
ASA-IM 80:20 Technology and Soy-Based Feed Produce Significantly Higher Fish Production and Profit than a Traditional Chinese Polyculture System for Pond Production of Grass Carp

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INTRODUCTION

The second year of a three-year cooperative pond feeding trial series 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 sinking 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 the 80:20 technology 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 Zhejiang, Jiangsu Province were used for the 2007 comparison trial. The six ponds were identically 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 350 grass carp per mu (5,250/ha) and 100 silver carp per mu (1,500/ha). Average grass carp and silver carp weights at stocking in the 80:20 ponds were 70 g and 98 g, respectively. Grass carp in the 80:20 ponds were fed to satiation twice daily with the 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 a primary fiber source. All feed was fed in extruded, floating pellet form. The feed was produced by the Ningbo Techbank Feed Mill in Ningbo, Zhejiang Province, China, and least-cost formulated based on ASA-IM formulation specifications and with ASA-IM technical support.

The three polyculture ponds were stocked with a combination of two sizes of grass carp, crucian carp, silver carp and bighead carp. Grass carp weighing an average of 70 g and 750 g were stocked at 150 fish per mu (2,250/ha) and 50 fish per mu (750/ha), respectively, for the two sizes. Crucian carp were stocked at 100 fish per mu (1,500/ha) at an average size of 100 g per fish. Silver carp and bighead carp were stocked at 100 and 20 fish per mu, respectively (1,500/ha and 300/ha). Average weights for silver carp and bighead carp at stocking were 500 g and 1,000 g, respectively. Fish in the polyculture ponds were fed a combination of a local sinking feed, fresh cut lettuce and sudan 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 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. Sudan grass and lettuce was cut fresh on the

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.

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.

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 17.37 mt of fish at harvest. The average fish yield at harvest was 482.5 kg/mu (7,238 kg/ha), composed of 391.7 kg/mu (5,876 kg/ha) of grass carp and 90.5 kg/mu (1,358 kg/ha) of silver carp (Table 4). Grass carp in the 80:20 ponds grew from 70 g to an average weight of 1,250 g in 191 days of feeding. Average feed conversion ratio (FCR) for grass carp fed the ASA-IM 32/3 feed was 1.18:1. Survival rates for grass and silver carp in the 80:20 ponds were 89.6% and 97%, respectively. Net income and return to investment (ROI) for the three 80:20 ponds averaged RMB 1,361/mu (\$2,722/ha) and 58.7%, respectively. Net economic return to the farmer for the 36 mu of 80:20 ponds was RMB 48,996 (\$6,533).

The 36 mu (2.4 ha) of polyculture ponds yielded 16.87 mt of fish at harvest. The average fish yield at harvest was 469 kg/mu (7,035 kg/ha), composed of 239 kg/mu (3,585 kg/ha) of two sizes of grass carp, 29 kg/mu (435 kg/ha) of crucian carp, 162.5 kg/mu (2,438 kg/ha) of silver carp, and 38 kg/mu (570 kg/ha) of bighead carp (Table 4). The 70-g and 750-g stocked grass carp had average harvest weights of 1,021 g and 2,176 g, respectively, after 191 days of feeding. The average harvest weight for the two sizes of grass carp combined was 1,327 g (Table 4). The estimated average feed conversion for the polyculture species fed the combination of local feed, lettuce and sudan grass was 3.47:1. Average FCR in the polyculture ponds if based on feed only was 3.07:1. The average survival rates for the 70-g and 750-g grass carp stocked were 87.9% and 96%, respectively. The average survival rate for the two sizes of grass carp combined was 90.0%. The survival rates for crucian carp, silver carp and bighead carp were 93.3%, 95.3%, and 100%, respectively. Net income and ROI for the three polyculture ponds averaged RMB 548/mu (\$1,096/ha) and 26.2%. Net economic return to the farmer for the 36 mu of polyculture ponds was RMB 19,728 (\$2,630).

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. Grass carp production was 64% higher in the 80:20 ponds than in the polyculture ponds. Average grass carp size at harvest was 22.5% larger in the 80:20 ponds than in the polyculture ponds for the 70-g grass carp stocked in both ponds.

FCR with the combination of local sinking feed and grass (3.47:1) was nearly three times the FCR with the soy-based 32/3 feed (1.18:1). An average of 434 kg of feed was fed per mu (6.51 mt/ha) in each 80:20 pond to produce a net yield of 367.5 kg/mu (5.51 mt/ha) of grass carp and 80.5 kg/mu (1,208 mt/ha) of silver carp. In comparison, the 586 kg of feed, 375 kg of lettuce, and 75 kg of sudan grass fed per mu (8.79 mt/ha of local feed and 6.75 mt/ha of lettuce and grass) in the polyculture ponds produced a net yield of only 135 kg/mu (2.02 mt/ha) of fed species (grass carp and crucian carp) and 170.5 kg/mu (2.56 mt/ha) of filter species (silver carp and bighead carp). The polyculture ponds required 35% more feed plus 16.2 mt of grass to produce 47% less total net fish production, and 272% less net fed fish production, than were produced in the 80:20 ponds.

The net economic return of RMB 48,996 from the 36 mu of ponds using the ASA-IM soy-based feed and 80:20 technology was two and half times more than the economic return of RMB 19,728 from the 36 mu of polyculture ponds. The 80:20 technology and soy-based feed yielded the fish farmer a ROI of nearly 59%, which was 2.24 times more than the ROI 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 640 kg/mu (9.6 mt/ha), compared to 391 kg/mu (5.8 mt/ha) in the 80:20 ponds. The nutrient load in the polyculture ponds was 1.64 times greater than the nutrient load in the 80:20 ponds. The significantly higher nutrient load in the polyculture ponds had a measurable impact on water quality. No water was flushed from the ASA-IM ponds during the course of the trial, while the polyculture ponds required an average of 3,000-m³ of flushing per pond. The ASA-IM ponds required an average of only 29 hours of aeration over the production season, while the polyculture ponds required 196 hours of aeration per pond for the same period. The poorer water quality in the polyculture ponds had the potential to contribute to excessive and harmful nutrient loading of the surrounding environment during periods of flushing and 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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these organizations contributed time, personnel, facilities and funding for this comparison feeding trial.

Table 1. Formula for the ASA-IM 32/3, all-plant protein, soy-based feed used in the 80:20 ponds in the 2007 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 Ningbo Techbank Feed Mill, Zhejiang Province, China, 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 14%	14.00
Wheat, Feed Flour 11.7%	12.00
DDGS 24/12	6.00
Corn Gluten Meal 60%	6.00
Soy Hulls 12%	5.50
Ca Phosphate Mono 21%	2.11
Soy Lecithin/Corn Blend	2.00
Fish Oil, local	1.50
Vit PMX F-2	0.50
Min PMX F-1	0.25
Choline Chloride 50%	0.09
Stay C 35%	0.03
Ethoxyquin, liquid 60%	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 2007 grass carp comparison pond feeding trial at the Yangzhong Aquaculture Farm in Jiangsu Province, China. The feed is a lower energy and higher fiber feed fed in extruded, floating pellet form.

Nutrient	Value, As Fed
DE Fish (extruded)	2360
NFE	38.97
Starch	16.98
Protein, crude	32.20
Protein, digestible	29.35
Fish Protein	0.00
Soy Protein	23.66
Fat	4.23
W-3 (omega 3 fatty acid)	0.49
W-6 (omega 6 fatty acid)	1.11
Fiber	6.57
Ash	6.33
Calcium	0.56
Phosphorus, available	0.60
Choline	2517
Vitamin C	105
Ethoxyquin	134.50
Arginine	1.99
Lysine	1.71
Methionine	0.49
Methionine + Cystine	1.01
Threonine	1.25
Tryptophan	0.36

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 2007 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. The premixes were produced by Phoenix Feed Mill in Chengdu, China, based on ASA-IM specifications and under ASA-IM guidance.

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 2007 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 technology in six, 12-mu (0.8-ha) ponds during a 191-day feeding trial.

Tech- nology	Stocking rate (fish/mu)			Stocking size (g)			Harvest wt (g/fish)			Production (kg/mu)			Survival (%)			FCR		Net income (RMB/mu) ¹⁰	ROI (%)
	GrC ¹	Fed ²	Filter ³	GrC ^{1,4}	Fed ²	Filter ^{3,5}	GrC ^{1,6}	Fed ²	Filter ^{3,5}	GrC ¹	Fed ²	Filter ^{3,7}	GrC ¹	Fed ²	Filter ³	Feed ⁸	F+G ⁹		
80:20	350	----	100	70	----	98	1,264	----	878	397	---	83.4	90.0	----	95	1.16	----	1,375	59.0
80:20	350	----	100	70	----	98	1,246	----	985	400	---	96.5	91.7	----	98	1.15	----	1,459	63.0
80:20	<u>350</u>	<u>----</u>	<u>100</u>	<u>70</u>	<u>----</u>	<u>98</u>	<u>1,240</u>	<u>----</u>	<u>963</u>	<u>378</u>	<u>----</u>	<u>91.7</u>	<u>87.1</u>	<u>----</u>	<u>98</u>	<u>1.22</u>	<u>----</u>	<u>1,250</u>	<u>54.0</u>
Mean	350	----	100	70	----	98	1,250	----	933	392	----	90.5	89.6	----	97	1.18	----	1,361	58.7
Poly	150/50	100	120	70/750	100	750	1,261	296	1,814	233	28	194.2	92.5	95.0	95.8	3.16	3.57	450	21.5
Poly	150/50	100	120	70/750	100	750	1,321	334	1,898	236	31	212.7	89.5	93.0	94.1	3.11	3.52	614	29.3
Poly	<u>150/50</u>	<u>100</u>	<u>120</u>	<u>70/750</u>	<u>100</u>	<u>750</u>	<u>1,403</u>	<u>318</u>	<u>1,696</u>	<u>247</u>	<u>29</u>	<u>194.7</u>	<u>88.0</u>	<u>92.0</u>	<u>98.3</u>	<u>2.95</u>	<u>3.33</u>	<u>578</u>	<u>27.7</u>
Mean	150/50	100	120	70/750	100	750	1,328	316	1,802	239	29	200.5	90.0	93.3	96.0	3.07	3.47	548	26.2

¹GrC = Grass Carp; the polyculture ponds stocked a combination of 150 small grass carp and 50 large grass carp per mu

²Fed = other fed species in polyculture system (crucian carp)

³Filter = filter species: silver carp in 80:20 ponds; silver carp + bighead carp in polyculture ponds stocked at 100/mu and 20/mu, respectively

⁴70-g and 750-g grass carp were stocked at 150/mu and 50/mu, respectively, in the polyculture ponds

⁵Silver and bighead carp were stocked at 500 g and 1,000 g per fish, respectively, in the polyculture ponds, and had average harvest weights of 1,701 g and 1,897 g

⁶Harvest weight of grass carp in the polyculture ponds represents the average weight for the two sizes of grass carp that were stocked

⁷Harvest biomass of silver and bighead carp averaged 162.5 kg/mu and 38 kg/mu, respectively, in the polyculture ponds

⁸FCR based on feed only

⁹FCR based on combination of feed and grass (dry weight)

¹⁰RMB exchange rate: RMB 7.5 = \$1.00