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The use of vermicompost in a white shrimp *Litopenaeus vannamei* culture

Abstract

Mexican shrimp production is increasing alongside growing food demand. Fertilization promotes primary productivity. Organic fertilizers, such as vermicompost with *Eisenia foetida*, support phytoplankton growth and aid the development of aquatic organisms. We analyse and evaluate several worm castings as promoters of shrimp development. Six different treatments were tested in 12-liter drums: T-1 solid vermicompost from cow manure and T-2 solid vermicompost from plant waste (0.5 g L-1); T-3 liquid vermicompost from cow manure and T-4 liquid vermicompost from plant waste (0.1 L L-1); T-5 Control (Urea) (0.45 g L-1); and T-6 Blank, with a duration of 33 days. Water quality parameters were within optimal ranges for shrimp culture. Regarding phytoplankton, the best treatment was T-2 (551,500 cells/ml). The microalgae groups identified were diatoms, chlorophytes, and cyanophytes. T-2 had the highest weight gain and 100% survival; however, no significant differences were observed (P>0.05). The highest survival rate was in the vermicompost treatment (92%). The highest phytoplankton levels were observed in the vermicompost treatments. Water quality is one of the important factors for thriving shrimp culture, and the inclusion of vermicompost will not alter physicochemical parameters, allowing a fast and normal growth of this species.

Keywords: *Litopenaeus vannamei*, Aquaculture fertilization, *Eisenia foetida*, Phytoplankton, Vermicompost.

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Introduction

Aquaculture is a growing and vital sector in the production of high-protein foods. Global aquaculture food production reached 59.9 million tons in 2010, including fish, crustaceans, mollusks, and other aquatic animals for human consumption.[1] Since 1985, shrimp farming in Mexico has increased, particularly in the country's northwest.[2] The average annual growth rate of shrimp production over the last 10 years is 6.24%, driven by the expansion of aquaculture for this species.[3]

Fertilization is practiced in the cultivation of any aquatic species, including shrimp.[4] The purpose of phytoplankton is to promote primary productivity by providing essential nutrients to support primary producers and to facilitate the establishment of subsequent trophic levels in the food chain.[5] Phytoplankton and zooplankton often contain between 40 and 60% protein on a dry matter basis, which contributes to the growth of aquatic organisms.[6-8] In addition to participating in the production of natural food, phytoplankton also contributes to maintaining better water quality within culture ponds, such as increasing oxygen levels through photosynthesis, regulating pH in the water column and sediment, and preventing the development of filamentous algae on the bottom, which cause severe management problems in ponds.[9]

Aside from natural pond food, shrimp farming in grow-out systems is supplemented with formulated feed, which represents up to 50% of operating costs.[10] This feed is also a significant source of pollution in both farming systems and the ecosystems into which effluents are discharged.[11,12] It is estimated that in Mexico, 130,000 tons of organic matter, 9,360 tons of nitrogen, and 3,040 tons of phosphorus are discharged into the environment annually by shrimp farming.[13] Therefore, the development of inland shrimp farming in low-salinity water is considered a more viable alternative to coastal pollution.[13,14]

Due to the problems described above, the use of organic fertilizers has begun; the most commonly used in aquaculture are farm animal waste (i.e., farm animal feces, with or without urine, and straw). Among organic fertilizers, vermicompost stands out, obtained through vermiculture; a biotechnology that uses the earthworm *Eisenia foetida* as a natural transformer that recycles all types of organic matter. Vermicompost contains a higher amount of carbon and phosphorus, and less potassium and nitrogen,[15] in addition, it is rich in all types of nutrients, vitamins, enzymes, antibiotics, and growth promoters, among others.[16-18] The use of vermicompost in aquaculture is gaining recognition for its energy conservation, optimal use of economic resources, simultaneous pollution control, and the production of a safe fertilizer that improves water quality in ponds.[19,20] Also, Water quality factors for a successful shrimp culture with the inclusion of vermicompost will not alter its physicochemical parameters, allowing a fast and normal growth of this species.[18]

This study will focus on analyzing and evaluating different earthworm vermicomposts as promoters of phytoplankton production, as well as their impact on shrimp production variables and water quality in low-salinity, non-replacement culture ponds.

Materials and methods

Production and analysis of vermicompost fertilizers

Organic fertilizer production

To prepare the different vermicomposts, four beds (4.0 x 1.0 x 0.5m) were prepared. Two were filled with cow manure as a substrate, and two with plant-based waste to produce solid and liquid vermicomposts. Subsequently, 1500 mature earthworms *E. foetida* were introduced (Rodríguez and Paniagua, 2006). The beds were watered to saturation every 2 days to lower the internal temperature to 22-26 °C and neutralize the pH to 6.5-8, while maintaining a humidity level of 70-80%. After three months, the earthworms were separated using mesh screens to obtain the solid vermicompost. The organic fertilizer production process took approximately four months.

Chemical analysis of vermicomposts

Samples of the different solid and liquid vermicomposts (cattle manure and plant-based waste) were taken after vermicomposting for analysis in the BIOTECSIN plant nutrition laboratory. pH was measured electrometrically using an electrode with a membrane sensitive to H+. Electrical conductivity was measured electrolytically using a conductivity cell as a sensor. Nitrogen (N) content was determined using the micro-Kjeldahl method, as well as phosphorus (P), cation analysis for potassium (K), calcium (Ca), and magnesium (Mg), organic matter, and micronutrients (Fe, Zn, Mg, and Cu).

Phytoplankton cultivation and monitoring

In the first stage, an inoculation was performed to analyse the number of phytoplankton in the low-salinity water, using the organic fertilizers produced. This was done in 18 tanks (three replicates per treatment) with a capacity of 19 L, which were filled to 12 L. Subsequently, the process was carried out in 1000 L ponds. The water used was sourced from shrimp farms in Las Glorias and Guasave and diluted with well water to reach 10 ppt. The tanks were equipped with an air diffuser to maintain a constant oxygen level within the system. Six treatments were carried out, using organic fertilizers, a control (urea), and a blank, as follows: T-1 solid compost of cattle manure, T-2 solid compost of vegetable waste, T-3 liquid vermicompost of cattle manure, T-4 liquid vermicompost of vegetable waste, and T-5 chemical fertilizer control (urea). Initially, the fertilization dose in the ponds was: T-1 and T-2, equivalent to 0.5 g/L; T-3 and T-4, equivalent to 0.1 g/L; and T-5, equivalent to 0.45 g/L of urea. Subsequently, on days 4, 7, 10, and 14, the doses were reduced to 0.25 g/L for T-1 and T-2, 0.05 g/L for T-3 and T-4, and 0.25 g/L for T-5.[21] Oxygen, temperature, pH, and salinity parameters were measured daily. Two 2-g shrimp, previously acclimated from 37 °C to 10 °C, were introduced into a 1000 L tank. This bioassay lasted 33 days.

Phytoplankton sample collection and preservation

Phytoplankton samples were collected weekly from each of the experimental tanks in 100 mL dark bottles. The samples were fixed with 1 ml of 1% Lugol's iodine solution to settle and preserve the plankton and left to stand until analysis.

Identification and enumeration

The phytoplankton was identified to the group level (diatoms, cyanobacteria, chlorophytes, etc.) using the manuals of Thomas[22] and Al-Kandari et al.[23] The samples were analyzed in a Neubauer cell counter under a compound optical microscope (Carl Zeiss Stemi 2000-C). One ml was taken from each sample and placed in the cells, covering both areas of the chamber. Cell counts were performed in the four corner squares. Because the samples were homogenized, the calculations were carried out using the following formula:

Number of cells/ml = C / 4 * 10,000, where C = number of cells counted in the four squares.

Shrimp juvenile culture

Once the best organic fertilizer (solid vermicompost from plant waste) was obtained, shrimp juvenile culture was carried out, again using a control treatment and an inorganic fertilizer (urea). Nine 1000 L waterers (each treatment in triplicate) were used, filled to 800 L, and stocked at a rate of 50 PL'12/m² in systems with zero water exchange, outdoors, for a duration of 94 days.[24] These were fertilized two weeks before introducing the shrimp juveniles. The fertilization was changed to that recommended by Chakrabarty:[19] 0.99 g/L of solid vermicompost and 0.034 g/L of urea for the first fertilization. This was halved (0.495 g/L of vermicompost and 0.017 g/L of urea) for the doses on days 4, 7, 10, and 14 after the first fertilization. Finally, on day 70, a supplemental fertilization was given with 0.2475 g/L of vermicompost and 0.0085 g/L of urea.

Chance to Shrimp fed were fed commercial feed (PURINA©) with 35% protein and given a daily ration, starting with 8% of their biomass for the first few weeks, which was gradually reduced to 5% over time.

Water quality

The following physicochemical variables were measured daily: pH (HANNA potentiometer), temperature, dissolved oxygen (YSI oximeter), and salinity (refractometer). Nitrites, nitrates, ammonium, silicates, and orthophosphates were measured.

Analysis of productive variables (growth rate, survival, and weight)

Weekly, the weight of the organisms in each treatment was recorded to determine the growth rate and length-weight relationship using the following formulas:

LW = [(W2 – W1)/t], where W2 is the final weight, W1 is the initial weight, and t is the number of days of culture.

The overall length-weight relationship for the different lengths was calculated using the following potential model:

Po = a (Lt) b, where Po is the weight of the organism in g, Lt is the total length in cm, and a and b are the adjustment coefficients used to determine whether growth is isometric or allometric in the length-weight relationship.

Survival was calculated using the following formula:

S = (TI/TF)*100, where S is the survival rate, and TI and TF are equal to the initial and final number of organisms.[25]

Bacteriological count by scattering

At the end of the experiment, an analysis was performed using the bacterial scattering method to identify colony-forming bacteria in the pond water, using MRS media for lactobacilli and TCBS media for vibrios.

Under sterile conditions, 1 ml was taken and transferred to a tube containing 9 ml of sterile saline solution (10:3 dilution). Successive dilutions were made until decimal dilutions were reached, up to 10:10 or the appropriate dilution, using a different sterile pipette tip at each step. Subsequently, 0.1 ml of the selected dilution was placed in the centre of the culture medium surface. The aliquot was spread across the plate surface with a previously sterilized plastic rod (loop) (immersed in alcohol and passed through a Bunsen burner flame, then allowed to cool).

A homogeneous distribution was made across the entire surface of the medium. Finally, the plates were incubated upside down at 35 °C in the dark. After an incubation period (24 to 72 h, depending on the type of microorganism), the number of colonies was counted and reported as colony-forming units (CFU/g).

Statistical analysis

Kolmogorov-Smirnov normality tests were performed to determine the distribution of all data obtained (parameters, phytoplankton quantity, nutrients, shrimp weights, survival). Subsequently, one-way analysis of variance and correlations were performed at the $P < 0.05$

level. Shrimp productivity variables, physicochemical water quality variables, and phytoplankton cell counts/ml were analysed using analysis of variance to compare results across treatments. The results were significant across treatments and were further analysed using Tukey's test to identify differences among treatment levels. The SAS System for Windows 9.0 and STATISTICA 7 software were used.

Results

Nutrient and micronutrient analysis of different vermicomposts

The first specific objective of this project was to produce various solid and liquid vermicomposts and to evaluate the nutrient and micronutrient quality of these products. A sample was taken from each analysis treatment and subsequently used to develop the second objective. Table 1 shows the pH, electrical conductivity, and percentages of nutrients and micronutrients, compared with the amounts required by the Mexican standard for the purchase and sale of vermicompost, NMX-FF-109-SCFI-2008.[26] Regarding pH, all treatments showed relatively neutral values and met the requirements of the Mexican standard. However, electrical conductivity values were outside the required ranges, except for the liquid vermicompost treatment made from plant waste, which had a value of 2.07 mS/cm. Solid vermicomposts showed the highest nutrient and organic matter content compared to liquid vermicomposts. The solid vermicompost made from plant waste had the highest organic matter content among the four vermicompost types, at 34.96%, followed by the solid vermicompost made from cattle manure at 30.92%. However, the liquid vermicompost from both treatments had very low organic matter content: 0.39% for the liquid vermicompost made from plant waste and 0.26% for the liquid vermicompost made from cattle manure. On the other hand, nutrient levels were higher in the solid vermicomposts, with significant differences in the percentages of key nutrients, such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg), compared to the liquid vermicomposts. Regarding micronutrients, the amounts present in the different vermicomposts do not show significant variations, except for iron (Fe), which is found in higher proportions in solid vermicomposts. Liquid vermicompost, being a leachate from solid vermicompost, contains lower nutrient concentrations. This also depends on how many times the vermicompost is washed.

Table 1 pH, electrical conductivity, nutrient, and micronutrient values of the different vermicomposts from the earthworm *E. foetida*. T-1 solid compost of cattle manure, T-2 solid compost of vegetable waste, T-3 liquid vermicompost of cattle manure, T-4 liquid vermicompost of vegetable waste

	T1	T2	T3	T4	Urea	NMX-FF-109-SCFI-2008*
PH	7.9	7.8	7.6	7.4	-	5.5- 8.5
CE (mmhos/cm)	6.66	7.7	2.07	4.45	-	≤ 4
MO %	30.92	34.96	0.26	0.39	-	20- 50
N %	2.59	3.85	0.51	0.85	46	1.5- 3.35
P %	0.77	0.72	0.1	0.07	-	0.1
K %	1.9	2.06	0.05	0.07	-	0.1
Ca %	1.61	1.54	0.3	0.24	-	2.8- 8.7
Mg %	1.36	1.54	0.13	0.13	-	0.2- 0.5
Fe (ppm)	76.77	35.3	10.42	10.47	-	-
Cu (ppm)	4.95	4.7	2.67	2.51	-	6.8
Zn (ppm)	1.05	1.1	1.11	0.9	-	1.4
Mn (ppm)	2.88	4.8	0.5	0.87	-	3.8

*Mexican Norm, who established vermicompost quality that can be used in farming and aquaculture.

Physicochemical variables of the water

Temperature, dissolved oxygen (DO), pH, and salinity

This experiment was conducted outdoors. The average salinity during the study was 7.84 ± 2.35; this parameter did not differ significantly between treatments ($P > 0.05$). However, significant differences were observed between samples due to rainfall during the experiment. Oxygen levels remained stable at 3.8 ± 1.13 mg/L and differed significantly between treatments. The average temperature was 28.04 ± 3.66 °C, and there were no significant differences between treatments ($P > 0.05$) during the bioassay. However, as with salinity, differences were observed between samples due to rainfall. Finally, the parameters pH and oxygen showed significant differences ($P > 0.05$) among the treatments. Ammonium was found in low quantities in all treatments. The urea treatment had the highest concentration. The average concentration was 124.31 ± 21.08 µg/L.

Phytoplankton assessment

Phytoplankton amount by group

Figure 1 shows the phytoplankton groups found during the study. The most significant quantity could not be identified due to its size (nanoplankton). The other groups found were diatoms, chlorophytes, and cyanobacteria. Significant differences ($P>0.05$) were found between the number of unidentified nanoplankton (N.I.) and the other groups (diatoms, chlorophytes, and cyanobacteria). No significant differences were found between microplankton size groups.

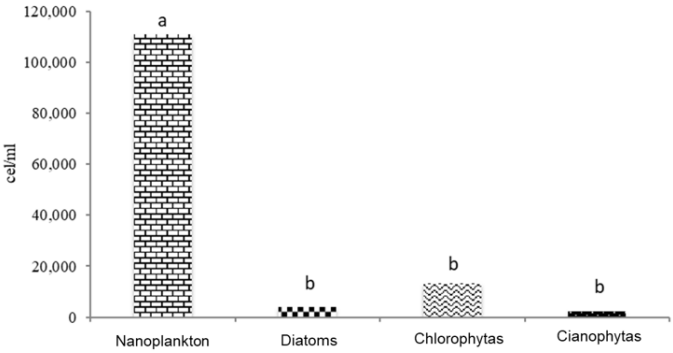

Figure 1 Quantity and groups found during the 33-day study.

Citation: Vergara LRR, Torres AP, PérezAEU, et al. The use of vermicompost in a white shrimp *Litopenaeus vannamei* culture. *J Aquac Mar Biol.* 2025;14(3):134–141. DOI: 10.15406/jamb.2025.14.00433

Phytoplankton variation by treatment

Figure 2 shows the number of phytoplankton collected in each treatment at each weekly sampling. The original results showed significant variation; therefore, normalization was performed using a base-10 logarithm to conduct an ANOVA ($P>0.05$). Treatment 4 (liquid vermicompost of cattle manure with plant waste) yielded the highest phytoplankton biomass in the entire experiment; however, it did not differ significantly ($P>0.05$) from treatment 2 (solid vermicompost of cattle manure with plant waste).

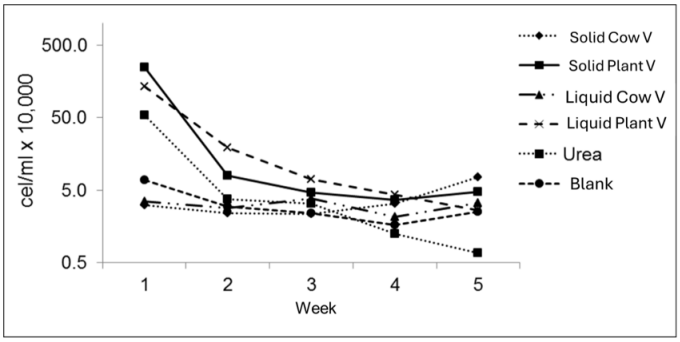

Figure 2 Variation in phytoplankton levels over time during the bioassay.

Regarding the sampling, a significant difference was found, with the first sample differing from the others. This was mainly due to natural phenomena (rain) that occurred during the experiment, causing variations in salinity and temperature, which in turn affected changes in phytoplankton colonies. However, there was no significant difference between treatments according to a Tukey analysis ($P>0.05$) (Table 2).

Shrimp weight gain during the experiment

Figure 3 presents a bar graph showing the initial and final weights of the shrimp for each treatment; the survival percentages are shown above the bars. The greatest weight gain was observed with the solid vermicompost treatment of plant waste, averaging 4.45g; however, no significant differences were found among treatments ($P>0.05$). This treatment also had the highest survival rate, with 100% of the cultured organisms surviving, as did the liquid vermicompost treatment of cow manure; however, the latter had less weight gain. Shrimp weight gain during the experiment.

Table 2 Physicochemical variables of fertilized water and *Litopenaeus vannamei* shrimp culture. T-1 solid vermicompost of cattle manure, T-2 solid vermicompost of plant waste, T-3 liquid vermicompost of cattle manure, T-4 liquid vermicompost of plant waste, T-5 Control (Urea), T-6 Blank

	T1	T2	T3	T4	T5	T6
Salinity (Ups)	7.2±3.13 a	7.5±2.54 a	7.9±2.08 a	7.6±2.06 a	8.4±2.19 a	8.4±1.70 a
Oxigen(mg/L)	3.67±1.05 b	3.75±1.20 ab	3.90±1.16 ab	3.78±1.18 ab	3.85±1.15 ab	3.95±1.13 a
Temperature (°C)	28.1±3.70 a	27.7±3.64 a	28.1±3.78 a	28.2±3.74 a	28.1±3.63 a	27.9±3.64 a
pH (UpH)	8.76±0.22 b	8.70±0.13 b	8.90±0.39 a	8.97±0.23 a	8.45±0.15 d	8.56±0.15 c
Amonia (µg/L)	2.22±0.56	3.14±2.97	3.54±1.23	2.62±1.57	124.31±21.08	2.17±2.65

The means and standard deviations of the parameters in the different treatments. Means with the same letter in each column are statistically equal, according to Tukey ($\alpha < 0.05$). *In the case of ammonium, the unit is changed to (µg/L) due to scaling effects; the conventional unit is (mg/L).

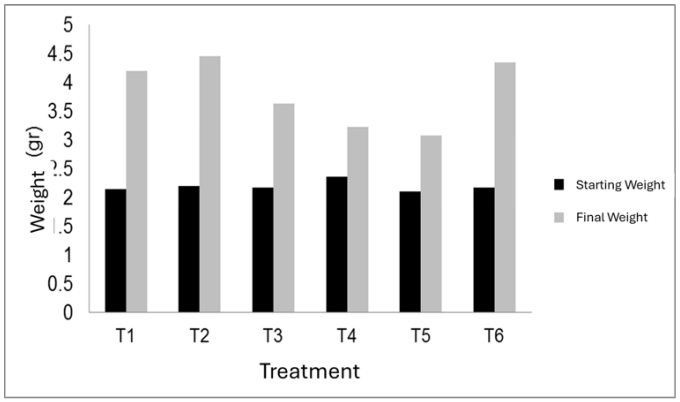

Figure 3 Weight gained by the different treatments during the experiment. T-1 Solid vermicompost of cattle manure, T-2 Solid vermicompost of vegetable waste, T-3 Liquid vermicompost of cattle manure, T-4 Liquid vermicompost of vegetable waste, T-5 Control (Urea), T-6 Blank.

Postlarvae culture

Physicochemical variables of the water

Table 3 shows the physicochemical parameters obtained throughout the experiment. These are within the optimal ranges for shrimp culture. The blank treatment had the highest average oxygen level (4.79 ± 0.229 mg/L) during the 94 days of the experiment. The average temperature among the three treatments was 28 °C. Salinity was highest in the vermicompost ponds, averaging 20.1 ± 4.4 psu. Finally, pH, like salinity, had the highest average in the treatment of Vermicompost 8.92 ± 0.07 UpH (Figure 4).

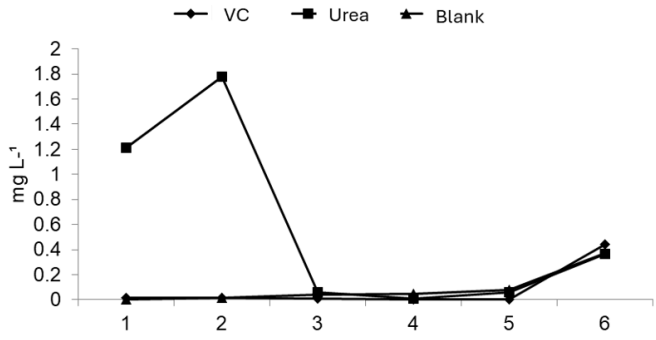

Figure 4 Ammonium concentration in experimental Litopenaeus vannamei shrimp cultures under different treatments.

Citation: Vergara LRR, Torres AP, PérezAEU, et al. The use of vermicompost in a white shrimp *Litopenaeus vannamei* culture. *J Aquac Mar Biol.* 2025;14(3):134–141. DOI: 10.15406/jamb.2025.14.00433

Table 3 Physicochemical variables of fertilized water and **Litopenaeus vannamei** shrimp culture in the different treatments.

	Vermicompost	Urea	Blank
Oxigen (mg/L)	4.78± 0.20[a]	4.75± 0.22[a]	4.79± 0.23[a]
Temperature (°C)	28.78± 1.86[a]	28.98± 1.91[a]	28.39± 1.88[a]
Salinity (Ups)	20.1± 4.4[a]	19.9± 4.8[a]	19.2± 4.9[a]
pH (UpH)	8.92± 0.07[a]	8.77± 0.08[a]	8.83± 0.08[a]

The averages and standard deviations of the parameters in the different treatments are shown.

Table 4 Productive variables, growth rate, final weight, and survival of shrimp experimentally cultured with (vermicompost and urea) and without fertilization (control) of the shrimp *Litopenaeus vannamei*.

	Growth rate	Final weight	Survival
Vermicompost	0.09±0.03	6.89±2.10[a]	92±12.12[a]
Urea	0.13±0.01	10.12±1.63[b]	83±8.19[a]
Blank	0.11±0.03	8.52±2.26[c]	81.67±15.31[a]

Ammonium, nitrites, nitrates, orthophosphates, and silicates

Ammonium concentrations were higher in the tanks fertilized with urea; however, they tended to decrease throughout the experiment and ended with amounts similar to those obtained in the vermicompost and control treatments. Meanwhile, the vermicompost and control treatments showed low levels of ammonia throughout the experiment.

In Figure 5, the nitrite graph shows that the urea treatment had the highest nitrite concentration. However, from week 3 to week 4, the concentration decreased to small amounts (0.006–0.008 mg L^{-1}). The vermicompost and control treatments, on the other hand, maintained lower concentrations but showed a significant increase at the end of the experiment.

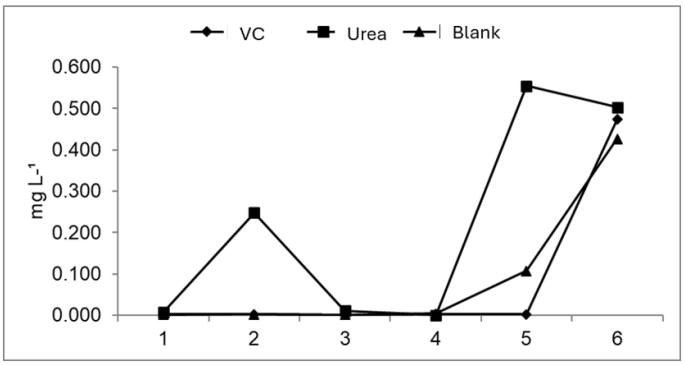

Figure 5 Nitrite concentration in experimental cultures of Litopenaeus vannamei shrimp under different treatments.

In Figure 6, unlike the previous nutrients (ammonium and nitrites), the urea treatment behaves similarly to the other treatments; likewise, at the end of the experiments, all three treatments tend to show an increase in concentration.

Orthophosphate concentration was highest in the vermicompost treatment, averaging 0.609 mg L^{-1} throughout the experiment; however, by week five, it decreased to approximately 0.200 mg L^{-1}. The urea and control treatments showed a similar trend with low levels of this nutrient (Figure 7).

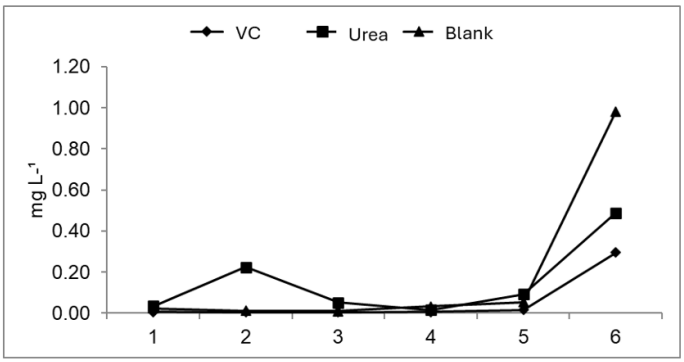

Figure 6 Nitrate concentration in experimental Litopenaeus vannamei shrimp cultures under different treatments.

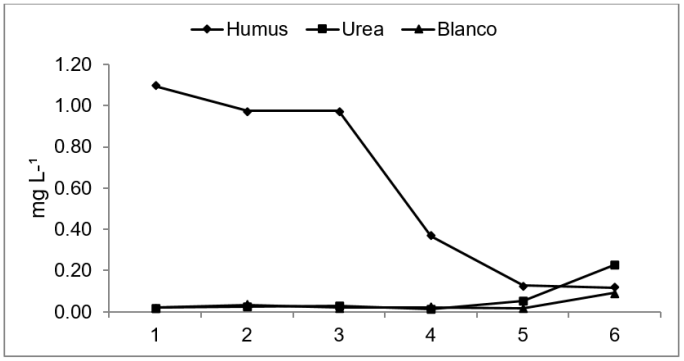

Figure 7 Orthophosphate concentration in experimental Litopenaeus vannamei shrimp cultures under different treatments.

Finally, silicates did not show a clear trend across the different treatments, as the samples yielded fluctuations (Figure 8). The vermicompost treatment averaged 2.5 mg L^{-1}, the urea treatment averaged 4.22 mg L^{-1}, and the control treatment averaged 3.06 mg L^{-1} throughout the experiment. Furthermore, in the final weeks of the experiment, a decrease in silicate levels was observed in all treatments.

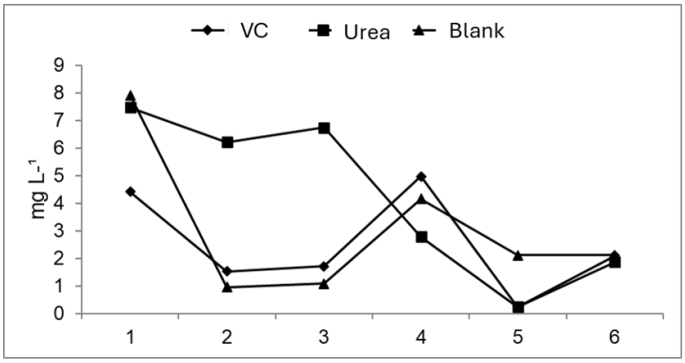

Figure 8 Silicate concentration in experimental *Litopenaeus vannamei* shrimp cultures under different treatments.

Shrimp production variables: Growth rate, final weight, and survival. Figure 9 shows shrimp growth throughout the 79-day culture period. The X-axis represents the time in weeks during which biometric measurements were taken. By week 6, the treatments showed values of approximately 5 g. In week 7, the urea-treated ponds began to show greater growth than the other treatments. The

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vermicompost ponds showed slower growth and ultimately had the lowest final weight among the treatments. Significant differences (P>0.05) in final weight were observed among treatments, with urea-fertilized ponds having the highest weight. No significant differences in survival were observed (P>0.05). The treatment fertilized with vermicompost had the highest survival rate, at 92%, followed by urea and, lastly, the unfertilized ponds.

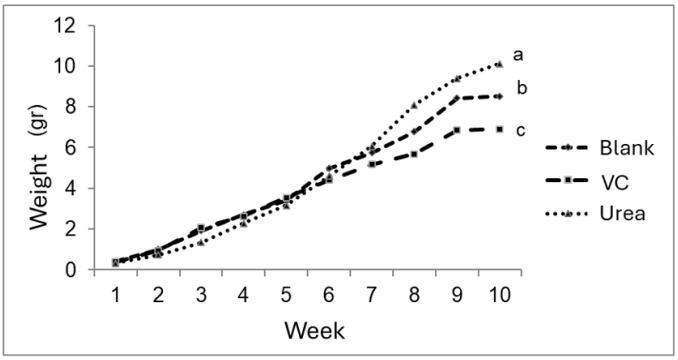

Figure 9 Shrimp growth under different treatments (vermicompost, urea, control) during the experiment.

Phytoplankton quantity by treatment

Figure 10 shows the number of phytoplankton (cells/ml) obtained weekly throughout the experiment (12 weeks). There was no consistent pattern across treatments; however, the vermicompost treatment tended to increase from week five onward, gradually reaching higher cell counts/ml. The control treatment also showed an increase in cell production in weeks 5 and 6, but this decreased by week seven. The highest cell counts/ml were recorded in the vermicompost treatment, which also showed a time-dependent growth pattern. As with objective two, most cells were nanoplankton-sized and therefore could not be identified. Finally, there were significant differences between the vermicompost and control treatments; the urea-fertilized treatment did not differ significantly from any of the other treatments.

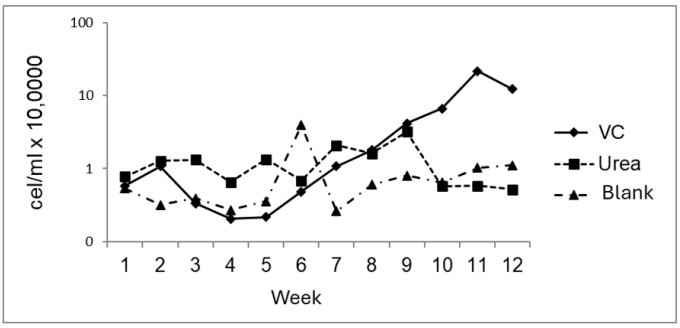

Figure 10 Phytoplankton production levels for the different treatments (vermicompost, urea, control) throughout the bioassay for objective three.

Discussion

Nutrient and micronutrient analysis of the different earthworm vermicomposts

There is little information on the effects of vermicompost nutrients in aquaculture and, to a lesser extent, on the specific use of this organic fertilizer in shrimp farming. The few published studies are mainly in fish farming.[27]

In this experiment, two different substrates were used to prepare the earthworm vermicompost; The richness of its nutrients can vary depending on the environment and the type of substrate used. Although studies were conducted on different substrates, such as cow, chicken, pig, and coffee pulp manure, cow manure was found to be the best substrate for reproduction.[9,28] In this experiment, it was one of the substrates used.

The solid vermicomposts yielded nutrients (N, P, K, Ca, Mg) and micronutrients (Fe, Cu, Zn) that meet the requirements of the Mexican standard.[26] Furthermore, they contained a higher amount of organic matter, consistent with the values reported by Félix et al.[29] who produced vermicompost using different substrates, one of which was vegetable waste, as in this case. While the large quantities of organic matter obtained in this first objective could potentially lead to eutrophication in the ponds due to nutrient saturation, the constant aeration within the systems was sufficient to provide the necessary oxygen, maintaining optimal conditions for shrimp cultivation. This aligns with the findings of Dhawan and Kaur,[30] who reported that even with high organic matter loads from various organic fertilizers, the dissolved oxygen levels in the ponds were not reduced.

Chakrabarty et al.[19] mention potassium (K), nitrogen (N), and phosphorus (P) as nutrients that stimulate phytoplankton growth. These elements are present in small amounts in various vermicomposts, with nitrogen and phosphorus producing nitrites and nitrates, respectively, and phosphorus producing phosphates. These nutrients are readily available to phytoplankton. Furthermore, these compounds in small proportions are not toxic to cultivated organisms.[31] However, a recent study by Yussof and McNabb[32] demonstrated that the addition of fertilizers containing phosphorus, nitrogen, and carbon promoted the growth of cyanobacteria, which are undesirable in ponds. In contrast, the addition of nitrogen and silica increased the growth of diatoms, especially Chaetoceros calcitrans.

The nutrient requirements for phytoplankton in shrimp farming demand certain elements for phytoplankton growth. Dissolved inorganic nutrients are required in a nitrogen-to-phosphorus (N:P) molar ratio of 16:1. If this ratio falls below 10:1, biomass development may be limited by nitrogen. Conversely, if this ratio reaches 20:1, biomass may be limited by phosphorus. This indicates that the nitrogen and phosphorus content among the different vermicomposts is lower than the required nitrogen ratio, which is less than 10:1. These systems were also supplied with balanced feed, which, since the shrimp do not consume it, contributes significant amounts of nitrogen, as do the feces and molts of the farmed organisms. The inorganic fertilizer, in this case urea, exceeds this ratio, as it contains up to 46% nitrogen. Therefore, it can also contribute to increased ammonia levels within the culture systems, in addition to phosphorus (P) being a limiting element.

Physicochemical variables of the water

pH, oxygen, and temperature behaved similarly to that obtained by Valenzuela et al.[33] who cultivated shrimp at low salinity, reporting that these variables did not directly affect the growth of the cultured organisms and coincided with the values obtained by Miranda et al.[34] They also cultivated white shrimp using healthy water. Regarding the average salinity of 7.2 to 8.4 psu, it was within the range used by Cervantes-Cervantes,[35] which ranged from 1 to 35 psu, and no significant differences in white shrimp growth were found. Furthermore, low salinity favors the growth of cyanobacteria,[36] which are undesirable in shrimp farming due to their toxicity and the unpleasant odor they can produce in the shrimp. The lowest oxygen concentrations were observed in the solid vermicompost treatments, with T1 (cow manure vermicompost) showing the lowest, possibly due to its high organic matter load. However, significant differences (P>0.05) were observed only in the control treatment. Furthermore,

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temperature, in conjunction with light, is considered an essential factor affecting all processes within the pond; this was confirmed in experimental studies at controlled temperatures.

Phytoplankton evaluation

The search for an organic fertilizer that will stimulate greater phytoplankton cell production, primarily from the diatom group, is crucial, as these are desirable for shrimp farming. Shrimp culture exhibits a downward trend in phytoplankton levels after the first week, contrary to the findings of Román et al.[37] and Chakrabarty et al.[38] Cortés-Lara,[25] observed a tendency for phytoplankton levels to increase after the first week. This decrease is primarily due to rainfall and water replenishment resulting from evaporation in the culture tanks during the experiment. These factors affected the acclimatization and development of the phytoplankton colonies by creating a new environment, directly affecting physicochemical parameters and nutrients, such as ammonium.[39] Vermicomposts made with a combination of cattle manure and plant waste, although also showing a decrease after the first week of sampling, exhibited the best phytoplankton production compared to the other treatments.

The representative phytoplankton groups (diatoms, chlorophytes, and cyanophytes) were similar to those found by Chakrabarty et al.[38] in fishponds and Cortés-Lara[25] in shrimp farming. However, the number of cells per group is below the required level according to the Clifford[37] table, which outlines the recommended phytoplankton levels for shrimp farming. Some studies demonstrate that diatoms and chlorophytes are desirable for the proper growth of farmed shrimp.[40] Diatoms are highly nutritious, given their high content of unsaturated fatty acids, the high permeability of their siliceous cell wall, which allows for enzyme digestion, their appropriate cell size, which facilitates easy ingestion, and their minimal association with toxins.

Significant differences ($P>0.05$) were found in the number of unidentified nanoplankton (N.I.) compared with the other groups (diatoms, chlorophytes, and cyanophytes), unlike Chakrabarty et al,[38] who found a greater number of diatom cells and a smaller number of cyanophyte cells.

Shrimp weight gain during the experiment

During the 18-day culture period, the treatment with solid vermicompost of plant waste showed the most significant increase in weight gain, which could be related to the amount of phytoplankton present in this treatment throughout the trial. However, there were no significant differences between treatments ($P > 0.05$), consistent with de Souza et al.,[21] who cultivated *Farfantepenaeus subtilis* shrimp with organic and inorganic fertilization. The highest 100% survival rate was recorded in the solid vermicompost of plant waste and liquid vermicompost of cattle manure treatments, showing higher survival rates than those obtained by Lara, who fertilized shrimp ponds with molasses and sodium nitrate, and also the survival rates recorded by Thakur and Lin[41] cultivating shrimp in closed systems.

Water quality

pH, salinity, temperature, and oxygen levels did not differ significantly among treatments in a 94-day shrimp culture. These parameters were within the optimal ranges for shrimp culture reported by other authors.[40] Therefore, they did not impact shrimp growth throughout the experiment, which was conducted under open-air conditions. The initial salinity of 28 psu was diluted throughout the culture period with healthy water as it recovered from evaporation. Because the experiment was conducted outdoors, salinity reached 10 psu in the last week of the bioassay. However, the average salinity across the three treatments (vermicompost, urea, and control) was approximately 20 psu, which may have affected the acclimatization of some phytoplankton colonies transitioning from brackish to freshwater conditions. Oxygen levels were maintained with aerators that operated throughout the experiment to keep solids in suspension and prevent low levels at night, due to the lack of photosynthesis caused by the absence of light. Additionally, shrimp metabolism is higher at night.[42]

Conclusions

Solid vermicompost made from plant waste has higher nutrient content because it meets the minimum requirements established by the Mexican standard for producing this type of compost. Rainfall during the experiment reduced salinity in the ponds and lowered nutrient levels, especially ammonium, which are limiting factors in the low phytoplankton production. Solid vermicompost made from plant waste was the best organic fertilizer, resulting in higher cell counts per millilitre, greater weight gain, and higher shrimp survival rates. Fertilization tests with varying application periods and dosages are now required in shrimp trials. The use of this fertilizer can reduce production costs, as it requires less food to feed the organisms and reduces production time.

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Conflicts of interest

We declare that there is no conflict of interest of any kind.

References

1. FAO. *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. 2025.
2. Wurmann CG, Madrid RM, Brugger AM. Shrimp farming in Latin America: current status, opportunities, challenges and strategies for sustainable development. *Aquaculture, Economics and Management*. 2004;8:117–141.
3. CONAPESCA. *Statistical Yearbook of Aquaculture and Fisheries.* National Aquaculture and Fisheries Commission. 2024.
4. Clifford HC. *Management of shrimp ponds*. International Shrimp Farming Seminar, Camarón 94, Mexico. 1994;16–34.
5. Primavera HA. Critical review of shrimp pond culture in the Philippines. *Review in Fisheries Science.* 1993;1:151–201.
6. Silva SS, Anderson TA. *Fish nutrition in aquaculture*. Chapman & Hall, New Delhi. 1995;320.
7. Wu W. *Fish culture and enhancement.* China Agricultural Press, Beijing. 2000. p. 66.
8. Hernández Rivera CI, Urbina–Flete SN, Altamirano–Perez MR. Feed conversion in Oreochromis niloticus fry using multifunctional feed with 24% and 14% protein. *Ibero-American Journal of Bioeconomy and Climate Change*. 2023;9(18):2275–2288.
9. Vaneet K, Meera A. Efficacy of vermicompost as fishpond manure– Effect on water quality and growth of Cyprinus carpio (Linn.). *Bioresource Technology*. 2010;101(15):6215–6218.
10. Jory DE, Dugger DM. Intensive nursery uses strategy for improved shrimp health. *Aquaculture Magazine*. 2000;26(6):67–72.
11. Barg UC. Guidelines for the environmental promotion of coastal aquaculture development. FAO Technical Document 328. Roma. 1995.

12. Kang'ombe J, Brown J, Halfyard L. Effect of using different types of organic animal manure on plankton abundance, and on growth and survival of Tilapia rendalli (Boulenger) in ponds. *Aquaculture Research*. 2006;37:1360–1371.

13. Martínez–Córdova LR, Martínez Porchas M, Cortés–Jacinto E. Mexican and global shrimp farming: sustainable activity or polluting industry? *International Journal of Environmental Pollution*. 2009;25(3):181–196.

14. Saoud IP, Davis DA, Rouse DB. Suitability studies of inland well waters for Litopenaeus vannamei culture. *Aquaculture*. 2003;217:373–383.

15. Barreto–Montenegro JC, Collazos–Lasso LF. Periphyton and its applications in aquaculture. *Orinoquia.* 2023;27(1):e–793.

16. Mitra A. *Vermiculture and vermicomposting of non– toxic organic solid waste application*. In: Azariah J, Azariah H, Darryi RJ, Editers. *Bioethics in India: Proceedings of Bioethics Workshop*: Biomanagement of Bioresources Madras. 1997.

17. Bhusan C, Yadav B. Vermiculture for sustainable agriculture. *Indian Farming Digest*. 2003;1:11–13.

18. Haro Haro A, Rodríguez Saldaña D, Ramónez JC, et al. Effects of vermicompost inclusion on water quality, feed intake, and production parameters of Nile tilapia (Oreochromis niloticus). *Food, Science and Engineering Journal.* 2024;31(1):1–7.

19. Chakrabarty D. *Vermicompost and organic pisciculture*. Akshay Krishi Vikash, West Bengal. 2008;1–16.

20. Tolera G, Getahun A, Geremew A, et al. Vermicompost using WH substrate improves the productivity of tilapia fingerlings in Batu aquaculture ponds (Ethiopia). *Acta Entomology and Zoology*. 2024;5(1):159–168.

21. de Sousa FM. Growth of marine shrimp Farfantepenaeus subtilis cultivated in tanks with different organic fertilization protocols. *Maringa*. 2009;31(3):221–226.

22. Thomas C. *Identifying marine diatoms and dinoflagellates*. Academic Press. USA. 1996.

23. Al–Kandari M, Al–Yamani F, Al–Rifaie K. Marine phytoplankton atlas of Kuwait's waters. *Kuwait Institute for Scientific Research. Safat, Kuwait.* 2009;350.

24. Esparza–Leal HM, Valenzuela–Quiñónez W, Rodríguez–Quiroz G. Intensive cultivation of white shrimp Litopenaeus vannamei (BOONE) in low-salinity well water as an aquaculture alternative for highly marginalized areas. *Ra Ximhai*. 2010;6(1):1–8.

25. Cortés–Lara MC, Cupul–Magaña AL, Cupul–Velázquez AM. Marine phytoplankton of Banderas Bay with a review of harmful algal blooms in the region. *Mexican Pacific*. 2011;9.

26. DOF. NMX–FF–109–SCFI–2008. Worm humus (vermicompost) – specifications and test methods. 2008.

27. Parsa Khanghah A, Can E. Effect of Vermicompost Supplement on Rainbow Trout Performance. *Marine Science and Technology Bulletin*. 2024;13(3):234–238.

28. Oribhabor BJ, Ansa EJ. Organic waste reclamation, recycling and re–use in integrated fish farming in the Niger Delta. *Journal of Applied Science on Environmental Management*. 2006;10(3):47–53.

29. Félix HJ, Flores SR, Armenta DA, et al. Microbiological properties of mature composts produced from different organic materials. *Ra Ximhai*. 2010;6(1):105–113.

30. Dhawan A, Kaur S. Pig Dung as Pond Manure: Effect on Water Quality, Pond Productivity and Growth of Carps in Polyculture System. *Naga*. 2002;25(1):11–14.

31. Bwala R, Omoregie E. Organic Enrichment of Fish Ponds: Application of Pig Dung vs. Tilapia Yield. *Pakistan Journal of Nutrition*. 2009;8(9):1373–1379.

32. Yusoff FM, McNabb US. The effects of phosphorus and nitrogen on phytoplankton dominance in tropical fish ponds. Aquaculture Research. 1997;28:591–597.

33. Valenzuela–Quiñónez W, Esparza–Leal HM, Nava–Pérez E, et al. El cultivo de camarón en agua de baja salinidad con alimento a base de harina de lombriz. *Ra Ximhai*. 2012;8(3):131–136.

34. Miranda I, Valles JL, Sánchez R, et al. Culture of the marine shrimp Litopenaeus Vannamei (Boone, 1931) in freshwater. *Scientific Journal*. 2010;20(4):339–346.

35. Cervantes Cervantes CM. Effect of salinity on some biochemical, immunological, physiological, and productive variables of experimentally cultured Litopenaeus vannamei shrimp. Master's Thesis, Natural Resources and Environment. Interdisciplinary Research Center for Regional Integral Development, Sinaloa Unit. *National Polytechnic Institute. Guasave, Sinaloa, Mexico*. 2011;64.

36. Rodríguez–Quiroz G, Paniagua–Michel. Vermicomposting of biosolids and treated water in northwestern Mexico. Ecoparque, a case study. *AIDIS Journal*. 2006;1(1):1–6.

37. Román MT, Bárbaro JC, Rosa NA, et al. Effect of fertilization with different N-P ratios on primary productivity in the shrimp farm. *Calisur. CIVA.* 2003;945–953.

38. Chakrabarty D, Das S, Das M. Relative efficiency of vermicompost as direct application manure in pisciculture. *Paddy and Water Environment.* 2009;7(1):27–32.

39. Nzilani Musyoka S, Nairuti R. Application of Vermicompost Fertilizer in Aquaculture Nutrition: Review. *Intech Open*. 2021.

40. Clifford HC. *Marine shrimp pond management: a review.* In: Wyban J, Editor. *Proceedings of the special session on shrimp farming*. World Aquaculture Society, Baton Rouge, LA, USA. 1992;110–137.

41. Thakur DP, Lin CK. Water Quality and Nutrient Budget in Closed Shrimp (Penaeus monodon) Culture Systems. *Aquacultural Engineering*. 2003;27:159–176.

42. Duarte J. Recambio preventivo de agua para evitar la depleción de oxígeno en granjas semiintensivas de camarón al noreste de Venezuela. In VI Congreso Venezolano de Acuicultura. Memorias. UNET. 2002;9–11.

43. Strickland JDH, Parsons TR. A Practical Handbook of Sea Seawater Analysis. Supply and Services Canada, Ottawa, Canada KIA 059. The Alger Press Ltd. 1992;310.