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A Fish Crop May Improve Rice Yields and Ricefields

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ICLARM's ecological modelling software ECOPATH II applied by a team of ICLARM, IRRI and CLSU scientists raises the question whether managing ricefields as a sustainable production system may require integration with fish.

Rice and fish are important in Asian diets. Up to now the supplies of rice and fish have come from different sources. The traditional practice of catching wild fish in ricefields is insignificant today. Recent investigations however, have indicated that integrated rice-fish systems offer possibilities of increasing rice yields by as much as 15% and at the same time harvesting up to 500 kg/ha of fish every rice crop.

Rice-fish integration may also provide incentives for farmers to reduce levels of pesticide use and fertilizer application without reducing rice production. Fish consume rice pests including weeds. Fish contributions to soil fertility have been reported. The nitrogen cycling scheme in Fig. 1 helps explain how N accumulation might occur.

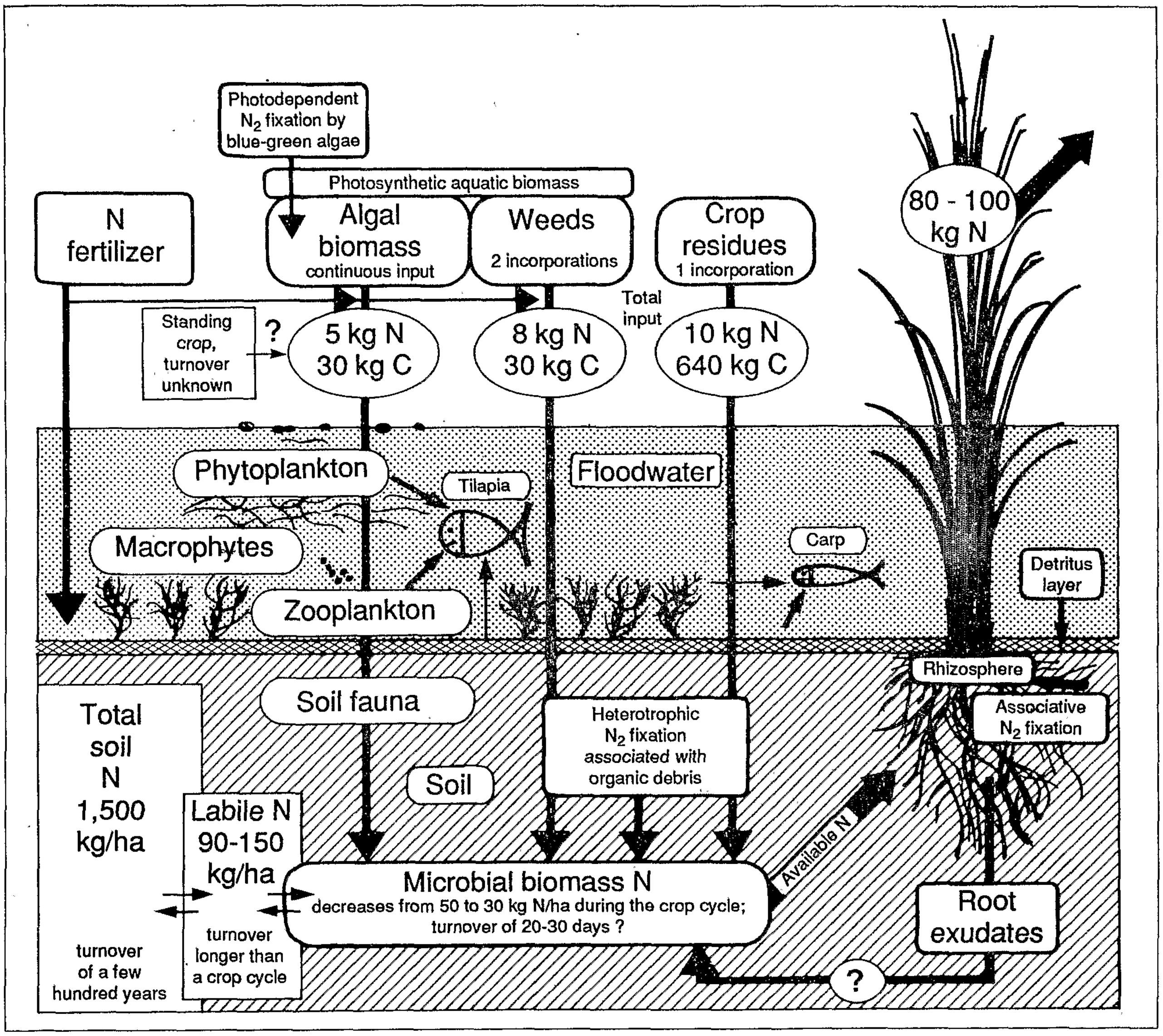

Fig. 1. Schematic representation of the rice-fish agroecosystem with a conceptual representation of the origin of the nitrogen absorbed by rice, the role of the microbial biomass in providing available nitrogen to rice and the pathways involved in the replenishment of the microbial biomass. All figures are per hectare per crop. (Source: Roger, P.A., R. Jimenez, S. Ardales and I. Watanabe. 1989. Nutrient input by the photosynthetic aquatic biomass in a ricefield and its contribution to the maintenance of soil microbial biomass. Poster presented at the 5th Symposium on Microbial Ecology, 27 August to 1 September 1989, Kyoto, Japan. Abstracts. 143 p.)

Fish not only contribute to N accumulation through their feces, but they may also reduce nitrogen losses. The culture of the microphagus Nile tilapia (*Oreochromis niloticus*) with rice at the beginning of the culture period may decrease ammonia volatilization by reducing the biomass of microalgae that increase floodwater pH. The bottom feeding action of common carp (*Cyprinus carpio*) could cause turbidity that would limit light available for phytoplankton growth.

To improve our understanding of the ecological interactions, we used the ECOPATH II microcomputer software from ICLARM to make an initial model of rice systems with and without fish. These preliminary models have been constructed from limited field data, but provide indicators for further critical field measurements and experimentation. Future models will assist in the development of guidelines for optimum management of rice-fish integrated systems.

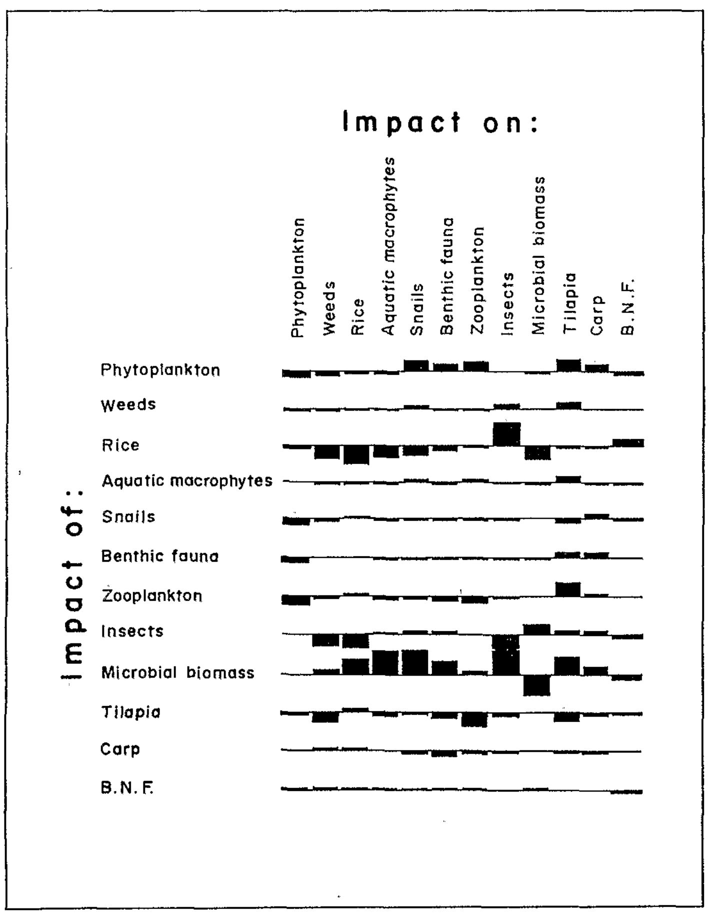

Fig. 2. Matrix of mixed impacts of components in a wetland irrigated field ecosystem stocked with tilapia and carp. Bars above horizontal lines show positive impact; bars below show negative impacts. For example, rice has a strongly positive impact on insects, i.e., the more rice, the more insects. But, insects have a negative impact on rice.

Developing a Model

An ecological model of nitrogen flows in wetland irrigated ricefields was developed from our understanding of nitrogen cycles. ECOPATH II was used to develop steady-state models of ricefields with and without fish.

Quantitative data were obtained from measurements performed in irrigated ricefields without fish on the International Rice Research Institute (IRRI) research farm, mostly during the dry season. Data for the rice-fish model, other than the fish biomass and diet, were estimated from measurements in irrigated ricefields. Fish biomass and diet data were average values from rice-fish experiments conducted at the Freshwater Aquaculture Center, Central Luzon State University, Philippines. Other data and nitrogen conversions were based on the 1979 *Handbook of environmental data and ecological parameters* by S.E. Jφrgensen (editor) published by the International Society for Ecological Modelling, Copenhagen (1,162 p.). Due to the paucity of data, especially on fish and biological productivity, the models must be considered hypothetical.

Effects of Fish

Rice, being the largest standing component of the ecosystem, has higher impacts than fish on the other components (Fig. 2). Rice has a marked negative effect on soil microbial biomass. This result is important as it indicates that intensification of rice production might lead to a decrease in soil microbial biomass and thus possibly soil available N and fertility.

Tilapia has negative impacts on most of the living components of the ecosystem except rice and microbial biomass. The beneficial effect of tilapia on rice might be related to its negative effects on insect pests and weeds and possibly to a faster turnover of nutrients, favoring the replenishment of soil microbial biomass and the release of N available to the plant.

Carp, interestingly, shows little interaction with the other components of the paddy system and is a much more passive crop than tilapia, causing little beneficial effect on rice production or on pest control.

Conclusions

These results raise the intriguing question that stocking ricefields with fish like tilapia not only produces fish, but also may lead to greater efficiency in rice production. Even more interesting is the suggestion that intensifying monocropped rice might lead to a decrease in microbial biomass and therefore soil fertility in the long term. We cannot conclude from these preliminary models that optimum management of ricefields as an ecosystem and as a production system may require the integration of fish. Our data have too many gaps and our rice-fish model is too hypothetical. Nevertheless, none of the results disagree with current knowledge of N cycling in ricefields. We conclude that the questions raised warrant more study of rice ecosystems using ECOPATH II and other ecological modelling techniques.

For further information on ECOPATH II, see Christensen, V. and D. Pauly. 1990. A draft guide to the ECOPATH II program (ver. 1.0). ICLARM Software 6.

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