

**Key Words:** Grass carp, extruded soybased feed, soybean meal, SPC, intensive pond aquaculture technology, China

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## **In-pond Raceway Aquaculture (IPA) Technology Successfully Demonstrated in China**

**Results of USSEC/China 2013 Freshwater Aquaculture Feeding  
Demonstration  
Project U13CXNA006**

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### **INTRODUCTION**

An in-pond raceway system to intensify pond aquaculture production demonstration was jointly conducted by the U.S. Soybean Export Council (USSEC) program, in collaboration with the Jiangsu Provincial Fisheries Extension Center and Wujiang Municipal Aquaculture Co., Ltd. to evaluate the technical and economic feasibilities of the in-pond raceway aquaculture (IPA) technology. The IPA technology was first developed in the United States as a means to increase fish production in the conventional pond units by culturing fish in confined raceway with aerated flowing water and removing fish metabolic wastes. Removal of the solid wastes significantly increases fish production by three times as compared to the conventional 80:20 pond culture technology. The technology was first transferred to China by USSEC through a cooperative project funded by the Iowa Soybean Association and tested at the Pingwang Fish Farm of the Wujiang Municipal Aquaculture Co. Ltd., Suzhou City, Jiangsu Province, China.

## **TRIAL PROTOCOLS**

Three earthen ponds of 32-mu (2.1 ha) at the Demonstration Farm of Wujiang Aquaculture Co. Ltd., Suzhou City, Jiangsu Province were renovated into one big pond for the demonstration of the USSEC IPA technology in 2013. Three concrete in-pond raceway cells were constructed in a 32-mu pond (Figure 1). The raceway cells are 22 meters in length, with two of the cells 5 meters in width and one of the cell 3 meters in width. A 13 x 3 m quiescent zone was constructed at the downstream end of the three raceway cells for collection of fish metabolic wastes. The average operating water depth is 1.6 m. Each raceway cell was equipped with the air-lift white water unit at the upper stream end for creating a constant water flow with high dissolved oxygen. The big pond was subdivided by an earthen dike to allow full circulation of the water flowing through the raceways and around the entire pond before re-entering the raceway cells.

The first demonstration fish were grass carp produced from the USSEC 2012 feeding trial and also purchased from local farms. The IPA cells 1 and 2 were stocked with 750 g and 300 g grass carp, respectively, in mid-May 2013. The IPA Cell 3 was stocked with 4.1 g grass carp in July 2013. The stocking data was shown in Table 1.

Grass carp in all three production cells were fed 4-5 times daily from the time of stocking until harvesting in November 2013. Grass carp in Cell 1 and 2 were fed with the USSEC 32/3 grass carp growout feed for the duration of the feeding demonstration. Grass carp in Cell 3 were fed the USSEC 36/7 SPC feed from fish size 4 g to 50 g, after which they were switched to the USSEC 32/3 feed. Both the 32/3 and 36/7 feeds were least-cost formulated and contained >40% soybean meal as the primary protein source (Table 1 -5). All feed was fed in extruded, floating pellet form. The feed was produced by the Ningbo Techbank Feed Company in Ningbo, Zhejiang Province, China, and least-cost formulated based on USSEC formulation specifications and with USSEC technical support.

Solid wastes were collected 2-3 times daily by a vacuum pump from the quiescent zone. Culture cells were periodically disinfected with approved chemicals for disease control. Fish were sampled monthly to monitor growth and FCR.

The comparison feeding demonstration was conducted about 6.0-month period. At the end of the feeding demonstration, the fish from each raceway cell harvested and weighed independently. Sub-samples of each species of fish were taken from each cell 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 cells. Data on production input costs was recorded throughout the demonstration to determine the economic return from each cell and the average for the three cells for each feed.

## **TRIAL RESULTS**

The first USSEC IPA demonstration was conducted from 4 May to 13 November, 2013.

Grass carp in IPA Cell 1 were harvested for marketing on November 13, 2013 (Table 6). The three year old grass carp in Cell 1 grew from 750 g to an average weight of 2,614 g in 182 days, with an FCR of 2.0:1 on the USSEC 32/3 soy-based feed. The total fish harvest weight from the 22 x 5 m Cell was 21,568 kg, with an average harvest biomass of 130.7 kg/m<sup>3</sup>. The grass carp survival rate was 94.5%.

Grass carp in IPA Cell 2 grew from 300 g to 1,660 g at the harvest, with an average FCR of 1.80:1 on the soybased feed. The total fish harvest weight was 14,223 kg, with a mean harvest biomass of 86.2 kg/m<sup>3</sup>. The grass carp survival rate was 85.3%. Grass carp in IPA Cell 2 will be transferred to Cell 1 for market size production in 2014.

Grass carp in IPA Cell 3 grew from 4.1 g to 80 g in 182 days. The FCR was 1.80:1 on the USSEC formulated 36/7 SPC feed. The total fish harvest weight from the 22 x 3 m Cell was 1348 kg, with an average harvest biomass of 56.2 kg/m<sup>3</sup>. The survival rate of grass fingerlings was 56.2%. The low survival was low due to the smaller stock size and some fish escaped from the fence soon after stocking. The fingerlings will be transferred to Cell 2 for further growout in 2014.

The USSEC IPA yielded an average return of investment (ROI) of 19.1% in the first year at the Wujiang Municipal Aquaculture Co. Ltd. Jiangsu Province, China despite of fish stock shortage, late fingerling stocking and abnormal hot summer in 2013 (Table 7).

The Wujiang IPA feeding demonstration yielded a total production of 41 metric tons of grass carp from the 2.1 ha pond unit containing the three IPA raceway cells. This represented nearly three times the average pond yield of 7.2 mt/ha obtained in the 2.57 million ha of fish ponds currently operated in China. The success of the initial USSEC IPA feeding demonstration proved that the IPA technology can help meet the demand for increased, sustainable aquaculture production in China with minimal environmental impact.

## **SUMMARY AND CONCLUSIONS**

The first USSEC IPA technology demonstration was successfully conducted in China. Grass carp in production Cell 2 will be transferred to Cell 1 and the fish in production Cell 3 will be transferred to Cell 2 for further growout culture in 2014. The production Cell 3 will be stocked with new fingerlings of grass carp. The IPA technology has attracted and generated considerable interests as a means to address the common constraints related to increasing demand for aquaculture products, increasing land value and rent prices, and water availability, water quality and food safety issues in China and elsewhere in the world. It is expected that more and more new IPA systems will be constructed in other regions in China in the coming years.

## **ACKNOWLEDGEMENTS**

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### **Chinese Currency and Production Unit Conversions:**

RMB 6.10 = US\$1.00

15 mu = 1.0 hectare (ha)

kg/mu x 15 = kg/ha

1.0 kg = 2.2 lb

6 mu = 1.0 acre (ac)

kg/mu x 13.2 = lb/ac

Table 1. Formula for the USSEC 32/3 soy-based feed used in the 2013 grass carp IPA demonstration at the Wujin Fish Farm in Jiangsu Province, China. The demonstration feed was produced by Ningbo Techbank Feed Company, Zhejiang Province.

<b>Ingredient</b>	<b>Percent of total</b>
Soybean Meal	43.00
Soy Protein Concentrate (SPC)	0.00
Soy Hulls	5.00
Wheat Flour	0.00
Wheat Midds	40.75
Corn Gluten Meal	2.00
Blood Meal, spray dried	5.00
Calcium phosphate mono - 21%P	1.48
Fish, Anchovy	0.00
Fish Oil	1.00
Soy Oil	0.00
Soy Lecithin	0.00
Vitamin Premix-F2	0.50
Mineral Premix F-1	0.25
DL-Methionine( 99%)	0.18
L-Lysine HCL (98.5%)	0.00
Choline Chloride 50%	0.19
Stay C - 35%	0.03
Ethoxyquin - Antioxidant	0.02
Solis MOS - Mycotoxin Binder	0.50
Mold Inhibitor	0.10
<b>Total</b>	<b>100.00</b>

Table 2. Calculated nutritional profile of the USSEC 32/3 soy-based growout diet tested in the 2013 grass carp IPA demonstration at the Wujin Fish Farm in Jiangsu Province, China. The demonstration feed was produced by Ningbo Techbank Feed Company, Zhejiang Province.

Nutrient	Amount	Unit
DE Fish (extr)	2217.59	kcal/kg
NFE	39.83	%
Starch	16.56	%
*Protein	32.01	%
Protein, dig.	28.86	%
Fish Protein	0.00	%
Soy Protein	20.27	%
Soy NFE	15.44	%
*Fat	3.04	%
W 3	0.31	%
W 6	0.58	%
Fiber	7.29	%
*Ash	6.06	%
Calcium	0.49	%
Phos Avail	0.51	%
Iron	486.55	ppm
Copper	30.63	ppm
Zinc	147.28	ppm
Selenium	1.09	ppm
Moisture	9.68	%
Vitamin C	105.00	mg/kg
Choline	2519.43	mg/kg
Ethoxyquin	134.50	mg/kg
Arginine	1.89	%
Lysine	1.83	%
Methionine	0.61	%
Meth+Cyst	1.15	%
Threonine	1.24	%
Tryptophan	0.38	%

Table 3. Formula for the USSEC 36/7 soy-based feed used in the 2013 grass carp IPA

demonstration at the Wujin Fish Farm in Jiangsu Province, China. The demonstration feed was produced by Ningbo Techbank Feed Company, Zhejiang Province.

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<b>Ingredient</b>	<b>Percent of total</b>
Soybean Meal	40.00
Soy Protein Concentrate (SPC)	5.00
Wheat Flour	15.00
Wheat Midds	17.00
Corn Gluten Meal	7.00
Blood Meal, spray dried	6.00
Calcium phosphate mono - 21% P	2.29
Fish, Anchovy	0.00
Fish Oil	1.00
Soy Oil	4.00
Soy Lecithin	1.00
Vitamin Premix-F2	0.50
Mineral Premix F-1	0.25
DL-Methionine( 99%)	0.16
L-Lysine HCL (98.5%)	0.05
Choline Chloride 50%	0.10
Stay C - 35%	0.03
Ethoxyquin - Antioxidant	0.02
Solis MOS - Mycotoxin Binder	0.50
Mold Inhibitor	0.10
<b>Total</b>	<b>100.00</b>

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Table 4. Calculated nutritional profile of the USSEC 36/7 SPC soy-based growout diet tested in the 2013 grass carp IPA demonstration at the Wujin Fish Farm in Jiangsu Province, China. The demonstration feed was produced by Ningbo Techbank Feed Company, Zhejiang Province.

<b>Nutrient</b>	<b>Amount</b>	<b>Unit</b>
DE Fish (extr)	2754.25	kcal/kg
NFE	35.65	%
Starch	17.01	%
*Protein	36.08	%
Protein, dig.	33.44	%
Fish Protein	0.00	%
Soy Protein	21.65	%
Soy NFE	13.34	%
*Fat	7.02	%
W 3	0.62	%
W 6	2.80	%
Fiber	3.96	%
*Ash	6.03	%
Calcium	0.55	%
Phos Avail	0.62	%
Iron	622.06	ppm
Copper	28.19	ppm
Zinc	136.10	ppm
Selenium	0.86	ppm
Moisture	9.35	%
Vitamin C	105.00	mg/kg
Choline	2524.89	mg/kg
Ethoxyquin	134.50	mg/kg
Arginine	2.10	%
Lysine	2.06	%
Methionine	0.69	%
Meth+Cyst	1.28	%
Threonine	1.42	%
Tryptophan	0.41	%



Table 5. Vitamin and mineral premix formulations used in the 2013 USSEC aquaculture feeding trial diets. Quantities of vitamins and minerals are per kilogram of premix. Premixes were produced by the Phoenix Feed Mill premix plant in Chengdu, Sichuan Province, under supervision of USSEC.

<b>Ingredient</b>	<b>Unit</b>	<b>Amount</b>
<b><u>Vitamin Premix F-2</u></b>		
	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
<b><u>Mineral Premix F-1</u></b>		
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 6. Stocking and harvest data for the 2013 USSEC IPA grass carp feeding demonstration at the Wujiang fish farm in Jiangsu Province, China.

<b>Description</b>	<b>IPA Cell 1</b>	<b>IPA Cell 2</b>	<b>IPA Cell 3</b>
IPA cell dimensions + water volume (m <sup>3</sup> )	22 m x 5 m x 1.5 m 165 m <sup>3</sup>	22 m x 5 m x 1.5 m 165 m <sup>3</sup>	22 m x 3 m x 1.5 m 99 m <sup>3</sup>
Fish stocking size (g)	750	300	4.1
Stocking density (fish/m <sup>3</sup> )	53	59	300
Total number fish stocked	8,732	9,687	30,000
Total fish stocking wt. (kg)	6,549	2,906	123
Total fish harvest wt. (kg)	21,568	14,223	1,348
Ave. fish harvest wt. (g)	2,614	1,660	80
Fish survival (%)	94.5	85.3	56.2
FCR	2.0:1	1.8:1	1.8:1

Table 7. Economics for the 2013 USSEC IPA grass carp feeding demonstration at the Wujiang fish farm in Jiangsu Province, China.

	<b>IPA Cell 1</b>	<b>IPA Cell 2</b>	<b>IPA Cell 3</b>	<b>Open Pond</b>
Gross Income (RMB)	289,011	199,122	18,872	38,400
Net Income (RMB)	32,576	39,542	-23,134	35,000
ROI (%)	12.7	24.7	-55.1	98.0



