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Comparison of ASA-IM 80:20 and Traditional Polyculture Technologies for Pond Production of Grass Carp

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INTRODUCTION

A fish feeding trial was jointly conducted by the American Soybean Association International Marketing (ASA-IM) program, the USDA Foreign Agricultural Service (FAS/ICD), the Nanjing Institute of Environmental Sciences (NIES) of the State Environmental Protection Administration of China (SEPA), and the Jiangsu Provincial Fisheries Extension Center (JFEC) to demonstrate the productivity, economic, and environmental advantages of the ASA-IM 80:20 pond technology in comparison to a Chinese polyculture technology that used a combination of local feed and fresh grass. The feeding trial was conducted on a commercial fish farm in the Yangzhong area of Jiangsu Province, China. The trial was managed by the ASA-IM aquaculture program and JFEC, in collaboration with FAS and SEPA.

80:20 POND TECHNOLOGY

The ASA-IM aquaculture program has demonstrated the advantages of its feed-based 80:20 pond technology in feeding trials conducted with at least 15 species of fish in nearly every province of China for more than a decade. The basis of the 80:20 technology is the feeding of a single species that will comprise approximately 80% of the target fish biomass at harvest, while producing an additional 20% of fish biomass in the form of a filter feeding fish that will feed on phytoplankton produced from the metabolic wastes of the fed species. The feeds used in the 80:20 technology are nutritionally balanced to meet all of the requirements of the target fed species, and are formulated to utilize renewable plant resources as the principle feed ingredients. Soybean meal is used as the primary protein source, and is balanced with other natural plant products to meet

the specific amino acid and other requirements of the cultured fish species. Fish production, in terms of biomass per unit of pond area, is limited to 400-500 kg per mu (6-7 mt per hectare) of the fed species, which is considered the limit for sustainability and environmental protection. Drug and chemical use is prohibited in ASA-IM 80:20 feeding trials so that harvested fish are contamination free and safe for human consumption. Many of the trials additionally demonstrate minimal to zero water exchange as a water conservation technique. The focus of 80:20 is on managing water quality, feed quality and stock quality to optimize fish production and food safety, and to minimize environmental impact. The 80:20 technology simultaneously promotes industry sustainability, the production of consumer safe “green” products, environmental protection and water conservation, all of which are critical issues for the China aquaculture industry.

FEEDING TRIAL PROTOCOLS

Six, 12-mu (0.8-ha) ponds at the Yangzhong Aquaculture Farm in Yangzhong, Jiangsu Province were used for the comparison trial. The six ponds were identically renovated and prepared for the trial. The ASA-IM 80:20 technology was applied in three of the ponds, and the local polyculture technology was applied in the other three ponds.

The three 80:20 ponds were stocked with 220 grass carp per mu (3,300/ha) and 100 silver carp per mu (1,500/ha). Average grass and silver carp weights at stocking in the 80:20 ponds were 299 g and 500 g, respectively. Grass carp in the 80:20 ponds were fed to satiation twice daily with the soymeal-based ASA-IM 32/3¹ grass carp feed (Tables 1-3). This feed is a low energy, high fiber feed that is designed to closely mimic the natural food intake of grass carp. Soybean meal is used as the primary protein source in the feed, and soy hulls as the primary fiber source. All feed was fed in extruded, floating pellet form.

The three modified polyculture ponds were stocked with a combination of grass carp, crucian carp, wuchang bream, silver carp and bighead carp. Grass carp were stocked at 160 fish per mu (2,400/ha). Crucian carp and wuchang bream were stocked as a combination at 150 fish per mu (2,250/ha). Silver carp and bighead carp were stocked at 100 and 40 fish per mu, respectively (1,500/ha and 600/ha). Average fish weights at stocking for the grass carp and the crucian carp plus wuchang bream combination were 525 g and 75 g, respectively. Average fish weights for silver carp and bighead carp at stocking were 700 g and 750 g, respectively. Fish in the polyculture ponds were fed a combination of a local sinking feed and fresh cut *Lactuca indica* grass. The local feed had a reported crude protein level of 28%. The local feed was fed twice daily based on the estimated biomass of the three feed-taking species correlated with a locally developed feeding table. Fish in the three polyculture ponds were fed the same amount of local feed at each feeding. *Lactuca* grass was cut fresh on the fish farm prior to feeding. The grass was fed at intervals based on its availability, with each of the three polyculture ponds receiving the same amount of grass at each feeding and over the course of the trial.

¹ The 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.

The trial was conducted over a 6-month period. At the end of the trial all ponds were drained and the fish from each pond harvested and weighed independently. Sub-samples of each species of fish were taken from each pond population to determine average fish weight for the species. Data on fish survival, gross and net production, average fish weight, and feed conversion efficiency were calculated for all ponds. Data on production input costs was recorded throughout the trial to determine the economic return from each pond and the average for the three ponds for each technology.

TRIAL RESULTS

The 36 mu (2.4 ha) of 80:20 technology ponds yielded 21.89 mt of fish at harvest. The average fish yield at harvest was 608 kg/mu (9,120 kg/ha), composed of 436 kg/mu (6,540 kg/ha) of grass carp and 172 kg/mu (2,580 kg/ha) of silver carp (Table 4). Grass carp in the 80:20 ponds grew from 299 g to an average weight of 2,199 g in 176 days of feeding. Silver carp grew from 500 g to 1,722 g at harvest. Average feed conversion ratio (FCR) for grass carp fed the ASA-IM 32/3 feed was 1.05:1. Survival rates for grass and silver carp in the 80:20 ponds were 90.1% and 100%, respectively. Net income and return to investment (ROI) for the three 80:20 ponds averaged RMB 1,200/mu (\$2,278/ha) and 40.3%. Net economic return to the farmer for the 36 mu of 80:20 ponds was RMB 43,200 (\$5,468).

The 36 mu (2.4 ha) of polyculture ponds yielded 19.03 mt of fish at harvest. The average fish yield at harvest was 528.5 kg/mu (7,928 kg/ha), composed of 288 kg/mu (4,320 kg/ha) of grass carp, 47.5 kg/mu (713 kg/ha) of crucian carp and wuchang bream combined, and 193 kg/mu (2,895 kg/ha) of silver carp and bighead carp combined (Table 4). Grass carp in the polyculture ponds grew from 525 g to an average weight of 1,973 g in 176 days of feeding. Crucian carp and wuchang bream grew from 75 g to an average weight of 317 g in 176 days of feeding. Silver and bighead carp grew from 700-750 g to an average weight of 1,380 g at harvest. Average feed conversion for the three polyculture species fed the combination of local feed and grass was 2.8:1, based on an estimated 25% dry weight for the grass. Average FCR in the polyculture ponds if based on feed only was 2.3:1. The survival rate for grass carp was 93.3%. The survival rates for crucian carp, wuchang bream, silver carp and bighead carp were all reported as 100%. Net income and ROI for the three polyculture ponds averaged RMB 229/mu (\$435/ha) and 7.3%. Net economic return to the farmer for the 36 mu of polyculture ponds was RMB 8,244 (\$1,043).

SUMMARY AND CONCLUSIONS

The ASA-IM 80:20 technology and soy-based 32/3 feed significantly out-performed the polyculture system and local feed in every aspect evaluated. Total fish production was 15% higher in the 80:20 ponds than in the polyculture ponds. Grass carp grew 11.5% larger in the 80:20 ponds than in the polyculture ponds.

FCR with the soy-based 32/3 feed was less than half the FCR with the combination of local feed and grass. An average of 385 kg of feed was fed per mu (5.78 mt/ha) in each

80:20 pond to produce a net yield of 370 kg/mu (5.55 mt/ha) of grass carp and 122 kg/mu (1.83 mt/ha) of silver carp. In comparison, the 588 kg of feed and 454 kg of grass fed per mu (8.82 mt/ha of local feed and 6.81 mt/ha of grass) in the polyculture ponds produced a net yield of only 213 kg/mu (3.19 mt/ha) of fed species (grass carp, crucian carp and wuchang bream combined) and 130 kg/mu (1.96 mt/ha) of filter species (silver carp and bighead carp combined). The polyculture ponds required 53% more feed plus 16.35 mt of grass to produce 15% less total fish, and 30% less fed fish, than were produced in the 80:20 ponds.

Economic return with the ASA-IM soy-based feed and 80:20 technology was more than 500% higher than with the polyculture system. The 80:20 technology and soy-based feed yielded the fish farmer a return on investment that was 5.5 times higher than the return obtained from the polyculture ponds.

There was also a significant difference in the environmental impact of the two technologies. The nutrient load in the polyculture ponds, based on the dry weight of the feed and grass inputs, was approximately 643 kg/mu (9.64 mt/ha), compared to 347 kg/mu (5.2 mt/ha) in the 80:20 ponds. The nutrient load in the polyculture ponds was 1.85 times greater than the nutrient load in the 80:20 ponds. The significantly higher nutrient load in the polyculture ponds had an adverse impact on water and soil quality in those ponds, and had the potential to contribute to excessive and harmful nutrient loading of the surrounding environment when the ponds were drained at harvest.

In summary, the combination of the ASA-IM 80:20 technology and soy-based feed yielded significant productivity, economic and environmental advantages in comparison to the traditional polyculture system. ASA-IM encourages the fish farming industry in China to adopt 80:20 pond technology and soy-based feeds as a method to improve fish production, industry sustainability, food safety and economic return.

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Table 1. Formula for the ASA-IM 32/3, all-plant protein, soy-based feed used in the 80:20 ponds in the 2006 grass carp comparison feeding trial conducted at the Yangzhong Aquaculture Farm in Jiangsu 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 Techbank Aquafeed Company, Shanghai, 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%	49.00
Wheat, Feed Flour 11%	12.00
Wheat Middlings 14%	10.00
Soybean Hulls	10.00
DDGS 27/10	8.00
Corn Gluten Meal 60%	6.00
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 80:20 ponds in the 2006 grass carp comparison pond feeding trial at the Yangzhong Aquaculture Farm in Jiangsu Province, China. The feed is a low energy, high fiber feed fed in extruded, floating pellet form.

Nutrient	Value, As Fed
DE Fish (extruded)	2055.17
NFE	39.25
Starch	16.61
Protein, crude	32.27
Protein, digestible	29.59
Fish Protein	0.00
Soy Protein	23.74
Fat	3.62
W-3 (omega 3 fatty acid)	0.50
W-6 (omega 6 fatty acid)	0.76
Fiber	7.40
Ash	6.42
Calcium	0.62
Phosphorus, available	0.64
Choline	2010.97
Vitamin C	105.00
Ethoxyquin	134.50
Arginine	2.00
Isoleucine	1.59
Lysine	1.72
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 80:20 ponds in the 2006 grass carp comparison pond feeding trial at the Yangzhong Aquaculture Farm in Jiangsu 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 at the Yangzhong Aquaculture Farm in Jiangsu Province, China that compared the ASA-IM 80:20 pond technology and soy-based feed to a traditional polyculture culture technology in six, 12-mu (0.8-ha) ponds during a 176-day feeding trial.

Tech- nology	Stocking rate (fish/mu)			Stocking size (g)			Harvest wt (g/fish)			P _G ¹ (kg/mu)			Survival (%)			FCR		Net income (RMB/mu) ⁷	ROI (%)
	GrC ²	Fed ³	Filter ⁴	GrC ²	Fed ³	Filter ⁴	GrC ²	Fed ³	Filter ⁴	GrC ²	Fed ³	Filter ⁴	GrC ²	Fed ³	Filter ⁴	Feed ⁵	F+G ⁶		
80:20	220	----	100	299	----	500	2,080	----	1,304	396	----	130	86.5	----	100	1.17	----	711	23.8
80:20	220	----	100	299	----	500	2,217	----	1,822	454	----	182	92.9	----	100	0.99	----	1,379	46.3
80:20	<u>220</u>	<u>----</u>	<u>100</u>	<u>299</u>	<u>----</u>	<u>500</u>	<u>2,299</u>	<u>----</u>	<u>2,040</u>	<u>459</u>	<u>----</u>	<u>204</u>	<u>90.8</u>	<u>----</u>	<u>100</u>	<u>0.98</u>	<u>----</u>	<u>1,511</u>	<u>50.7</u>
Mean	200	----	100	299	----	500	2,199	----	1,722	436	----	172	90.1	----	100	1.05	----	1,200	40.3
Poly	160	150	140	525	75	725	2,015	320	1,300	287	48	182	91.0	100	100	2.3	2.8	166	5.0
Poly	160	150	140	525	75	725	1,935	330	1,460	291	50	204	96.0	100	100	2.2	2.7	310	10.0
Poly	<u>160</u>	<u>150</u>	<u>140</u>	<u>525</u>	<u>75</u>	<u>725</u>	<u>1,970</u>	<u>300</u>	<u>1,380</u>	<u>286</u>	<u>45</u>	<u>193</u>	<u>93.0</u>	<u>100</u>	<u>100</u>	<u>2.4</u>	<u>2.9</u>	<u>210</u>	<u>7.0</u>
Mean	160	150	140	525	75	725	1,973	317	1,380	288	48	193	93.3	100	100	2.3	2.9	229	7.3

¹P_G = Gross Production

²GrC = Grass Carp

³Fed = other fed species in polyculture system (crucian carp and wuchang bream)

⁴Filter = filter species; silver carp in 80:20 and silver carp + bighead carp in polyculture

⁵FCR based on feed only

⁶FCR based on combination of feed and grass (dry weight)

⁷RMB exchange rate: RMB 7.9 = \$1.00