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First trial growing vaccinated Nile tilapia in IPRS in Colombia

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Results show adequate growth, improved survival and economic performance

Aerial view of the raceways of the IPRS system used in the trial at El Guajaro Aquaculture, a commercial tilapia farm near Cartagena, Colombia.

El Guajaro Aquaculture, a commercial tilapia farm near Cartagena, Colombia, has been facing a challenging situation regarding its water supply. It can no longer pump water from El Guajaro Lake because its water is highly eutrophic. However, the water quality from the lake is suitable for aquaculture, with alkalinity averaging 401 meq/L (milliequivalents per liter; range 380 to 420), hardness averaging 161.5 mg/L, (145 to 185); pH averaging 8.12 (7.9 to 8.4) and salinity values between 0.6 to 1.0 ppt. Therefore, the farm recently set up a water recirculating system that does not use water from the lake. The original farm water has a heavy organic load, which affects dissolved oxygen on the farm.

We recently carried out a study to assess the performance of vaccinated Nile tilapia in an in-pond raceway system (IPRS). We acknowledge the support of **Acuacultivos El Guajaro** (http://www.acuaguajaro.com.co/) in Cartagena Colombia for their support and use of their tilapia farm facilities; and also the U.S. Soybean Export Council (**USSEC** (https://ussoy.org/)) for their financial support for this trial.

Study setup

The farm designed a 1.14-hectare pond with an average depth of 1.4 meters and total volume of 15,960 cubic meters. Three IPRS raceways were built in the pond, each with 154 cubic meters of culture volume, for a total raceway culture volume of 462 cubic meters and representing 2.89 percent of the total pond water volume.

Each raceway was stocked with 25,044 tilapia fingerlings (average weight 41.3 grams) vaccinated against the bacterium *Streptococcus agalactiae* type B. Fish were stocked at 163 fish per cubic meter and an initial biomass of 6.72 kg per cubic meter. Fish growth was assessed biweekly, and various water quality parameters were monitored twice a week, including dissolved oxygen, temperature (twice daily, morning and late afternoon) ammonia, nitrite, pH, hardness and alkalinity. Fish were fed six times a day the first month and then fed no less than four times a day (based on body weight) rest of the trial. Mortalities were collected from the raceways and counted.

Fish were fed a USSEC formula feed with 38 percent crude protein (CP) on the first month and 32 percent CP for the rest of the study. This diet also included 6 percent lipids, 12 percent humidity, 10 percent fiber, 12 percent ash and 48 percent soy inclusion.

When the fish reached 100 to 125 grams, the small screens of the IPRS were removed and replaced with larger screen mesh. Use of larger screens and screen maintenance improved water flow through the raceways as the fish grew and required better water quality.

Results and discussion

The vaccinated tilapia used in this trial yielded a total of 25,327 kg per ha, with a survival of 83 percent, an FCR averaging 1.29 and an average weight gain of 4.34 grams per day. El Guajaro Aquaculture typically has survival rates of 60 percent using non-vaccinated tilapia. Although non-vaccinated raceways were not included in this study, the *Streptococcus agalactiae* type B, vaccination appeared to have increased survival rates of 83 to 85 percent. Endemic low dissolved oxygen across the farm contributes to fish stress and traditional pond production as low as 15,000 kg per ha per harvest.

Under low oxygen concentration conditions, fish were fed up to approx. 456 kg per ha per day by day 77, but increasing biomass and stressful conditions forced management to increase aeration and to lower feed amounts fed to 388 kg per ha per day during the last weeks of the trial. Increasing aeration and decreasing feed intake were reflected on the weight gain (grams per day), which averaged 4.34, slightly lower than the IPRS standard of 4.4 to 4.5 grams per day reported by the corresponding author at a recent aquaculture congress in 2019 for red tilapia. Higher weight gains (grams per day) have been observed with tilapia by other researchers.

Fish were stocked to target 500 grams at harvest. Stocked at 41.3 grams average, our vaccinated tilapia reached market size in 106 days. Long episodes of low dissolved oxygen lead to early partial harvest as indicated in Table 1. Average weight at partial harvest is not included on the calculation of overall average weight per raceways. Overall average weight was calculated by divided total weight harvested by number of total fish harvested. This average reflects a better way how fish was marketed.

Arana, IPRS, Table 1

Raceway	Harvest date	Partial harvest (kg)	No. fish harvested	Fish average weight (g)
RW1	2 Oct 2019	1,101	3,172	347
RW1	16 Oct 2019	1,532	3,581	428
RW1	30 Oct 2019	3,624	7,373	492
RW1	31 Oct 2019	3,582	7,222	496
Sub-totals	–	9,838	21,347	461
RW2	2 Oct 2019	1,041	2,975	350
RW2	16 Oct 2019	1,254	3,043	412
RW2	30 Oct 2019	7,419	15,026	494
RW2	30 Oct 2019	9	18	488
Sub-totals	–	9,723	21,063	462
RW3	5 Oct 2019	1,792	4,480	370
RW3	28 Oct 2019	5,565	10,954	508
RW3	30 Oct 2019	1,955	4,133	473
Sub-totals	–	9,312	19,927	467
TOTAL	–	28,873	62,337	463

Table 1. Biomass production and average fish weights from the three raceways in the IPRS system tested.

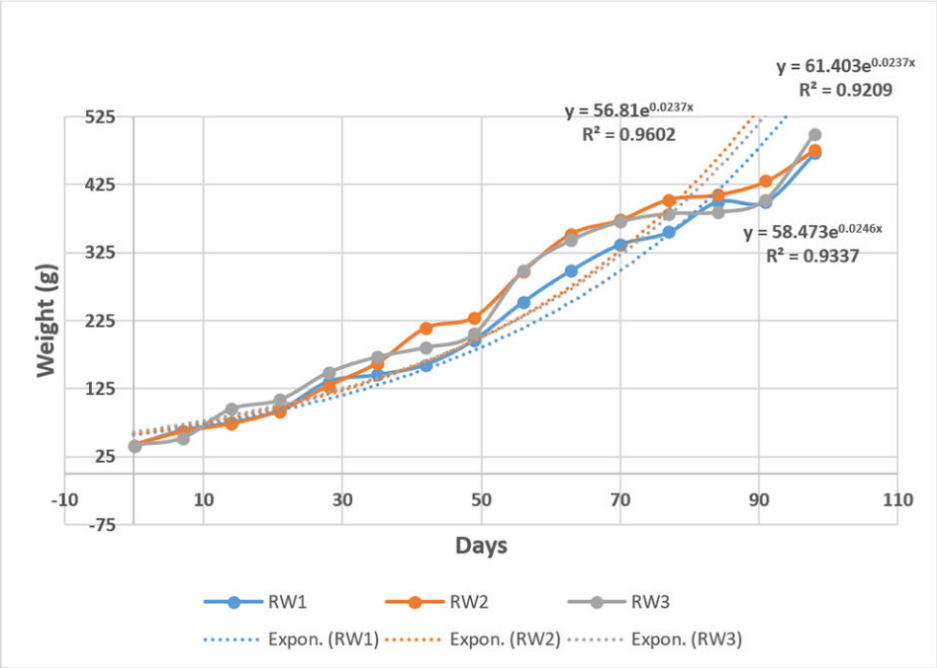

Fig. 1: Growth (weight in grams) of vaccinated tilapia in the IPRS study.

Aeration was increased from 11.5 Hp to 19 Hp during the last 1.5 months of the trial before harvest. The surge in electric power usage was a concern, but the resulting final production was adequate, as shown in the financial statement. Traditional ponds typically use 12 Hp per cycle only at night aeration.

Arana, IPRS, Table 2

Variable	RW3	RW2	RW1	Total
No. fish stocked	25,044	25,044	25,044	75,132
Initial total weight (kg)	1,034	1,034	1,034	3,102
Initial average weight (g)	41.3	41.3	41.3	–
Stocking date	16 July 2019	16 July 2019	16 July 2019	–
Harvest date	30 October 2019	30 October 2019	30 October 2019	–
Total days of culture	106	106	106	–
Harvest biomass (kg/raceway)	9,312	9,723	9,838	28,873
No. fish harvested	19,927	21,063	21,347	62,337
Survival (%)	79.6	84.1	85.2	–
Kg per cubic meters harvested	60.5	63.1	63.9	–
Final average weight (g)	467	462	461	463
Average weight gain (g/day)	4.41	4.35	4.27	–
FCR	1.32	1.30	1.27	1.29

Table 2. Production data from the three raceways in the IPRS system tested.

Water temperature during the trial was closely monitored because of its potential impact on *Streptococcus agalactiae* type B induced mortality in tilapia. Water temperatures at 2 p.m. reached as high as 33.7 degrees-C and as low as 31.5 degrees-C. Morning temperatures at 6 a.m. were as high as 31.5 degrees-C and as low as 29.0 degrees-C.

One of the biggest issues at the El Guajaro is water with high organic matter content, which increases the dissolved oxygen consumption that is vital for adequate growth and well-being of the cultured fish. As shown in Fig. 2, at 6 a.m. the dissolved oxygen (DO) readings collected were as high as 2.8 ppm and as low as 1.0 ppm. However, as mentioned earlier, feed intake was decreased and aeration increased to support maintaining DO above 1.5 ppm, at limits that would still support adequate tilapia growth. The DO levels in the afternoon (2 p.m.) were not an issue, with readings as high as 13.0 ppm and low as 4.5.

Fig. 2: Dissolved oxygen readings from inside raceway 2 at 6 a.m. and 2 p.m. during the IPRS trial.

At the beginning of the trial the ammonia concentration was 0.5 ppm, then during the first 1.5 weeks it increased to 1.1 ppm and as the population of nitrifying bacteria became established. Ammonia levels during the trial went from 1.1 to 0.1 and then increased slightly to 0.2 ppm at the end of the trial. The nitrite levels followed a similar pattern, with readings of 0.65 ppm at the beginning of the trial, increasing to 0.95 during the first weeks, followed by a steady decline to 0.6 ppm at the end of the trial.

A combination of increased mechanical aeration, decreased feeding intake and increased water exchange helped maintain DO above 1.5 ppm in the morning, and to lower ammonia and nitrite concentration to safe levels.

Observed surface water velocity averaged 10.0 cm per second. Water flow appeared to reduce the abdominal fat content of the tilapia. In traditional ponds the fat dress out of the fish is 11.8 percent; in our IPRS tilapia it lower at 11.2 percent. It is worth mentioning that Cartagena customers mentioned

that tilapia from our trial had firmer flesh and more noticeable silver coloration, and were very well accepted.

Higher consumption of electric energy has been a concern of potential users of the IPRS system. In this trial, because of the specific eutrophic conditions at the location, more mechanical aeration was needed, which increased the energy cost to (U.S.) 11 cents per kg of fish for IPRS; for traditional ponds, this cost is typically 7 cents. However, this was compensated by the water exchange power usage (pumping), with costs of 1 cent per kg of fish for the IPRS compared to 9 cents per kg of fish for traditional ponds.

Arana, IPRS, Table 3

VARIABLE COSTS	IPRS %	Traditional pond %
Feed	55.46	50.06
Fingerlings	3.04	2.31
Vaccination	8.41	6.38
Power, aeration, pumping	10.18	11.92
Transport, rent, others	1.24	1.76
Personnel	10.46	11.92
Maintenance	3.41	4.83
Others	1.57	2.22
TOTAL VARIABLE COSTS	93.77	94.21
FIXED COSTS		
IPRS construction	2.14	0
Administration	2.74	3.87
Marketing	0.4	0.56
Loans	0.95	1.36
TOTAL FIXED COSTS	6.23	5.79
TOTAL COSTS (variable + fixed) USD/kg	100	100
Sales (USD/kg)	1.56	1.56
Profit (USD/kg)	0.36	0.23
Return on investment (ROI, %)	30	16

Table 3. Financial data for the IPRS trial vs. traditional ponds.

Conclusions

The water quality at the tilapia farm where this IPRS trial was carried out has good alkalinity, hardness and salinity levels, but also a high content of organic matter which results in permanent low dissolved oxygen concentrations in the morning in its traditional ponds. During the IPRS trial, mechanical aeration had to be increased and feed applications decreased to maintain adequate oxygen levels for tilapia growth.

The high temperature and low DO in the morning provided favorable conditions for pathogenic *Streptococcus agalactiae* type B to develop. However, the use of vaccinated fish in the IPRS trial produced increased survival rates vs. traditional pond results, 83 and 60 percent, respectively.

Use of the IPRS technology increased production vs. traditional pond results, from 15 tons per ha to 25 tons per ha per harvest. One important aspect of the IPRS is that frequent removal of fish waste in the system likely had a significant positive impact in increasing tilapia production. The farm's 16 percent return on investment (ROI) for traditional ponds was increased to 30 percent in the IPRS system, an increase of 53 percent.

These encouraging results, together with the very positive reactions to fish form the IPRS trial by customers in Cartagena, indicate the significant potential for the IPRS technology for the production of tilapia and other fish species in Colombia and other countries in the region.

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