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The use of napier grass (*Pennisetum purpureum*) and maize (*Zea mays*) bran as low-cost tilapia aquaculture inputs [1]

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Abstract

Napier grass (*Pennisetum purpureum*) and maize (*Zea mays*) bran were tested as low-cost inputs to earthern ponds and concrete tanks. In Experiment 1, fresh napier grass was given at 50 kg dry matter (DM) ha^{-1} day^{-1} alone and in combination with maize bran at 3% fish body weight day^{-1} and/or agricultural limestone (L) applied at 100 kg ha^{-1} per 2 weeks. Treatments were applied over 181 days to a mixed-sex 1:1 polyculture of *Tilapia rendalli* and *Oreochromis shiranus* stocked at 2 m^{-2} in 200 m^2 ponds. In Experiment 2, fresh napier grass (NG) was given whole (WG), chopped (CG) or ground (GG) at 50 kg (DM) ha^{-1} day^{-1} or in combination with maize bran (MB) at 3% fish body weight day^{-1} for 108 days to a mixed-sex polyculture of six *T. rendalli* and six *Oreochromis karongae* stocked at 2.4 m^2 in 5 m^3 tanks.

In Experiment 1, treatments which included a combination of napier grass and maize bran performed significantly better ($P < 0.05$) than did other treatments. Average extrapolated yield from NG + MB and NG + MB + L was 1729 kg ha^{-1} compared with 1255 kg ha^{-1} for other treatments. Average specific growth rates (SGR) for stocked *T. rendalli* and *O. shiranus* were 0.78% day^{-1} and 0.75% day^{-1}, respectively, in NG + MB and NG + MB + L compared with 0.58% day^{-1} and 0.60% day^{-1} in other treatments. Fry and fingerlings contributed 47.7 ± 0.7% to the final catch weight of all treatments.

In Experiment 2, SGR values in CG + MB (1.46% day^{-1} and 1.31% day^{-1} for *T. rendalli* and *O. karongae*, respectively) were not significantly different from those for CG alone. CG treatment performed significantly better ($P < 0.05$) than other treatments. The addition of maize bran to CG

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failed to improve fish growth performance. The no-input control produced significantly less fish growth than other treatments.

Keywords: Low-cost inputs; Napier grass; Maize bran; *O. karongae*; *O. shiranus*; *T. rendalli*

1. Introduction

The major constraints to small-holder fish farming in Malawi are lack of fish feeds (ICLARM–GTZ, 1991), and low alkalinity (Jamu, 1990) which makes production of natural food difficult (Boyd, 1990). Imported technologies recommended in Malawi require fertilizers and/or feeds, which are expensive and generally unavailable. Maize bran has been used as a major fishpond input, but is also used for human consumption during the rainy season (Kadongola, 1990). Consequently, many fishponds are left unfed (Edwards, 1987). An alternative may be the use of widely available napier grass as a low-cost feed or organic fertilizer (Williamson, 1975; Chikafumbwa et al., 1991). Lime may be applied to enhance pond fertility (Jamu and Costa-Pierce, 1995).

In Malawi, the main fish species cultured are the macrophytophagous *Tilapia rendalli* and phytoplanktivorous *Oreochromis shiranus*. *Oreochromis karongae* is a newly recruited fish species which matures at higher body weights (greater than 70 g) (Maluwa and Dickson, 1991) than *O. shiranus* (less than 20 g) (Maluwa, 1990). *O. karongae* is still under investigation as an aquaculture candidate. The objective of this study was to determine the effect of napier grass presented in various forms either alone or combined with maize bran and/or lime on the growth of *T. rendalli*, *O. shiranus* and *O. karongae*.

2. Materials and methods

Two completely randomized design experiments were conducted at the National Aquaculture Center, Zomba, Malawi. For Experiment 1 (Table 1), there were four treatments: napier grass (NG) alone; a combination of napier grass and maize bran (NG + MB); napier grass and lime (NG + L); NG + MB + L. Each treatment was in triplicate 200 m^2 (average water depth of 70 cm) earthen ponds over 181 days. On 18 November 1992, each pond was randomly stocked with a mixed-sex polyculture of 200 *T. rendalli* plus 200 *O. shiranus* (total stocking rate 2 m^{-2}). Individual mean body weights (MBW $\pm$ SD) were 9.6 $\pm$ 0.3 g for *T. rendalli* and 8.9 $\pm$ 0.8 g for *O. shiranus*.

Napier grass was given once a day at 50 kg dry matter (DM) ha^{-1} day^{-1} (Chikafumbwa, 1990). Chikafumbwa (1990) found that increasing napier grass application rates above 50 kg DM ha^{-1} day^{-1} resulted in no improvement in fish growth. Based on the evidence from the field (Chikafumbwa et al., 1993), it was hypothesized that diversifying the input strategy rather than simply increasing the amount of napier grass might permit the use of higher feeding rates. Maize bran was therefore given in addition to NG at a rate of 3% fish body weight day^{-1} adjusted at monthly samples. Agricultural limestone was applied at 100 kg ha^{-1} per 2 weeks in liming treatments. Water loss

Table 1
Effect of napier grass (NG), combination of NG plus maize bran (NG + MB), NG plus lime (NG + L) and NG + MB + L on *Tilapia rendalli* (TR) and *Oreochromis shiranus* (OS) weight gain, specific growth rate (SGR), survival and yield in 200 m^2 earthern ponds over 181 days

		Treatment			
		NG	NG + MB	NG + L	NG + MB + L
Average initial weight (g)	TR	9.8	9.2	9.5	9.9
	OS	7.8	9.3	9.3	9.4
Average final weight (g)	TR	28.2 ^{b}	37.6 ^{a}	27.3 ^{b}	35.7 ^{a}
	OS	29.0 ^{b}	35.7 ^{a}	28.2 ^{b}	36.8 ^{a}
Specific growth rates (% day^{-1})	TR	0.58 ^{b}	0.78 ^{a}	0.58 ^{b}	0.77 ^{a}
	OS	0.59 ^{b}	0.74 ^{a}	0.61 ^{b}	0.75 ^{a}
Fish survival rate (%)	TR	60 ^{ab}	69 ^{a}	70 ^{a}	54 ^{b}
	OS	70 ^{a}	71 ^{a}	69 ^{a}	52 ^{b}
Fry and fingerling contribution to total fish yield (%)		42 ^{b}	45 ^{b}	46 ^{b}	58 ^{a}
Stock fish yield (kg ha^{-1})		320 ^{b}	465 ^{a}	370 ^{b}	360 ^{b}
Total fish yield (kg ha^{-1})		560 ^{b}	850 ^{a}	680 ^{b}	865 ^{a}

Fish yield was extrapolated from 200 m^2 earthern pond.
Total fish yield was a combination of fry and fingerlings, and stock fish.
Figures in the same row having the same superscript letter are not significantly different ($P > 0.05$).

owing to evaporation and seepage was replaced weekly to maintain water levels. Incoming water from the Domasi River had a total alkalinity of 12–15 mg l^{-1} as $CaCO_3$.

Treatments in Experiment 2 (Table 2) were as follows: whole napier grass (WG); chopped napier grass (CG); ground napier grass (GG); combination of whole napier grass and maize bran (WG + MB); chopped napier grass and maize bran (CG + MB);

Table 2
Effect of whole grass (WG), chopped grass (CG), ground grass (GG), WG plus maize bran (WG + MB), CG + MB and no-input control on *Tilapia rendalli* (TR) and *Oreochromis karongae* (OK) weight gain, specific growth rate (SGR), survival rate and yield in 5 m^3 concrete tanks over 108 days

		Treatment					
		WG	CG	GG	WG + MB	CG + MB	No input
Average initial weight (g)	TR	7.7	7.0	7.6	7.3	7.16	7.06
	OK	8.7	8.2	8.9	10.1	8.61	7.83
Average final weight (g)	TR	29.3 ^{b}	29.6 ^{b}	27.7 ^{b}	27.7 ^{b}	36.8 ^{a}	15.2 ^{c}
	OK	33.9 ^{ab}	39.7 ^{a}	28.7 ^{b}	35.1 ^{a}	37.3 ^{a}	25.7 ^{c}
Specific growth rate (% day^{-1})	TR	1.20 ^{b}	1.29 ^{b}	1.16 ^{b}	1.20 ^{b}	1.46 ^{a}	0.68 ^{c}
	OK	1.22 ^{b}	1.41 ^{a}	1.05 ^{c}	1.12 ^{b}	1.31 ^{a}	1.06 ^{c}
Survival rate (%)	TR	100 ^{a}	100 ^{a}	100 ^{a}	88 ^{b}	94 ^{a}	100 ^{a}
	OK	100 ^{a}	100 ^{a}	100 ^{a}	94 ^{a}	100 ^{a}	100 ^{a}
Fry production (g per 5 m^3)		–	–	–	–	–	–
Stock fish yield (g per 5 m^3)		379 ^{ab}	416 ^{a}	338 ^{b}	344 ^{b}	441 ^{a}	245 ^{c}

Figures in the same row having the same superscript letter are not significantly different ($P > 0.05$).

no input. Each treatment was triplicated in 5 m^3 concrete tanks (2.25 m × 2.25 m × 1 m depth) over 108 days. On 14 January 1993, each tank was stocked with a mixed-sex polyculture of six *T. rendalli* (7.3 ± 0.3 g) and six *O. karongae* (8.7 ± 0.8 g) at a density of 2.4 m^{-2} (12 fish per tank). Napier grass was given whole, chopped into 2–5 mm pieces or ground once a day at 50 kg DM ha^{-1} day^{-1}. Maize bran was given daily at 3% fish body weight adjusted at monthly samples.

In both experiments, fish were sampled every 4 weeks using a seine net with 5 mm mesh. Fish were sedated with benzocaine (Ross and Ross, 1984) before weighing; total and standard lengths were measured. Ten per cent of the total number of fish stocked in Experiment 1 and 90–100% of those stocked in Experiment 2 were measured at each sampling.

Water quality parameters monitored were: maximum and minimum water and air temperatures daily; dissolved oxygen concentrations (using a YSI Model 57 oxygen meter, Yellow Spring Instrument Inc., Ohio) weekly at 05.00 h and pH (using Hach one pH meter, Loveland, Colo, USA) weekly; electrical conductivity every 2 weeks, and alkalinity every 4 weeks according to standard methods (APHA, 1985).

At the end of the study, ponds and tanks were seined and drained to collect all fish. In Experiment 1, all fish were counted and batch weighed. Total and standard lengths were measured for 20 *T. rendalli* and 20 *O. shiranus* per pond. All fry and fingerlings were collected, counted and batch weighed. In Experiment 2, all fish were weighed and total and standard lengths measured.

Final weight, specific growth rates and fish yields were subjected to one-way analysis of variance (ANOVA). SGR was calculated according to Winberg (1956) as

$$\mathrm{SGR} = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \times 100$$

where W_1 is weight at time T_1 and W_2 is weight at time T_2. Differences among treatment means were tested for significance ($P < 0.05$) using Tukey's test (Zar, 1984).

3. Results

Production data for Experiment 1 are shown in Table 1. Survival for *T. rendalli* ranged from 60 to 70% and that for *O. shiranus* ranged from 69 to 70% in all treatments, except in NG + MB + L, where *T. rendalli* had 54% and *O. shiranus* 52% survival. Highest mean catch body weights (37.6 g for *T. rendalli* and 36.8 g for *O. shiranus*), specific growth rates (0.78% day^{-1} for *T. rendalli* and 0.75% day^{-1} for *O. shiranus*), and extrapolated net yields were obtained in polyculture ponds fed NG + MB (850 kg ha^{-1}) and NG + MB + L (865 kg ha^{-1}), and were significantly higher ($P < 0.05$) than for other treatments. The contribution of fry and fingerlings to net yields averaged 47.7 ± 7% (Table 1).

Water quality parameters monitored were not significantly different ($P > 0.05$) between treatments. Dissolved oxygen (05.00 h) decreased from 5.3 ± 0.3 to 1.4 ± 0.2 mg l^{-1} and pH decreased from 7.7 ± 0.2 to 6.2 ± 0.1. Electrical conductivity decreased from 45.5 ± 1.0 to $33.3 \pm 0.6\ \mu mho\ cm^{-1}$ in all treatments, except in NG + L, where it increased to $62.2\ \mu mho\ cm^{-1}$. Alkalinity was above $40\ mg\ l^{-1}$ as $CaCO_3$ in limed ponds and was between 31 and $35\ mg\ l^{-1}$ as $CaCO_3$ in ponds that were not limed. Approximately 50% of the pond water was lost owing to evaporation and seepage and had to be replaced weekly.

Data for Experiment 2 are shown in Table 2. *T. rendalli* survival averaged 88%, and that for *O. karongae* was 94% in WG + MB and 100% in WG, CG, GG and the no-input control. Highest mean catch body weights, specific growth rates and fish yields were obtained in tanks fed CG + MB and CG, and were significantly higher ($P < 0.05$) than for other treatments. All fed tanks had fish yields statistically higher ($P < 0.05$) than the no-input control. There were no significant differences ($P > 0.05$) between any other treatments. Fry and fingerlings were not observed in tanks.

The water quality parameters monitored in tanks were not significantly different ($P > 0.05$) between treatments. Dissolved oxygen (05.00 h) decreased from 5.2 ± 0.5 to $0.8 \pm 0.3\ mg\ l^{-1}$ in all treatments with time except in the no-input control. pH decreased from 8.2 ± 0.2 to 6.9 ± 0.2 in all treatments except in the control. Conductivity increased from 55 ± 4 to $260 \pm 30\ \mu mho\ cm^{-1}$. Alkalinity increased from 30 ± 3 to 128 ± 22 in all treatments except in the control. Maximum water temperatures ranged from 27 to 34°C and minimum from 22 to 29°C.

4. Discussion

Pond polyculture of *T. rendalli* and *O. shiranus* typically yields about $950\ kg\ ha^{-1}\ year^{-1}$ in Malawi (Noble and Costa-Pierce, 1992). Application of napier grass alone above $50\ kg\ DM\ ha^{-1}\ day^{-1}$ degraded water quality and decreased fish growth and production (Chikafumbwa, 1990). In the present study, fish yields obtained in a combination of napier grass and maize bran were significantly higher ($P < 0.05$) than in napier grass alone, confirming the field observation that combination diets containing a mixture of NG and MB permit higher feeding rates compared with increasing the level of NG alone.

However, yields in this study were lower than yields previously reported by Chikafumbwa et al. (1993) using similar inputs. This may have been due to the necessity of replacing approximately 50% of the pond volume each week, which flushed the nutrients away and reduced pond water natural productivity.

Specific growth rates and fish yields were similar in NG + MB and NG + MB + L, suggesting that addition of lime to ponds fed a combination of napier grass and maize bran did not affect fish growth and yields. Similarly, addition of lime to ponds fed napier grass alone did not significantly improve fish production. Boyd (1982) recommended alkalinities of above $20\ mg\ l^{-1}$ as $CaCO_3$ in ponds. In this study, ponds had alkalinities above $30\ mg\ l^{-1}$ as $CaCO_3$, suggesting that addition of agricultural lime was not necessary. The increase in pond water alkalinities from 15 to over $30\ mg\ l^{-1}$ (as $CaCO_3$) in unlimed ponds fed napier grass was probably due to residual lime in the mud at the pond bottom.

Results of Experiment 2 suggest that napier grass should be chopped. Addition of maize bran to chopped napier grass fed to *O. karongae* and *T. rendalli* polyculture may not be necessary. However, where labour is limiting, the use of whole napier grass may result in slightly lower fish growth and yields. Specific growth rates for *O. karongae* (1.22–1.31% day^{-1}) were similar to specific growth rates of *O. karongae* raised in ponds fertilized with 470 kg ha^{-1} $week^{-1}$ chicken manure with maize bran fed at 3% fish body weight day^{-1} (Maluwa and Brooks, 1994).

In conclusion, *T. rendalli* and *O. shiranus* can be grown successfully in ponds receiving napier grass and maize bran. In ponds, higher yields and specific growth rates were obtained in tilapia polyculture fed combinations of napier grass and maize bran. In tanks, fresh napier grass should be given chopped and addition of maize bran to *T. rendalli* and *O. karongae* is not necessary.

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