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Evaluation of Rice-Fish Culture in South Eastern Nigeria

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Abstract: A rice-fish culture trial was conducted in Umudike, south eastern Nigeria using Oreochromis niloticus and FARO 44 rice variety in 6 plots (198 m^2 each). Two treatments, sole rice and rice-fish culture were employed with each treatment replicated three times. Juvenile O. niloticus with mean weight 12 g were stocked at the rate of 2/m^2 4 weeks after transplanting 4 week old rice seedlings using 20 cm spacing between lines and rows. Basal fertilizer (NPK 20:10:10) was applied at the rate of 300 kg ha^{-1} while 20 kg ha^{-1} urea was used as top dressing. Brewery spent grain was used as supplementary feed at the rate of 2% body weight of fish once daily. The fish and rice were harvested after 80 days of culture and 108 days, respectively. The rice-fish culture gave an average gross yield of 1327.78 and 2434 kg ha^{-1} for fish and rice, respectively while the sole rice treatment had an average yield of 2510 kg ha^{-1}. Since the integration of fish in the rice plots did not significantly ($p<0.05$) reduce rice production adoption of this system will not only lead to increase in animal (fish) protein production but also generate additional income for farmers.

Key words: Fish-rice cultivation, south eastern Nigeria, *Oreochromis niloticus*, protein production, sole rice treatment

INTRODUCTION

Fish supply in many developing countries is less than 10% of the estimated requirement of 35 g per caput per day. The projected fish demand and supply by the year 2010 for countries in West Africa shows only Cote D'Ivoire, Gambia, Ghana, Senegal and Togo have a per caput fish consumption above the world average of 13 kg $year^{-1}$ Seki and Bonzon (1993). To meet the country's fish requirement, a low input technology that efficiently utilizes land resource by integrating fish culture with crop production is desired.

Growing fish and rice together in the same paddy fields is an old widespread practice in South East Asia. It offers the advantage of producing two crops from the same piece of land Ali (1992). Paddy-fish systems are low cost, effective and bring about economic returns and is recognized as an additional source of food and income in rural areas Li Kangmin (1988). This long established Asian system of agricultural production called offers solution to Africa's problems of decline in per capita food production and declining soil fertility Spore (1992).

In rice fields where fish is also grown, the bunds are strong with height ranging from 25-60 cm and slope of about 30-45% Coche (1967). Trenches and sumps which serve as fish refuge are provided. They can be dug on one side only, all round (peripherally) or diagonally across each plot. In recent times pond refuges have been used instead because of their flexibility to different rice-fish culture cycles Dela-Cruz (1990). The number of trenches, contour and size depends on size of the plot, fish stocked and soil.

Hitherto, long duration varieties of rice (about 160-185 days) were used but rice breeding has brought in new varieties of short duration (105-125 days). The duration of crop is important in view of the pisci-culture practice, to be adopted.

A wide variety of fish species are used in rice fields and they include carp, tilapia, *Heterotis, Clarias* etc. Polyculture has also been introduced to utilize the different ecological niche available in irrigated rice ecosystem. This has resulted in improved yield in rice and reduced production cost. Moreover, the concept of integrated pest management excludes the use of pesticides and utilizes fish for biological control of pest in rice fields Kyaw (1993). Fish is also known to play important role in the control of malarial mosquito that abound in areas with irrigation facilities thus leading to improved health-status of farmers.

Given the vast area (more than 2 million hectares) of swamp in the Niger Delta and the flood plains of the major rivers in the country, the adoption of this low-input technology will go a long way in meeting the nations fish demand. Preliminary studies are being undertaken at

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various centres (Yaro, 2001; Okoye, 2003) to develop this technology. It is along the same line that this study was embarked upon to develop suitable protocols to adopt this technology in the South Eastern Zone of Nigeria.

MATERIALS AND METHODS

The study was carried out in the freshwater fish farm area of the Michael Okpara University of Agriculture, Umudike, Nigeria. This area lies on latitude 05°29'N and longitude 07°33'E. The rice plots received their water from a secondary canal emanating from the National Root Crops Research Institute (NRCRI) dam which receives water from the Anya Stream.

Six plots of 198 m^2 (11×18 m) were used for the experiment. Two treatments, sole rice and rice fish cultivation were employed with each treatment randomly assigned in triplicate. Four plots designated for rice-fish culture treatment, trenches of 50 cm width and 30 cm depth that served as fish refuge were constructed peripherally and the soil partly used to build 60 cm high perimeter bunds. All the plots were then prepared by slashing, ploughing and harrowing. Puddling of the plots and application of basal fertilizer (NPK 20:10:10) at the rate of 300 kg ha^{-1} were carried out just before transplanting four week old rice seedlings earlier prepared in nursery beds from seeds of FARO 44 obtained from National Cereals Research Institute. Plant spacing used was 20 cm between lines and rows. The water level in the plots was then gradually increased up to a maximum of 30 cm as the rice plants grew. Periodical weeding starting 24 Days After Transplanting (DAT) the rice seedings.

Juvenile Oreochromis niloticus of 12 g mean weight were stocked in rice-fish culture plots at 2/m^2 28 DAT. The fish were fed at 2% body weight once daily with brewery spent grain for eighty days. Fifty-five DAT the rice seedlings, 20 kg ha^{-1} urea was applied to each of the plots as top dressing. The average plant height and plant population were also recorded by random sampling. Twelve days after flowering set in bird scaring commenced until 80 days after fish stocking when both rice and fish were harvested. No pesticide was used during the culture period.

Water samples were collected from the plots during the culture period for the determination of the physico-chemical characteristics such as temperature, pH and dissolved oxygen using Celsius thermometer, pH meter and Winklers method for dissolved oxygen determination, respectively.

Statistical analysis: The data obtained were subjected to t-test to determine any difference between the treatments.

RESULTS

The results of the water quality parameters taken are presented in Table 1. The mean temperature readings were 29.0±1.0 and 29.2±1.20°C for the sole rice and rice-fish plots, respectively. The mean pH values were 6.1±0.1 and 6.7±0.50 for sold rice and rice-fish plots, respectively. While the mean dissolved oxygen values were 2.4±0.90 and 5.6±0.90 mg L^{-1} for the sole rice and rice-fish plots, respectively. The dissolved oxygen level of the rice-fish plots were significantly ($p<0.05$) higher than those of the sole rice plots.

The average tiller heights were 71.4 and 70.8 cm for the sole rice and rice-fish plots, respectively while the plant population, were 195 and 191 panicles m^{-2} for sole rice and rice-fish plots, respectively (Table 2). After 108 days the average yield of 49.7 kg (2.51 t ha^{-1}) obtained from the sole rice plots was not significantly different ($p<0.05$) from the average yield of 48.20 kg (2.48 t ha^{-1}) obtained from the rice-fish plots.

An average of 83% of fish stocked in the rice-fish plots was recovered at harvest 80 days after stocking. The final average individual weight of 79.19 g was obtained from the initial average weight of 12 g giving a gross yield of 26.29 kg (1,327.78 kg ha^{-1}) per plot.

Table 1: Physico-chemical features of the experimental plots

	Sole rice			Rice-fish		
Parameter	Range	Mean	Std. dev.	Range	Mean	Std. Dev.
Water temperature °C	28-30	29.0	±1.0	28-30.4	29.2	±1.20
pH Hydrogen ion concentration	6.0-6.2	6.1	±0.10	6.2-7.2	6.7	±0.50
Dissolved oxygen (mg L^{-1})	150-3.30	2.40	±0.90	4.7-6.5	5.6	±0.90

Std. Dev. = Standard Deviation

Table 2: Performance of the various treatments

	Sole rice	Rice-fish
Plant population (mean)	195	191
Average plant height (cm)	71.4	70.8
No of weeding (x)	2	1
Trench size (cm)	-	50×30
Fish species	-	0.niloticus
Stocking rate (m^2)	-	2
Stocking size (g)	-	12
Stocking time (week)	-	4
Final weight (g)	-	79.19
Mean weight gm (g)	-	67.19
No of fish harvested	-	332
Survival rate (%)	-	83
Feeding rate (%)	-	2
Culture period 1) fish (days)	-	80
Culture period 2) rice (days)	-	108
Gross yield/plot 1) fish (kg)	-	26.29
Gross yield/plot 2) rice (kg)	49.7	48.2
Gross yield/ha 1) fish (kg)	-	1,327.78
Gross yield/ha 2) rice (kg)	2.510	2.434

DISCUSSION

The water temperature recorded in this study (Table 1) fall within the limits for fish culture in the tropics. Temperature is never a limiting factor in tropical fish culture (Boyd, 1982). The pH values were to a large extent stable (6.0-7.2). This could be attributed to the fact that most of the hydrogen ions were autochthonous and not affected by any allochthonous inputs. The dissolved oxygen level in the sole rice plots were however very low (mean 2.4±0.9) and significantly different ($p<0.05$) from the value in rice fish plots. This may be attributed to the high level deposition of silt and organic matter in rice plots (Miah *et al*., 1994) which utilize considerable amount of dissolved oxygen for decomposition. These organic matter are apparently consumed by the foraging fish in rice-fish plots thereby significantly reducing the requirement for dissolved oxygen from decomposing organic matter. Besides, fish perturbation of the soil can result in aeration of soil and water and would have been responsible for the higher dissolved oxygen level (mean value 5.6±0.90 mg L^{-1}) observed in the rice-fish plots.

Integration was effective in suppressing weeds in the rice/fish plots since only a single weeding was carried out in the plots. Fish is known to control weed by directly feeding on the weeds and by bottom feeding activity which results in the uprooting of submerged and emergent vegetation. This informed our decision to introduce fish in the rice plots 4 weeks after transplanting when the rice seedlings would have fully established and withstand the foraging activities of fish. Turbid environment created by fish feeding activities also lead to limited light penetration which results in weed control (Cagauan, 1955). The level of water equally plays an important role in growth of weed in rice fields. Many weeds do not germinate in flooded fields. Hora and Pillay (1962) recommended that rice plots for fish culture should have 3-5 cm of water in the first 2 weeks after transplanting and gradually increased to 20 cm. In this study, the water in both treatments was gradually increased to 30 cm from 50 m and this may have limited the growth of weed even in the sole rice plots which were weeded only twice as against the common practice of weeding thrice in plots with low water levels.

MacKay *et al.* (1986) reported that incidence of pest and disease in rice paddies significantly decreased when fish were present in rice fields. The species and quantity of pest eaten by fish are closely related to their lifecycle (Xiao, 1991). In this study no incidence of pests and diseases were reported. The reason may be that rice cultivation is not very common in this area as to warrant high incidence of rice pests and diseases.

The average tiller heights of 71.4 and 70.8 cm for the sole rice and rice-fish plots, respectively compared with what obtained in earlier reported studies (Mustow *et al*., 1996). Same applies to the plant populations. The rice yield obtained from both the sole rice plots and rice-fish plots were not significantly different ($p<0.05$). Thus the presence of trenches which served as fish refuge in the rice-fish plots did not significantly reduce rice yield, (Nguyen *et al*., 1997) reported that utilization of 10.9% land for trenches in rice-fish plots did not decrease significantly rice production. Though Okoye (2003) reported increase in rice yield in rice-fish plots it is not apparent in this study.

After 80 days of culturing fish in rice-fish plots the mean individual weight of *0. niloticus* increased from 12 to 79.19 g with an average growth rate of 0.84 g day^{-1} and 83% survival. This translated to a gross yield of 1.328 kg ha^{-1}. This was achieved without extra fertilizer except that used for conventional rice farming. Feeding at 2% body weight in this study is in line with the observation of Radriamiaraus *et al.* (1995) that feeding should be carried out if the stocking density is higher than 25 fingerlings per h. However, the feed used was an inexpensive industrial by-product affordable by resource poor farmers. The fish yield in this study, performed better than that reported for tilapia of similar initial stocking size in North central Nigeria (Okoye *et al*., 2001) given that was culture for 5 months.

CONCLUSION

There is no doubt therefore from the result of this study that adopting this technology in the South Eastern part of Nigeria holds exciting promise for farmers to maximize their resources, reduce their investment risk through crop diversification and improve nutrition and food security for the country.

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