Intensive Grow-out Of Pacific White Shrimp *Litopenaeus vannamei* In Greenhouse-enclosed Raceways With Limited Water Discharge

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Introduction

- In the last few decades, production of the Pacific white shrimp, *Litopenaeus vannamei*, has been negatively affected by disease epizootics and environmental concerns over the effluent impact on receiving streams
- Traditional shrimp grow-out methods typically use outdoor ponds and require high water exchange
- The possible introduction of harmful pathogens with the incoming water and the release of nutrient-rich effluent into receiving streams are issues of concern

Introduction

- These issues force the industry to seek out more sustainable management practices
- Limited discharge recirculating aquaculture systems (RAS) are an option that can reduce disease introduction and the negative environmental impact created by traditional pond culture
- Previous research has indicated that good shrimp production can be achieved under low water exchange

Objective

- To evaluate the feasibility of using a small scale greenhouse-enclosed raceway system for the production of marketable-size *L. vannamei*
- Specifically the study was designed to evaluate:
  1. Whether or not the system is suitable for the production of food size shrimp
  2. The effect of using foam fractionator and limited water exchange on selected water quality indicators and shrimp performance
  3. The potential use of molasses to suppress ammonium buildup in the culture medium

Materials & Methods

- Juvenile shrimp (0.76 ± 0.08 g) were stocked (279 shrimp/m^3) in six 40 m^3 (68.5 m^2) EPDM-lined raceways filled with a mix of “aged” water from a two-month nursery trial and small amount of chlorine-treated water pumped from a nearby shallow lagoon
- Each RW has six banks of three 5.1 cm airlift pumps, six 1 m long air diffusers, a pressurized sand filter, a center longitudinal partition over a 5.1 cm PVC pipe fitted with spray nozzles connected to a venturi injector


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Materials & Methods

- Two of the RWs (2, 3) were outfitted with home made foam fractionator (FF)
- The study had three treatments:
  1. Two RWs to be operated with limited discharge and molasses application whenever NH_4-N levels above 1 mg/L were found
  2. Two RWs to be operated with limited discharge and FF with molasses application whenever NH_4-N levels above 1 mg/L were found
  3. Two RWs were operated with increased water exchange and no molasses application

Materials & Methods

- Shrimp were fed (4 times/d) a 35% CP commercial diet (Hyper-Intensive 35, Zeigler Bros., Gardners, PA)
- Weekly rations were adjusted based on FCR of 1:1.4, growth of 1.2 g/wk and assumed mortality of 1%/wk

Materials and Methods

- Temp., salinity, dissolved oxygen and pH were monitored twice daily NH_4-N were monitored daily in all six RW
- Alkalinity, settleable solids, turbidity, algal counts, TSS, VSS, $cBOD_5$, NO_2-N, NO_3-N, and reactive phosphorus were monitored weekly
- Alkalinity and pH were controlled with sodium bicarbonate and agricultural lime

Materials & Methods

- Data was analyzed using SPSS statistical analysis software
- A significance level of α=0.05 was used for all tests
- Repeated Measures ANOVA to identify differences between treatments in daily and weekly water quality indicator
- One-way ANOVA to identify differences between treatments for survival (arcsine transformed), mean final weight and FCR followed by SNK tests

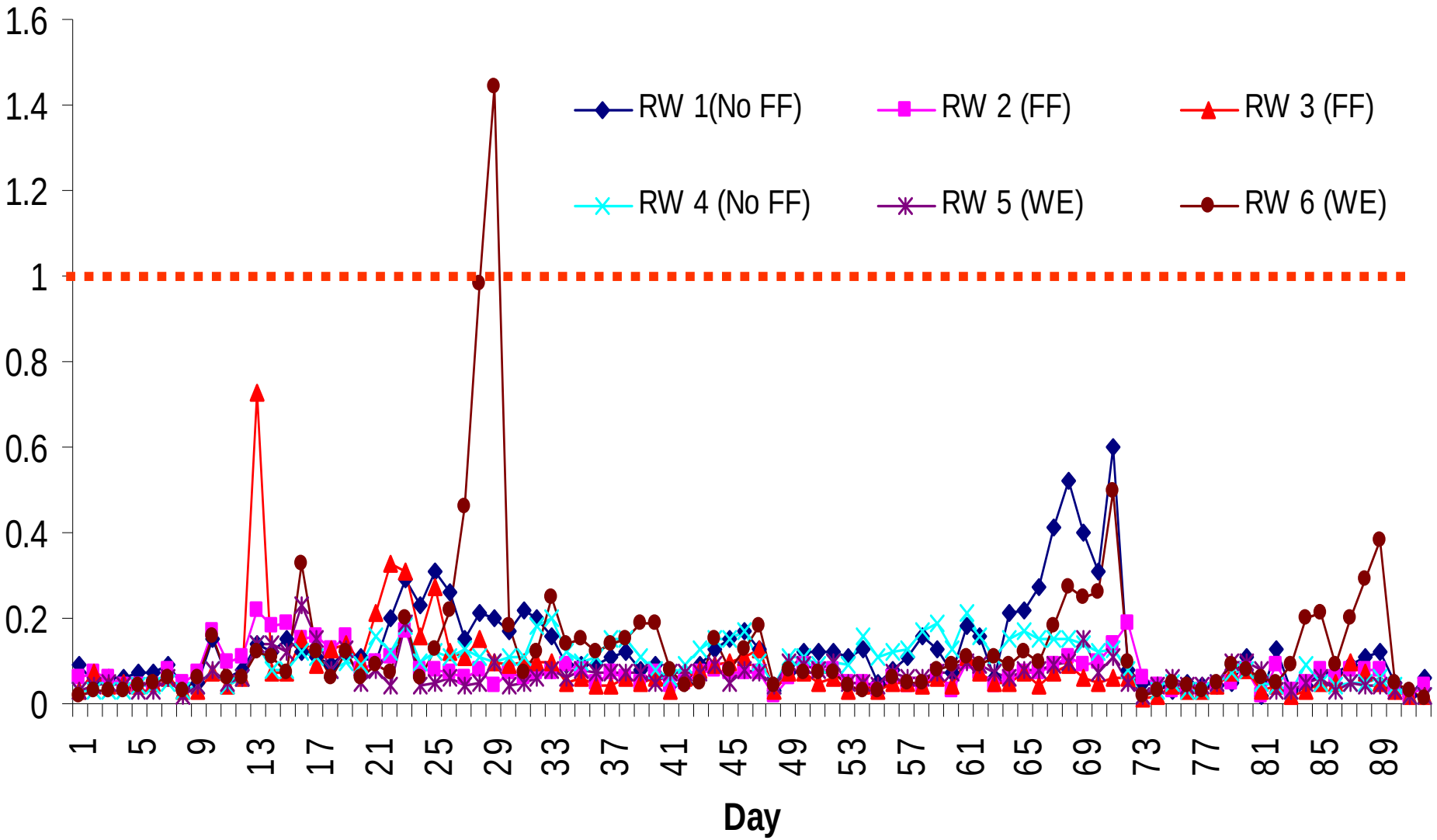
Results

- All six raceways required only limited water exchange (< 1.36% total vol./d)
- Because NH_4-N levels stayed below 1 mg/L in all four RWs targeted for molasses application, no molasses was required to control the buildup of this metabolite
- NO_2-N levels in all six RWs were low throughout the study (< 2.5 mg/L)
- pH values as low as 5.9 were found in the raceways which were adjusted with sodium bicarbonate and agricultural lime

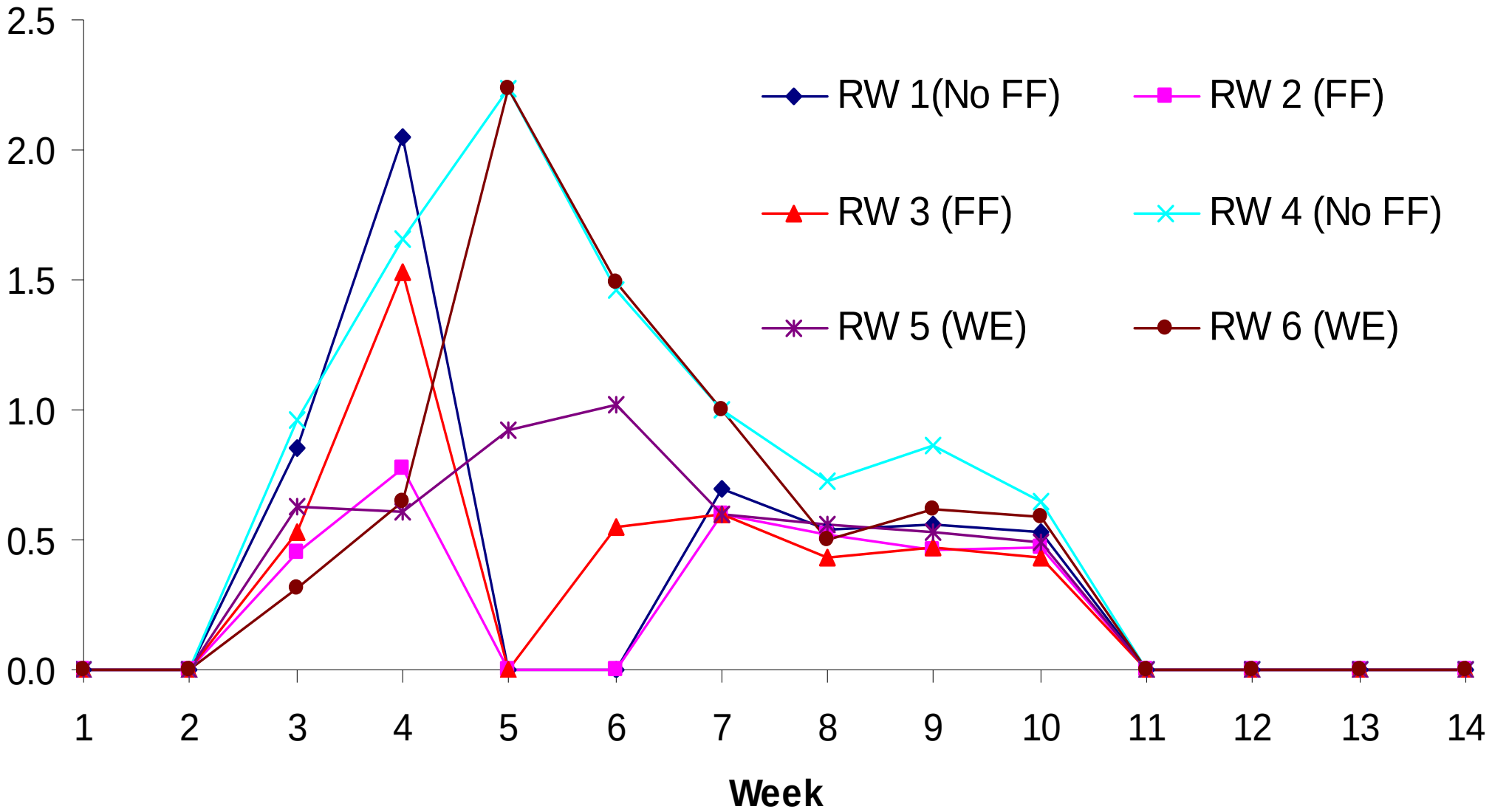
Results

- The RP levels were significantly higher in RWs operated under limited water discharge vs. RWs operated with higher water exchange
- The SNK test showed no statistically significant differences in daily NH_4-N levels between treatments
- No significant differences were found between treatments in $cBOD_5$, TSS, VSS, SS, NH_4-N, NO_2-N, NO_3-N, alkalinity, turbidity, and algal counts

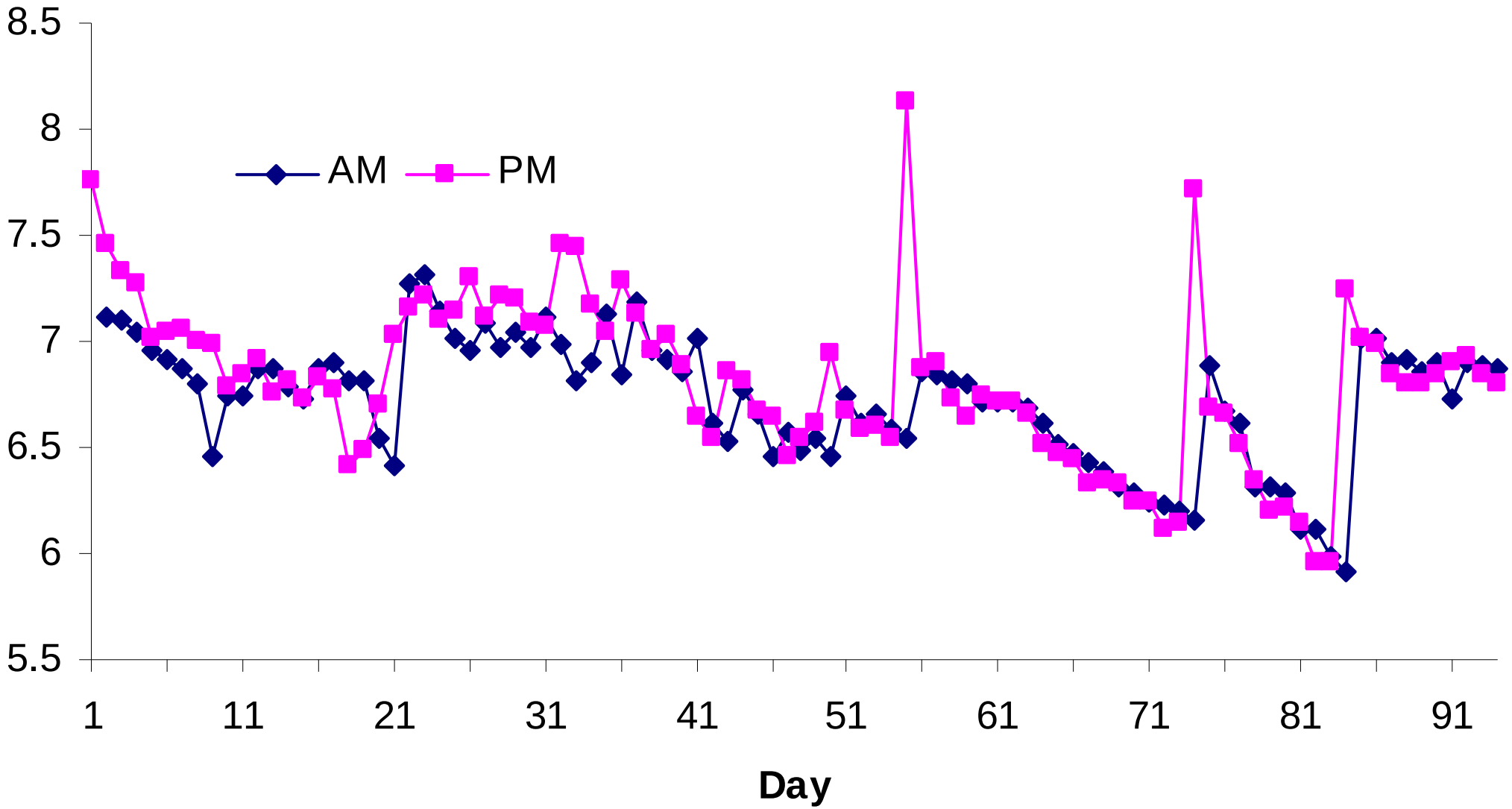
Daily changes in NH_4-N (mg/L)



Weekly changes in NO_2-N (mg/L)



Daily changes in pH (RW 5)



Summary of daily water quality for the raceways grow-out study

RW	Temp. (C) a.m.	Temp. (C) p.m.	DO (mg/L) a.m.	DO (mg/L) p.m.	pH a.m.	pH p.m.	NH_4-N (mg/L)	Sal. (ppt)
No FF [1]	28.1	29.1	5.7 [ac]	5.5	6.7	6.7	0.11	35
FF [2]	28.1	29.4	5.5 [ab]	5.4	6.7	6.7	0.08	36
WE [3]	28.8	30.1	5.8 [c]	5.7	6.7	6.7	0.10	34

[1] RW's designed to be operated with molasses & limited water exchange w/o FF
[2] RW's designed to be operated with molasses & limited water exchange w FF
[3] RW's designed to be operated with increased water exchange and w/o FF

Summary of daily & weekly water quality the raceways grow-out study

RW	$cBOD_5$	TAN	NO_2-N	NO_3-N	RP	TSS	VSS	SS	Turb.	Algae
	(mg/L)							(mL/L)	(NTU)	($x10^4$)
No FF [1]	28.9	0.11	0.53	67.5	13 [a]	358	255	9.4	185	144.3
FF [2]	26.2	0.80	0.28	74.1	13 [a]	383	263	8.6	202	154.7
WE [3]	26.8	0.10	0.46	65.6	11 [b]	395	270	9.4	202	163.6

[1] RW's designed to be operated with molasses & limited water exchange w/o FF
[2] RW's designed to be operated with molasses & limited water exchange w FF
[3] RW's designed to be operated with increased water exchange and w/o FF
Columns w/o superscript letters suggest no statistically significant differences

Results & Discussion

- All shrimp submitted for disease diagnosis (TVMDL) showed no signs of viral or bacterial infections
- Except for the jumping of the shrimp experienced in two RWs, the system was suitable for the production of food size shrimp
- Higher survival and yields with lower FCR and water use were found in the RWs operated with FF
- Although yield > 4 kg/m^3 was achieved there was no need to inject oxygen into the culture medium

Litopenaeus vannamei Performance In A 94 d Grow-out Trial In Greenhouse-enclosed RW's Stocked With Juveniles (0.76 g) At A Density Of 279/m^3 & Operated With Limited Water Exchange

Treatment	Wt_f (g)	Growth (g/wk)	Yield (kg/m^3)	Sur. (%)	FCR	New Water (%/d)
No FF (1) [1]	17.2^{a}	1.29^{a}	4.11^{ab}	85.9^{b}	1.28^{ab}	0.74^{a}
No FF (4) [1]	17.2^{a}	1.28^{a}	3.91^{ab}	81.5^{b}	1.34^{ab}	0.51^{a}
FF (2) [2]	16.1^{b}	1.18^{b}	4.21^{a}	93.9^{a}	1.25^{a}	0.55^{a}
FF (3) [2]	15.9^{b}	1.17^{b}	4.26^{a}	96.1^{a}	1.24^{a}	0.51^{a}
WE (5) [3]	17.0^{a}	1.27^{a}	3.84^{b}	80.9^{b}	1.37^{b}	1.36^{b}
WE (6) [3]	17.4^{a}	1.30^{a}	3.75^{b}	77.2^{b}	1.41^{b}	1.34^{b}

[1] RW's designed to be operated with molasses & limited water exchange w/o FF
[2] RW's designed to be operated with molasses & limited water exchange w FF
[3] RW's designed to be operated with increased water exchange and w/o FF

Discussion

- Future studies will evaluate the feasibility of increasing shrimp biomass load at harvest to about 8 kg/m^3
- Improvements in the design of all six RW are currently underway to prevent shrimp from jumping out
- Possible advantages from using “aged” water over virgin water in grow-out phase

Discussion

- The study was terminated after 94 d due to heavy shrimp losses in two raceways due to jumping out of the raceways with 1% to 5% losses/night
- All efforts to prevent the jumping were unsuccessful
- Efforts included:
  - Increasing the height & angle of the fence around the raceway
  - Keeping the lights and music on at night
  - Saturation of the culture medium with oxygen injection
  - Installation of security camera to identify the cause of jumping
  - Use of an electric shocker to prevent animals from disturbing the greenhouse

Acknowledgements

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