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Effect of Aqueous Minerals Supplementation on Growth and Survival of *Litopenaeus vannamei* in Low Salinity Water

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A B S T R A C T

In the present study it has been evaluated to identify the efficient source mineral supplementation for *vannamei* in low salinity waters. Aqueous mineral supplementations were tested for the efficiency on survival and growth of *L. vannamei* in low salinity water. Experiment was conducted at 3ppt salinity for a period of 7 weeks highest growth performance in *vannamei* was observed from magnesium (Mg^{+2} 80mg l^{-1}) incorporated to water. The highest survival of 70% was recorded for potassium (30mg l^{-1}) treated water. All the aqueous mineral supplementation treatments indicated highest growth and survival than that of control.

Introduction

The culture of shrimp and other fish and crustaceans using low salinity water is a trend that continues to grow throughout the world. In 2011, aquaculture accounted for 52.5% of the world's fish food supply (FAO 2011). Most fish, crustacean and mollusc aquaculture production (61%) occurs in inland waters. In the same year, brackish water production accounted for 8%.

In most locations throughout the world the primary candidate of choice for shrimp culture in low salinity water is the Pacific white shrimp, *Litopenaeus vannamei*, which is native to the Pacific coast from Northern Peru to Mexico. In 2011, *L. vannamei* production worldwide was close to 2.5 million tonnes, which is roughly 71% of total shrimp and prawn production worldwide (FAO 2011). All indications are that the production of *L. vannamei* will continue to expand, particularly in countries such as China, Vietnam and Thailand. The Pacific white shrimp is a euryhaline species that can tolerate a wide range of salinities 0.5 – 45 g L-1 (Menz and Blake, 1980). The remarkable ability of *L. vannamei* to grow in less than ideal environments has made it the species of choice for culturing in low salinity water (Alday-Sanz, 2010).

The success of many farmers in rearing shrimp in low salinity environments, variable growth and survival among ponds are still being reported on a regular basis (Roy *et al.*, 2009a). The problem is compounded by the fact that no low salinity water is the same with large variations in source, salinity, and ionic profile being reported (Boyd and Thunjai, 2003). While it is suspected that some of the "mortality" and variability is due to stocking errors, environmental factors, and farm management, there is sufficient evidence to suggest that less than ideal ionic profiles are indeed responsible for much of the observed mortality (Roy *et al.*, 2007a).

In order to improve growth, survival, and production of shrimp reared in low salinity water two different strategies have been employed by researchers and farmers. These strategies include water modification approaches which alter the low salinity rearing medium to make it more acceptable for production of shrimp and nutritional strategies that focus on modification of diets offered to shrimp, usually with supplements that provide an osmoregulatory advantage at low salinity.

A dietary source of 23 minerals has been demonstrated as essential in 1 or more animal species. These elements are divided into two groups: the 7 macro minerals (calcium, chlorine, magnesium, phosphorus, potassium, sodium, and sulphur) and 16 trace minerals (aluminium, arsenic, cobalt, chromium, copper, fluorine, iodine, iron, manganese, molybdenum, nickel, selenium, silicon, tin, vanadium, zinc). Thirteen minerals are required in the diet of most terrestrial animals and may be essential for aquatic animals. Among these minerals, eight are cations: calcium (Ca^{2+}), copper (Cu^{2+}), iron (Fe^{2+}), magnesium (Mg^{2+}), manganese (Mn^{2+}), potassium (K^{+}), sodium (Na^{+}), and zinc (Zn^{2+}); and five anions or are usually found in anionic groupings: chloride (Cl^{-}), iodine (I^{-}), molybdenum (Mo^{2-}), phosphate (PO^{43-}) and selenite (SeO^{32-}) (Scott *et al.*, 1982).

Since aquatic animals can obtain minerals from both ambient water and feed, dietary supplements of selected minerals could facilitate better survival and growth of shrimp held in low salinity conditions.

The present study was aimed to observe the mineral supplementation on growth and survival of *L. vannamei* in low salinity water.

Materials and Methods

The experiment was conducted in Wet Laboratory of the Department of Aquaculture, College of Fishery Science, Sri Venkateswara Veterinary University, Muthukur, for a period of 7 weeks. *Litopenaeus vannamei* (1000 numbers) were obtained from CP Hatchery, Nellore, who has been authorized by Coastal Aquaculture Authority (CAA), Chennai to produce seed. Post larvae (PL10) transported by road in plastic bags containing 15 ppt saline water. PL transferred to the same salinity water in the wet lab. Acclimatization was carried out over 8 days. During this time salinity was lowered from 15 ppt to 3ppt bore well water at an average rate of 4ppt day^{-1} (Araneda *et al.*, 2008). During this period the seed were fed with control diet.

Experimental design

The aquarium tanks used for experiments were of size 60x30x30 cm. Twenty one aquariums were stalked on iron racks. Aquariums were located in a secured place where there is no direct sunlight and covered all the sides with black paper to avoid algal growth in the tank. Water in the aquariums was aerated by using air stones connected to the air compressor. Filters are used for filtering the aquarium water. The underground water was taken into a tank and allowed to aerate for 48 hours and was used for filling the aquaria. Salinity was checked before taken the water into aquarium. The water is allowed to filter for 24 hours before introducing the shrimps into the aquaria.

Ten numbers of Shrimps with initial average weights of 0.15 – 0.18gm were introduced in to each aquarium and triplicates were maintained for each treatment (Aqueous supplementation of K-20mg and K-30mg, Mg-40mg and Mg-80mg) includes control. Regular water exchange of 25% was done every day. Left over feed, excreta and other debris were siphoned off from the bottom of the tank without disturbing the shrimps.

Experimental feed preparation and Feeding

In the experiment, formulated feed with the crude protein (35%) were used for feeding. Fishmeal, soybean meal, groundnut oil cake, maize and deoiled rice bran were the ingredients used for control feed. Experimental diets were prepared with same ingredients as used in control diet. All the ingredients used in feeds were obtained from local markets. Ingredients used in the feeds were estimated for proximate composition (AOAC, 1995) (Table 1).

Each ingredient was procured in required quantity and ground into powder and sieved. All the ingredients were then mixed in required proportion and water was added at the rate of 30 ml per every 100g of feed and dough was prepared. Maida (1%) was used as a binding agent in the feed. The dough was cooked for 20 minutes in pressure cooker and then cooled. 1% Vitamin mixture was added. The homogenous dough was pressed through a hand pelletizer (La Monferrina s.r.l, Italy) with a sieve of 1 mm diameter. The feed was dried in shade and then in hot air oven at 80-90^{0}C to reduce the moisture content to 10% and stored properly in dry and air tight bottles and kept in dark cool place.

Growth performance

The growth parameters of all the shrimps of each aquarium were individually estimated by taking their total body length and weight at 7 days interval. Individual shrimp length and weight were recorded. Individual shrimp weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) was assessed using the following formulae:

Weight gain (%) = (FW-IW) × 100/ IW,

FCR = Feed given (DW)/ body weight gain (WW),

SGR (%) = [ln (FW) – ln (IW)/ [N] ×100.

Where FW = final weight, IW = initial weight, DW = dry weight, WW = wet weight, ln = natural log and N = number of culture days

Survival rate

Survival of the shrimps at each fort-night was noted down and survival rates are calculated.

Statistical analysis

Statistical analyses were performed using web agristat package (WASP) version 2.0. The data obtained on Growth, Survival and Food Conversion Ratio was statistically analyzed by applying Randomized Block Design (RBD) of two-way classification.

Results and Discussion

Growth of *L. vannamei* supplied with aqueous minerals

Weight of shrimp in grams and weight increment data observed weekly for different treatments were presented in figures 1 and 2. An overall study indicated that the K-20mg recorded total weight increment of 3.64±0.05g in the 49 days experimental period. This was followed by the Mg-40mg (3.30±0.05), K-30mg (3.28±0.07gm) they stood in second and third positions respectively.

Specific growth rates of *L. vannamei* supplied with aqueous minerals supplementation

Specific growth rates for *L. vannamei* treated with different diets were calculated and presented in figure 3. The specific growth rates by end of the experimental period (49 days) were calculated for all treatments. Control group has the lowest Specific Growth Rate of 6.03%. The highest value was in K-20mg with 6.50%. The treatments that stood second and third positions were Mg-80mg (6.38%) and Mg-40mg (6.17%). These were followed by, K-30mg (6.16%).

Feed conversion ratio of *L. vannamei* with aqueous minerals supplementation

The Feed Conversion Ratio in different experiments of *L. vannamei* groups were calculated and presented in figure 4. The range for Feed Conversion Ratio observed during the period of experiment was 0.21 (K-20mg) – 3.68 (control).

The Feed Conversion Ratio was subjected to analysis of variance (ANOVA) and treatments found to be non-significant.

Survival of *L. vannamei* supplied with aqueous minerals

Survival percentages of *L. vannamei* shrimp in various experimental treatments are presented in figure 5. The survival percentage throughout the period of experiment was lowest in the control and all treatments. The treatment K-30mg had shown highest survival rate when compared to the other treatments. The subsequent positions were occupied by Treatments K-30mg, Mg-80mg, Mg-40mg, K-20mg followed by control.

Treatment K-30mg has shown significant difference from all other treatments. There was significant difference in between experimental period also.

As the production of shrimp in inland low salinity waters continuous to expand, so does the need for cost effective methods for increasing the availability of essential ions to the organisms in order to ensure proper growth and survival.

Traditional practices, such as the application agricultural fertilisers (k-mag and murate of potash), commercial mineral mixtures application directly to the water without knowing the demand of shrimp, have been proven effective at improving growth and survival (Mc Nevin *et al.*, 2004).

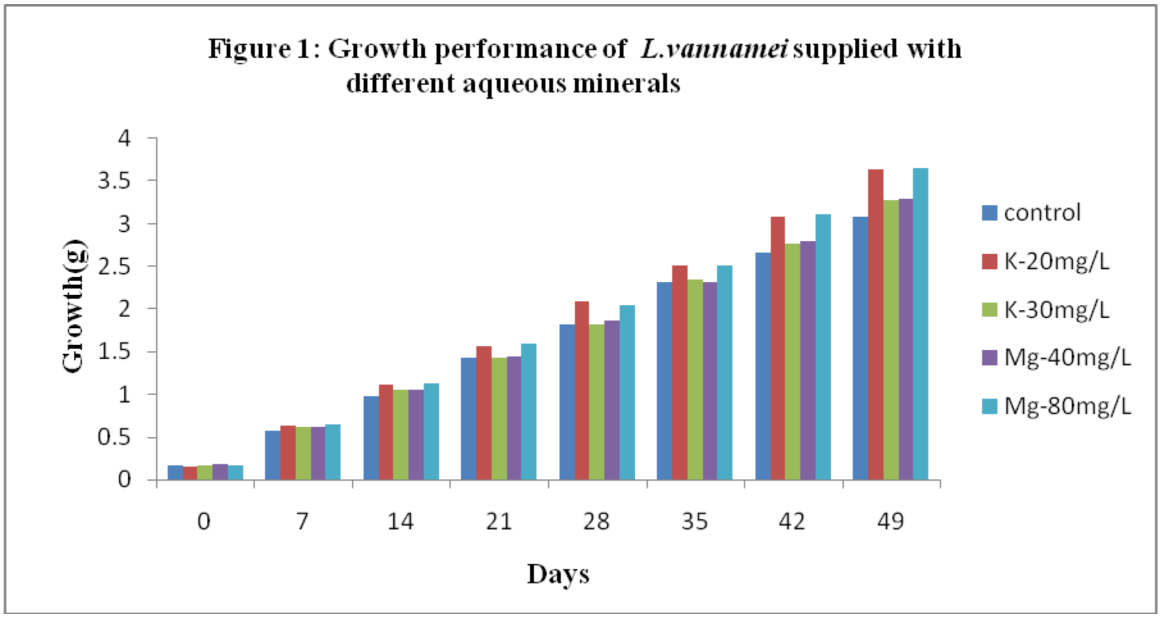
However, the use of these minerals needs to be optimised based on demand of the aquatic organism rather than dumping them in to the pond. It may either allow reduction in the level of supplementation of these minerals and also the risk of mortality of the animals.

Experiments in the present study were concluded at a salinity of 3 ppt, which is comparable with the salinity utilised by commercial shrimp farms where the bore wells are the basic source of water.

Maintenance of sodium, potassium and magnesium is necessary for proper physiological functioning of body, osmoregulation, building of body and also as activities for many enzymes which play role in carbohydrate metabolism and protein synthesis (Davis *et al.*, 2005).

Table.1 Proximate compositions of the various ingredients used in formulate feeds

S. No	Ingredients	Moisture%	Crude protein%	Crude Fat%	Crude Fiber%	Ash %
1	Fish Meal	8.60	58.10	10.00	0.30	19.20
2	Soya bean meal	10.80	38.00	5.90	1.30	5.30
3	Groundnut oil cake	6.00	37.70	13.80	13.20	7.30
4	Deoiled rice bran	7.20	12.10	1.30	15.20	23.80
5	Maize	15.90	8.00	4.80	1.10	1.40



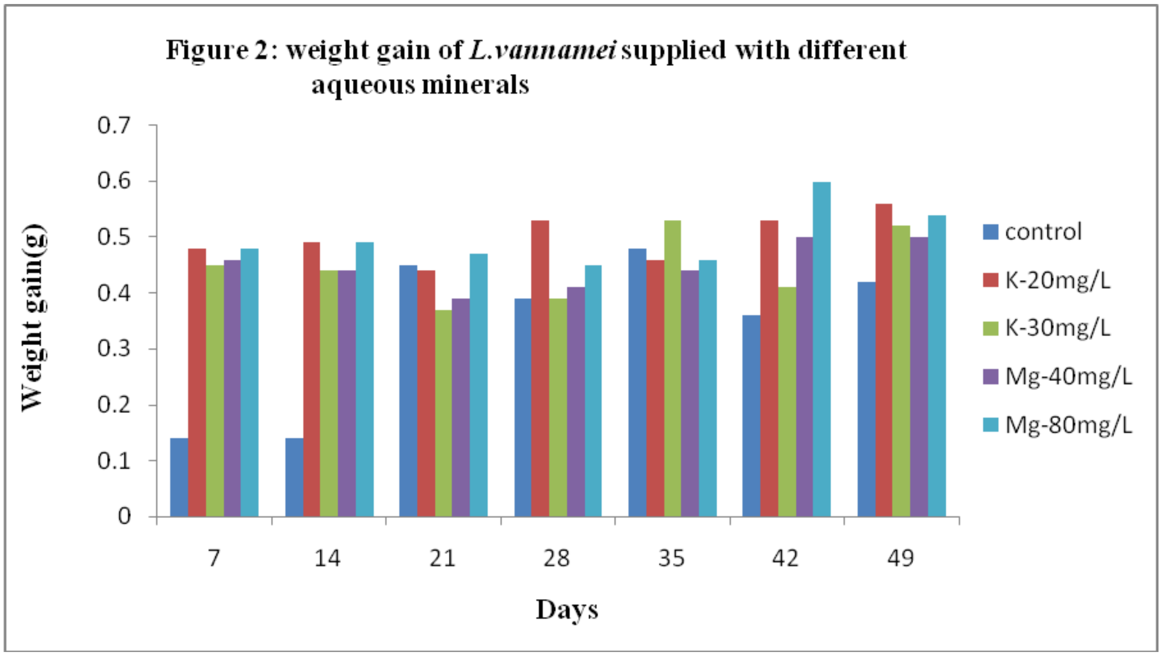


Figure 3: Specific growth rate of *L.vannamei* supplied with different aqueous minerals.

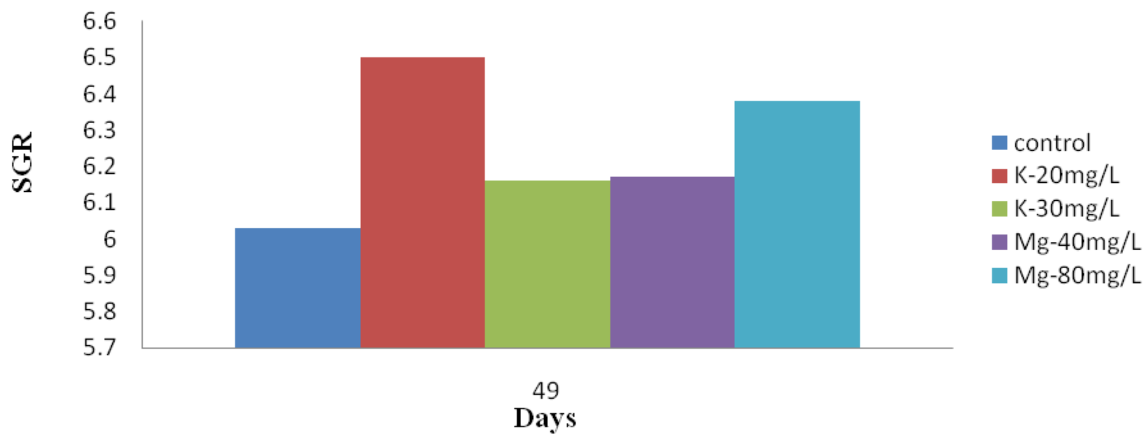


Figure 4: Feed conversation ratio of *L.vannamei* supplied with different aqueous minerals

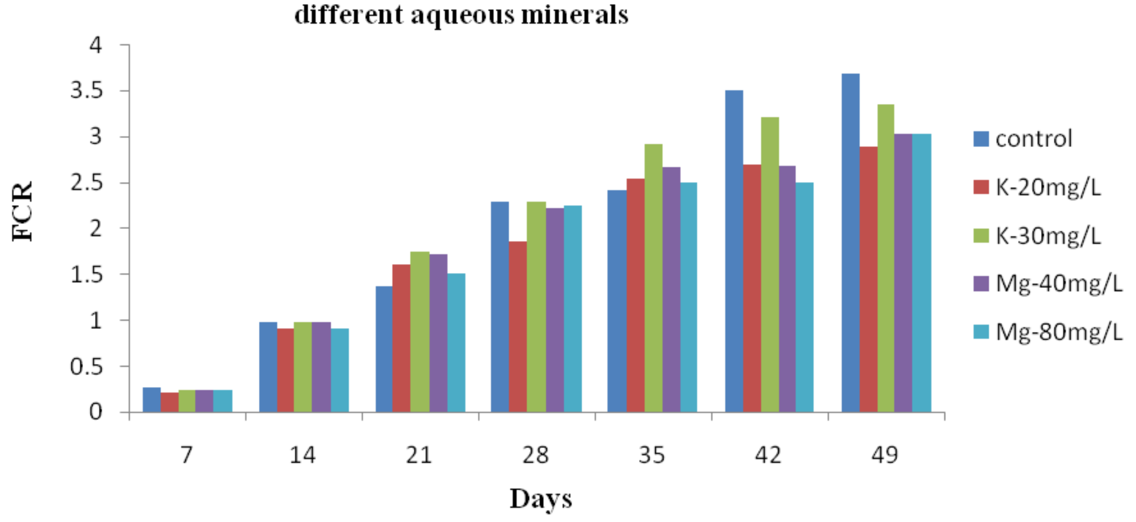
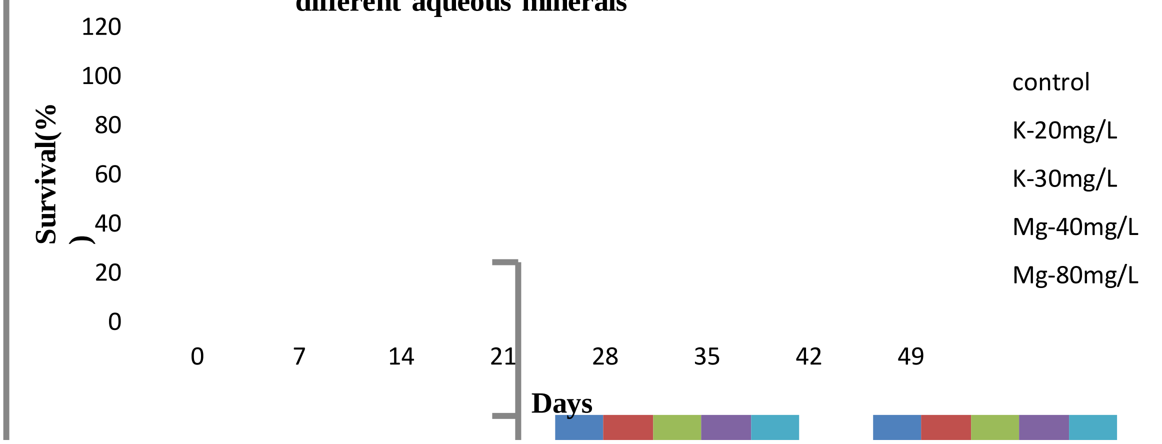


Figure 5: survival percentage of *L.vannamei* supplied with different aqueous minerals



Growth of *L. vannamei* in aqueous minerals supplementation

Aquatic organisms collect most of their required mineral content from the surrounding water. In present study results indicated that the significant($p<0.05$) increase in growth, lower FCR and higher specific growth rate at aqueous potassium supplementation 20mg l^{-1} than to that of control diet. Individual weight gain and specific growth rate and percent weight gain were increased with increasing potassium concentration in aqueous source utilized in *L. vannamei* culture in low salinity waters (Roy *et al.,* 2007a). However, in the present study weight gain, specific growth rate and feed efficiency were not increased with the increase of concentration of potassium supplementation from 20mg $l^{-1}$to 30mg l^{-1}. Pragnell and Fotedar (2005) found that *Penaeus latisulcatus* reared in low salinity well water with 100% and 80% potassium concentration as compared to sea water resulted in slower growth.

Even though potassium concentration increased weight gain was not observed, it may be due to higher aqueous potassium concentration in shrimp tissue water decreases and the concentration of free amino acids in the tissue increases. With the progression of above process animal undergo stress it might have resulted in weight loss. Addition of magnesium to the water from 40mg l^{-1} to 80mg l^{-1} increased growth and specific growth rate. Roy *et al.,* (2007a) also noticed similar growth increase in *L. vannamei* low salinity culture with magnesium addition from 10mg $l^{-1}$to 160mg l^{-1}. Ahmad Ali (1999) was noticed suppressed growth with the magnesium addition in diet in *Penaeus indicus*. He was opined that the magnesium requirement might be satisfied through absorption from the water. However, feed efficiency did not show significant difference with the magnesium addition to the water.

Survival of *L. vannamei* in aqueous minerals supplementation

The results of the present study showed that aqueous potassium supplementation is necessary for the survival of *L. vannamei* in low salinity water culture. The shrimps have shown higher survival at the addition of potassium 30mg l^{-1} to the water. Roy *et al.*, (2007a) were observed similar increase in survival of *L. vannamei* with the increase of K^+ in the water. Zhu *et al.,* (2004) were observed improper Na/K ratio in low salinity water made significant impact on survival of *L. vannamei*. Pragnell and Fotedar, (2005) were reported that the potassium deficiency in low salinity water culture reduce the *P. latisulcatus* survival. Results in the present study indicated that addition of magnesium as aqueous source to the *L. vannamei* culture in low salinity water enhanced the survival of shrimp.

In the present study results showed increasing trend in survival with the increase of magnesium addition to the water. Our observation in the present experiment are also in agreement with previous studies evaluating the impact of magnesium and other minerals supplementation on survival of *L. vannamei* in low salinity waters (Davis *et al.,* 2005 and Roy *et al.,* 2007a). However, Roy *et al.,* (2007a) observed increase of survival in *L. vannamei* in low salinity water up to 40mg l^{-1} of magnesium supplementation to the water, further addition of magnesium resulted in decrease of survival.

It can be concluded that the aqueous minerals supplementation enhances the growth and survival of *L. vannamei* in low salinity water.

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