

Key Words: Grass carp, soybean meal, soy hulls, LVHD cage technology, China

Grass Carp Production in Cages: LVHD vs. Traditional Cages and Feed vs. Feed + Grass

**Michael C. Cremer, Zhou Enhua and Zhang Jian
ASA-IM/China Aquaculture Program**

INTRODUCTION

A cage feeding trial was jointly conducted by the American Soybean Association International Marketing (ASA-IM) program and the Nanning Municipal Fishery Extension Center to evaluate the feasibility of culturing grass carp in cages with the ASA-IM soy-based grass carp feed. The feeding trial was conducted at Heng Xian Reservoir in Guangxi Province and compared grass carp growth in 4-m³ LVHD¹ cages and 16-m³ traditional cages with feed only and with feed plus grass. The trial was designed to assess the feasibility of intensive grass carp culture in cages for application in reservoirs throughout China.

SOY-BASED DIET FOR GRASS CARP

ASA-IM has had significant success culturing grass carp in ponds with an all-plant protein, 32/3 soy-based feed in which the majority of protein and fiber are provided by soybean meal and soy hulls, respectively.² This diet is lower in energy and higher in fiber than other carp feeds, and is formulated to more closely mimic the natural feeding habit of grass carp. Grass carp grown in ponds in several regions of China on this feed have exhibited rapid growth, good feed conversion efficiency (FCR $\leq 1.2:1$ ³), good health and body conformation, and high economic return. However, it was unknown whether grass carp would perform as well on this feed in cages in freshwater reservoirs. A preliminary cage feeding trial in 2005 was inconclusive due to problems associated with the manufacturing of the feed. A more thorough evaluation of the feasibility of using the ASA-IM 32/3 soy-based feed for grass carp in cages was subsequently scheduled for 2006. The 2006 trial was designed to evaluate grass carp growth with the 32/3 feed only,

¹ LVHD – Low Volume High Density fish culture in cages of size 1-m³ to 4-m³

²The numerical component of the feed description refers to the percentage of protein and fat, respectively, in the ration, i.e. 32/3 indicates 32% crude protein and 3% crude fat.

³ FCR = Feed Conversion Ratio

versus the 32/3 feed plus supplemental grass, in LVHD cages as well as larger, traditional cages. The trial was conducted over a 6-month period. Data on fish survival, gross and net production, average fish weight, and feed conversion efficiency were obtained at harvest for all cages. All fish from each cage were counted and weighed at harvest to obtain this data. Data on production input costs was recorded throughout the trial to determine the economic return of the various feeding regimes and cage sizes.

FEEDING TRIAL PROTOCOLS

Six, 4-m³ LVHD cages and three, 16-m³ traditional cages were used in the feeding trial to assess feed-based grass carp production in cages. Grass carp in three of the 4-m³ LVHD cages were fed the ASA-IM 32/3 feed only (Tables 1-3). Grass carp in the other three 4-m³ LVHD cages were fed the ASA-IM 32/3 feed plus supplemental grass. Grass carp in the three 16-m³ traditional cages were also fed the ASA-IM 32/3 feed plus supplemental grass. Grass carp were fed the 32/3 feed to satiation twice daily in all cages, with fish in the three cages of each feed treatment receiving the same amount of feed at each feeding. All feed was fed in extruded, floating pellet form. Elephant grass *Pennisetum purpureum* was fed fresh to the grass carp in three of the LVHD cages and the three traditional cages twice weekly for the first two months, and once weekly thereafter. The elephant grass had crude protein and fiber contents of 7.5% and 36.3%, respectively, based on a dry matter basis.

Grass carp were stocked in the six LVHD cages at a density of 150 fish per m³ (600 fish per cage). Grass carp were stocked in the three traditional cages at a density of 50 fish per m³ (800 fish per cage). Mean weight of the grass carp in all cages at stocking was 173 g. Grass carp were stocked in the nine trial cages on 27 April 2006, and harvested on 18 October 2006. The target harvest size for grass carp in all cages was 1,000 g.

FEEDING TRIAL RESULTS

Grass carp in the three LVHD cages receiving feed only exhibited the best overall performance and highest economic return of the three feed treatments tested in the trial. Grass carp in the three LVHD cages receiving feed only grew from 173 g to an average weight of 1,065 g per fish in 168 days, and yielded an average of 148.5 kg per m³ (594 kg/cage) at harvest (Table 4). Grass carp in each of the three cages were fed 773.6 kg of the 32/3 feed, and exhibited an average FCR of 1.58:1. The average survival rate for grass carp in these cages was 92.8%. Net income averaged RMB 436 (\$55.20) per cage, and yielded a return on investment (ROI) of 10.7% at an average market price for grass carp of RMB 7.6/kg (\$0.96/kg).

Grass carp in the three LVHD cages that received both feed and grass grew from 173 g to an average weight of 1,091 g per fish in 168 days, and yielded an average of 134.8 kg per m³ (539 kg/cage) at harvest (Table 4). Grass carp in each of these three cages were fed 683 kg of the 32/3 feed and 539 kg of grass. Average FCR for the combination of feed and grass was 1.88:1. FCR, if based on feed only, was 1.57:1. The average survival rate for grass carp in these cages was 83.2%. Net income averaged RMB 274 (\$34.68) per

cage, and was only 63% of the income obtained from the feed only treatment. The feed plus grass LVHD treatment yielded a ROI of 7.2%.

Grass carp in the three traditional cages demonstrated the poorest overall growth, FCR and yield per unit of cage volume. Grass carp in each of the three traditional cages received 883.5 kg of feed and 734.6 kg of grass. Grass carp in these cages grew from 173 g to an average weight of 972 g per fish in 168 days, and yielded an average of 43.4 kg per m³ (694 kg/cage) at harvest (Table 4). Average FCR for the combination of feed and grass was 1.92:1. FCR, if based on feed only, was 1.59:1. The average survival rate for grass carp in the traditional cages was 89%. Net income was intermediate in comparison to the LVHD cages at an average of RMB 378 (\$47.85) per cage, which yielded a ROI of 7.7%.

SUMMARY AND CONCLUSIONS

Results of the feeding trial indicate that feed only is sufficient to produce grass carp in cages, and that supplemental feeding with fresh grass is not required. Best overall performance in the trial was obtained in the LVHD cages receiving feed only. Grass carp in these cages grew well on the soy-based 32/3 feed, and exhibited satisfactory yield, FCR, market size and economic return. When fresh grass was added to the diet, there was no improvement in fish growth, fish health or FCR in either the 4-m³ or 16-m³ cages. The addition of fresh grass to the diet significantly increased labor and feed input costs, but generated no corresponding benefit to offset these increased costs.

Feed conversion efficiency was best in the LVHD cages where grass carp received feed only, with the soy-based 32/3 feed yielding healthy fish with good body conformation. Average FCR in the cages receiving both feed and grass was similar to the feed only cages when calculated on the 32/3 feed input only. However, with the supplemental grass factored in, feed conversion efficiency was substantially poorer for fish receiving both feed and grass. FCR for the combination of feed and grass, with the grass adjusted to dry matter weight, was 1.88:1 in the LVHD cages and 1.92:1 in the traditional cages, and was substantially higher than the FCR of 1.57:1 for fish fed the 32/3 feed only, without supplemental grass.

The 4-m³ LVHD cages performed better than the 16-m³ traditional cages in terms of fish growth and production per unit of cage volume. The average harvest weight of grass carp in the LVHD cages was 9-11% larger than the harvest weight of grass carp in the traditional cages, even though production per unit of cage volume in the LVHD cages was 3.1 to 3.4 times the production level in the traditional cages.

No drugs or chemicals were used in the ASA-IM grass carp cage trial, allowing the harvest of high quality, uncontaminated fish that met the standard for a “green” product. Water quality remained good at the grass carp trial site, although there was a noticeable decline in localized water quality at more intensively managed fish farm sites within the Heng Xian reservoir.

In summary, results indicate that the 32/3 soy-based feed and 4-m³ LVHD cages comprise a good technology package for cage production of grass carp, and supplemental feeding with grass was shown to be unnecessary and of negative economic value.

ACKNOWLEDGEMENTS

ASA-IM gratefully acknowledges the participation and cooperation of the Nanning Municipal Fishery Extension Center and the Guangxi Provincial Fishery Extension Center for their significant contributions of time, personnel and facilities to conduct the grass carp cage feeding trial detailed in this report.

Table 1. Formula for the ASA-IM 32/3, all-plant protein, soy-based feed used in the 2006 grass carp cage feeding trial in Heng Xian Reservoir, Nanning, Guangxi Province, China. The feed is a low energy, high fiber feed fed in extruded, floating pellet form. The feed was produced as a least-cost formulation by Baiyang Feed Mill, Nanning, under supervision of ASA-IM. Individual batches of feed produced over the 6-month trial duration may have varied in ingredient composition due to differences in specific ingredient nutrient profiles and ingredient availability.

Ingredient	Percent of total
Soybean Meal 46	50.00
Wheat Middlings	12.00
Wheat, Feed Flour 11.5%	12.00
Soybean Hulls	10.00
Corn Gluten Meal 60%	6.00
DDGS 27/10	5.00
Ca Phosphate Mono 21%	2.50
Fish Oil, Unspec.	1.70
Vit PMX F-2	0.50
Min PMX F-1	0.25
Stay C – 35%	0.03
Ethoxyquin	0.02
TOTAL	100.00

Table 2. Calculated nutritional profile of the ASA-IM 32/3, all-plant protein, soy-based feed used in the 2006 grass carp cage feeding trial in Heng Xian Reservoir, Nanning, Guangxi Province, China. The feed is a reduced energy, high fiber feed fed in extruded, floating pellet form.

Nutrient	Value, As Fed
DE Fish (extruded)	2363.6
NFE	39.93
Starch	17.76
Protein, crude	32.22
Protein, digestible	29.74
Fish Protein	0.00
Soy Protein	24.20
Fat	3.27
W-3 (omega 3 fatty acid)	0.50
W-6 (omega 6 fatty acid)	0.63
Ash	6.37
Calcium	0.62
Phosphorus, available	0.63
Choline	1980.08
Vitamin C	105.00
Ethoxyquin	62.50
Arginine	2.01
Isoleucine	1.59
Lysine	1.73
Methionine	0.49
Methionine + Cystine	1.00

Table 3. Vitamin and mineral premix formulations included in the ASA-IM 32/3, all-plant protein, soy-based feed used in the 2006 grass carp cage feeding trial in Heng Xian Reservoir, Nanning, Guangxi Province, China. Quantities of vitamins and minerals are per kilogram of premix.

Ingredient	Unit	Amount
<u>Vitamin Premix F-2</u>		
Vitamin A	IU/kg	1,200,000
Vitamin D3	IU/kg	200,000
Vitamin E	IU/kg	20,000
Vitamin K	mg/kg	0
Vitamin C	mg/kg	0
Biotin	mg/kg	40
Choline	mg/kg	0
Folic Acid	mg/kg	1,800
Inositol	mg/kg	0
Niacin	mg/kg	40,000
Pantothenate	mg/kg	20,000
Pyridoxine (B6)	mg/kg	5,000
Riboflavin (B2)	mg/kg	8,000
Thiamin (B1)	mg/kg	8,000
Vitamin B12	mcg/kg	2,000
Ethoxyquin	mg/kg	500
<u>Mineral Premix F-1</u>		
Iron	ppm	40,000
Manganese	ppm	10,000
Copper	ppm	4,000
Zinc	ppm	40,000
Iodine	ppm	1,800
Cobalt	ppm	20
Selenium	ppm	200

Table 4. Results of the 2006 ASA-IM aquaculture trial in Heng Xian Reservoir, Nanning that demonstrated fingerling to market growth performance of grass carp in LVHD and traditional cages when fed the ASA-IM 32/3 soy-based feed only and the 32/3 feed plus grass.

Cage No.	Feed treatment	Stocking size (g)	Stocking rate (fish/m ³)	No. days fed	Harvest wt (g/fish)	P _G ¹ (kg/m ³)	Survival (%)	FCR feed only	FCR feed+grass	Net income (RMB/ m ³)	ROI (%)
4	4-m ³ feed only ²	173	150	168	1,053	144.6	91.5	1.63	-----	79	7.8
5	4-m ³ feed only ²	173	150	168	1,059	149.6	94.2	1.56	-----	117	11.5
6	4-m ³ feed only ²	<u>173</u>	<u>150</u>	<u>168</u>	<u>1,084</u>	<u>151.3</u>	<u>92.6</u>	<u>1.54</u>	-----	<u>130</u>	<u>12.8</u>
Mean		173	150	168	1,065	148.5	92.8	1.58	-----	109	10.7
1	4-m ³ feed + grass ³	173	150	168	998	134.5	89.8	1.57	1.88	66	6.9
2	4-m ³ feed + grass ³	173	150	168	1,028	138.5	89.8	1.52	1.82	97	10.1
3	4-m ³ feed + grass ³	<u>173</u>	<u>150</u>	<u>168</u>	<u>1,248</u>	<u>131.4</u>	<u>70.0</u>	<u>1.62</u>	<u>1.94</u>	<u>43</u>	<u>4.5</u>
Mean		173	150	168	1,091	134.8	83.2	1.57	1.88	69	7.2
7	16-m ³ feed + grass ⁴	173	50	168	982	42.2	86.0	1.64	1.99	14	4.6
8	16-m ³ feed + grass ⁴	173	50	168	946	44.5	94.0	1.54	1.86	32	10.4
9	16-m ³ feed + grass ⁴	<u>173</u>	<u>50</u>	<u>168</u>	<u>987</u>	<u>43.6</u>	<u>88.4</u>	<u>1.58</u>	<u>1.91</u>	<u>25</u>	<u>8.1</u>
Mean		173	50	168	972	43.4	89.0	1.59	1.92	24	7.7

¹P_G = Gross Production

²Grass carp in the feed only LVHD cages were fed 773.6 kg of feed per cage

³Grass carp in the feed + grass LVHD cages were fed 683 kg of feed and 539 kg of grass per cage

⁴Grass carp in the feed + grass traditional cages were fed 883.5 kg of feed and 734.6 kg of grass per cage