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Nursery trial compares filtration system performance in intensive raceways

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Trial evaluates bead filtration, foam fractionation and pressurized sand filtration

Concerns regarding influent disease epizootics and the environmental impacts of aquaculture effluents have led the shrimp-farming industry to research methods of increasing biosecurity and reducing environmental impacts through limited water exchange. With these objectives, the authors conducted a 74-day nursery study at the Texas Agricultural Experiment Station Shrimp Mariculture Research Facility in Corpus Christi, Texas, USA, in the spring of 2003.

The raceway operated with a pressurized sand filter showed a high dissolved organic load in the culture water.

Raceway study

Three 45-cubic-meter, HDPE-lined, greenhouse-enclosed raceways designed to refine the biosecure management of intensive nurseries were operated under limited water discharge. The performance of Pacific white shrimp (*Litopenaeus vannamei)* was evaluated using three water treatment systems: bead filtration, foam fractionation, and pressurized sand filtration. Selected water quality indicators were monitored to assay the systems and their effects on shrimp growth and survival.

All culture tanks were equipped with a longitudinal center partition positioned over a bottom water distribution manifold. Water mixing and circulation was generated by 18 airlift pumps made of 5.1-mm PVC pipe positioned on both sides of the partition and water pumped through the bottom manifold and its associated spray nozzles. Aeration was provided via six 1-m-long air diffusers and a venturi injector operated with air or oxygen.

The raceways were filled with filtered seawater adjusted to 30 ppt salinity using municipal freshwater. Following chlorination and dechlorination of the residual chlorine after 24 hours, the water was inoculated with the marine diatom *Chaetoceros muelleri* at 50,000 per milliliter. Raceways were stocked with 5-day-old postlarvae (PL).

Stocking, feeding

Although stocking density was intended to be similar, an error during the stocking process resulted in densities of 3,800; 6,500; and 5,000 PL per cubic meter for raceways operated with the bead filter, pressurized sand filter and foam fractionator, respectively. Newly hatched artemia nauplii were fed during the first 10 days after stocking.

Dry feed rations with 45 to 50 percent crude protein were then targeted at 18 percent per day of total estimated biomass down to 7 percent per day toward harvest. Rations were further adjusted based on feed consumption and growth.

Environmental parameters, harvest

Temperature, dissolved oxygen, pH, and salinity were monitored at least twice daily. Settleable solids were monitored daily beginning on day 49. Ammonia, nitrite, nitrate, reactive phosphorus, total suspended solids, volatile suspended solids, five-day carbonaceous biochemical oxygen demand and chemical oxygen demand were monitored weekly in each tank. Random shrimp samples were sent for disease diagnosis every two weeks.

The bead filter and foam fractionator were operated continuously for 46 days. The pressurized sand filter was operated for only 33 days with an average daily use of 25 minutes. At harvest, shrimp were netted in baskets weighed after water drained for 20 seconds. Another 5 percent of the recorded yield was subtracted to account for excess water weight. Survival rates were based on total biomass and shrimp average weights.

Samocha, Changes in water quality over 74 days, Table 1

Day	Water Quality Indicators (mg/l) $_cBOD_5$	Water Quality Indicators (mg/l) COD	Water Quality Indicators (mg/l) NH_3-N	Water Quality Indicators (mg/l) NO_2	Water Quality Indicators (mg/l) NO_3	Water Quality Indicators (mg/l) RP	Water Quality Indicators (mg/l) TSS	Water Quality Indicators (mg/l) VSS
1	9.2	580	2.09	0.21	3.52	1.48	20	10
7	5.2	413	1.52	0.05	4.54	1.30	90	10
15	4.5	626	3.78	0.60	2.22	7.16	110	35
22	6.2	2,651	2.48	3.55	11.37	2.32	40	25
28	6.2	1,681	2.22	5.68	21.56	3.00	45	30
35	9.2	3,883	2.40	8.79	20.64	3.18	110	60
42	18.5	2,323	2.59	13.69	50.38	3.59	120	80
49	58.8		4.88	19.07	74.42	5.39	220	110
56	NA	NA	0.42	0.78	35.26	9.38	400	200
58	54.9	NA	4.99	4.93	41.42	11.78	600	500
63	17.6	NA	8.38	0.87	51.18	15.54	300	250
70	36.8	NA	15.02	0.10	55.82	20.63	400	150
74	73.6	NA	22.64	0.78	55.39	25.57	700	200

Table 1. Changes in water quality over 74 days in an intensive shrimp nursery raceway operated with a pressurized sand filter.

cBOD5 = Five-day carbonaceous biochemical oxygen demand
COD = Chemical oxygen demand

NH3-N = Ammonia nitrogen
NO2 = Nitrite
NO3 = Nitrate
RP = Reactive phosphorus
TSS = Total suspended solids
VSS = Volatile suspended solids

Results

Overall yields ranged 2.42 to 5.26 kilograms per cubic meter for the study (Table 2). Survival rates ranged 96.3 to 100 percent, while FCRs varied 1.09 to 1.70. The raceway operated with the pressurized sand filter at the highest stocking density produced the best survival, average weight, and yield with the lowest FCR value and water exchange (less than 0.5 percent per day) among the three raceways.

Samocha, Performance summary of the intensive nursery study, Table 2

Treatment	PL/m^3	Initial Weight (mg)	Days	Final Weight (g)	Yield (kg/m/m^3)	Survival (%)	New Water (% total volume/day)	FCR
BF	3,780	0.6	74	0.65	2.42	96.3	1.35	1.70
PSF	6,540	0.6	74	0.85	5.26	100.1	0.47	1.09
FF	5,010	0.6	74	0.69	3.18	97.8	2.06	1.50

Table 2. Performance summary of the intensive nursery study with Litopenaeus vannamei operated with limited discharge.

BF = Bead filter PSF = Pressurized sand filter FF = Foam fractionator

Although high ammonia and nitrite levels were found in the culture water, all harvested shrimp were in apparent excellent health, with no visual signs of bacterial or viral infection, no external fouling or damage to cuticles and no broken appendages.

Pressurized sand filter

Table 1 summarizes the changes in water quality indicators in the raceway operated with the pressurized sand filter. The results suggested that accumulation of particulate matter under well-mixed and oxygenated water conditions stimulated the development of beneficial microorganisms that can help with the nitrification process.

Furthermore, the low FCR value obtained in this system suggested the shrimp actively fed on bacterial flocs and other particulate matter developed in the system. Four days before the harvest of this raceway, a constant 40 liters per minute supply of oxygen was needed to support the high oxygen demand.

Foam fractionator

The raceway with the foam fractionator had a persistent green algal bloom of up to 5 x 106 cells per milliliter throughout the study. The efficient removal of the particulate matter by the foam fractionator (Fig. 1) may have resulted in this heavy blooming. Occasional water exchanges were needed to alleviate shrimp stress created by the blooms.

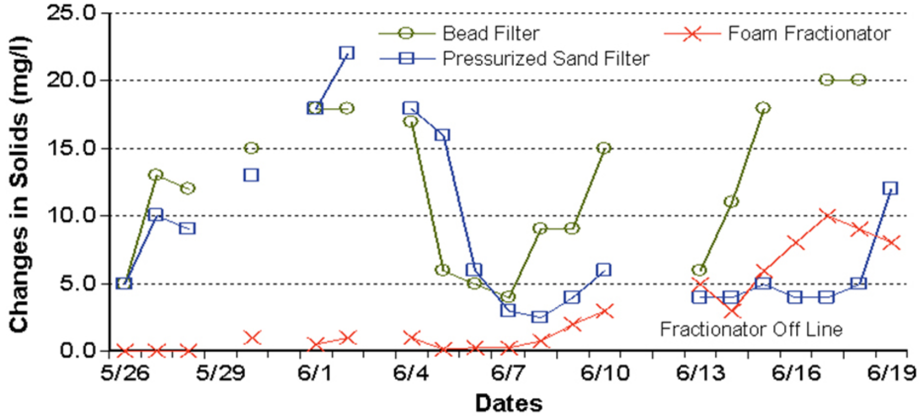

Fig. 1: Changes in settleable solids in raceways operated with bead filter, pressurized sand filter, and foam fractionator over 74-day nursery trial.

To avoid further deterioration of the shrimp health, the foam fractionator was taken off line about a week before the harvest. Interestingly, the raceway operated with the bead filter also required occasional water exchanges to alleviate signs of shrimp stress. Inadequate filtration may have been to blame for the inferior performance of the shrimp in this raceway.

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