raising fish in rice plots would therefore not negatively affect rice development and would improve yields when fish are artificially undernourished. The analysis showed that there was better tillering and better tiller fertility as well as a higher harvest index in RFF. The improvement of RFF yields could be justified by the permanent availability of organic matter resulting from the digestion of fish under an artificial feeding regime and the remaining fish food, which would have favored a better development of rice plants. This improvement could induce an increase of more than 0.2 tons of rice per hectare on average.

4.2 Fish Growth Factors in Rice-Fish Culture

Fish growth levels in RFF were higher than in RFWF. This could be justified by the rearing conditions characterized mainly by the supply of food in RFF and the absence of artificial feeding in RFWF. Indeed, in the traps, there was natural production of food for fish such as phytoplankton and benthos (mollusks, crustaceans especially zooplankton and annelids). This richness in natural and varied food necessarily has an influence on the profitability of the system since the expenses related to the purchase of the food will be minimized.

4.3 Economic Profitability of Production Systems

Here, it is indeed a polyculture. The farmer harvests the rice and at the same time produces fish in an extensive system where he does not need to bring food to the farm. Only the two productions will not be sold at the same time because the rice used was of short cycle (4 months) while it takes 6 months to have fish at market size. In all cases, rice-fish culture we demonstrated, was the more profitable for producers. If producers choose practicing the extensive production of fish, they could orientate them towers the RFWF system and for it, they could preserve them from buying fish foods that cost. But in the intensive form of the production of fish, it is become necessary to complete natural foods (benthos, plankton) to boost the fish growth. Also, reducing fish feed costs could increase the net margin and therefore the economic profitability of rice-fish farming.

5. CONCLUSION

To carry out this study, a methodology was adopted, data collected, analyzed and discussed. It appears that the presence of fish has visibly had a positive impact on rice yield in rice-fish farming. Indeed, the rice yield increased in the polyculture systems compared to the conventional system (respectively 2.33 and 2.17 and 2.04 t/ha). Most of the previous studies conducted on this subject confirmed this result and indicated an increase of around 5 to 30% in rice yield. This increase in rice yield could be explained by the important number of grains per panicle and per plant in the presence of fish. In our study, factors causing the increase in the value of these components and the increased vegetative development of the plants were identified subject to confirmation with other tests. Indeed, the possible fertilization by fish excrement increased the availability of nutrients for rice cultivation. The presence of fish has reduced the abundance of weeds in stocked rice fields explained by the presence of a significant layer of water. Also, the growth performances obtained with polyculture with food supply were better. Finally, the short duration of fish rearing in rice fields (60 days) did not allow sufficient growth of carp to reach market size. The implementation of additional facilities did not lead to a loss of rice yield. On the contrary, the reduction in rice area in rice-fish farming systems (10% of the rice field) was well compensated by an increase in rice yield thanks to fish. The negative economic gain from fish production ultimately did not compensate for the investments made due to the short breeding period.

In Benin, no scientific study has been conducted and published on the feasibility and adoption of the rice-fish farming system. This study is part of a perspective to test a new technique that is productive, economical and could be adapted to the agro-ecological conditions of Benin. But experiments will be carried out on the large scale to test again for its popularization.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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