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Three Year Study Demonstrates Production, Profit and Environmental Advantages of ASA-IM 80:20 Technology and Soy-Based Feed in Comparison to a Traditional Chinese Polyculture System for Pond Production of Grass Carp

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INTRODUCTION

A three-year cooperative pond 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 Ministry of Environmental Protection (MEP), and the Jiangsu Provincial Fisheries Technology Extension Center (JFEC) to demonstrate the production, economic, and environmental advantages of the ASA-IM 80:20 pond technology and soy-based feed in comparison to a Chinese traditional polyculture technology. The feeding trials were conducted on a commercial fish farm in the Yangzhong area of Jiangsu Province, China, using the same ponds for three consecutive years. The trial was managed by the ASA-IM aquaculture program and JFEC, in collaboration with FAS, NIES and MEP.

80:20 POND TECHNOLOGY

The ASA-IM aquaculture program has demonstrated the advantages of its feed-based 80:20 pond technology with soy-based feeds 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 service species, such as 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 nutritional 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 (6-7.5 mt per hectare) of the fed species, which is considered the limit for sustainability and environmental protection in open pond systems. 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

Comparison trials conducted in 2006, 2007 and 2008 utilized a complex of six, 12-mu (0.8-ha) ponds at the Yangzhong Aquaculture Farm in Zhenjiang City, Jiangsu Province. Each year, the six ponds were identically prepared for that year’s 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.

2006 Trial – In the initial trial in 2006, 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). The three polyculture ponds were stocked with a combination of grass carp, crucian carp, wuchang bream, silver carp and bighead carp, with grass carp stocked at 160 fish per mu (2,400/ha), crucian carp and wuchang bream stocked as a combination at 150 fish per mu (2,250/ha), and silver carp and bighead carp stocked at 100 and 40 fish per mu, respectively (1,500/ha and 600/ha). Average grass and silver carp weights at stocking in the 80:20 ponds were 299 g and 500 g, respectively. Average fish weights at stocking in the polyculture ponds were 525 g for grass carp, 75 g for the crucian carp plus wuchang bream combination, 700 g for silver carp and 750 g for bighead carp. The polyculture stocking was based on traditional stocking regimes for the local area.

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 and 4). Satiation feeding was based on the ASA-IM 90% satiation technique. The 32/3 feed is a low energy, high fiber feed designed to closely mimic the natural food of grass carp. Soybean meal is used as 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.

primary protein source in the feed, and soy hulls as the primary fiber source. All 32/3 feed was fed in extruded, floating pellet form.

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.

2007 Trial - The year two trial modified the fish stocking size in all ponds, as well as the species mix and feeding program for the polyculture system as a means for further comparison of the production technologies and feeds. The three 80:20 ponds were stocked with 350 grass carp per mu (5,250/ha) with an average weight of 70 g, and 100 silver carp per mu (1,500/ha) with an average weight of 98 g. 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), with average weights of 500 g for silver carp and 1,000 g for bighead carp.

Grass carp in the 80:20 ponds were fed to satiation twice daily with the ASA-IM 32/3 grass carp feed (Tables 2 and 4) and the 90% satiation technique. The feed was least-cost formulated based on ASA-IM formulation specifications and with ASA-IM technical support.

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 were cut fresh on the fish farm prior to feeding. The grass and lettuce were fed at intervals based on availability, with each of the three polyculture ponds receiving the same amount of grass and lettuce at each feeding and over the course of the trial.

2008 Trial - The year three trial compared the 80:20 and polyculture systems for the production of larger grass carp to determine whether the advantages of the 80:20 system and soy feed continued to be applicable for the production of ≥ 3 kg fish that had been already been cultured for two years (year one fry to 100 g, year two 100 g to 1,200 g, year three 1,200 g to >3 kg). In the third year trial, the three 80:20 ponds were stocked with 140 grass carp per mu (2,100/ha) with an average weight of 1,225 g, and 100 silver carp per mu (1,500/ha) with an average weight of 950 g. The three polyculture ponds

were stocked with a combination of two sizes of grass carp, crucian carp, wuchang bream, silver carp and bighead carp. Grass carp weighing an average of 1,225 g and 100 g were stocked at 80 fish per mu (1,200/ha) and 100 fish per mu (1,500/ha), respectively, for the two sizes. Crucian carp and wuchang bream were each stocked at 100 fish per mu (1,500/ha) at an average size of 100 g per fish. Silver carp were stocked at 100 fish per mu (1,500/ha) at an average size of 950 g, and bighead carp were stocked at 20 fish per mu (300/ha) at an average weight of 1,250 g.

Grass carp in the 80:20 ponds were fed to satiation twice daily with the ASA-IM 32/3 grass carp feed (Tables 3 and 4) using the ASA-IM 90% satiation technique. Fish in the polyculture ponds were fed a local sinking feed reported to have a 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. Feeding of grass in the polyculture ponds, which was included in the 2006 and 2007 trials, was eliminated in the 2008 trial due to the high cost of growing, harvesting and feeding grasses that was experienced in the 2006 and 2007 trials.

The 2006, 2007 and 2008 trials were each conducted over a 6-month period. At the end of each 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

2006 Trial

Results of the 2006 trial are summarized in Table 5. 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 (21.89 mt) than in the polyculture ponds (19.03 mt), and grass carp grew 11.5% larger in the 80:20 ponds (299 g to an average weight of 2,199 g in 176 days) than in the polyculture ponds (525 g to an average weight of 1,973 g in 176 days).

FCR with the soy-based 32/3 feed (1.05:1) was less than half the FCR with the combination of local feed and grass (2.8:1). 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.

Net economic return to the farmer for the 36 mu (2.4 ha) of 80:20 ponds was RMB 43,200 (\$5,468), compared to a net economic return of RMB 8,244 (\$1,043) for the 36 mu of polyculture ponds. Economic return with the ASA-IM soy-based feed and 80:20 technology was more than 500% higher than with the polyculture system. Return on investment (ROI) was 5.5 times higher with the 80:20 technology and soy-based feed 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 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 required substantially more aeration and water exchange than was required in the 80:20 ponds.

2007 Trial

Results of the 2007 trial are summarized in Table 6. As in 2006, 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 (1,250 g) than in the polyculture ponds (1,021) 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 (2.4 ha) 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.

2008 Trial

Results of the 2008 trial are summarized in Table 7. The ASA-IM 80:20 technology and soy-based 32/3 feed out-performed the polyculture system for the production of 3-year old, >3 kg grass carp. Grass carp production was 42% greater in the 80:20 ponds (460 kg/mu) than in the polyculture ponds (325 kg/mu). Average grass carp size at harvest was 27.5% larger in the 80:20 ponds (3,283 g) than in the polyculture ponds (2,575) for the 1,225-g grass carp stocked in both ponds. The addition of crucian carp and wuchang bream to the polyculture mix only added an average of 49 kg/mu to production at harvest.

FCR with the local sinking feed (3.64:1) was twice the FCR with the soy-based 32/3 feed (1.83:1). An average of 528 kg of feed was fed per mu (7.92 mt/ha) in each 80:20 pond to produce an average net yield of 288 kg/mu (4.32 mt/ha) of grass carp and 113 kg/mu (1.70 mt/ha) of silver carp. In comparison, 916 kg of local feed was fed per mu (13.74 mt/ha) in the polyculture ponds to produce a net yield of 253 kg/mu (3.80 mt/ha) of fed species (two sizes of grass carp, crucian carp and wuchang bream) and 118.6 kg/mu (1.78 mt/ha) of filter species (silver carp and bighead carp). The polyculture ponds required 73% more feed and produced 8% less total net fish production, and 14% less net fed fish production, than were produced in the 80:20 ponds.

The 2008 net economic return of RMB 76,716 from the 36 mu (2.4 ha) of trial ponds using the ASA-IM soy-based feed and 80:20 technology was the best economic return obtained during the three years of this trial program, and was 21% higher than the net economic return from the 36-mu of polyculture ponds. This economic return was achieved during a period of record high feed prices. Feed price for the ASA-IM 32/3 feed averaged RBM 4.8/kg (\$0.71/kg) for the trial, and was 85% higher in cost than the local feed, which had an average cost of RBM 2.6/kg (\$0.39/kg). Even with the high feed price, the 80:20 technology and soy-based feed yielded the fish farmer a ROI of 42.2%.

The nutrient load in the polyculture ponds was approximately 1.73 times more than in the 80:20 ponds. The nutrient load in the polyculture ponds, based on the dry weight of the feed input, was approximately 824 kg/mu (12.4 mt/ha), compared to 475 kg/mu (7.1 mt/ha) in the 80:20 ponds. The higher nutrient load in the polyculture ponds resulted in

the average use of 738 hours of aeration per 12-mu (0.8-ha) pond, and was 1.8 times greater than the hours of aeration applied in the 80:20 ponds. No water was flushed from either the ASA-IM or the polyculture ponds during the course of the 2008 trial.

SUMMARY

The combination of the ASA-IM 80:20 technology and soy-based feed yielded significant productivity, economic and environmental advantages in comparison to traditional polyculture systems during a sequence of feeding trials conducted over a three-year period in the same ponds with different size grass carp and a variety of polyculture species combinations. The consistently higher economic return and lower environmental impact of the ASA-IM technology and feed in all of the trials is a convincing argument for the use of proper management techniques and high quality, soy-based feeds. 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, 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 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. Formula for the extruded ASA-IM 32/3, 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 was produced as a least-cost formulation by Ningbo Techbank Aquafeed Company, 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
Soybean 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 3. Formula for the extruded ASA-IM 32/3, soy-based feed used in the 80:20 ponds in the 2008 grass carp comparison feeding trial conducted at the Yangzhong Aquaculture Farm in Jiangsu Province, China. The feed was produced as a least-cost formulation by Ningbo Techbank Aquafeed Company, 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 46.5%	35.00
Wheat Middlings 16.5%	22.50
Soybean Hulls 23.5%	17.50
Wheat, Feed Flour 11.5%	10.00
Corn Gluten Meal 65%	7.50
Fishmeal, Anchovy 64.5%	3.00
Ca Phosphate Mono 21%	2.03
Fish Oil	1.50
Vit PMX F-2	0.50
Min PMX F-1	0.25
Choline Chloride 50%	0.12
Mold Inhibitor	0.05
Stay C 35%	0.03
Ethoxyquin, SQ Mixture 6	0.02
TOTAL	100.00

Table 4. Average, calculated nutritional profile of the ASA-IM 32/3, soy-based feed used in the three grass carp comparison pond feeding trials conducted at the Yangzhong Aquaculture Farm in Jiangsu Province, China in 2006, 2007 and 2008. The feed is a low energy and high fiber feed with a DE:DP ratio of approximately 7.7:1 and a fiber content of approximately 8%. The feed was fed in extruded, floating pellet form.

Nutrient	Value, As Fed
DE Fish (extruded)	2245
NFE	38.00
Starch	17.10
Protein, crude	32.17
Protein, digestible	29.65
Fish Protein	0.65
Soy Protein	22.60
Fat	3.84
W-3 (omega 3 fatty acid)	0.50
W-6 (omega 6 fatty acid)	0.92
Fiber	7.98
Ash	6.51
Calcium	0.63
Phosphorus, available	0.62
Choline	2338
Vitamin C	105
Ethoxyquin	134.50
Arginine	1.99
Lysine	1.72
Methionine	0.50
Methionine + Cystine	1.00

Table 5. 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

Table 6. 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>100</u>	<u>70</u>	----	<u>98</u>	<u>1,240</u>	----	<u>963</u>	<u>378</u>	----	<u>91.7</u>	<u>87.1</u>	----	<u>98</u>	<u>1.22</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

Table 7. Results of the 2008 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 Feed ⁸	Net income (RMB/mu) ¹⁰	ROI (%)
	GrC ¹	Fed ²	Filter ³	GrC ^{1,4}	Fed ²	Filter ^{3,5}	GrC ¹	Fed ^{2,6}	Filter ^{3,5}	GrC ¹	Fed ^{2,6}	Filter ^{3,7}	GrC ¹	Fed ²	Filter ³			
80:20	140	----	100	1225	----	950	3,280	----	1,850	459	---	185	100	----	100	1.84	1,944	38.5
80:20	140	----	100	1225	----	950	3,240	----	2,400	454	---	240	100	----	100	1.87	2,317	45.9
80:20	<u>140</u>	----	<u>100</u>	<u>1225</u>	----	<u>950</u>	<u>3,330</u>	----	<u>1,980</u>	<u>466</u>	----	<u>198</u>	<u>100</u>	----	<u>100</u>	<u>1.79</u>	<u>2,132</u>	<u>42.2</u>
Mean	140	----	100	1225	----	950	3,283	----	2,077	460	---	208	100	----	100	1.83	2,131	42.2
Poly	80/100	200	120	1225/100	100	950	2500/1175	455	1,875	317	34	243	100	35	100	4.00	1,507	32.3
Poly	80/100	200	120	1225/100	100	950	2580/1255	358	1,750	332	50	231	100	70	100	3.53	1,776	38.1
Poly	<u>80/100</u>	<u>200</u>	<u>120</u>	<u>1225/100</u>	<u>100</u>	<u>950</u>	<u>2645/1163</u>	<u>402</u>	<u>1,835</u>	<u>328</u>	<u>64</u>	<u>242</u>	<u>100</u>	<u>80</u>	<u>100</u>	<u>3.40</u>	<u>1,984</u>	<u>42.5</u>
Mean	80/100	200	120	1225/100	100	950	2575/1198	405	1,820	325	49	239	100	62	100	3.64	1,755	37.6

¹GrC = Grass Carp; the polyculture ponds were stocked with a combination of 100 small grass carp and 80 large grass carp per mu

²Fed = other fed species in polyculture system (crucian carp and wuchang bream at 100 fish/mu each at an average stocking size of 100 g for each species)

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

⁴1225-g and 100-g grass carp were stocked at 80/mu and 100/mu, respectively, in the polyculture ponds

⁵Silver and bighead carp were stocked in the polyculture ponds at 950 g and 1,250 g per fish, respectively; average harvest weights for the silver and bighead carp were 1,820 g and 2,832 g, respectively; figures in table are for silver carp only

⁶Average harvest weights for crucian carp and wuchang bream in the polyculture ponds were 437 g and 373 g, respectively; figures in the table are the average weight for the two species combined

⁷Harvest biomass of silver and bighead carp in the polyculture ponds averaged 182 kg/mu and 57 kg/mu, respectively

⁸RMB exchange rate: RMB 6.7 = \$1.00