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THE ECONOMICS OF RICE-CUM-FISH AGRO-PISCICULTURAL FARMING SYSTEM IN IMO STATE, NIGERIA

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ABSTRACT
Small-scale rural aquaculture in association with crop-based farming systems was recently integrated into the Unified agricultural extension system of Nigeria. Dissemination is through the Small plots Adoption Technique (SPAT) in on-farm participatory trials. Rice-cum-fish culture is the most widely acknowledged extension package in the agro-piscicultural farming system.
The study is aimed at determining the optimum integration level of fish in rice-cum-fish culture systems, provision of sustainable income to the rural farm family, and resource optimization of the diverse agro-ecosystems in Nigeria. The trial thus evaluated the optimum stocking density of fish in paddy fields using peripheral trenches and the profitability of the farm enterprise.
4 fish per m^2 integration level provided the best results in terms of water quality, fish survival, yield and financial returns. Production was 21.6t ha^{-1} yr^{-1} for fish and 12.6t ha^{-1} yr^{-1} for rice.
Cost-benefit ratio (CBR) of the venture was 1:1.8. This implies that for every ₦1.00 invested in the farming system at the observed optimal level, a gross income of ₦1.80 and net income of ₦0.80 accrues to the farmer. The Gross Ratio, G.R. (1:0.01), Operating Ratio O.R.(1:0.5) and Capital Turnover Ratio CTR (1:0.55), all suggest a lucrative business.

INTRODUCTION:
Small-scale fish culture in association with rice in paddy fields is a new production technology in Nigeria. Dissemination to the rural farmer is through the Small Plots Adoption Technique (SPAT) as an extension package in the unified Agricultural Extension System by State Agricultural Development Programmes (ADP's) in Nigeria.

Institutional linkage through on farm research (OFR) are funded by the National Agricultural Research Project (NARP), a World Bank assisted project and co-ordinated by the Federal Agricultural Co-ordinating Unit (FACU). In the package, fish is reared in trenches in the periphery of paddy fields. The advantage is that the fish is allowed to mature to table size even after water has dried up in the rice fields. The treneches serve as fish haven.

The importance of integrated small-scale agro-piscicultural farming system has already been reported (Pullin, 1995, Turkish, 1995; FAO 1990, 1997; Randriamiarana *et al.* 1995) especially in South east Asia where rice-cum-fish culture development is in the advanced stage. Yield data associated with stocking densities of fish practiced by farmers which are wide and varied now constitute a major problem (Micha 1995). According to

Randriamiarana *et al* (1995), the main constraints which has impeded the development of rice-cum-fish farming in South East Asia and Sub-Saharan Africa (including Nigeria) is the absence of any satisfactory fish breeding technique and rice-fish combination ratio. As a result, it has been difficult to realize an estimated production target of 200Kg/ha/cycle set in Madagascar. On the other hand, Tokrisna (1995) reported a yield of 200 to 250 Kg/ha/4-6 months from experimental trials in Thailand at undisclosed stocking densities of fish in irrigated rice fields.

In Nigeria, however, integrated rice-cum-fish farming system is in it's very early stage of development, but with good prospects. Most aspects of the cultural practices (including the stocking rate of fish in paddy fields) are still in the experimentation stage.

In the present study, attempt is made to determine the optimum stocking density of fish in such paddy fields and to evaluate the economic efficiency of the new farming system. It is believed that an economic analysis of this nature is capable of creating awareness on the profitability of the farming system and consequently the interest to adopt.

MATERIALS AND METHOD

Experimental Unit

The trial was carried out in rice-cultivating communities of Ndionuoha, Umuna and Uboma -Abueke rice fields, all in Okigwe agro-ecological zone of Imo State. Twelve (12) paddy plots were used for the experiment. Four of the rice fields belonged to a participating farmer from each of the three communities. A plot measured 8.2m x 7.2m (or 59.04m^2 in area). This is within the minimum economic size unit in the small Plot Adoption Technique (SPAT) at the homestead level. A "central cell", measuring 4.1m x 4.2m (or 17.0m^2 in area) was mapped out for the paddy. The square cell was surrounded on the four sides by a trench (the fish haven) of 60cm wide and 60cm deep. The experimental plot was barricaded with raised bonds to avoid the entry or exit of wild and reared fish respectively. An opening was created on each side in which bamboo pipes passed through to allow for movement of tidal water in and out of the plot. The pipes were provided with fine-meshed synthetic screens to fitter off wild fish and debris. The fish-cum-rice fields were fed by rainwater, which reaches the peak during the months of July-August. Selected sites for the three replicates were flat terrains with a preponderance of clay. The clayey soil retained water to an average depth of 8.0cm persistently for four months (July-October) annually.

The trial which was originally conceived in 1994 and funded by the National Agricultural Research Project (NARP) through the Imo ADP were faulted by fish escapade, and so could not be reported at the farming systems workshop under the REFILS (Research and Extension Farmers Input Linkage System). In the present independent study, the researcher took advantage of the past experience in the provision of barricade bonds as a modification.

Experimental Design

The experiment which was conducted in 2001 lasted for four months (July – October). It was designed as a randomized complete block (RCB) experiment with three treatments consisting of varying stocking densities of the manually sexed male individuals of the African cichild, *Oreochronis niloticus*, L. in association with rice crop as follows:-

Treatment (T_1):	2 fingerlings m^{-2} + Rice
Treatment (T_2):	4 fingerlings m^{-2} + Rice
Treatment (T_3):	6 fingerlings m^{-2} + Rice
Control (T_4):	0 – fingerlings (Sole rice).

The control (T_4) consists of the farmer's present practice. The current practice among the small-scale rural farmer is the cultivation of sole rice in paddy fields. The choice of Tilapia (*0 niloticus*) was based on the fact that it is a herbivore (Lagler et al, 1977) which thrives well in rice fields (Zhong Gongfu, 1995, feeding on aquatic macrophytes and algae (Njoku, 2000). The farmer is saved the problem of feeding and feed-related costs. The fingerlings averaged 5.0cm in total length and 15.0g in body weight as adopted by Njoku (1999). Such juveniles are less susceptible to shock and more adapted to captive environments. At the above rates, the stocking densities for the various treatments were as follows. T_1, (55 fingerlings), T_2 (68 fingerlings), T_3 (102 fingerlings), T_4 (0-fingerling). The treatments were assigned to the experimental plots at random and replicated three times in a 3 rep x 4 treatment layout of 12 experimental units. Each of the rice-cultivating communities served as a replicate of the experiment. Rice seedlings were obtained from the farmer's nurseries and planted in the "central cells" of the plot three weeks before the introduction of fish component. This is to enable rice seedlings become properly established first. An improved long-grain, high yielding and blast – resistant SML variety distributed by the Imo ADP was used for the trial. This variety is also known to be resistant to lodging with high adaptability to varied ecological environments. Each replicate experiment in the on-farm trial was jointly managed by the farmer, and the researcher.

Sampling /Data Analysis

Bi weekly sampling was executed to measure the growth responses of fish and water temperature. There was also surveillance over disease and pest attacks and water level dynamics. Being an On-Farm Adaptive Research (OFAR) with farmer participation, simple phisico-chemical parameters only were measured. These include surface – water temperature, pH, dissolved oxygen and water turbidity. Analysis were in accordance with standard procedure recommenced by APHA (1980) and AOAC (1985). After harvest, component yields of fish and rice as well as survival rate of fish were recorded. The data were statistically evaluated using the two-way analysis of variance (ANOVA) as described by Wonnacott and Wonnacott (1977), and Njoku (1997 and 1999), as follows:-

$$Xij = Xi + Ti + Bj + Eij$$

Where Xij = Observed mean yield of fish and rice
Xi = Unknown rice and fish yields common to all treatments
Ti = Yield due to treatment effect
Bj = Yield due to location
Eij = Yield due to experimental error.

Difference in mean yield were compared with the least significant difference (LSD) method at the 95% level. Differences in yield and the accruing income between locations were tested with F- maximum ratio (Njoku, 1999) while the Duncan's multiple range test (DMRT) was employed in determining the level of significance in treatment mean yields according to the method documented by Njoku et al (1998) at 95% level. Yields at different stocking densities of fish were then subjected to cost-benefit analysis (CBA) to determine their relative economic advantage.

Economic Analysis

The economic efficiency of the new agro-piscicultural farming system was measured based on four financial criteria. These include:-

(i) **The Cost-benefit Ratio (CBR)**

This is the measure of the total costs as compared to the total income after due monitization of all input and output variables in the production process. It is calculated as follows:-

$$CBR = \frac{\text{Total income}}{\text{Total cost}}$$

(ii) **Gross Ratio (GR)**

This is a profitability index that gives an idea of the proportion of gross income that is used to service fixed expenses. It is calculated as:

$$GR = \frac{\text{Total Fixed Expenses}}{\text{Gross income}}$$

(iii) **Operating Ratio (OR)**

This is a profitability index that indicates the proportion of gross income that goes into payment of operating costs. It is calculated thus:

$$OR = \frac{\text{Operating expenses (variable costs)}}{\text{Gross income}}$$

(iv) **Capital Turnover Ratio (CTR)**

This ratio is a profitability measure that shows what proportion of the invested capital is of the gross income. It is determined as follows:

$$CTR = \frac{\text{Gross income}}{\text{Average capital invested}}$$

RESULTS AND DISCUSSION

Physico-chemical characteristics of the pond water

Table 1 presents the results of the physcio-chemical parameters of pond water, evaluated every fortnight. The mean dissolved oxygen (D.O.) in T_1 (2 fish m^2) was 24.4mgl^{-1}, 22.1mgl^{-1} in T_2 (4 fish m^{-2}), 22.9mgl^{-1} in T_3 (4 fish m^{-2}); and 25.3mgl^{-1} in T_4 (0-fish). Variation in dissolved oxygen exhibited no definite pattern. This was also true of transparency, even though water was clearest in T_4 (0- fish). Water acidity increased as the stocking density of fish increased from a pH of 10.9 in T_1 (2 fish m^{-2} to 6.8 in T_3 (6 fish m^{-2}). There was no noticeable variation in surface water temperature between treatments.

Fish recovery and growth response

Table 2 shows percentage recovery of fish at harvest at the three stocking rates. In treatment, T_1 (2 fish m^{-2}), recovery was 100%, 94% in T_2 (4 fish m^{-2}) and 80.4% in T_3 (6 fish m^{-2}). Though fish recovery was generally high for all treatments, fish survival in T_3 (6 fish m^{-2}) was significantly lower ($P< 0.05$) than at other stocking densities. Increased stocking density of fish in rice fields up to 6 fish M^{-2} had no adverse effect on pond water. The most acid condition (pH 6.8) recorded in T_3 (6 fish m^{-2}) is considered good for fish culture (Woynarovich, 1976, Veldkamp 1996). The conducive state of the water may have accounted for the high rate of survival (80.4 to 100%) and growth response of fish.

Yields for the fish and Rice components

Table 4 and 5 present yields for the fish and rice components at different stocking densities of fish in the paddy fields. From the results, it was evident that the agro-pisciculture thrived best when rice fields were integrated with fish at a density of 4 fish m^{-2} (T_2). Component yields at this level were 8.6 kg of fish per plot of 17.04m^2 for 4 months and 17.8kg of rice per plot of 17.04m^2 for 4 months. When extrapolated over an hectare farm (Table 6) in one year production cycle, the yields translated to 21. 6t ha^{-1} yr^{-1} of fish and 12.6t ha^{-1} yr^{-1} of rice. Yield data on integrated rice-cum-fish trials are not readily available for comparison, but reports from Idonesia (Micha, 1995) indicates a production of between 0.25t – 1.0t ha^{-1} yr^{-1} of fish and 1.3t ha^{-1} yr^{-1} of rice. Elsewhere in Madagascar (Randriamiarana *et al,* 1995) and Ivory Coast (Micha, 1995), 0.55t to 0.25t ha^{-1} per 4-6 months cycle, and 2-3t ha^{-1} yr^{-1} in fresh water rice farms respectively have been reported.

In South East Asia, Micha (1995) considers fish yields of 20-30t ha^{-1} yr^{-1} in rice fields as low. The fact that the fish were not fed may have accounted for the short fall in yield expectations. It is pertinent to note, however, that the production in the present trial of 15.2t ha^{-1} yr^{-1} of fish in addition to the 12.7t ha^{-1} yr^{-1} of the rice is an additional benefit to the farmer who under the present practice, cultivate only rice in this plot of land with a production that hardly exceeds the present figure in their sole rice fields.

Cost – Returns Analysis

At the observed optimum socking density of fish (4 fish m^{-2}) in rice fields (Table 6) the fish out-put of 21.6t ha^{-1} yr^{-1} and rice of 12.6t ha^{-1} yr^{-1} were realized at a cost of ₦5,382,300.00 for fish and ₦2000,00 for rice. This gave a total production cost of ₦7,382,400.00 In the sole rice (control) experiment, T_4 (farmer's practices), a yield of 15.9t ha^{-1} yr^{-1} accrued at a cost of N200,000.00.

On the revenue ledger, the fish and rice outputs of 21.6t ha^{-1} and 12.6t ha^{-1} in T_2 (4 fish m^{-2}) sold for ₦10800.00 and ₦2520,000 respectively, giving a total proceed of ₦13,320,000.00. This gave a net income of ₦5,937,600.00.

Cost benefit ratio (CBR) which measured the total cost of the venture against the total accruing revenue was 1:1.8. This implies that for every N1.00 invested in the integrated farming system at the 4 fish m^{-2} integration level, a gross income of N1.80 and net income of N0.80 accrues to the former. Gross Ratio (G.R) was computed as 1:0.01, the Operating Ratio (O.R) as 1:0.5, and the capital turnover ratio (CTR) as 1:0.55. The Gross ratio (0.01) which gave an idea of the proportion of the gross income that went into the payment of fixed (capital) costs shows that very little of the total income was spent on fixed costs (construction of fish trench) which were held at very low level. The operating ratio (0.5) indicated that only 50% of the total revenue was expended on production cost.

In strict economic terms, the computed value for the O.R. symbolizes an efficient business. The estimated capital turnover ratio (CTR) of 0.55 implies that the entire capital spend in the production process amount to just 55% of the gross income which means that the business turnover (net profit) is as much as 45%. This is considered as highly lucrative in business rating (Horne, 1979).

CONCLUSION AND RECOMMENDATION

Agro-eco systems analysis and farmer- participatory research and evaluation, technique according to Light foot and Pauly (1995) provide a good basis for an integrated resource management and propagation of a new technology such as the integrated rice cum-fish agro-eco-pisciultural farming system. The study which is targeted at the rural peasantry could go a long way in alleviating the poverty –stricken resource – poor rice farmer by encouraging him to incorporate fish for additional income. Propagation of the new innovation in rice-cum-fish culture, (the observed optimum stocking rate of fish in trenches within the paddy field) should recognize the "Farmer-Participatory Approach". Small adoption plots should be established on-farm, side-by-side with farmer's own plots of sole rice and results evaluated together. This way the Extension Officer is likely to arouse the interest of the adopting farmer.

Table 1: Bi weekly variation in water quality conditions of experimental plots stocked with different densities of fish in association with rice in the fish-cum-rice integrated farming system. Water parameters

Sampling Period (Weeks)	T_1 (2 fish m^{-2})				T_2(4 fish m^{-2})				T_3 (4 fish m^{-2})				T_4 (Control)			
	Do (mgl^{-1})	Trans. (cm)	PH	Temp (^0C)	Do	Trans.	PH	Temp (mgl^{-1}) (cm) (^0C)	Do (mgl^{-1})	Trans. (cm)	PH	Temp (^0C)	Do (mgl^{-1})	Trans. (cm)	PH	Temp (^0C)
Initial 0	28.6	55.0	12.6	29.0	28.5	54.9	12.6	29.2	29.0	54.9	10.5	29.0	28.5	55.1	12.5	28.9
2	28.0	52.0	12.4	29.1	27.6	50.2	10.4	29.0	29.1	52.5	8.1	29.2	27.9	50.6	10.5	28.0
4	28.2	48.2	11.8	29.0	26.1	48.5	11.9	29.1	28.5	49.0	8.0	28.5	28.0	48.1	14.6	28.2
6	26.0	40.5	11.0	28.9	26.2	47.1	12.0	28.8	28.0	42.5	7.6	31.0	25.9	44.4	11.4	29.0
8	27.1	34.0	10.5	29.8	21.5	40.3	11.6	30.0	23.5	38.1	7.5	31.1	26.6	31.0	12.2	29.9
10	25.0	35.0	10.8	31.2	20.0	41.4	6.2	30.5	21.1	20.5	6.3	31.5	26.0	26.8	12.2	31.1
12	22.0	31.3	10.0	30.8	18.1	33.5	9.5	30.8	18.5	19.6	9.5	30.9	25.4	21.2	11.0	31.8
14	20.5	26.5	9.4	31.6	16.8	26.8	9.1	31.0	15.0	18.0	9.1	32.2	21.0	18.5	12.0	32.0
16	14.5	20.0	9.8	31.8	14.3	20.1	9.2	31.8	13.6	18.5	8.2	32.0	8.5	16.1	6.1	32.4
Mean	24.4	38.1	10.9	30.1	22.1	36.3	8.3	30.8	22.9	34.8	6.8	31.6	25.3	40.3	11.2	30.1
Variation	8.1	35.0	3.2	2.9	14.2	34.8	3.4	3.0	15.4	36.4	6.5	3.5	10.0	39.0	6.4	4.4

Figures are based on 3 replicate determinations
Means on the same row with similar superscripts are not significantly different (P = 0.05).
Source: Present study.

Table 2: Details of fish recovery at harvest from the paddy fields in association with rice in the on-farm fish-cum-rice trial (Data based on mean value from three replicates)

Treatment level	Number Stocked	Number recovered ($N\pm$ S.D.)	% Recovery
T_1(2 fish m^{-2})	35	35 ± 2.0	100.0^a
T_2 (4 fish m^{-2})	68	64 ± 3.0	94.0^a
T_3 (6 fish m^{-2})	102	82 ± 3.0	80.4^b

ab: Means in the same column with different superscripts are significantly different at P = 0.05 level.
sd: Standard deviation of treatment means among replicates.

Source: Present study.

Table 3: **Weight increment (g) of fish during the 4 month on-farm trial (Data from three replicate determinations)**

Sampling Period		Treatment levels (fish densities)		
	T_1	T_2	T_3	T_4
Weeks)	(2 fish m^{-2})	(4 fish m^{-2})	(6 fish m^{-2})	(0-fish)
Initial 0	15.0	15.0	15.0	–
2	18.5	18.0	20.0	–
4	35.5	28.0	25.0	–
6	48.0	35.0	30.0	–
8	50.0	46.0	35.0	–
10	66.5	58.0	38.0	–
12	85.0	75.0	60.0	–
14	130.5	90.0	85.0	–
Final 16	180.0	150.0	120.0	–
Number recovered	35	64	82	–
Mean weight gain	165.$\pm$ 4.5^a	135.0$\pm$3.o^a	105.0$\pm$2.5^b	–
Daily weight gain	1.40	1.13	0.88	–
Total weight gain	5775.0	8640.8	610.0	–

ab = Means in the same row different superscripts are significantly different (P=0.05).

Source: Present study.

Table 4: **Yield (kg) of fish component in the on-farm rice-cum-fish integrated trial in three communities of Imo State**

Treatment		Locations		Means	
	I	II	III	(x$\pm$S.E.)	LSD (0.05)
T_1 (2 fish m^{-2})	5.70^a	6.80^a	4.90^a	5.80$\pm$0.02	15.0
T_2 (4 fish m^{-2})	9.00^b	8.94^b	7.98^b	8.64$\pm$ 0.06	NS
T_3 (6 fish m^{-2})	8.30^b	8.43^b	9.10^b	8.61$\pm$0.04	
T_4 (0 fish)	—	—	—	—	—

Source: Present Study

Table 5: Yield (kg) of rice component in the on-farm rice-cum-fish integrated trial in three communities of Imo State.

Treatment		Locations		Means	
	I	II	III	(x±S.E.)	LSD (0.05)
T_1 (2 fish m^{-2})	18.1^{a}	16.5^{a}	17.0^{a}	17.2± 0.02	NS
T_2 (4 fish m^{-2})	18.5^{b}	17.0^{b}	18.0^{b}	17.8± 0.03	28.5
T_3 (6 fish m^{-2})	12.8^{b}	11.5^{b}	10.6^{b}	11.6± 0.2	15.0
T_4 (0 – fish)	22.0^{c}	21.6^{c}	23.0^{c}	15.5± 0.1	_
Replicates					
Mean	17.9	16.7	17.2		
LSD (0.05)	NS	NS			

abc = Means in the same column with different superscripts are significantly different at ∝= 0.05.

Source: Present study.

Table 6: Cost-returns Analysis of the on-farm rice-cum-fish Agro-Piscicultural trial (Yield in tons ha^{-1})

Treatment	Fish (Tons ha^{-1})				Rice (Tons ha^{-1})				Input-costs + ₦'000			Output Returns * ₦'000			Cost-Benefit
	Rep I	Rep II	Rep III	Mean (x±S.E)	Rep I	Rep II	Rep III	Mean (x±S.E)	Fish (A)	Rice (B)	Total A + B)	Fish (C)	Rice (D)	Total (C + D)	(C+D)/ A+B)
T_1 (2 fish M^{-2})	14.19	13.00	12.30	13.16±1.6	12.10	12.00	12.00	12.00±0.6	3737.7	1428.6	5166.3	6580.0	2400.0	8980	1.1.7
T_2 (4 fish M^{-2})	22.50	22.29	19.89	21.60±20	13.20	12.00	12.90	12.60±0	5382.3	2000.1	7382.4	10800.0	2520.0	13320.0	1:18
T_3 (6 fish M^{-2})	20.70	21.00	22.68	21.45±1.8	9.00	8.22	7.50	7.74±0.3	7076.7	2000.1	9076.8	10725.0	1548.0	12273.0	1:1.4
T_4 (o-fish)	-	-	-	-	6.72	15.42	16.50	15.90±0	-	2000.1	2000.1	-	3180.0	3180.0	1:1.6

S.E. Standard error of the mean (X)
* Based on farm-gate price of ₦500kg^{-1} of fish and N200.00 kg^{-1} of rice
\+ Based on prevailing costs of labour, fingerlings and seedlings as detailed below:
Fingerling: ₦20 x 205 = ₦1400. Seedlings = ₦1000 per plot x 12 plots = ₦12,000
Labour: Excavation of perimeter trench for fish haven @ ₦500 x 9 plots = 4500
Land preparation and rice transplantation @ ₦1000 x 12 plots = ₦1200
Harvesting of fish and rice @ ₦500 for rice x 12 plots = ₦600 and ₦300 for fish x 9 plots = ₦2,700
Processing of rice at a lump sum of ₦1200

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