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Technology Series No. 1 An Improved Traditional Shrimp Culture Technique for Increasing Pond Yield

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Introduction

Shrimp farming has contributed about 5% of world shrimp production of approximately 1.7 m.m.t. in 1980. Statistics have indicated that shrimp supplies from the wild have been levelling off since 1978 largely due to over-fishing in many traditional shrimp fishing grounds. Due to increasing demand, an additional 200,000 m.t. needed by the year 1990 is expected to be largely satisfied through shrimp farming.

In 1980, more than 84% of world shrimp production through aquafarming were derived from seven Asian countries of which Southeast Asia contributed approximately 45%. Most of the shrimp farms in the developing nations (80% in Southeast Asia) are still operating on the traditional or extensive method of farming. Such traditional farms (Fig. 1) are characterized by low stocking densities (e.g. 5,000/ha) and hence low yield ranging between 100 to 300 kg/ha/yr, irregular pond size and shape, relatively low technical management inputs as well as comparatively small investment. Because of high market price, such traditional practices are still commercially viable to small-scale shrimp growers despite low pond yields.

Shrimp yields in ponds can be_increased by application of modern farming techniques such as intensification of culture operation by regularization of pond size, increasing stocking rate, employment of aeration (Fig. 2), application of formulated feed, etc. This will mean a considerable increase of financial and technological inputs, which most small farmers in the developing countries may be able to afford.

In order to provide shrimp growers with an appropriate technology that will immediately improve their pond yields and hence increase their income, a series of research studies has been conducted by SEAFDEC-NACA to refine existing traditional culture practices for the tiger shrimps, Penaeus monodon (Fabricius). Results showed that the natural food produced in a shrimp pond through fertilization is not fully consumed in the first two months at a stocking rate of 5,000 postlarvae per hectare. Research studies have demonstrated that the natural food produced by organic and inorganic fertilization using the traditional practice can sustain an optimal growth of shrimp at a density of 20,000 postlarvae per hectare for a period of 60 days.

Supplementary feeding is needed to sustain the growth of the shrimps after 60 days by feeding with formulated pellet feeds or trash fish. Research has further proven that excessive stocking over 20,000 post larvae per hectare in such traditional shrimp farm affects growth resulting in reduced rate of returns to investments.

The present research was conducted in earthen ponds utilizing tidal energy for water replenishment and maintenance of water quality. Research findings indicated that growth is accelerated after each molting, which usually occurs during spring tides, when the pond water is renewed. Hence, intensive feeding during this period enhances shrimp growth.

These research findings have been packaged and tested at government extension farms as well as in private shrimp farms in the Philippines. The results have indicated yields ranging from 350–500 kg per crop (120–150 days) or 700 to 1,000 kg/ha/yr. This packaged technology is by no means complete or perfect but serves to provide interested traditional shrimp growers with the necessary appropriate techniques to increase at least two to five-fold their existing production with minimal additional inputs.

The Technology

The vital components of the shrimp farming technology include grow-out facilities, seed supply and operational and management procedures. While adequate facilities are absolutely necessary, competent management ensures effective farm operation and achievement of production target.

Pond Facilities

Where pond facilities have to be newly constructed for the cultivation of the tiger shrimps, it is essential that the site chosen fulfills the following basic requirements:

- availability of good water quality - unpolluted water, pH ranges from 7.5–8.5, salinity 15–30 ppt, tidal amplitude 1–2 meters.

- clayish loam soil - ability to hold water with soil pH exceeding 6.5; acid sulphate soil should be avoided.

- easily accessible.

Sites which are close to source of seed supply are certainly an added advantage.

Most brackishwater shrimp farms are converted from mangrove swamps and hence they are usually located in the intertidal zone and exposed to tidal impacts. The site chosen should take into consideration tidal amplitude in order to utilize tidal energy for water exchange or harvesting. Ponds sited below low water neap tide may have difficulty in draining out water completely at neap tide, hence increasing cost in pumping.

The importance of acid sulphate soil need careful consideration as such soils are prevalent in many mangrove swamps and tidal lowlands. Ponds constructed on acid sulphate soil are initially low in natural productivity because of high acidity of soil and water, thus retarding growth of benthic organisms which are important food sources of shrimps. While acid sulphate soil can be corrected by leaching and liming, it is time consuming and requires more financial inputs.

The grow-out ponds are of simple design, rectangular in shape with size about 0.5–1 hectare, and depth 0.8–1.2 meers. Each pond has its own inlet and outlet gates to facilitate water exchange, pond preparation and harvesting. A diagonal ditch, 5–10 meters wide and 30–50 cm deep extending from inlet to outlet gates, is constructed to facilitate draining of water, collection of shrimp during harvest and to serve as the hiding place for shrimps during daytime (Table 1).

Most of the existing traditional shrimp ponds are large (3–15 hectares each), irregular in shape and relatively shallow (usually less than 40 cm) often resulting in great variation in water temperature and salinity. These ponds could be easily improved by restructuring, making them more regular in shape, uniform in size, sufficiently deep and installing inlet and outlet gates to facilitate water exchange through supply and drainage canals (Fig.3).

Seed Supply

Postlarvae of shrimp can be collected from the wild or supplied by a shrimp hatchery. Research has proven that hatchery-bred fry showed similar growth performance to those from the wild stock. Prior to stocking, the postlarvae (P_{25}-P_{30}), which are 35 to 40 days old, should be first acclimatized before stocking. This should be done in the early morning or late evening so that water temperature fluctuation is minimized. If the pond salinity differs significantly from that of the hatchery, acclimatization should be gradual.

Pond Preparation

Two weeks before stocking, the pond is thoroughly drained and sun-dried until the mud in the pond bottom cracks (Fig. 4). In the meantime, both the inlet and outlet gates are enclosed with a layer of fine nylon netting of mesh size 0.5 mm to prevent escape of fry and entry of predators or other undesirable aquatic organisms. In case the pond is not fully dried, rotinone powder or fresh derris root extract can be used to eradicate the predators. Rotinone powder usually contains 4–5 % rotinone and can be applied effectively at 2 gm/cubic meter of pond water for common fishes and 8 gm/cubic meter for eel.

Fresh derris root is more effective than dry root. The root should be thoroughly crushed and soaked overnight in water (5kg of root in 20 liters of water), squeesing out as much rotinone extract as possible. The solution of rotinone extract is then broadcast to the pond at the rate of 4 grams of root per one cubic meter of pond water.

After drying, dolomitic lime ($CaMgCo_3$) is applied to the pond bottom (Fig. 5) and the earthen dikes at the rate of 500–800 kg/ha when the soil pH is between 6–6.5. The amount of lime required depends on the acidity level of the soil and can be determined following the method of Boyd (1976) [1].

To provide shade to the shrimp larvae, coconut fronds are distributed throughout the pond bottom except the central ditch. Usually, about 500 pieces of coconut fronds are used per hectare. The pond is now ready for fertilization. Production ponds usually have high organic matter content (8–16%) in the pond mud. Application of fertilization raises the level of organic matter to increase production of natural food in the pond. Chicken manure is broadcast at a rate of 600 kg/ha throughout the pond (Fig. 6). Water is then allowed to enter the pond to a depth of 5–10 cm (Fig. 7) which the pond is further enriched with organic fertilizer consisting of ammonium phosphate (16–20–0) at a rate of 37.5 kg/ha and urea (46–0–0) at 12.5 kg. (In productive ponds where organic matter is higher than 16%, additional fertilization is not required. Liming the pond alone can produce a luxurious growth of natural food). Fresh seawater is then allowed to enter the pond until the desired depth is attained. Acclimatized postlarvae (P_{25}-P_{30}) are then stocked in early morning or late evening (7:00 AM - 1:00 PM) at a rate of 20, 00 pieces per hectare.

[1] Boyd 1976. Lime requirement and application in fishponds. FAO Aquaculture Conference, FIR: AQ/Conf/76/E. 13:3 p.

Routine Management

The water in the pond is maintained at 80 cm throughout the culture period. Water is partially replenished during spring tide by making use of the tidal energy. The purpose of water exchange in addition to maintaining water quality, is also to stimulate molting of the animals, resulting in acceleration of growth. Howevrr, this procedure also drains out some of the natural food and reduces pond fertility. Hence, in order to maintain natural productivity, the pond water is regularly enriched with chicken manure after the last day of water exchange. This is done by submerging chicken manure wrapped in polypropylene bags placed at different locations in the pond. Ten bags are used per hectare of pond, each containing 20 kg of manure. One bag is hung directly in front of the inlet gate so that the incoming water can disperse the nutrient to other parts of the pond. The submerging of manure in the pond is to allow gradual release of nutrients and to prevent over-manuring.

Supplementary feed is given only after 60 days of culture. Formulated pellet feed (with 35% crude protein) of finely chopped trash fish are used to feed the growing juveniles in the pond from the start of the third month of culture. The shrimps are fed either every other day or continuously for seven days after the spring tide, twice a day at 7:00 AM and 5:00 PM. This feeding strategy is based on the higher food intake after molting. Natural food production is maintained through continuously fertilizing the pond. This helps to minimize the use of supplementary feed. The feeding rate on the third month is 6% biomass and 4% from the fourth month until harvest.

Harvesting and Yield

Harvesting should be done during spring tide after 5–6 days of changing water to ensure that the majority of shrimps have molted and the shells hardened. A bag net is installed at the outlet gate during harvesting. The shrimps are drained into the bag by releasing the pond water and are collected periodically until the water in the pond is completely drained out. The remaining shrimps in the pond are collected by hand.

The culture period is between 120 and 150 days per crop. The mean size of the harvested shrimp ranges from 22 to 40 grams. Survival rate is about 80%. The average yield ranges from 350 to 500 kg/ha/crop or 700 – 1000 kg/ha/yr. This is at least two to five-fold increase over the highest yield attained in traditional practice.

Financial Analysis

The cost benefit analysis using the traditional practice versus the improved techniques (Table 2) based on one hectare farm indicates that fixed cost in the former accounted for about 61% of total expenditure of which land cost contributed over 47%. The cost of shrimp seeds and labor which accounted for 12% and 19%, respectively, are the major expenditures in the operation of the traditional farms. In contrast, the fixed cost in the improved techniques contributed only about 45% and operating cost 55%. However, the cost of land, seeds and feeds remain the major expenditures of the enterprise. It is apparent that the annual net income from improved technique is about tripled that derived from traditional practice. Furthermore, spreading the annual net income over the 12-month period shows that growers can reap a monthly income of 2,138 pesos (US$118) per hectare using improved techniques as against a monthly income of 738 pesos (US$41) per hectare using traditional practice. In other words, to earn a reasonable monthly income of 2,000 pesos, a shrimp grower will need about 3 hectares of shrimp farm using traditional farming practice as opposed to one hectare using the improved technology. The increase in yield of 500 kg of the tiger shrimp (worth 45,000 pesos or US$2,500) through the improved method is attained at an additional input cost of 25,200 pesos (US$1,400) per hectare. This leads to an additional income of 1.78 pesos per peso invested.

From the above analysis, profitability is shown to be highly influenced by cost of land, seed and feed. Hence, the relative profitability of the improved techniques over that of the traditional method will vary under the following assumed conditions that (a) it is possible to have five crops in two years, (b) land cost could be lower in some region, (c) seed cost could be further decreased and (d) land area for shrimp cultivation may be increased to 2 hectares instead of one hectare.

The net income from traditional versus improved techniques when maximizing the full growing season of the tropics indicates that the difference in income is 22,510 pesos or US$ 1,250 with 2.5 crops per hectare per year or five crops in two years. It should be noted that existing output from single cropping is insufficient to cover the operational costs for both traditional and improved techniques. For the shrimp farms to be profitable, the shrimp growers must al least have two crops a year (Table 3).

Even if the land and seed price were depressed by half the existing value, the income difference between the traditional practice and improved technology is still high in favor of the latter irrespective of number of croppings per year.

Moreover, if the culture area for traditional practices increased from 1 to 2 hectares, the annual net income of the improved technology based on one hectare at given seed and land price is still higher than that using the traditional practice and moreso when the seed price is depressed. When the land price is reduced by half, the net income from 2 hectare-traditional shrimp farm is comparable and even slightly better than that of the improved technology using only one hectare. However, the availability of cheap land price is becoming more remote. In addition, the level of production used in the present evaluation represents that of a low average of 400 kg/crop while that used for traditional practice represents the highest average yield attained. Considering that most traditional culture practice usually have yields less than 200 kg/ha/year, the improved technique is certainly a better technology to augment yield and improve the income level of the small-scale shrimp farmers.

Conclusion

The improved method of extensive shrimp farming has demonstrated to be a technically and economically viable technology that if implemented to all existing traditional shrimp farms may augment production by at least 2.5 to 3 times existing output. If 80% of the shrimp farms in Southeast Asia currently under the traditional method of farming adopt the improved technology, it is calculated that shrimp production in the region could increase from the approximately 38,529 m.t. produced in 1980 to 96,625–126,225 m.t. an increase by 150%–230% and the income of the shrimp price is maintained. Since the world market is expected to consume an additional 200,000 m.t.of shrimps by 1990, themarket price is expected not to be any lower than the present level.

Table 1. Comparison of the level of inputs between traditional and improved farming practices.

Description	LEVEL OF INPUTS	
	Traditional	Improved
Pond size	more than 3 hectares	5000 sq. m - 2 ha.
Pond shape	Irregular	rectangular or square
Depte	30 – 40 cm	80–100 cm
Water gate	One	Two gates, inlet and outlet
Central ditch	None	5–10 m wide, 50 cm deep
Pond Preparation		
draining	Yes	Yes
drying	Yes	Yes
eradication of predator	Yes	Yes
liming	Yes	Yes
fertilization	Prior to stocking only	Throughour culture period
Stocking	3000–8000/ha	20,000/ha
Supplementary feed	None	Two months after stocking
Water management	Tidal	Tidal

Table 2. Comparison of cost and return between traditional practice and improved farming techniques (based on one hectare, 2 croppings a year and given prices of land, seeds, etc.) value in peso.

	TRADITIONAL PRACTICE		IMPROVED TECHNIQUES
A. Income			
P. monodon (300 kg × 100 pesos)	30,000	800 kg × 90 pesos	72,000
M. ensis (100 kg × 20 pesos)	2,000	100 kg × 20 pesos	2,000
Miscellaneous	2,000		2,000
Sub Total A	34,000		76,000
B. Fixed Cost/Taxes			
Land (60,000 pesos × 20% interest)	12,000 (47.7%)		12,000 (23.8%)
Improvement (3,000 pesos × 20% interest)	600 (2.4%)		4,000 (7.9%)
Depreciation (5 years)	600 (2.4%)		4,000 (7.9%)
Property tax	1,800 (7.2%)		1,800 (3.6%)
Sales tax (1% of income)	340 (1.3%)		760 (1.5%)
Sub Total B	15,340 (61%)		22,560 (44.7%)
C. Operating Cost			
Seed (0.3 centavos/pc)	3,000 (12.9%)		12,000 (23.8%)
Labor (400 pesos × 12)	4,800(19.0%)		4,800 (9.5%)

	Fertilizer, lime	1,000 (4.0%)	3,000 (6.0%)
	Feed	0	4,980 (10.0%)
	Maintenance, miscellaneous	1,000 (4.0%)	3,000 (6.0%)
	Sub Total C	9,800 (39.0%)	27,780 (55.3%)
D.	Total Cost (B + C)	25,140	50,340
E.	Net Operating Income (A - C)	24,200	48,220
F.	Net Income (A-B-C)	8,860	25,660
G.	Net Income Over Total Cost	35.24%	50.9%

1 US$ = 18 pesos

Table 3. Comparison of net income (in Pesos) from traditional vs improved technique, using different assumptions as available land area, land and seed prices.

	Assumption	Traditional	Improved	Income Differences
A.	1 Ha. given land and seed price			
	1 crop	-5 970	470	5 500
	2 crop	8 860	25 660	16 880
	3 crop	16 025	38 535	22 510
B.	1 ha., low seed price			
	1 crop	-4 720	2 530	7 250
	2 crops	10 360	31 660	21 300
	2.5 crops	17 900	46 225	28 325
C.	1 ha., low land price			
	1 crop	320	5 530	5 210
	2 crops	15 760	32 560	16 800
	2.5 crops	23 010	46 115	23 105
D.	2 has., traditional vs 1 ha. improved: given seed price and land price			
	2 crops	20 120	25 660	5 210
	2.5 crops	34 450	38 535	4 085
	Low seed price			
	2 crops	23 120	31 660	8 540
	2.5 crops	38 900	46 225	7 325
	Low land price			
	2 crops	33 920	33 560	1 360
	2.5 crops	48 420	46 115	2 305

a. Given land price is P60 000/hectare, low land price is calculated P30 000/ha.
b. Given seed price is at 0.30 pesos/PL, low seed price is calculated at 0.15 pesos/PL.

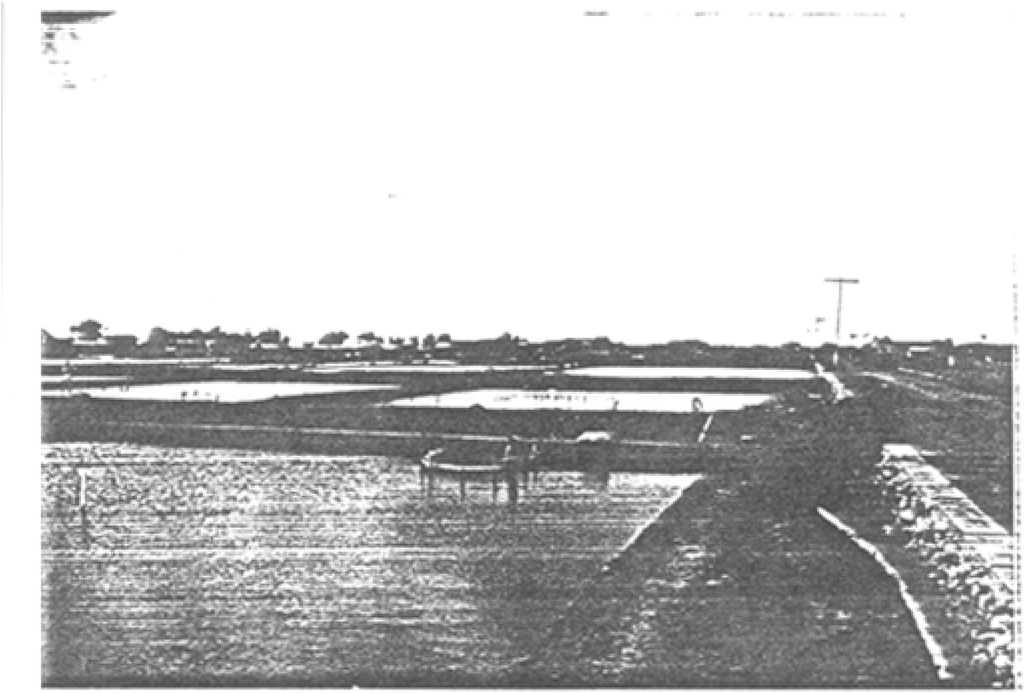

Figure 1. A typical traditional shrimp farm

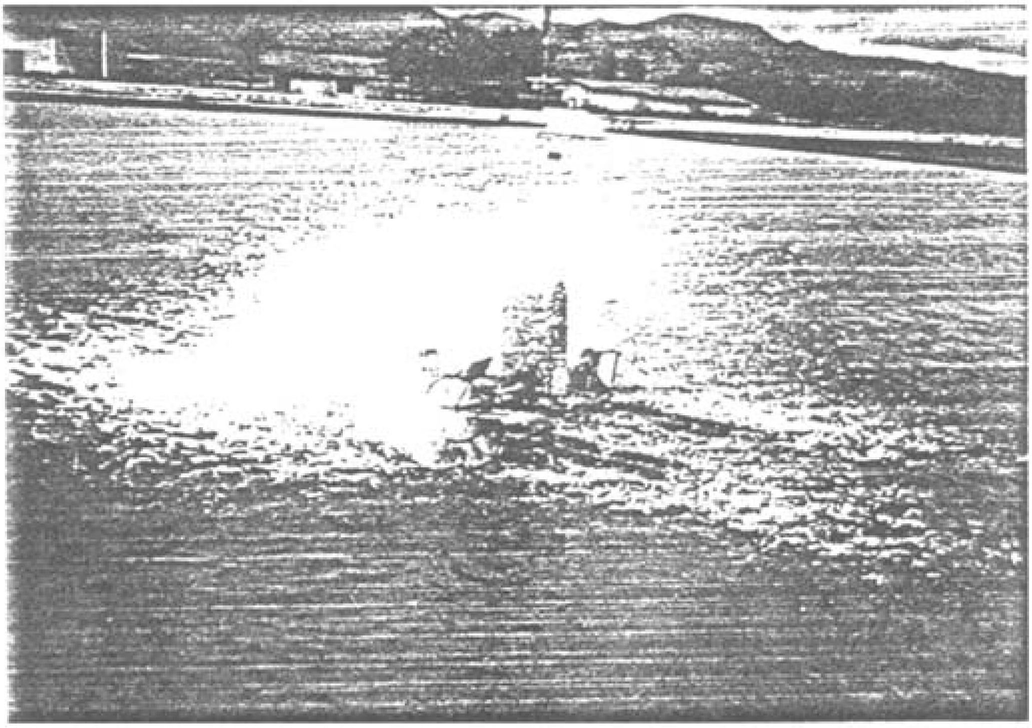

Figure 2. Due to increased stocking density, paddlewheels are installed to improve dissolved oxygen and water circulation.

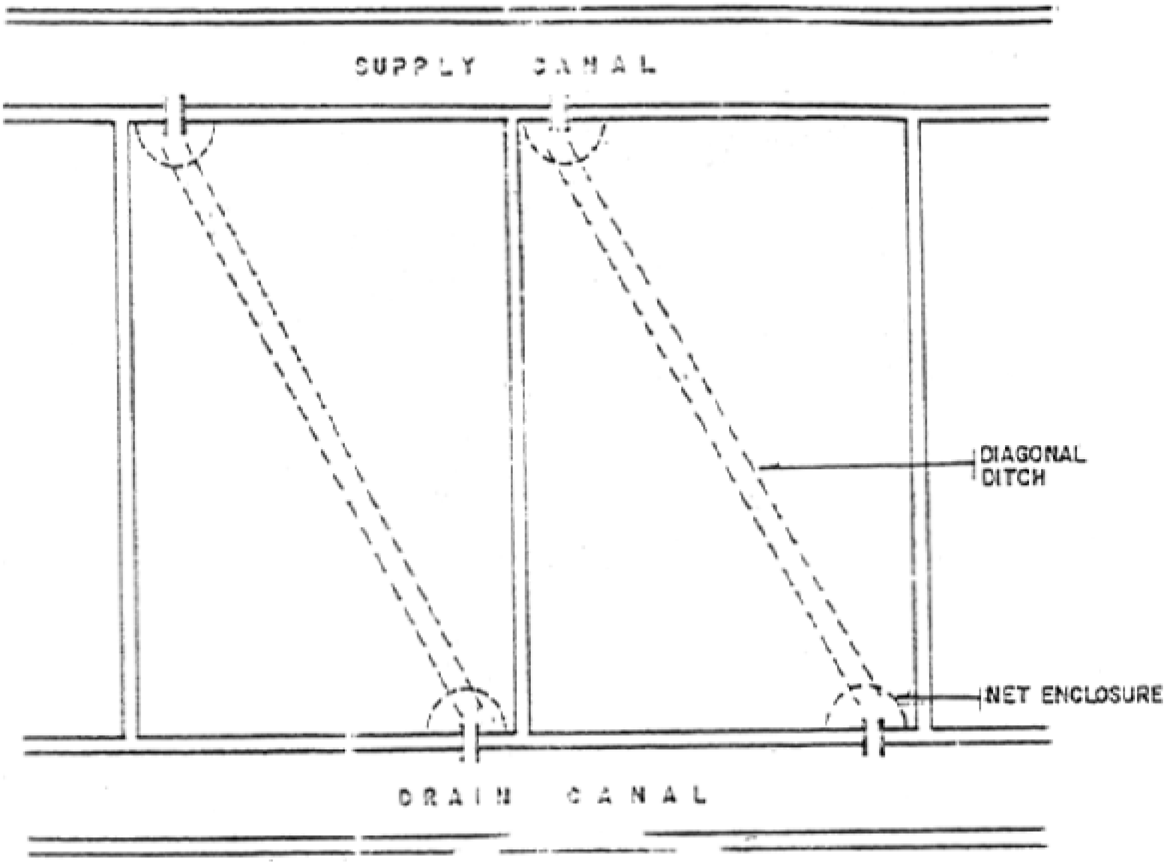

Figure 3. Lay-out of improved extensive pond.

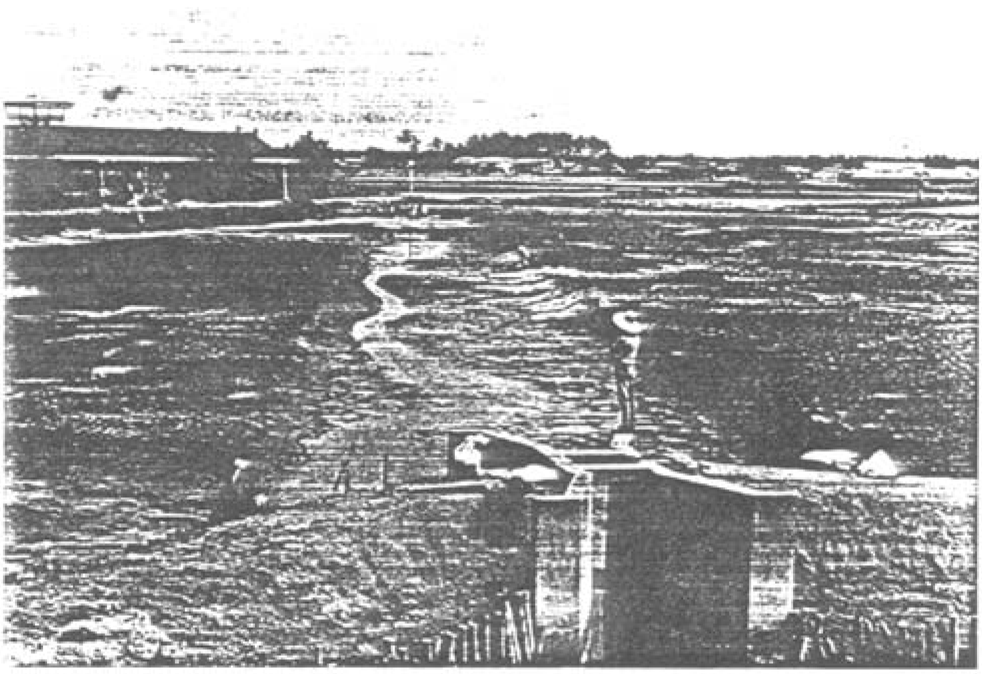

Figure 4. Pond bottom is sun-dried until the soil cracks.

Figure 5. Application of agricultural lime.

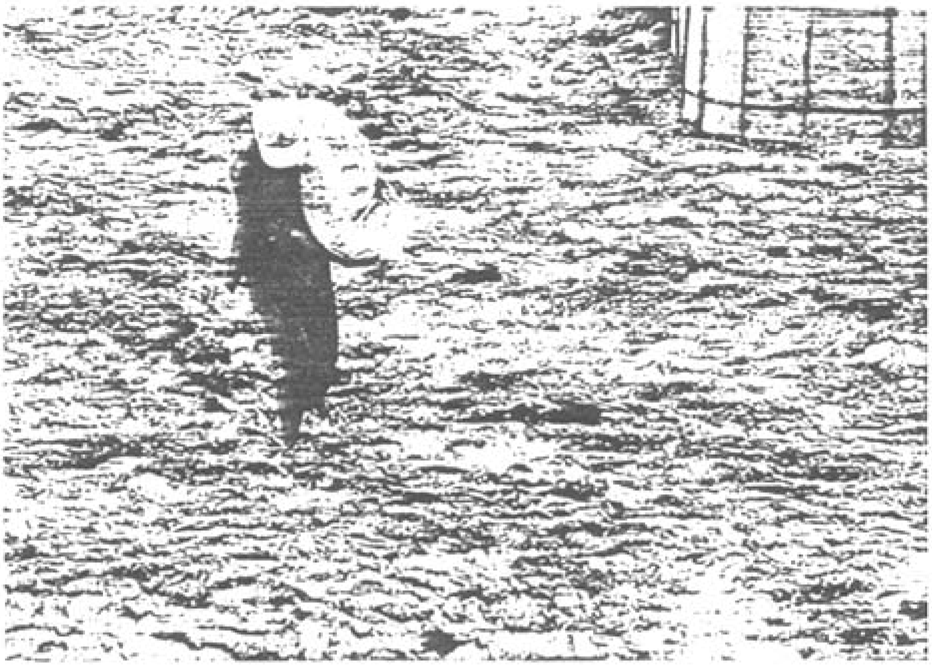

Figure 6. Application of organic fertilizer, e. g. chicken manure.

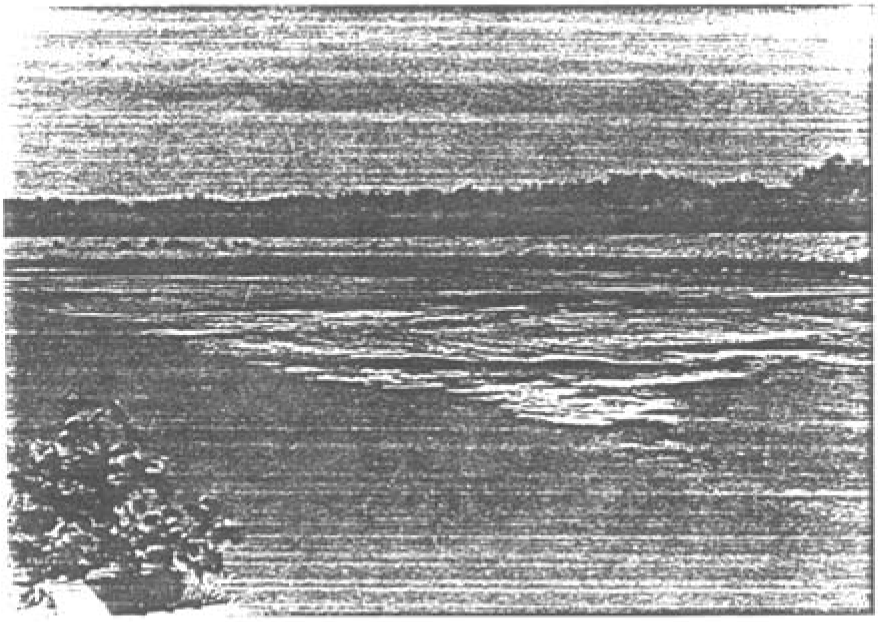

Figure 7. Post pond preparation - flooded with seawater to about 10.0 cm depth.