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Artemia cyst production at Kelambakkam near Chennai

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Abstract

Two rearing experimetnts on cyst production of *Artemia* were carried out in a salt pan a Kelambakam, near Chennai The rearing media containing this parthenogentic strain of *Artemia* when enriched with both organic and inorganic fertilizers was found to augment water and soil fertility, leading to increase in population and cyst production After the stocking, there was an initial decrease in the population of *Artemia* However, the population increased when the first generation of nauplii emerged during 16th - 19th day of culture Ovo-viviparity was noticed when the salinity was around 115 ppt A density of 99 nos /l was attained with chicken manuring from an initial stocking of 40 nos /l, while the inorganic fertilization yielded a still higher population density of 176 nos /l from an initial of 16 nos /l From 61st day onwards, salinity related stress was created by gradually increasing the salinity up to 160-200 ppt, which resulted in the change of reproduction from ovo-viviparity to oviparity During the period of cyst production, adults showing oviparity were found to be more among total adults in the population Intensive and frequent rains caused sudden reduction in salinity, which has adversely affected the population, particularly those of adults In addition, stratification in salinity was noticed A cyst production of 3 9 kg/ha/189 days was obtained in the pond without fertilization, while it was 8 6 kg/ha/189 days in the pond with organic fertilizer However, a higher production 21 32 kg/ha/199 days was achieved with inorganic fertilizers

Introduction

Artemia cysts have gained a unique position in aquaculture system as they are highly nutritive, can be stored under ideal conditions for a prolonged period and hatched as and when required to get nauplii for feeding early larval stages of cultivable crustaceans and fish (Sorgeloos, 1980) Though the cysts are essential for the success of aquaculture, cyst supply from natural sources is inadequate to meet the ever-increasing demand (Sorgeloo 1980) To increase the overall productio attempts were made to culture *Artemia* b inoculation in suitable saline habitats t produce cysts In the present paper, th results of experimental culture of *Artemi* in salt-pan areas at Kelambakkam nea Chennai are presented

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Material and methods

Experimental ponds

First experiment was carried out in 3 rectangular ponds, each measuring 230 m^2, while the second one was done in one 0.4 ha pond, situated the saltpan areas belonging to M/s S.K.M. Subbaiya Pillai & Son at Kelambakkam, 35 km south of Chennai. These were originally shallow evaporation ponds, which were converted for *Artemia* culture by raising their dykes. Initially, they were sun-dried for a week. The ponds were filled initially with 70 ppt saline water drawn from a feeder canal.

Fertilization

In the first experiment, two out of three ponds were manured with chicken droppings and the third one as control (without fertilization). In the second experiment, inorganic fertilizers (urea, superphosphate and di-ammonium phosphate) were used. Basal dose of fertilizers was given prior to stocking. Re-fertilization was done at an interval ranging from 3 to 21 days at half/quarter of the basal dose depending on development of phytoplankton blooms. In the first experiment, basal dose was 250 kg chicken droppings/ha in pond-I, while it was 500 kg/ha in pond-II. Totally 20 re-fertilizations were done during the culture period of 189 days with a total of 57 kg (@ 2,467 kg/ha) chicken droppings in pond-I and 120kg (@ 5,196 kg/ha) in pond-II. In the second experiment, 0.4 ha pond was initially fertilized with a basal dose of urea and super-phosphate each at a rate of 50 kg/ha. Di-ammonium phosphate was also added at a rate of 25 kg/ha/application from 58th day of culture, as phosphorus level did not increase appreciably with urea and super-phosphate. 17 re-fertilizations were done during the culture period (199 days) and the rate of fertilization in total, was 450 kg urea/ha, 450 kg super-phosphate/ha and 275 kg di-ammonium phosphate/ha.

Stocking and sampling

Local parthenogenetic strain of *Artemia* was stocked at 40 nauplii/litre in the first experiment on 5th day and 16 nauplii/litre in the second experiment on the first day of culture. Periodical samplings for analyses of population structure and of nutrients in the water/soil were carried out. Further, phytoplankton composition was also qualitatively analyzed.

Water management

Salinity of the rearing medium was maintained between 70 and 115 ppt up to 60th day and thereafter, it was gradually increased by addition of high saline water and also by evaporation due to typical hot climate prevailing in the area, to certain extent. Salinity rose to 175 - 185 ppt on 98th day in the first experiment and 160 ppt and 190 ppt on 98th day and

115th day respectively in the second experiment. The maximum salinity recorded was 200 ppt in both the experiments.

Harvest

Harvest of cyst was done either by collecting the floating cysts or those accumulate near the inner periphery of the pond during the morning hours (6 to 9 A.M). In the first experiment, cyst collection was started from 133rd day and continued up to 189th day. In the second experiment, it was carried out in two phases: the first one during 98th - 140th day and the second during 176th - 199th day. Harvested cysts were initially stored in saturated brine for 10-15 days and later processed by cleaning and sun drying.

Results

Effect of fertilization

Soil characteristics: In the first experiment, the organic carbon content of soil was 0.3 %, which increased to 0.48 % in pond I and to 0.62 % in pond II after fertilization. However, there was a decrease (from 0.3 % to 0.26 %) in the control pond. In the second experiment, a progressive increase from the pre-fertilization level of 0.63% to 0.96% was noticed as a result of fertilization/re-fertilization. Similarly, progressive increase of available phosphorus and nitrogen from the pre-fertilization to the post-fertilization level was also noticed in all the experimental ponds of both the experiments, while there was not much change in these nutrients in the control pond of the first experiment (Table 1).

Initial reduction in soil *p*H was observed when the ponds were manured with chicken droppings. Soil *p*H decreased from the pre-fertilization level of 7.9 to 6.5 when fertilized with chicken droppings in pond-I and to 6.2 in pond-II. However, it remained static in the control pond of the first experiment. As the culture progressed, *p*H showed a progressive trend and reached 7.5 - 8.1 on 133rd day (Table 1). Soil *p*H though declined marginally in the beginning (from 8.2 to 7.9), was not much affected because of inorganic fertilization in the second experiment, where it varied from 7.7 to 8.3 (Table 1).

Water characteristics

Phosphate content of the water varied from trace to 0.160 ppm in the control pond, while it was 0.008 to 0.040 ppm and 0.010 to 0.180 ppm respectively in pond I and II of the first experiment (Table 2). The values of phosphate ranged from 0.26 to 0.41 ppm in the second experiment, where inorganic fertilization was carried out (Table 2). However, nitrate content in the first experiment reached a maximum of 0.7 ppm on 54th day in the pond-I, while a maximum value of 0.8 ppm was attained on 61st day in pond-II. A reduction in nitrogen content from 0.120 ppm to 0.010 ppm was noticed in the control pond during the course of the first experiment. Irrespective of fertilization, total alkalinity showed a similar pattern in all these ponds (Table 3).

Phytoplankton

In the first experiment, dominance of chain-forming phytoplankton *Oscillatoria*

Table 1. *Influence of fertilization on soil fertility*

Particulars	Sampling day	First Experiment Control Pond	First Experiment Pond - I	First Experiment Pond -II	Second Experiment
Organic carbon (%)	Pre-fertilization	0.3	0.3	0.3	0.63
	Day-8	0.3	0.36	0.37	—
	Day-37	—	—	—	0.78
	Day-89	0.29	0.39	0.57	—
	Day-91	—	—	—	0.90
	Day-133	0.26	0.48	0.62	—
	Day-149	—	—	—	0.94
	Day-199	—	—	—	0.96
Available nitrogen (mg/100g soil)	Pre-fertilization	15.8	15.8	15.8	—
	Day-8	15.8	18.5	19.9	—
	Day-37	—	—	—	—
	Day-89	16.9	28.8	29.0	—
	Day-91	—	—	—	—
	Day-133	16.3	29.8	31.2	—
	Day-149	—	—	—	—
	Day-199	—	—	—	—
Available phosphorus (mg/100g soil)	Pre-fertilization	1.38	1.38	1.38	2.82
	Day-8	1.38	1.50	1.50	—
	Day-37	—	—	—	5.2
	Day-89	1.05	2.90	3.60	—
	Day-91	—	—	—	6.8
	Day-133	1.10	3.40	4.70	—
	Day-149	—	—	—	7.2
	Day-199	—	—	—	7.2
p^H	Pre-fertilization	7.9	7.9	7.9	8.2
	Day-8	7.9	6.5	6.2	—
	Day-37	—	—	—	7.9
	Day-89	7.7	7.4	7.2	—
	Day-91	—	—	—	8.3
	Day-133	8.1	7.9	7.5	—
	Day-149	—	—	—	7.8
	Day-199	—	—	—	7.7

sp. and *Spirulina* sp. was observed throughout the culture period. In the second experiment, unicellular *Aphanothece pallida* occurred along with chain-forming *O. terebreformis* and *S. subsalsa*. The latter two species dominated in the salinity of less than 160 ppt, while the first species dominated in the salinity above 160 ppt and formed as a mat-like layer in the bottom.

Table 2. *Effect of fertilization on phosphate and nitrate of water phase*

Particulars	Sampling day	First Experiment			Second Experiment
		Control Pond	Pond - I	Pond - II	
Phosphate (ppm)	Day- 3	0.008	0.012	0.016	——
	Day- 14	0.008	0.01	0.014	——
	Day- 23	0.008	0.008	0.1	——
	Day- 26	——	——	——	0.36
	Day- 33	0.008	0.02	0.02	——
	Day- 45	——	——	——	0.3
	Day- 54	0.008	0.01	0.014	——
	Day- 61	0.008	0.01	0.014	——
	Day- 68	0.01	0.02	0.02	——
	Day- 74	0.008	0.02	0.05	——
	Day- 76	——	——	——	0.26
	Day- 82	0.01	0.02	0.06	——
	Day- 89	0.008	0.03	0.07	——
	Day- 91	——	——	——	0.38
	Day- 98	0.01	0.01	0.035	——
	Day- 103	Trace	0.02	0.01	——
	Day- 112	0.02	0.01	0.18	——
	Day- 124	0.01	0.04	0.06	——
	Day- 133	0.01	0.03	0.04	——
	Day- 143	0.16	0.04	0.018	——
	Day- 149	——	——	——	0.36
	Day- 168	——	——	——	0.41
	Day- 199	——	——	——	0.39
Nitrate (ppm)	Day- 3	0.12	0.41	0.66	——
	Day- 14	0.1	0.48	0.7	——
	Day- 23	0.01	0.5	0.72	——
	Day- 33	0.1	0.62	0.7	——
	Day- 54	0.06	0.7	0.74	——
	Day- 61	0.08	0.68	0.8	——
	Day- 68	0.06	0.58	0.76	——
	Day- 74	0.04	0.6	0.7	——
	Day- 82	0.02	0.66	0.8	——
	Day- 89	0.01	0.67	0.78	——
	Day- 98	0.01	0.5	0.6	——
	Day- 103	0.01	0.5	0.6	——
	Day- 112	0.01	0.5	0.58	——
	Day- 124	0.01	0.4	0.42	——
	Day- 133	0.02	0.42	0.42	——
	Day- 143	0.01	0.01	0.4	——

Biomass production

In the first experiment, the sampling on 14th day after stocking, revealed that *Artemia* population initially showed a decrease in density as their number decreased from 40 to 32/litre in the control

Table 3. *Influence of fertilization on total alkalinity of water*

Sampling day	Total alkalinity (ppm)			
	First experiment			Second
	Control Pond	Pond-I	Pond-II	Experiment
3	120	124	122	——
14	128	128	128	——
23	132	130	134	——
26	——	——	——	132
33	148	136	140	——
45	——	——	——	124
54	130	132	132	——
61	134	136	134	——
68	140	132	134	——
74	168	162	170	——
76	——	——	——	172
82	200	216	220	——
89	214	228	248	——
91	——	——	——	168
98	220	230	260	——
103	168	216	244	——
112	160	156	172	——
124	180	168	176	——
133	120	120	120	——
143	132	128	128	——
149	——	——	——	164
168	——	——	——	164
199	——	——	——	130

pond (Fig. 1); from 40 to 28/litre in pond-I (Fig. 2) and from 40 to 34/litre in pond-II (Fig. 3). The population observed on 16th day after stocking was composed of nauplii of first generation. Out of 33 total nos./litre sampled, 31 were of the first generation nauplii in the control pond (Fig. 1), 32 out of 35 and 28 out of 39 respectively in ponds I and II (Figs. 2 & 3). In the second experiment, sampling on 19th day showed the occurrence of first generation nauplii (Fig. 4). After the initial decrease, population showed a growth phase and population density reached a maximum of 80, 84 and 99 nos./l respectively in the control and ponds I and II of the first experiment on 43rd day (Figs. 1, 2 & 3). In the second experiment, the population density was 68 nos./l on 61st day (Fig. 4). All developmental stages were found present throughout the culture period. Adults showed an ovoviviparous mode of reproduction when the salinity was less than 150 ppt and oviparous above 150 ppt. During the period of cyst production, number of adults

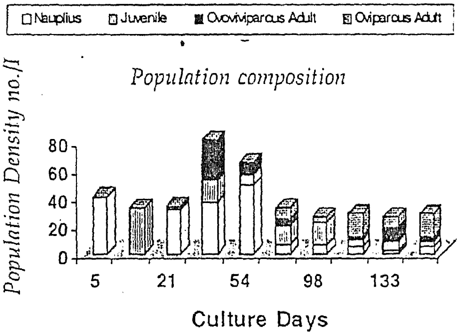

Fig. 1. *Population composition in Control Pond of Experiment I.*

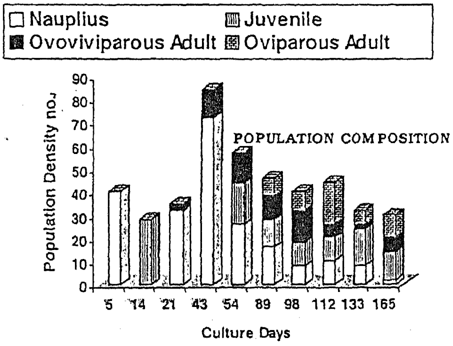

Fig. 2. *Population composition in Pond –I of Experiment I.*

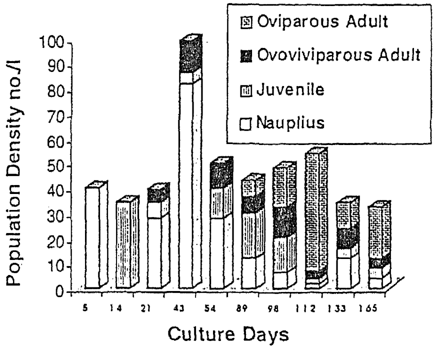

Fig. 3. *Population composition in Pond –II of Experiment I.*

showing oviparity was found among total adults. In the first experiment, 80.0%, 62.5% and 83.3% of adults were oviparous respectively in control and ponds I and II on 165th day while cyst was harvested. In the second experiment, among the total population of 85 nos./l, 49 were oviparous adults on the first day of cyst-harvest (98th day of culture).

Effect of rain on salinity

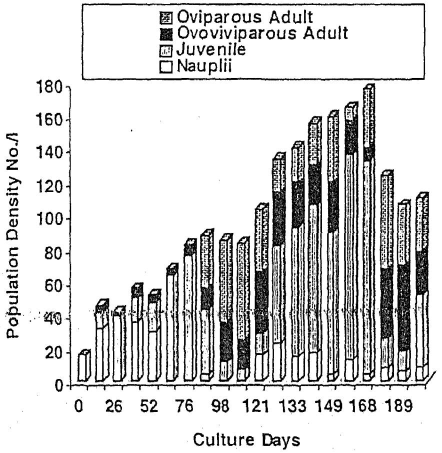

Fig. 4. *Population structure in Experiment –II*

The experimental site was affected due to frequent rains, resulting reduction in salinity. Intensive rain caused quick and sudden reduction in the salinity values of the surface waters, while that of the bottom remained unaffected and thereby creating salinity stratification. Similar salinity stratification was noticed on 133rd, 136th, 186th and 189th day in the first experiment and 182nd and 183rd day in the second experiment (Table 4). Due to wind action over the experimental site, a gradual mixing of surface and bottom water took place, resulting in a uniform saline condition in the experimental ponds.

Effect of rain on biomass

The alteration in the salinity, caused by the rains, has affected the structure and density of *Artemia* population. Though the saltpan area around Kelambakkam received 647 mm rain during the first experiment period, the population experienced the first heavy rain to an extent of 45 mm on 42nd day. Subsequently 133.4 mm, 39 mm and 46.2 mm of rain were experienced on 43rd, 44th and 46th day respectively. As a result of quick and rapid dilution, sudden reduction in salinity from 100-115 ppt to 70 ppt was observed on 43rd day and it took 10 days (54th day) to reach a salinity range of 95-100 ppt in the first experiment (Table 4). The above-mentioned salinity reduction has adversely affected the population density. On 43rd day, the population was 80nos./litre in the control pond which was reduced to 64 on 54th day (Fig. 1). Similarly, the observed reduction was from 84 to 57 nos./l and

Table 4. *Effect of rain on salinity of the culture pond (S =surface, B= bottom)*

Sampling Day	First Experiment				Second Experiment	
	Rain (mm)	Salinity (ppt)			Rain (mm)	Salinity (ppt)
		Control Pond	Pond - I	Pond - II		
0	0	70	70	70	0	70
36	0	115	100	115	0	—
42	45.0	—	—	—	0	—
43	133.4	70 - S 115 - B	70 - S 100 - B	70 - S 100 - B	0	—
44	39.0	—	—	—	0	—
46	46.2	—	—	—	0	—
54	0	95	100	100	0	—
61	0	100	100	100	0	110
72	4.2	—	—	—	0	—
74	4.4	135	130	135 - S 140 - B	0	—
98	0	185	175	180	0	160
103	0	180	185	195	0	—
107	21.2	—	—	—	0	—
110	5.2	—	—	—	0	—
111	12.0	—	—	—	0	—
112	0	170 - S 175 - B	170	160	0	—
115	0	—	—	—	0	190
124	0	200	195	175	10.0	—
126	20.6	—	—	—		—
128	0	—	—	—		165
130	3.0	—	—	—		—
131	30.2	—	—	—	2.4	—
133	2.0	140 - S 170 - B	150 - S 175 - B	145 - S 170 - B	0	—
134	6.6	—	—	—	0	—
135	5.6	—	—	—	0	—
136	0	135 - S 165 - B	140 - S 175 - B	150 - S 170 - B	0	—
140	4.0	—	—	—	20.0	—
141	1.0	—	—	—	5.2	—
143	0	150 - S 155 - B	165	160	0	—
147	0	—	—	—	2.0	—
148	0	—	—	—	16.6	—
149	0	—	—	—	0.2	160
151	0	—	—	—	5.2	165
152	0	—	—	—	0.2	
156	0	—	—	—	0	170
176	4.6	170	165	170	0	200
178	0	170	175	170	0	175
179	0	—	—	—	17.2	—
180	0	—	—	—	41.0	—
181	0	—	—	—	25.0	—
182	24.0	—	—	—	0	110 - S 135 - B
183	68.0	—	—	—	16.2	110 - S 135 - B
184	0	—	—	—	10.0	—
186	9.4	80-S160-B	95-S 160 - B	100 - S 160 - B	0	—
187	8.0	—	—	—	0	—
188	0	—	—	—	2.2	—
189	0	75 - S 165 - B	100 - S 165 - B	105 - S 150 - B	0	130

from 99 to 50 nos./litre respectively in ponds I and II of the first experiment (Figs. 2 & 3). During the period of second experiment, a total of 111.6 mm of rain was received between 179th and 188th day, resulting in the reduction of salinity from 200 ppt (on 176th day) to 110 - 135 ppt (on 182nd day) and 130 ppt (on 189th day) (Table 4). Correspondingly, the population decreased from 176 nos./l (on 168th day) to 106 nos./l (189th day), mostly due to the mortality of adults (Fig. 4). However, moderate rain caused only very little change in the salinity and did not affect the growth of the population. In the second experiment, 2.0 mm, 16.6 mm, 0.2 mm, 5.2 mm and 0.2 mm rains were recorded on 147th, 148th, 149th, 151st and 152nd day respectively. Salinity, which was 165 ppt on 128th day remained the same till 151st day and increased to 170 ppt on 156th day (Table 4). Sampling on 140th day indicated that the population was 156 nos./l (17 nauplii, 89 juveniles, 25 ovoviviparous adults and 25 oviparous adults/litre) and it was 176 nos./l, (4 nauplii, 129 juveniles, 8 ovoviviparous adults and 35 oviparous adults/litre) on 168th day (Fig. 4). The minimum/maximum water temperature observed was 25.0/36.2ºC in the first experiment and 29.4/36.0º C in the second experiment.

Cyst production

In the first experiment, cyst production was 3.9 kg, 5.4 kg and 8.6 kg/ha/189 days in the control and ponds I and II respectively. A cyst production of 21.32 kg/ha/199 days was obtained in the second experiment (Table 5).

Discussion

In the first experiment, the population density showed a decline soon after stocking as observed by Camara *et al.* (1990). In the first and second experiments, the population mainly consisted of nauplii of first generation after 16 - 19 days of stocking, indicating Kelambakkam strain mature within 16-19 days and release nauplii of first generation. Gopalakrishnan *et al.* (1989) observed maturity of Gujarat strain of *Artemia* in 41 days, in the saline habitats of 50 ppt to 200 ppt and 57 days in a salinity range of 125-160 ppt. For Tuticorin strain, Royan *et al.* (1978) recorded 12 days to attain maturity in 138 ppt to 180 ppt in Tuticorin saltpan. However, the same strain showed egg pouch formation under laboratory conditions in 23-27 days in 35 ppt - 140 ppt (Royan 1980). In Didwana Lake strain, adult stage was attained in 15 days; development of egg sacs by 20th day; maturity by 34th day and breeding by 48th day in the laboratory condition (Bhargava *et al.*, 1987). Nevertheless, the present study has indicated that Kelambakkam strain of *Artemia* attained maturity in a shorter period when compared to other Indian strains.

The intensive and frequent rains affected the saline condition of the saltpan including the experimental ponds. Tackaert (1990) reported stratification in salinity during rainy season in the brine reservoirs of the salt-works in the Island of Madura, Indonesia. Further, such stratification in salinity has altered the

Table 5. Artemia - *harvested cysts - initially stored in brine and subsequently processed - obtained dry cyst (g)*

	Dry cyst (g) in the First Experiment			Dry cyst (g) in the Second Experiment	
Culture-day	Control Pond	Pond - I	Pond - II	Culture-day	Cyst (g)
Day-133	2.2	2.0	5.1	Day-98	233.0
Day-136	2.1	4.3	6.8	Day-100	247.1
Day-143	2.	5.6	6.6	Day-115	202.2
Day-149	6.7	7.2	11.1	Day-117	4350.5
Day-161	9.0	10.6	17.3	Day-121	
Day-165	10.5	14.9	21.1	Day-125	
Day-171	9.5	15.3	25.3	Day-128	
Day-176	9.2	13.5	26.5	Day-133	
Day-178	15.0	18.0	25.7	Day-140	
Day-180	11.8	15.0	22.8	Day-176	3498.0
Day-186	7.7	12.4	21.5	Day-178	
Day-189	3.2	4.8	8.2	Day-182	
Total	89.8	124.0	198.5	Day-183	
Production	3.9 kg/ha	5.4 kg/ha	8.6 kg/ha	Day-189	
			Day-199		
				Total	8531.0
				Production	21.3 kg

structure and density of population. The number of adults was drastically reduced when a sudden decrease of 30 ppt was noticed. The very object of intentional salinity stress created for change of reproductive behaviour, i.e., from ovo-viviparity to oviparity had been reversed by such decrease in the salinity of rearing medium. Those leftover cysts in the inner periphery of the pond were washed back into the pond by rain, which in turn hatched out into nauplii. Thus, a higher percentage of nauplii were present in the population after the rain. The present observation indicated that change in salinity by rain is a critical parameter affecting the production, as stated by Arana (1990).

Sorgeloos and Kulasekarapandian (1984) pointed out that *Artemia* feeds on the food particles measuring less than 50 microns. In the present study, two chain-form algae (*Oscillatoria* spp. and *Spirulina* spp.) dominated in the first experiment, while unicellular alga (*Aphanothece pallida*) was also present along with those two chain-form algae in the second experiment. It is presumed that the unicellular alga could have become a suitable food for *Artemia* than those of two chain-form algae. Further, the presence of unicellular algae in the second experiment confirmed its suitability as feed, since a higher cyst production has been realized. The dominance of non-compatible algal feeds such as *Oscillatoria* spp. and *Spirulina* spp. in the first experiment may be one of the reasons for the low population density and subsequent low cyst production, as suggested by Camera *et al.*, (1990).

Chicken manure was used either alone or in combination with other fertilizers in *Artemia* culture (Tarnchalanukit and Wongrat 1987; Primavera *et al.*, 1980; Arana 1987). The present study indicated that the fertilization of rearing medium has enhanced nutrient levels, which in turn resulted in good cyst production, as observed by Gopalakrishnan *et al.* (1989). Soil *p*H showed a decline in the initial phase of manuring with chicken droppings but showed a progressive trend subsequently. However, inorganic fertilization did not show any such initial decline in soil *p*H.

In the present study, a high production of 21.32-kg dry cysts/ha/199 days was achieved with inorganic fertilization in the second experiment, which is considerably higher when compared with that of the first experiment with chicken droppings. Similarly, a maximum population density was recorded in the second experiment (176 nos./l) than that of the first experiment (99 nos./l). Tarnchalanukit and Wongrat (1987) reported an average cyst production of 25 kg wet weight/ha/month in 1980 and 17 - 139 kg dry wt/ha/5-9 months in 1983 in Thailand. Further they estimated a production of 22.7 kg wet cysts/ha and 8,295 kg biomass/ha when cultured in monoculture/integrated systems.

Primavera *et al.* (1980) observed that fertilization with 100 kg dried chicken manure and 15 kg urea in a 0.5 ha pond in The Philippines resulted in good production of lab-lab and phytoplankton, which in turn caused rapid growth in *Artemia* population. They observed riding adults and noticed few cysts in a week after stocking. They also noticed that only moderate lab-lab was produced when the pond was fertilized with only 10 kg urea resulting in gradual death of the stocked *Artemia*. Arana (1987) recorded 10.5 kg processed cysts/0.5 ha/month in NE Brazil when the culture pond was fertilized with dried chicken manure and urea-diammonium phosphate though the rate of fertilization was not mentioned. Instead of organic fertilizers, inorganic fertilizers such as diammonium phosphate (DAP) and urea were used by Royan (1990) and got a production of 22 kg dry cysts of San Francisco Bay strain in 6 months in salt ponds near Jamnagar, Gujarat, India.

Thus the present study clearly indicated that the fertilization of culture ponds has augmented *Artemia* cyst production. However, the use of chicken droppings as manure is so popular in South-East Asian countries, such usage has not given the desired results in the present first experiment, which may be perhaps due to the nature of soil of the ponds. Hence it is suggested that a combination of organic and inorganic fertilizers may enhance overall production of *Artemia* biomass and cyst.

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