Research Application Summary

On-farm analysis of the use of clear plastic pond sheeting for enhanced growth and productivity of *Tilapia rendalli* and *Oreochromis shiranus* polyculture in earthen ponds

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Abstract

The effect of clear plastic sheeting on growth of *Tilapia rendalli* and *Oreochromis shiranus* polyculture and pond productivity was assessed in twelve 200m^2 ponds in Dowa district, Malawi. Clear plastic sheets of 200 microns were installed 50 cm above water surface, covering 0%, 50% and 80% of the pond area. The experiment was conducted in a Randomised Blocked Design. Final mean weight and specific growth rate were significantly high ($p<0.05$) in 80% cover ponds. Survival rate, chlorophyll *a*, and zooplankton concentration were also highest in 80% covered ponds although non-significant. Fish grew at 1.12% Body Weight (BW) per day in ponds with 80% cover showing an increase of 30% from the uncovered ponds which had SGR of 0.75% BW/day. The study has further shown that 80% pond sheeting is more profitable than 0% and 50% pond plastic sheet. Hence, covering ponds with 80% clear plastic sheeting can boost aquaculture production.

Key words: Earthen pond, polyculture, pond sheeting, *Oreochromis shiranus*, *Tilapia rendalli*

Résumé

L'effet de la bâche en plastique transparente sur la croissance de *Tilapia rendalli* et la polyculture d'*Oreochromisshiranus*, et la productivité de l'étang ont été évalués dans douze étangs de 200 m2 dans le district de Dowa, au Malawi. Les bâches en plastique transparente de 200 microns ont été installées 50 cm au-dessus de la surface de l'eau, couvrant 0%, 50% et 80% de la surface de l'étang. L'expérience a été menée dans une conception randomisée en blocks. Le poids moyen final et le taux de croissance spécifique étaient significativement élevés ($p <0,05$) dans les étangs de 80% de couverture. Le taux de survie, la chlorophylle *a* et la concentration en zooplanctons étaient également plus élevés dans des étangsde 80% de couverture, bien que non significatifs. Les poissons ont augmenté à 1,12% du poids corporel par jour dans les étangs avec une

couverture de 80% montrant un accroissement de 30% des étangsnon couverts qui avaient un SGR de 0,75% de poids corporel / jour. L'étude a également démontré que la couverture d'un étang à 80% est plus rentable quela couverture d'un étang à 0% et 50% par des bâchesen plastique. Par conséquent, couvrir lesétangsà 80% avecune bâche en plastique transparent peut stimuler la production aquacole.

Mots clés: étang en terre, polyculture, bâche d'étang, *Oreochromis shiranus, Tilapia rendalli*

Background

Modern methods of aquaculture have been introduced in Malawi to increase fish supply for the country's growing population as well as generate income and employment in the rural areas. Although fish used to provide the cheapest form of animal protein in 1970s (Balavin,1987), reduced fish catches and an increase in human population have led to a decline in per capita fish consumption from 12.8kg in 1970s to about 5.8kg at present (Wely, 2003). Aquaculture development in Malawi aims at improving fish production through small-scale producers in order to supply fish to the rapid growing population and also generate income in rural areas. *Tilapia rendalli, Oreochromis shiranus, Oreochromis karongae* and *Clarias gariepinus* are some of the major cultured species in Malawi. They are grown in earthen ponds by most smallholder farmers. Most aquaculture research has dwelt on increasing pond productivity through fertiliser, manure, feeds and improved breeds. This study however aimed at determining the effect of pond plastic sheeting on fish survival, growth rate, yield and water quality parameters in a polyculture of *O.shiranus* and *T.rendalli.* In addition, the economic analysis of plastic sheeting technology in the polyculture was done.

Literature Summary

According to FAO, four main fish species are commonly cultured in Malawi, i.e., *Oreochromis shiranus, Oreochromis karongae, Tilapia rendalli* and *Clarias gariepinus*. Polyculture fish farming is the practice of maximising the ecological potential of a pond environment by stocking fish that do not compete with one another over food. The growth rate of *Tilapia rendalli* exceeds that of *O. shiranus* and *O. karongae* and is therefore considered a suitable candidate for aquaculture farming.

Food consumption and growth in fish increase with temperature to a maximum then fall abruptly because energy required for maintenance rapidly increase thus decreasing energy available

for growth (Soderberg,1997). Meade (1989) also reported that rates and efficiencies of feeding, digestion and growth depended upon temperature. He also reported that each species has a characteristic growth curve that changes with temperature and size and that each temperature range is bounded by an upper and lower lethal limits beyond which fish cannot survive. These effects were examined in this study.

Study Description

A randomised blocked design (RBD) experiment was conducted on 12, 200m^2 ponds in Dowa district, Malawi from 13th April to 10th September 2011. The experimental treatments involved covering 80%, 50% and 0% of the pond area with a plastic. sheet. Each treatment was replicated two times in each block. The 200micron sheets were put on a bamboo arched frame (dome shaped frame) made over the pond and placed 50cm above the pond to allow air circulation in the ponds.

Oreochromis shiranus and *Tilapia rendalli* fingerlings of average weight 11.53±0.26g were stocked at a density of 5 fish/m^2 in a 1:1 ratio. The fish were fed with maize bran at 3% body weight per day for the whole experimental period. Two weeks prior to stocking, all ponds were fertilised with poultry manure. Fish were weighed before stocking and thereafter 60 fish (30 fish for each species) were sampled every four weeks during the whole experimental period. The standard length, total length and weight of fish were taken and recorded. Temperature measurements were taken every week at 10: 00 and 16:00 hours. Other water quality parameters such as pH, dissolved oxygen, conductivity, turbidity and pH were measured using a water quality monitor every 2 weeks. To measure zooplankton and chlorophyll concentration, water samples were collected in plastic bottles with recommended preservative added. Data on economics were collected using a checklist of inputs and outputs. Specific growth rate and survival rate of fish were calculated after harvesting using standard formulas.

Genstat thirteenth edition was used to analyse the data. The mean values were compared using analysis of variance and t-test.

Research Application

There was a significant difference between final fish weight for both *Tilapia rendalli* and *Oreochromis shiranus* ($p<0.05$). Fish cultured in 80% pond cover had a significantly higher final mean weight (43.22±1.47) compared to those in either 50% pond cover (34.02±0.82) or 0% pond cover (32.14±1.00).

Similarly, the SGR and survival was highly significant ($p>0.05$) in 80% pond cover compared to the other 2 treatments for both *Tilapia rendalli* and *Oreochromis shiranus.* The SGR of *Tilapia rendalli* and *Oreochromis shiranus* was 0.75% g/day, 0.88% g/day and 1.12% g/day for 0%, 50% and 80%, respectively (Table 1). The study showed that the growth and survival rates of *Tilapia rendalli* and *Oreochromis shiranus* were high where 80% of the pond area was covered by plastic sheets. The final mean weight increased from 32.14g in 0% cover to 43.22g in 80% cover representing a 26% increase in fish weight from 0% to 80%. The potential production rate by smallholder farmers in Malawi is between 0.7 to 1.2ton/ha/yr. The experiment revealed production rates that were higher than the potential production (i.e., 1.12, 1.86 and 2.55ton/ha/yr for 0%, 50% and 80%, respectively). This can partly be attributed to close supervision of farmers' pond activities by researchers. The SGR of fish significantly increased by 33% from 0.75% BW/day in 0% pond to 1.12% BW/day in 80% pond.

Table 1. Effect of clear plastic pond sheeting on initial fish weight (Mean±SE), SGR, survival and reproduction rate of *Tilapia* spp. cultured under 0%, 50% and 80% pond cover.

Treatment	Initial weight (g)	Final weight (g)	SGR (%BW/day)	Survival rate (%)
Both *T. rendalli and O. shiranus*				
0%	12.12±0.41	32.14±1.00^{a}	0.75^{a}	28.50^{a}
50%	11.69±0.49	34.02±0.82^{a}	0.88^{b}	40.00^{b}
80%	10.74±0.44	43.22±1.47^{b}	1.12^{c}	44.80^{b}
T. rendalli				
0%	13.69±0.67	26.85±1.12^{c}	0.59^{d}	27.40^{c}
50%	12.77±0.79	27.36±0.75^{c}	0.71^{e}	38.70^{d}
80%	10.87±0.67	35.74±1.86^{d}	1.04^{f}	42.07^{d}
O. shiranus				
0%	10.53±0.42	37.43±1.47^{e}	0.95^{g}	29.70^{e}
50%	10.33±0.46	40.68±1.23^{f}	1.05^{h}	41.25^{f}
80%	10.87±0.50	50.70±1.91^{g}	1.20^{i}	47.60^{g}

Values with different letters in the same column for each category are significantly different across treatments (Least Square Difference $p>0.050$)

Temperatures in the ponds were within optimum range for tilapia fish. Levels of pH varied between experiments, but were within the ideal range of 5-9 (Buttner, Soderberg and Terlizzi, 1993). Similarily DO which is a major characteristic of water quality that is important to the growth and survival of fish (Diana, 1995)

were also within the allowable range of greater than 5ppm. Tilapia can generally tolerate low DO (Meade, 1989), however low DO may result into reduced growth and increased mortality. In contrast, turbidity in all treatments fell outside the acceptable range of less than 200ppm for the ponds (Boyd, 1990).

Table 2. Water quality parameters in fish ponds covered to 80%, 50% and 0% with plastic sheeting in Malawi.

Parameter	80%	50%	0%
Temperature (°C)	20.20	19.65	19.38
DO (ppm)	6.58	6.69	6.42
Salinity	0.06	0.06	0.05
Conductivity	0.105	0.137	0.123
Turbidity	371	365	379
TDS	0.09	0.07	0.07

The primary productivity was higher in covered ponds. Phytoplankton concentration, measured in terms of chlorophyll a, was highest in 50% ponds but zooplankton concentration was highest in 80% pond cover. In both cases, the lowest concentrations were observed in 0% (control) ponds. Zooplankton concentration varied significantly among treatments with 80% pond cover having highest overall concentration of zooplankton (Fig. 1).

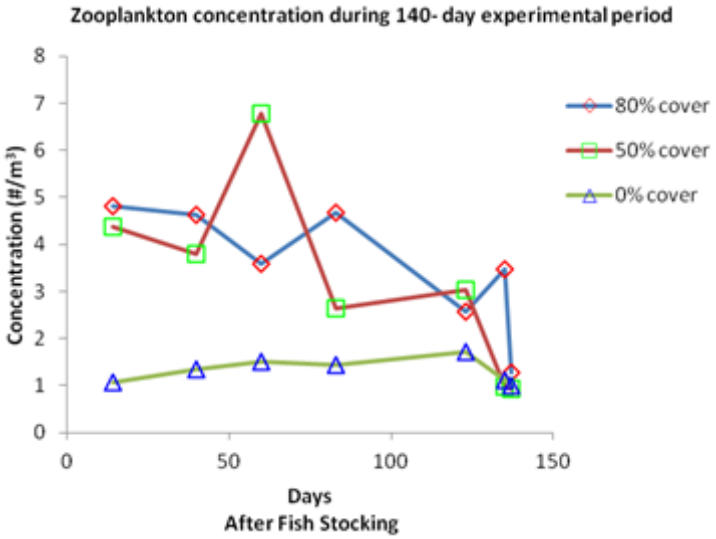

Figure 1. Mean zooplankton concentration in different treatments.

There was a strong and positive relationship between zooplankton ($R^2 = 0.772$) and the pond cover. With reference to ponds with plastic sheet compared to cover, zooplankton concentration was reduced by 2.088 mg/l in ponds without covers. Hence zooplankton concentration is affected positively by pond covering which in turn affect fish weight as fish feed on zooplankton.

Economic analysis showed that 80% pond cover had a significantly higher production level, income and gross margin than either 50% or 0% pond cover. In terms of variable costs, the highest was in the 80% pond cover. This was expected because of the cost of plastic sheet.

Table 3. Cost benefit analysis of *Tilapia rendalli* and *Oreochromis shiranus* cultured in 0%, 50% and 80% pond cover.

Item	Units	0% cover	50% cover	80% cover
Total fish sales	MK	883,768.6	1,205,549	1,741,013
Variable cost	MK	162,946	497.034	804,369
Production levels	Ton/ha/yr	1.12	1.86	2.55
Gross margin	MK	720,822.2	708,515.5	936,644.1

1United States Dollar= 165 Malawi Kwacha

Values with different letters in the same column are significantly different across treatments (Least Square Difference $p<0.050$).

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