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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 3 (9): 1420-1423, 2000

Study on the Impact of Fertilization on the Production of *Artemia* (Cyst and Biomass) and Salt in an Integrated System from the Solar Salt Works of Bangladesh

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Abstract: An on-farm study was undertaken to investigate the possibility of *Artemia* culture with salt in the traditional solar salt beds of Bangladesh and to find out the impact of various fertilization treatments on the production performance of *Artemia* (cysts and biomass) and salt through integrated approach. Four treatments in two consecutive years of experiment like, T_1 and T_2 (in the first year), T_3 and T_4 (in the second year) was applied for this integrated culture system. Treatments were comprised of application of urea and triple super phosphate (TSP) and dried and powdered chicken manure at different doses. Study reveals that modified solar salt beds of Bangladesh having suitable water quality can be successfully utilized for salt *Artemia* production in the winter months. A significant higher production of *Artemia* cysts (P=0.0015) and biomass (P=0.0136) was found for treatments T_3 (15.23 kg/ha DW) and T_3 (196.10 kg/ha WW) respectively. No effect of *Artemia* - salt integration system was observed on the quantity of salt production.

Key words: *Artemia*, cyst, biomass, production, fertilization, salt

Introduction

In Bangladesh, preliminary study on the production of *Artemia* (cysts and biomass) from the traditional solar salt beds of coastal areas was done by Mahmood (1990) and Ahmed and Awal (1991). It has been reported by many authors that *Artemia* (cysts and biomass) production rate influenced by strain character, fertilizer/feeding, physico - chemical parameters of the production ponds and goegraphical location. Regarding the selection of feed/fertilizer for a particular strain of *Artemia* different authors described different approaches. Some of the experiments of Chaecheongscio Fisheries Station, Thailand recommended the following feeds which can be directly fed *Artemia* such as, chicken feed, rice bran, minced fish, chopped chicken etc. Feasibility test of culturing *Artemia* in man made salterns and producing adults and cysts for use in aquaculture was done in the Philippiness by Santose and Sorgeloos (1980). They found rice bran enriched with vitamins and traces of mineral a good food for *Artemia*. But in Thailand, *Artemia* is mainly produced in modified salt ponds integrated with salt or salt/fish/shrimp production where *Artemia* ponds treated with chicken manure at a rate of up to 1250 kg/ha prior to inoculation. *Artemia* culture bears immense importance for Bangladesh, specially for shrimp fishery development. Non availability of shrimp post larvae (PL) as per requirement and shortage of larval feed are the two most important constraints in intensifying shrimp culture in Bangladesh. Larval food for shrimp in Bangladesh can be made available by utilize the solar salt beds in the winter months through integrated approach that showed success in many countries with similar environmental condition like Bangladesh. The present total salt farming area of Bangladesh is about 12,000 ha, where from a total of approximately 180 metric tons of dry cysts and 2400 metric tons of biomass can be obtained per annum. This much production of *Artemia* cysts and biomass can sufficiently stop the present drainage of foreign exchange for *Artemia* cyst import and will also be helpful for salt farmers by increasing their income and consequently stimulate aquaculture production particularly the shrimp industry. However, production of quality cysts is of prime importance. A good hatching performance and nutritive value of cysts (in terms of fatty acid profile) as per nutritive requirement of predators is also vital. With these considerations this study was undertaken to investigate the possibility of *Artemia* culture with salt in the traditional solar salt beds of Bangladesh to find out the impact of various fertilization treatments on the production performance of *Artemia* (cysts and biomass) and salt through integrated approach.

Materials and Methods

Selection of site: The experiment was carried out in the traditional solar salt work of the south-east coastal district "Cox'sBazar" of Bangladesh during the winter months (January to April) of two consecutive years. For this field work, an area of about two hundred decimal land suitable for salt production activity nearby the river Bak-Khali was hired. The land location was near the estuary of the river. Therefore, intake of high saline water from the Bay of Bengal during the field operation was one of the important considerarions.

Modification of salt beds into *Artemia* production ponds (APPs): In each salt street of traditional field, generally the fifth compartment was modified as *Artemia* Production Pond (APP) by digging it upto a depth of 45 cm. Concentrated salt waters from the evaporation ponds of the salt streets were regularly added into the APP's and finally maintained water depth between 30-35 cm with water salinity varying from 75 to 190 ppt. To prevent mixing of floating *Artemia* cysts with pond mud, polythene sheet with bamboo frame was placed inside all the embankments of the APPs.

Release of *Artemia* nauplii and culture treatments: Imported *Artemia* cysts of Great Salt Lake, U.S.A, Utah, were used as source of mother cysts. Cysts were hatched in the laboratory in natural sea water (around 35 ppt) and released in to the APPs at a rate of 25 nauplii/L of pond water.
Chemical fertilizers (urea and triple super phosphate) and organic manure (chicken manure) were applied at different doses in two consecutive years as follows:

First year
For treatment T_1,
Initial fertilization = Urea 50 kg + TSP 20 kg.

Dress up fertilization = Urea 25 kg + TSP 20 kg.

For treatment T_2,

Initial fertilization = 250 kg chicken manure/ha.

Dress up fertilization = 125 kg chicken manure /ha/3-4 days interval.

Based on the findings of the first year, the rate of application of fertilizers/manure for different treatments in the second year was determined as follows:

Second year

For treatment T_3,

Initial and dress up fertilization same as T_2 of previous year.

For treatment T_4,

Initial fertilization = 500 kg chicken manure/ha.

Dress up fertilization = 250 kg chicken manure /ha/3-4 days interval.

In each year, for each treatment, there were three replications. Application of chemical fertilizers were done by dissolving the required amount in proportionate amount of water, while in case of organic manure, chicken manure were dried in open air and powdered into fine particles and then sieved for removal of feathers and bigger size particles and than applied in required amount by spreading on the water surface.

Water quality parameters: Water quality parameters like, water temperature, dissolve oxygen content, water pH, water salinity etc. were measures weekly basis. Abundance of food particles in the water body was estimated by measuring the transparency level with Sacchi disc.

Harvesting and collection of *Artemia* (cysts and biomass) and salt: *Artemia* cysts were collected from the surface of each of the APP's with the help of a double screen scope net with mesh 500 and 150 μm respectively. Cysts harvesting started after 20 days of culture in both the years and second year respectively which was performed every day in the early morning (to prevent mixing with *Artemia* biomass).

Biomass harvesting was repeatedly done when the population exceeded 125 individuals/L of water. For harvesting of biomass a nylon dipnet of 800μm mesh was used. *Artemia* was harvested at rate of 10-15% of its actual standing crop every 3-4 days interval. For the determination of *Artemia* densities water sample of 2.0L was taken from the middle and four corners of each pond early in the morning when the *Artemia* were more uniformly distributed. Prior to taking the samples, the surrounding water columns were thoroughly mixed so as to stir up bottom dwelling animals. Biomass standing crop and the density of animal/L were determined according to the method described by Sorgeloos *et al.* (1986).

Results

Water quality parameters: Physico-chemical parameters like water temperature, dissolve oxygen, pH and salinity were recorded weekly basis during the culture experiment of both the years. In the first year, the experimental period was continued from 3rd February to 27th April and in the second year the period was 14th January to 5th May.

In all the treatments, a steady increase in temperature was observed from the initial days of culture to onward with the on-set of summer. The average range for T_1, T_2, T_3 and T_4 was found 16.4-27.1°C, 16.4-27.5°C, 14.1-30.1°C and 15.3-29.3°C without any significant variation among the treatments.

No significant variation was also observed in average dissolved oxygen content of the water of the APPs under different treatments. The average range of dissolve oxygen content for T_1, T_2, T_3 and T_4 was 7.5-8.5, 7.0-8.5, 7.0-8.5 and 6.8-8.5 ppm.

Also for water pH, no significant variation was found among the treatment means. For all the four treatments, average pH range was found to vary between 7.0-7.8.

However, the salinity concentration of the water of the APP's under different treatments were found to increasing rapidly with the increase in culture length. The average initial and final salinity concentration of the APP's under different treatments were recorded as 85.0-180.0 ppt for T_1, 80.0-178.0 ppt for T_2, 75.0-178.0 ppt for T_3 and 80.0-190.0 ppt for T_4. As all the APPs were located in similar area and the evaporation of the pond water depends upon the environmental temperature and flow rate of wind, the salinity increment in all the ponds were found with almost similar rate and manner.

Production of *Artemia* cysts (DW), biomass (WW) and raw salt: In both the years, harvesting of cysts was started after 20 days of inoculation of *Artemia* nauplii in the production ponds. In both the years, an increasing trend in cyst production was observed with the increase in salinity level. In all the treatments, cysts production was higher in March and April. Mean production rate with significant variation ($P=0.0026$) between T_1 and T_2 was 11.11 kg (DW) and 14.44 (DW) /ha respectively. Significantly higher rate of dry cysts production (15.23 kgDW/ha) was obtained from T_3 among all the four treatments ($P=0.0015$). The production rate of T_4 was 11.23 kg(DW) /ha.

Biomass obtained from all the treatments were initially showed higher rate, which was because of the lower salinity and ovoviviparous reproductive mode of the female population. But with the increase in salinity a decreasing trend in biomass production was observed. In the later part of the culture period harvesting of higher amount of biomass from all the ponds was obtained as a process of total harvesting. Production rate of biomass from T_1, T_2, T_3 and T_4 was found116.47 kg (WW), 170.88 kg (WW), 196.10 kg (WW) and 146.76 kg (WW) /ha respectively without any significant variation within the treatments.

Production of raw salt in the first year was started from the third week of February. But due to unfavourable climatic condition, in the second year, the production of salt was started from the first week of March. In both the years, initially the production rate was somewhat lower in all the treatments, but gradually found to increase with the rise in average air temperature during rest of the culture days. But occasional cloudy weather and mild rain during the field work causes decline in salt production rate in several days. Mean raw salt production rate from T_1, T_2, T_3 and T_4 was 50.73, 50.66, 70.66 and 68.24 mt/ha respectively. The variation in the rate of salt production within the treatments in the same year was found insignificant but found significant between the years.

Discussion

Production of *Artemia* in respect to both cysts and biomass is directly related to the environmental temperature and salinity of the culture media and these two factors are also said to responsible for the quality of the product also. During the whole culture period of both the years, temperature was found

Table 1: Physico-chemical parameters of the water of the *Artemia* Production Ponds (APP'S) of different treatments.

Treatments	Months	Parameters			
		Temperature (°C)	Dissolve Oxygen (ppm)	pH	Salinaty (ppt)
T_1	January	-			-
	February	16.4 23.2	7.5-8.5	7.1-7.5	85.0-115.0
	March	24.0-26.1	8.0-8.5	7.0-7.3	120.0-155.0
	April	25.2-27.1	7.5-8.5	7.1-7.3	140.0-180.0
T_2	January	-	-	-	-
	February	16.4-23.5	7.0-8.5	7.1-7.6	80.0 120.0
	March	24.0-27.1	5.8-6.5	7.3-7.5	125.0 155.0
	April	25.5-27.5	6.5 8.5	7.4 7.6	145.0-178.0
T_3	January	14.1-17.0	7.1 7.5	7.0-7.2	75.0-80.0
	February	15.1 23.3	8.0-8.5	7.1-7.4	75.0-80.0
	March	22.1-26.2	7.1-8.0	7.0-7.2	85.0 130.0
	April	27.2-29.2	7.1-7.5	7.0-7.6	150.0 180.0
	May	30.1-30.1	7.0-8.5	7.2 7.4	178.0-178.0
T_4	January	15.3-16.0	6.8-7.0	7.0 7.2	80.0-85.0
	February	16.1 22.0	8.0-8.5	7.1-7.8	70.0-85.0
	March	22.2-27.0	7.1-8.0	7.0-7.2	80.0-130.0
	April	27.0-29.0	7.0-8.0	7.0-7.6	145.0-180.0
	May	29.0-29.3	7.5-8.5	7.2-7.4	190.6 150.0

Table 2: Treatmentwise average production of *Artemia* (cyst and biomass) and raw salt.

Production item	Treatment			
	Year 1		Year 2	
	T_1	T_2	T_1	T_2
Artemia cysts (DWKg/ha)	11.11a	14.44a	15.63b	11.23a
Artemia biomass (WWKg/ha)	116.47a	170.88b	196.10c	146.76d
Raw salt (mt/ha)	50.73a	50.70a	70.66b	68.24b

*DW = Dry weight *WW = Wet weight

Data with similar superscripts mean insignificant variation.

to varied in the range of 15-30°C, but in most of the culture days, average temperature was between 23-28°C which was found suitable for the enhancement of the production mechanism that may offer maximum yield with strain from Great Salt Lake (GSL) origin which is in general agreement with the findings of Vanhaecke and Sorgeloos (1989). Occasional fall of temperature by 1-2°C due to rain or other climatic factors had no effect on cyst and biomass production.

Increase in salinity with the rise in water temperature at the on-set of summer is a very important and vital factor for production of salt and determining the reproductive mode of the female *Artemia* in a culture system. Gradual increase in salinity level of the APP's was found as a suitable factorfor the culture of *Artemia* in integrated salt-*Artemia* production system in Bangladesh (both qualitatively and quantitatively). Other factors like, dissolve oxygen (6-10 ppm) and pH (7-7.8) of the culture media were also found suitable in *Artemia* production as described by Tarnchalanukit and Wongrat (1987). So the present environmental conditions of the APPs in salt-*Artemia* culture system can be considered as suitable for production of *Artemia* cysts and biomass.

In the month of March and April, during both the cropping years, a direct relationship between cyst production and water temperature was observed and the highest rate of dry cyst production (15.63 kg/ha) was obtained from the ponds of T_3. It is also reported that, neither temperature directly controls the cysts production, nor it is the only influencing factor (Vanhaecke and Sorgeloos, 1989), but several other influencing factors like, physiological (Persoone and Sorgeloos, 1980; Lenz and Dana, 1987) and physical factors (Versichele, 1983), which are indirectly related to environmental temperature and metabolism, are also equally responsible. Study also reveals direct relationship between salinity and temperature that determined the mode of reproduction of the female population (Amat, 1982; Persoone and Sorgeloos, 1980; Lenz and Dana, 1987; Browne *et al.*, 1984). Generally, this animal release nauplii in suitable low saline conditions directly and as the salinity increased, the adverse condition promotes the formation of cysts (Gilchrist, 1960). A similar direct and close relation between salinity level and cyst production was observed in the present study. A similar finding and relationship was also reported by Lenz (1987); Amat *et al.* (1987) and Gilchrist (1960).

Artemia has a general tendency to form and release cysts with the increase in salinity level and worsening environmental conditions. But release of nauplii in high saline environment upto 150 ppt as observed in the present study is also not unlikely. As reported by Olenykova and Pleskachevskaya (1979), fully grown *Artemia* could have both oviparous and ovoviviparous mode of reproduction; ovoviviparous reproduction mostly dominate at low salinity levels, whereas cysts are mostly produced at salinities higher then 150 ppt. So the increased amount of biomass as well as cyst production with the consequent increase in salinity level (upto 150 ppt) in the production ponds as observed in the present study was not unlikely that confirmed the findings of Olenykova and Pleskachevskaya (1979).

As the appliaction of fertilizer and the availability of food in the production ponds play a vital role in determining the rate of cyst production and its quality, the production of dry cyst obtained from various treatments has been compared and found higher production rate (15.63 kg/ha) in T_3 and the difference in production rate with T_1 was found highly significant (P= 0.0026). Lavens *et al.* (1986) reported that the quality of food available to the reproducing adults is a parameter of primary importance in determining the hatching quality of encysted offspring. Findings of the present study also revealed that more cyst and biomass can be obtained by applying chicken droppings (at the rate of 125 kg/ha/3-4 days interval) than other feed, which is in agreement with the findings of Jumalon *et al.* (1983); Tackaert *et al.* (1987) and Tarnchalanukit and Wongrat (1987). Regarding biomass, higher production (196.10 kg/ha WW)was also obtained from the ponds of T_3. In the same year, the rate of production of biomass was lower (146.76 kg/ha WW) in the ponds of T_4 which was apparently due to the application of chicken manure at a double dose that of T_3 resulting an unsuitable condition in the production ponds of T_4. This condition hampered the smooth growth and survival of *Artemia* population in the culture system. The main problems noted were the discoloration of the pond water to dark brown and presence of maximum biotic and abiotic particles in the pond water. As a result a significant variation in the production rate of biomass (P=0.0136) was observed between the treatments of second year, while this variation was found insignificant (P=0.1400) between the treatments of the first year.

The rate of production of salt in the first year was comparatively lower than the second year. And the rate of production of salt from both the treatments of first year was slightly above 50 mt/ha without any significant variation between the treatments which indicates that fertilization/manuring had no effect on rate of salt production. Similarly in the second year, the rate of production of salt from T_3 and T_4 were found 70.66 and 68.24 mt/ha respectively, without any significant variation between the treatments. But a significant variation was noted for year wise production.

Several causes were identified for the lower rate of production in the first year, which included delay in start of salt production as a result of modification of ponds, larger volume of brine was built up and used, which is not usual, unfavourable climatic condition and shorter dry season. In salt- *Artemia* culture, though *Artemia* generally plays beneficial role for qualitative and quantitative improvement of salt (Johns *et al.* 1981; Davis, 1980; Sorgeloos, 1986), but in course of the present study, no such effect particularly for qualitative improvement was observed that may be evaluate through hatching and nutrition study. For other qualitative aspect, *Artemia* also controls algal bloom and organic impurities present in solar salt ponds by grazing on them which otherwise inhibits early precipitation of gypsum and contaminates the salt during crystalization (Davis, 1980). However, the production rate of salt in the second year from both the treatments was found similar to that of the local salt beds.

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