

# **1995 and 1996 80:20 POND FIELD TRIALS WITH CRUCIAN CARP, PACU, TILAPIA AND WUCHANG CARP**

**H.R. Schmittou, Zhang Jian and M.C. Cremer<sup>1</sup>**

**American Soybean Association**

**Beijing, China**

## **ABSTRACT**

Fourteen pond trials were conducted in 1995 and 1996 to assess the fingerling to market growth of crucian carp, pacu, tilapia and wuchang carp (bream) with a variety of aquafeed formulations. The objective of the trials was to test and demonstrate the technical and economic feasibility of production of these species in 80:20 culture systems with feeds formulated primarily from plant proteins. An all-plant protein diet ('J') was tested against similar diets ('H' and 'K') containing primarily plant protein and 5% fish meal.

The all-plant protein 'J' diet produced as good or better growth than the 'H' diet containing fish meal with crucian carp. Crucian carp of approximately 50 g grew to an average of 227 g in six trials. The production target of 250 g was reached in only two trials. Float and sink forms of the test diets produced inconsistent results. Observations indicate crucian carp are not aggressive feeders and may require training at the fry to fingerling stage to readily adapt to floating feeds. Economic return with crucian carp was highly variable.

Pacu reached the production target of >400 g in two trials conducted and with all three diets tested ('H', 'J' and 'K'). There was no difference in pacu growth among the test diets, or among floating and sinking forms of the 'H' diet. Feed conversion ratios of 1.2-1.6 indicated rapid and economical growth of pacu on all diets.

Nile tilapia growth was best on the 'K' diet, although tilapia grew rapidly on both the 'J' and 'K' diets tested in one trial in 1995. Average daily growth rates were 8.3% and 9.7% of body weight, respectively, with 31-g fingerlings growing to 355-410 g in 126 days. A 1996 trial stocked fingerlings of 6 g that were unable to attain market size by the end of the production season. There was no growth difference of fingerlings with the 'J' and 'H' feeds.

Bream growth was also better on the 'K' diet, with only minor variations in growth among the 'H' and 'J' diets in three trials. Floating feeds produced better growth than sinking feeds with bream. Average bream growth, feed conversion ratio and economic return with the three diets was 356 g, 1.8 and Y3255/mu.

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<sup>1</sup> These trials were conducted in 1995 and 1996 by Dr. H. N. Schmittou and Mr. Zhang Jian of the American Soybean Association/China. Results of the trials were compiled and this report prepared by Dr. Michael Cremer, also of the American Soybean Association/China.

## Chinese Currency & Production Unit Conversions:

RMB 8.26 = 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

## INTRODUCTION

The American Soybean Association (ASA) began conducting field trials in 1992 to assess the technical and economic feasibility of feed-based 80:20 aquaculture technologies in ponds. ASA defines 80:20 pond fish culture as the raising of fish crops in ponds where a single feed-taking, high-value species of a single size group composes approximately 80% of the total fish harvest weight, and one or more other “service”, or non-feed-taking species, compose the other 20%. The technology is a modification of standard intensive pond monocultures used with various fish species throughout the world. The distinguishing feature with 80:20 is the 20% inclusion of one or more service species. Service species usually consist of filtering fish (primarily silver carp), but may include a predaceous fish if control of undesirable reproduction and/or wild fish is needed.

Development and testing of aquafeed formulations is an important component of establishing technical and economic feasibility for 80:20 culture species. In 1995, ASA established a goal of developing at least one economical aquafeed ration for each of eight high-value freshwater aquaculture species. Four species were targeted for 80:20 aquafeed testing in 1995 and 1996: crucian carp, pacu, Nile tilapia and wuchang carp (bream). Crucian carp was selected as the priority species because of its rapidly increasing market demand.

The objective of the 1995-96 trials was to test and demonstrate the technical and economic feasibility of production of the four target species in 80:20 culture systems with feeds formulated primarily from plant proteins. Plant proteins are preferred for aquafeeds because they are renewable and potentially more responsive to market demand, in comparison to fish meal, which is subject to greater supply fluctuation and price instability. Soybean meal in particular has become a standard protein source in feeds for omnivorous and herbivorous fish because of its high protein content (44-48%) and good palatability and digestibility. In the U.S. catfish industry, grow-out feeds that previously contained 30% or more fishmeal now utilize soybean meal as the primary protein source with no reduction in growth or feed conversion rate. As the majority of production species in China are omnivorous or herbivorous, they are good candidates for production in feed-based 80:20 production systems utilizing nutritionally balanced, all-plant or largely plant protein feeds. Common carp, grass carp, crucian carp, wuchang carp, black carp, Nile tilapia, pacu and channel catfish are all good candidate species for 80:20 production with these feeds.

ASA conducted fourteen field trials in 1995-96 in collaboration with the China National Fishery Technology Extension Center and its affiliate offices in seven provinces. Seven 80:20 field trials were conducted with crucian carp, two with pacu, two with Nile tilapia and three with bream. Trial results and observations are reported by species in this report.

## RESULTS

### Crucian Carp

Seven field trials were conducted in 1995 (3) and 1996 (4) to continue to assess crucian carp *Carrasias auratus gibelio* 80:20 production potential. An all-plant protein feed ('J' diet) was tested against a feed containing 5% fishmeal ('H' diet) (Table 1). Both feed formulations were tested in pelleted (sinking) and extruded (floating) forms. Fingerling stocking size averaged 52 g in 14 of 19 test ponds in the seven trials, with fingerling size variations from 25 g to 89 g in the other 5 ponds (Table 2). Stocking density for all trials averaged 1400/mu (21,000/ha), with a range of 1080-1800/mu (16,200-27,000/ha). Standard guidelines for ASA fish culture trials were followed.<sup>2</sup>

Results of crucian carp production and economic return with the two test feeds are presented in Table 2. Average fish growth by fingerling size group and feed type was as follows (all fish weights are averages):

- 27 g fingerlings grew to 147 g on the 'H' diet
- 35 g fingerlings grew to 184 g on the 'H' diet
- 52 g fingerlings grew to 222 g on 'H' and 'J' diets
- 87 g fingerlings grew to 275 g on the 'J' diet
- $H_{\text{sink wt}} = 232 \text{ g (5 trials)}$        $FCR = 2.0$     $S = 95\%$
- $J_{\text{sink wt}} = 255 \text{ g (2 trials)}$        $FCR = 2.0$     $S = 99\%$
- $H_{\text{float wt}} = 206 \text{ g (3 trials)}$        $FCR = 2.4$     $S = 94\%$
- $J_{\text{float wt}} = 202 \text{ g (1 trial)}$        $FCR = 2.4$     $S = 100\%$

The all-plant protein 'J' feed produced as good or better growth in crucian carp than the 'H' feed with fish meal in all trials where the diets were compared, both in sinking and floating forms. Fingerlings averaging approximately 50 g grew to an average of 231 g on the 'J' diet, and 225 g on the 'H' diet. Results with sinking and floating forms of the 'H' diet were mixed, with each producing better results in two of four comparative trials. The sinking form of the 'J' feed produced better results than the floating form in one comparative trial.

Growth performance of crucian carp was not affected by latitude. There were insignificant differences in production performance between latitudes of 45° (Heilongjiang), 40° (Tianjin), and 31° (Jiangsu) with the 'H' diet. The 'J' diet was tested at only the 31° latitude. Best

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<sup>2</sup>Schmittou, H.R. 1995. Guidelines for 80:20 Pond Production of Omnivorous Freshwater Fishes. American Soybean Association, Beijing, China.

economic returns were obtained in 1996 trials in Harbin and Tianjin, with an average net income of Y2,908/mu (\$5,280/ha).

The following conclusions and recommendations for future program activities are based on the results of these trials:

- While the no fish meal, 50% soybean meal 'J' diet produced as good or better growth with crucian carp than the 'H' diet that included fishmeal, both diets were marginal in meeting performance targets. The target market size of 250 g (average fish harvest weight) was reached in only two of twelve feeding trials, once with the 'J<sub>sink</sub>' diet (Wujiang 96) and once with the 'H<sub>sink</sub>' diet (Harbin 95). Modifications of the diets are indicated to improve growth performance.
- A minimum fingerling size of 55 g or larger is required to reach a market size of 250 g with the diets tested.
- Float and sink forms of the diets tested gave inconsistent results. Additional testing is warranted to determine the economic efficiency of floating feeds with the crucian carp. Trial observations indicated crucian carp are not aggressive feeders and may require training at the fry or fingerling stage to readily adapt to floating feeds.
- Differences in fish size, age, condition, and genotype, as well as variations in stocking density, management and trial duration, made comparison of results between trials difficult. To reduce variation, ASA will stress stricter standards for field trials in 1997, to include standardized stocking density and fish size and age, standardized genotype where feasible, increased replication both within treatments and among sites, and stricter management control by cooperators.
- Results to date indicate good potential for crucian carp as an 80:20 species. To better assess and quantify crucian carp pond production potential, ASA will begin implementation in 1997 of a multi-year sequence of field trials. This sequence will include:
  - 1997 - evaluation of crucian carp strains in fry-fingerling trials to identify growth differences
  - 1998 - evaluation of stocking density effect on fry-fingerling growth using the crucian carp strain(s) that exhibited the best combination of growth, survival and FCR in 1997 strain trials, followed by mass selection of fingerlings based on size
  - 1999 - evaluation of grow-out performance of mass select and average fingerlings from each density in 1998 trials, followed by mass selection of market fish based on size for use as breeding stock
  - 2000+ - breeding of 1999 select fish and evaluation of growth of fingerlings from select and average size brood fish

## **Pacu**

Two field trials were conducted in 1995 (1) and 1996 (1) as an initial assessment of pacu *Piaractus (Colossoma) brachyomum* production potential in 80:20 systems with high quality aquafeeds. Pacu production with three ASA feeds, 'H', 'J' and 'K' diets (Table 1), was compared to production with a local feed in 1995. A floating form of the 'H' feed was evaluated against the previously tested sinking form in 1996. Fingerlings of sizes 36 g and 50 g were stocked at densities of 600 and 800 fish per mu (9,000 and 12,000 fish per hectare), respectively, in the two trials.

Results of pacu production and economic return with the test feeds are presented in Table 3. Average fish growth by fingerling size and feed type was as follows:

- 50 g fingerlings grew to 418 g on ASA diets and 349 g on local diet ('95)
  - $H_{\text{sink wt}} = 425 \text{ g (1 trial)}$  FCR = 1.6 S = 99.8%
  - $J_{\text{sink wt}} = 407 \text{ g (1 trial)}$  FCR = 1.6 S = 99.8%
  - $K_{\text{sink wt}} = 422 \text{ g (1 trial)}$  FCR = 1.6 S = 99.6%
  - Local = 349 g (1 trial) FCR = 4.1 S = 99.6%
- 36 g fingerlings grew to 452 g on the 'H' diet ('96)
  - $H_{\text{sink wt}} = 449 \text{ g (1 trial)}$  FCR = 1.2 S = 99.5%
  - $H_{\text{float wt}} = 455 \text{ g (1 trial)}$  FCR = 1.2 S = 99.5%

Pacu grew rapidly on all three diets tested, averaging 6.5% of body weight per day in the 1995 trial where diets 'H', 'J' and 'K' were compared. There was no difference in growth rate among the three diets, with the all-plant protein 'J' feed performing as well as the 'H' and 'K' feeds with fish meal. All three feeds produced substantially better growth and FCR than the local feed tested. In the 1996 trial, pacu grew at an average of 10.6% of body weight per day, growing from 36 g to 452 g in 109 days with an FCR of 1.2. Floating and sinking forms of the 'H' feed did not produce any difference in growth in the 1996 trial. Average net economic return with the 'H' feed tested in 1996 was Y1114/mu (\$2,023/ha).

The following conclusions and recommendations for future program activities are based on the results of these trials:

- Pacu grew rapidly and exhibited high survival and low FCR on ASA aquafeeds both with and without fishmeal in initial field trial evaluations in Jiangsu Province. Growth and FCR with a local feed was significantly poorer than with ASA feeds.
- Fingerlings of size 35-50 g appear suitable for stocking at densities up to 800/mu (12,000/ha) to produce market fish of size 400-450 g. Testing of pacu at higher densities and with different size fingerlings is needed to better quantify production opportunities.
- Based on results to date, pacu is an excellent species for 80:20 pond production. It is recommended that field trial testing with pacu be expanded to better quantify production capacity and economic return with soybean-based aquafeeds.

## **Nile Tilapia**

Two field trials were conducted in 1995 (1) and 1996 (1) as an initial assessment of Nile tilapia *Oreochromis niloticus* 80:20 production potential with high quality aquafeeds. Sinking forms of the ASA diets 'J' and 'K' were tested against a local feed in a fingerling to market production trial in 1995. Fingerlings of size 31 g were stocked at 1500/mu (22,500/ha) in this trial. Floating forms of the ASA diets 'H' and 'J' were tested against each other in a fry to market production trial in 1996.

Results of Nile tilapia production with the test feeds are presented in Table 4. Average fish growth by fish size group and feed is shown below:

- 31 g fingerlings grew to 355 g and 410 g on the 'J' and 'K' diets, respectively, with 97% survival and an average FCR of 2.1
- 46 g fingerlings grew to 500 g on a local feed with 61% survival and FCR of 2.7
- 5.75 g fry grew to 171 g on the 'H' and 'J' diets with 81% survival and FCR of 1.25

Nile tilapia growth and FCR were 13% and 17% better, respectively, with the 'K' diet than with the 'J' diet, although tilapia grew rapidly on both test diets. Average daily growth rates of 8.3% ('J') and 9.7% ('K') of body weight were obtained. Fingerlings of size 31 g grew to 355-410 g in 126 days. FCR and survival were better with both of the ASA feeds than with the local feed. Differences in fingerling stocking size and poor survival of fish fed the local feed prevented direct comparison of local feed performance with the ASA diets.

Fry of size 6 g were too small in the 1996 trial to attain market size fish by the end of the production season in temperate, central China. An average harvest size of 171 g resulted in negative economic return.

Additional testing is required to adequately quantify Nile tilapia production potential in 80:20 systems with soybean-based aquafeeds.

## **Wuchang Carp (Bream)**

Three field trials were conducted in 1995 and 1996 to begin to assess Wuchang carp (bream) *Megalobrama amblycephala* production potential in 80:20 aquaculture systems with high quality aquafeeds. A 40% soybean meal, 5% fish meal 'K' diet was tested in two trials in 1995. This was followed in 1996 with a trial that compared the ASA 'H' and 'J' diets in sinking and floating forms. Stocking densities in the two 1995 trials were 1009/mu (15,135/ha) with 85-g fingerlings and 1158/MU (17,370/ha) with 39-g fingerlings. Stocking density in the 1996 trial was 888/mu (13,320/ha) with 110-g fingerlings.

Results of bream production and economic return with the test feeds are presented in Table 5. Average fish growth by fingerling size group and feed was:

- 39-g fingerlings grew to 410 g on the 'K' feed
- 85-g fingerlings grew to 390 g on the 'K' feed

- 110-g fingerlings grew to 302-355 g on the ‘H’ and ‘J’ feeds

Bream growth on the all-plant protein feed was as good or better than growth on the feeds containing fishmeal. Feed conversions were 1.8 for the ‘H’ and ‘J’ diets and 1.95 for the ‘K’ diet. Variations in growth with different size fingerlings were presumed due to variations in survival and duration of the respective trials. For example, the trial where 39-g fingerlings grew to 410 g was exceptionally long (234 days), and had significantly lower survival (83.1%) than other trials (ave. 98.2%).

Economic returns were high in two of the three trials reporting economic data. Lowest return was RMB2251/mu (\$4,087/ha) with the ‘K’ feed in 1995; highest return was RMB3695/mu (\$6,710/ha) with the ‘J’ floating feed in 1996. Average economic return for the floating ‘H’ and ‘J’ feeds was RMB3678/mu (\$6,679/ha), and for the sinking feeds RMB3335/mu (\$6,056/ha). The market price of wuchang bream in the trial area was RMB 24-30/kg (\$2.90-3.63/kg).

Based on the results of these trials, the following conclusions and recommendations for future program activities are made:

- Fingerling bream at various sizes and stocking densities grew well and exhibited high survival and low FCR on formulated aquafeeds both with and without fish meal in initial field trial evaluations in Jiangsu, Zhejiang and Shanxi Provinces. Economic returns were high in all trials.
- Bream exhibited good growth potential on both floating and sinking forms of formulated aquafeeds.
- Field trial testing with bream should be expanded to better quantify production capacity and economic return with soybean-based aquafeeds.

TABLE 1. ASA-FORMULATED FISH DIETS USED IN 80:20 POND FIELD TRIALS IN 1995 AND 1996.

Ingredient	Percent by Diet		
	‘H’	‘J’	‘K’
Fish Meal	5.00	0.00	5.00
Soybean Meal	40.00	50.00	40.00
Cottonseed Meal	5.00	5.00	5.00
Rapeseed Meal	5.00	5.00	5.00
Corn Gluten	9.00	10.00	5.00
Wheat Bran <sup>1</sup>	0.00	5.00	14.00
Rice Bran	20.00	8.00	10.00
Wheat Flour	10.50	11.30	10.60
Vegetable Oil	2.00	2.20	1.90
Vitamin Premix	1.00	1.00	1.00
Mineral Premix	0.95	0.95	0.95
Vitamin C	0.05	0.05	0.05
Mono-cal-phos	1.50	1.50	1.50

<sup>1</sup> Wheat bran was substituted for alfalfa, which was the ASA-specified ingredient, by the feed manufacturer, as alfalfa was not available



TABLE 2. PRODUCTION PERFORMANCE OF DIETS 'H' AND 'J' IN 80:20 POND FIELD TRIALS WITH CRUCIAN CARP *Carassias auratus gibelio* IN 1995 AND 1996.

	Treatment	No.	Stocking		No.	Harvest		Survival		Income
Location/Date	(diet)*	Reps	No/mu <sup>1</sup>	wt/fish (g)	Days	kg/mu <sup>2</sup>	wt/fish (g)	(%)	FCR	net/mu (RMB) <sup>3</sup>
CRUCIAN CARP										
Harbin - 95	H-s	1	1400	55	150	315	265	85	1.9	na
Harbin - 95	H-s	1	1400	35	150	218	184	84	1.9	na
Harbin - 95	H-s	1	1400	25	150	171	146	83	1.9	na
Harbin - 96	H-s	1	1080	28	140	148	143	94	1.7	3038
Harbin - 96	H-f	1	1080	28	140	158	152	96	1.7	3038
Wujiang - 95	H-s	1	1500	50	207	>240	>200	80	na	na
Wujiang - 95	J-s	1	1500	51	207	288	240	80	na	na
Wujiang - 96	H-s	1	1190	56	221	273	231	99.7	2.2	848
Wujiang - 96	H-f	1	1190	56	221	230	194	99.8	2.6	197
Wujiang - 96	J-s	1	1190	56	221	296	251	99.1	2.0	1034
Wujiang - 96	J-f	1	1190	56	221	240	202	99.8	2.4	288
Yuge - 95	H-s	1	1400	59	na	343	245	100	1.9	na
Yuge - 95	J-s	1	1398	87	na	193	275	50	na	na
Yuge - 96	H-s	2	1500	47	142	308	212	96.8	2.1	678
Yuge - 96	H-f	2	1500	47	142	254	184	91.6	2.6	-358
Tianjin - 96	H-s	1	1803	48	181	408	227	91.2	2.0	2473
Tianjin - 96	H-f	1	1800	48	181	432	240	91.5	1.9	3082

<sup>1</sup>Multiply by 15 to convert stocking density to number of fish per hectare

<sup>2</sup>Multiply by 15 to convert stocking production to kilograms per hectare

<sup>3</sup>Divide by 8.26 to convert RMB to U.S. Dollars; multiply by 15 to convert to income per hectare

TABLE 3. PRODUCTION PERFORMANCE OF DIETS ‘H’, ‘J’ AND ‘K’ IN 80:20 POND FIELD TRIALS WITH PACU *Piaractus (Colossoma) brachypomum* IN 1995 AND 1996.

Location/Date	Treatment (diet)*	No. Reps	Stocking		No. Days	Harvest		S (%)	FCR	Income net/mu (Yuan)
			No/mu	wt/fish (g)		kg/mu	wt/fish (g)			
<b>PACU</b>										
Pukou - 95	H-s	2	600	50	113	255	425	99.8	1.6	na
Pukou - 95	J-s	2	600	50	113	244	407	99.8	1.6	na
Pukou - 95	K-s	2	600	50	113	252	422	99.6	1.6	na
Pukou - 95	Local -s	1	600	50	113	209	349	99.6	4.1	na
Pukou - 96	H-s	1	800	36	109	357	449	99.5	1.2	1095
Pukou - 96	H-f	1	800	36	109	363	455	99.5	1.2	1133

TABLE 4. PRODUCTION PERFORMANCE OF DIETS ‘H’, ‘J’ AND ‘K’ IN 80:20 POND FIELD TRIALS WITH NILE TILAPIA *Oreochromis niloticus* IN 1995 AND 1996.

Location/Date	Treatment (diet)*	No. Reps	Stocking		No. Days	Harvest		S (%)	FCR	Income net/mu (Yuan)
			No/mu	wt/fish (g)		kg/mu	wt/fish (g)			
<b>NILE TILAPIA</b>										
Beijing - 95	J-s	1	1500	31	126	517	355	97	2.3	na
Beijing - 95	K-s	1	1500	31	126	597	410	97	1.9	na
Beijing - 95	Local-s	1	1500	46	126	459	500	61	2.7	na
Pukou - 96	J-f	2	na	5.75	148	251	171	78	1.2	-1142
Pukou - 96	H-f	2	na	5.75	148	234	172	84	1.3	-963

TABLE 5. PRODUCTION PERFORMANCE OF DIETS ‘H’, ‘J’ AND ‘K’ IN 80:20 POND FIELD TRIALS WITH WUCHANG CARP (BREAM) *Megalobrama amblycephala* IN 1995 AND 1996.

Location/Date	Treatment (diet)*	No. Reps	Stocking		No. Days	Harvest		S (%)	FCR	Income net/mu (Yuan)
			No/mu	wt/fish (g)		kg/mu	wt/fish (g)			
<b>WUCHANG CARP</b>										
Yuge - 95	K-s	1	1009	85	na	385	390	97.8	2.1	na
Hangzhou - 95	K-s	1	1158	39	234	395	410	83.1	1.8	2251
Qinxi (Taiyuan) - 96	H-s	1	888	110	na	186	302	99.4	1.9	3093
Qinxi (Taiyuan) - 96	H-f	1	888	100	na	204	340	99.6	1.7	3661
Qinxi (Taiyuan) - 96	J-s	1	888	110	na	201	339	99.2	1.8	3576
Qinxi (Taiyuan) - 96	J-f	1	888	110	na	202	355	95.1	1.7	3695