RICE FIELD FISH CULTURE IN THE LOWER CHIENGRAK – KLONG DAN IRRIGATION PROJECT AREA

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INTRODUCTION

Rice field fish culture, as an intensive form of fish farming, has been practised for a long time in Japan, Taiwan, Indonesia, and India. Fish farming was started in Japan 100 years ago and has attained very good results during the last 50 years.

For Thailand, this type of fish farming is a new occupation. It started about 1957, and is therefore only in the formative stage. The ways in which fish farming is conducted are similar to those used abroad. The differences are only in the details. It is of interest to note that rice field fish culture in Thailand started in the Lower Chiengrak-Klong Dan Irrigation Project Area, which is a part of the alluvial Central Plain of the country, where one crop of rice is grown per year.

This fish farming will give farmers in the Area additional income from the same land, and it will enable the farmers to utilize their fields for more than 6 months of the year.

An inquiry was made to discover who first started rice field fish culture in the Area. It was learned that Mr. Guan Teetong, a farmer of Tambol Bang Chalong of Amphur Bangplee in Samudhaprakarn Province, and Mr. Chat Klinrod, a farmer of Tambol Charakebua of Amphur Bangapi in Bangkok Province were the porsons who started this venture. They started at about the same time. Mr. Guan Teetong received advice from Mr. Piroj Lipikorn, Head of the Extension Service Section of the Inland Fisheries Division of the Fisheries Department, and Mr. Chat Klinrod received advice from the Bangkhen Fisheries Experiment Station of the same Department.

In 1959 the Fisheries Department received an appropriation of 500,000 bahts for a fish culture loan fund. At the same time, the Provinces of Bangkok, Chacherngsao and Samudhaprakarn also made a drive, encouraging the farmers in the Area to take up fish cultivation. Mr. Chob Bunnag, the Fisheries Officer of Chacherngsao Province, and Mr. Chanid Puranabura, the Fisheries Officer of Samudhaprakarn Province, were active in this drive and worked in cooperation with the Chiefs of the Amphurs and the Extension Service Officers of the Rice and Agriculture

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Departments. In this year of 1962, it is estimated that in Chacherngsao, Samudhaprakarn and Bangkok Provinces there will be 300 farmers and landowner who have prepared a total of 10,000 rai (1600 hectares) of their rice fields for fish cultivation.

Lower Chiengrak-Klong Dan Irrigation Project Area.

The Lower Chiengrak-Klong Dan Irrigation Project Area lies within the following limits: on the north it is bounded by the Ram Indra Road (Bangken - Minburi - Chacherngsao), on the east by the Chacherngsao - Bangpakong Road, on the south by the Sukumvit Highway (Bangpakong - Klong Dan - Samudhaprakarn) and on the west by the Sukumvit Highway and Paholyothin Highway (Samudhaprakarn - Samrong - Prakanong - Pratumvan - Bangkhen). The area of this irrigation project area is about 950,000 rai (152,000 hectares).

In the Area there are many big, small and feeder canals, which crisscross like webbing. The total length of all these canals is about 30,000 sen (1200 kilometers) with a total area of about 30,000 rai (4800 hectares) of surface water maintained in the dry season.

Soil and Water

The soils of this Area belong to two major groups, i.e., Bangkok Soils Series and Ongkarak soils Series.

Bangkok soils are heavy clays. They are almost impervious to water. The surface is slightly acid. The lower horizons have less or no acidity. It appears that their iron and aluminium content is not of sufficient amount to be toxic to farm crops. In some localities, the Bangkok soils may have appreciable amounts of saline traces, especially when they have recently developed from Tachin Soils, the typical soils of mangrove swamps, which can be observed beside the Sukumvit Highway. The area of the Bangkok soils in the Area is about 800,000 rai (128,000) hectares).

Ongkarak soils occur in the north-east of the Area, between Minburi and Chacherng. sao, north of the Bangkok-Chacherngsao Rairoad line. These soils have a high acidity and are called "acid sulphate soils" by soil specialists. These soils occupy an area of about 150,000 rai (24,000 hectares).

Typical samples of Tachin soils, Bangkok soils and Ongkarak soils, displayed by the Rice Department at its Soil Laboratory in Kasetsart University Campus, have pH values as shown in table 1. From the table one can expect that the new Bangkok soils, doveloped from the Tachin soils, have a high pH and still have some saline effects. In order to utilize these soils for rice cultivation, it is necessary to reduce the salt content to a trace. These new Bangkok soils lie between Samrong Canal and Sukumvit Highway, which acts also as the sea dike for the Area. The Royal Irrigation Department has helped in reducing the salinity of the soils by giving this section of the Area sufficient water for the farmers to flush their fields. At present there are irrigation men, continually analysing the water samples collected near the Sukumvit Highway. If the water has a salinity of 3 parts per thousand, the drainage gates are opened to flush this waste water into the Gulf of Thailand, The rice yield of these soils is 35–37 tang per rai. (One tang of rice paddy weighs 10 kg.).

Table 1

pH values of typical samples of Tachin soils, Bangkok soils, and Ongkarak soils.

Typical Soil Sample	Depth in Inches from Surface	pH value
Tachin Soils	0 – 6	7.4
(saline soils)	6 – 24	7.9
	24 – 48	8.3
Bangkok Soils	0 – 10	4.6
(slightly acid soils)	10 – 20	5.0
	20 – 38	6.4
	38 – 48	6.6
Ongkarak Soils	0 – 7	3.9
(acid sulphate soils)	8 – 20	3.7
	21 – 30	3.3
	31 – 48	3.2

The older Bangkok soils lie north of the Samrong Canal. The rice yield per rai is 45–50 tang. At present the rice field fish culture in this section of the Area indicates that the farmers plan to utilize their fields 12 months of the year. In that case, the soil will not be dried and exposed to the air. This will result in a complete reduction of the soil mass to a point that rice and fish cultivation may give increasingly unsatisfactory results. This matter will be discussed later in this paper.

The Ongkarak soils are not only of high acidity but also have a high potential acidity as the depth increases. Soil and water of very high acidity will not give good rice and fish yields. Besides being very acid, the Ongkarak soils also contain noxious substances, especially aluminium sulphate. The surface may have this substance in a concentration of about 800 parts per million and the concentration will be greater as the depth increases. It is known that aluminium sulphate starts to have toxic effects on rice plants and fish at 200 parts per million.

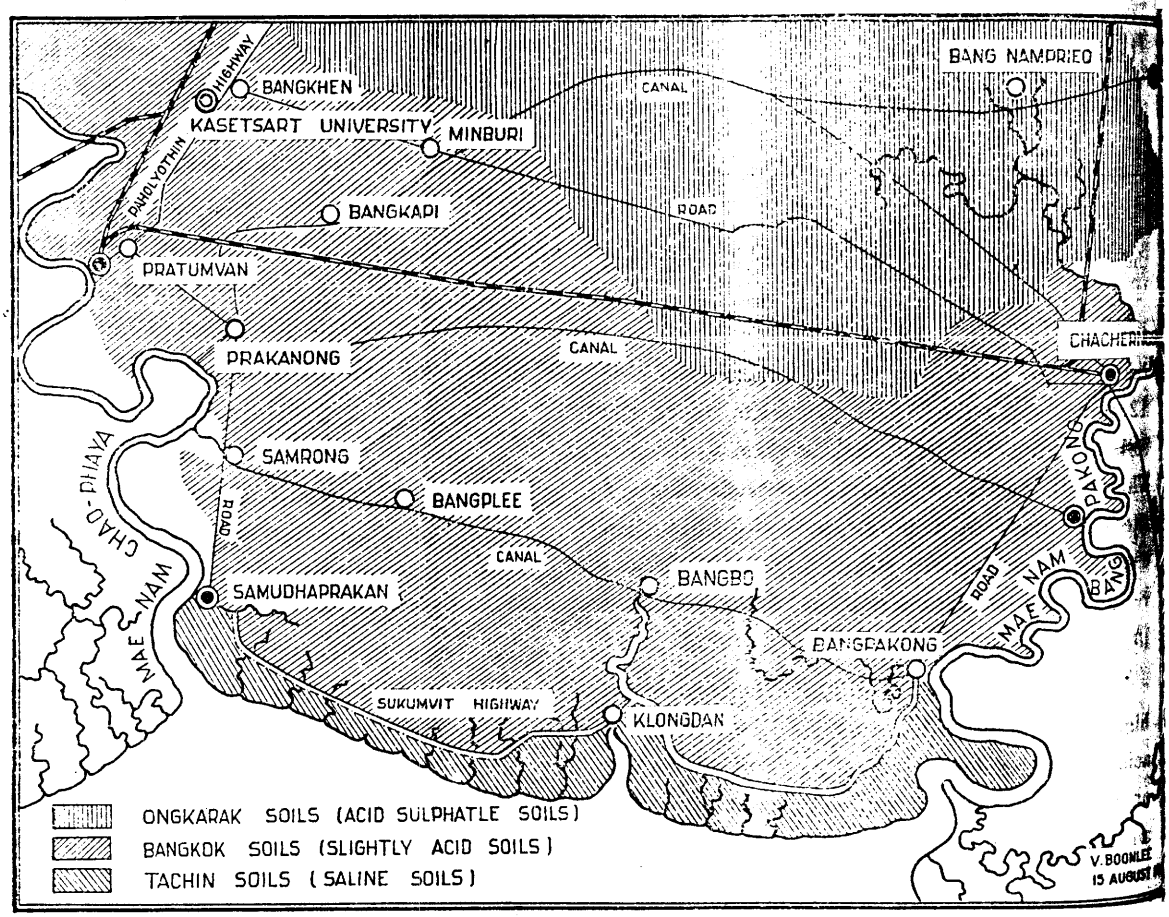
Whether use can be made of the Ongkarak soils for rice growing generally depends upon the availability of water or early rain in June to flush the field to reduce the concentration of aluminium sulphate which collects on the soil surface during the dry season. The farmers test whether soil and water are suitable for rice cultivation by spitting some chewed betel-nut into the water. If the color of the chewed betel-nut stays red in the water, the soil and water are appropriate for starting rice transplanting. If the color changes from red to black, the farmers have to wait until more irrigation water is supplied or more rain falls to dilute the

aluminium substances. Even though rice planting can be done, if there is a shortage of rainfall while the rice plants are still young and the soil becomes dry, acidity and aluminium substance will increase and will cause the young rice plants to die. On the other hand, the run-off from the Ongkarak soils may pass from field to field and thereby bring down to the lower section of the Area the water having high acidity and aluminium substances. Therefore, it is expected that the Lower Area may be affected by the acid water containing aluminium substances which come from the adjacent Upper Irrigation Area. This may be the cause of decreased production in the Lower Chiengrak-Klong Dan Irrigation Project Area when draught occurs. But, when the Phumipol Irrigation Scheme is completed, there will be sufficient water to come down and replace the water that has high acidity and aluminium substances.

Fish

The fresh-water fish found throughout the Area are pla chon (*Ophicephalus striatus*),

SOIL MAP OF THE LOWER CHIENGRAK-KLONGDAN IRRIGATION PROJECT AREA



SOURCE : ROYAL IRRIGATION DEPARTMENT AND RICE DEPARTMENT

pla kasong (*O. lucius*), pla chado (*O. micropeltes*), pla duk-ui (*Clarias macrocephalus*), pla duk-dan (*C. batrachus*), pla salid (*Trichogaster pectoralis*), pla kadi-nang (*T.leeri*), pla kadi-mor (*Trichopterus trichopterus*), pla krim (*Trichopsis vittatus*), pla mor thai (*Anabas testudineus*), pla salat (*Notopterus notopterus*), pla lai (*Fluta alba*), pla lod (*Mastacembalus spp.*), pla tapien (*Puntius gonionotus*) and pla siew (*Rasbora spp.*). The fish that have been introduced into the Area for pond culture are major Chinese carps (*Aristichthys, Ctenopharyngodon, Hypophthalmichthys*), common carp (*Cyprinus carpio*), pla sawai (*Pangasius pangasius*) Pla tepo (*P. larnaudi*), and tilapia (*Tilapia mossambica*).

Pondfish culture started in this Area about 30 years ago. At present. the work is largely conducted by the muslim Thais of Tambol Klong Ton and Tambol Prakanong in Bangkok Province. Only the major Chinese carp, common carp and pla duk give the pondfish culturists a reasonable income, because there is a demand for these fish in the Bangkok market.

Mr. Guan Teetong and Mr. Chat Klinrod were the first two persons who were able to learn to breed common carp with success.

In 1947, when the Fisheries Department advised the public on the cultivation of the tilapia, several people in the Area began tilapia cultivation. The yields were good but the income was negligible, because the Bangkok residents did not favor tilapia flesh, which turns soft more quickly than that of the native fresh-water fishes. Tilapia is not well liked by the people in the city but is fairly popular in the rural districts.

The cultivation of other fishes in ponds, e.g., pla sawai and pla tepo, is not well established but the cultivation of pla duk is increasing because there is a demand in the market.

Keeping trapping ponds used to be a secondary occupation to rice cultivation in the Area. In the early days a farmer would have a trapping pond of 1 or 2 ngan (400 or 800 square meters). The fish caught were mainly pla chon pla salid, pla mor thai and pla duk. The majority of the fish were transported alive in galvanized boxes to the markets in Bangkok. Pla salid was the only fish that was salted-dried. About 15 years ago, the yield of the trapping ponds decreased. It dropped to about 19 kilograms per rai as against the former yield of from 600 to 1600 kilograms per rai. As a result in 1947 some of these trapping pond owners tried pondfish cultivation. In 1957 the rice field fish culture started.

Rice Field Fish Culture

As already mentioned, rice field fish culture is still new. Up until 1961, it has been confined to the Bangkok soils section of the Area. The procedures used for this fish farming are still transitional and subjected to frequent changes. However, the development of this type of farming during the past 5 years needs to be recorded, because it will serve as a basis for guidance and information for future improvement.

In Bangkok Province, the rice field fish culturists prefer to cultivate common carp and major Chinese carp; in the Samudhaprakarn Province, pla salid, common carps and tilapia respectively; and in the Chacherngsao

Province, common carps, pla kapong (*Lates calcarifer*), pla salid, milkfish (*Chanos chanos*) and tilapia. The cultivation of pla duk (*Clarias*) in the rice fields is receiving attention in Samudhaprakarn and Chacherngsao Provinces. Some farmers released this fish into the fields. It seemed to them the fish grew fast. During 7-8 months in the field, the fish reached 50 cm. in length and 300 grams in weight.

That some farmers are able to raise fish in the field in the dry season and continue to grow rice and fish in the rainy season inspires other farmers to try out the same idea. This means the use of the same field for 12 months of the year. Another benefit from this method is that, besides getting both rice and fish crops, the farmers do not have to plough and harrow the fields. Rice paddy can be harvested while the fields are still flooded. After drying the bundles of paddy on the rice stubble, small boats can be hauled into the fields to transport the paddy to the home lot. The farmers feel they have achieved something by reducing the cost of ploughing and harrowing and of conveying the bundles of paddy.

Fish farming is generally conducted in the following way.

(*1*) *Making of fish fields, trenches and ponds*

(1.1) A fish field varies in size from a minimum of 10 rai (1.6 hectares) to a maximum of 40 rai (6.4 hectares), but the size which is preferred is 20 rai (3.2 hectares). The field is generally rectangular in shape. It is believed that if the fish field is rather small, the result will not be good because the cultivated fish may not be able to evade predators. The most common predator is pla chon. If the field is too large, it is hard to harvest all the cultivated fish.

The farmer makes a dike and digs a trench around the inner limit of the field. The dike is 0.8 - 1.2 meters high. The trench is 2-3 meters wide and 0.5 - 1.0 meter deep. As the land is flat, the farmer has to arrange that the fish can come to assemble at one point in the field, which is usually near the home lot. At that point, the trench is made square, 3 – 4 meters wide and half a meter deeper. Besides this, another trench may be made across the middle part of the field. This trench is also 3 meters wide and 1 meter deep. It helps in the final harvesting of the cultivated fish.

Some farmers prefer to provide a narrow strip around the field, between the inner side of the dike and the trench. This strip will act as a berm and is usually 3 meters wide. Its purpose is to help maintain the dike and for the growing of local grass on which the pla salid can make bubble-nests.

(1.2) As the water level in the canal during the dry season may be low, the farmer must have a water storage pond at a point close to a big, small or feeder canal, so he will have water available for use whenever he wants it. The farmer moves the water to this water storage pond with a pump or water-lifting contrivance operated by a wind-driven propeller, such as those commonly met with in the Tambol Klong Dan and Tambol Bangpakong.

When the pumped water reaches a certain height, it flows from the pond to the fish fields, the breeding pond, the hatching

pond, nursery pond and the resting pond. The water storage pond is sometimes used as the resting pond.

The water-storage pond usually has an area of one half or three fourth of a rai (800 or 1200 square meters), and is usually of an elongated shape. This shape costs less and makes it convenient to use the water-storage pond as the resting pond. The water-storage pond is usually 3-4 meters wide and 1.5-2.0 meters deep.

At every point where the water will enter the field or the pond there is a wooden drainage pipe fitted with fine screen in order to prevent inside fish from going out and outside fish, either predators or food competitors, from coming in.

The farmer may or may not have the following ponds, depending on necessity and appropriateness :— breeding pond, hatching ponds and nursery ponds. If the breeding pond is needed, it will be of 400-500 square meters and 1.0-1.5 meters deep. The resting pond and nursery pond may be used interchangeably. A pond of this type will have an area of one rai (1600 square meters) and will be 0.7-1.0 meter deep. Usually the farmer, who breeds common carps and pla salid for sale, will have a breeding pond, a hatching pond and a nursery pond.

(2) Cultivating fish

This activity covers two periods, the dry season and the rainy season.

(2.1) After the harvesting of rice paddy in December, the fish field is dried and repaired. The remaining rice stubble which has been left in the field is cut close to the ground and scattered in piles. Then the water is let into the fields, up to a depth of 50 centimeters.

In case a new field is to be used, the weeds such as *Scirpus articulatus*, *Scirpus grossus*, *Cyperus procerus*, *Cyperus molaccensis*, *Chara sp.*, *Nitella hyalina*, *Fimbristylis miliacea*, and *Ischnaemum rugosum* are cleared by letting the water into the field up to a depth of 30–40 cm. Small common carps are then released. If the weeds, e.g., Scirpus, are still above the water level, they are cut down below the water surface. Then the weeds will not grow again. It is expected also that the common carp will work the weeds loose from the earth. The weeds, already cut and loosened, are then collected in piles in the fields.

During the dry season common carps are cultivated. Pla salid and pla duk are not known to be used. The amount of young common carp reared varies.

(2.11) Mr. Guan Teetong, in 1961, used a large number of young common carp of 4–5 cm. He did not keep a record, but estimated that he used about 200,000 fish for his 20 rai field. Within 5 months the carp reached marketable size, 300–500 grams in weight. He collected 218 kilograms of the marketable size and a large number of young fish of 6–7 cm. He sold some of these young fish and kept 8000 fish for further growing during the rice growing season. If only the marketable fish were considered, the production of fish would be 21 kilograms for rai. Mr. Guan did not feed his fish. He said that the fish ate about 1500 kg. of paddy grain that was left in the field during the

harvest and that the rice stubble which decayed in the field helped in the producition of fishfood.

(2.12) Mr.Chat Klinrod, in 1961, released 6–7 cm. common carp in the ratio of 1 fish for 10 square meters of field area. His field was 10 rai. In 5 months he harvested 1137 fish, with an average weight of 550 grams, and a total weight of 532 kilograms, His production of fish was 53.2 kg. per rai. Once a day Mr. Chat gave his fish prepared food, a mixture of boiled broken rice and rice bran. It was estimated 1500 kg. of the prepared food were used during this five month period.

The enemies of the cultivated fish in the field during the dry season were hawks and cormorants. There were no pla chon in the fields during this period of fish farming.

(2.2) The cultivation os fish in the same field with the growing rice paddy takes place during the second period, the rainy season. It starts after the harvesting of fish in the first period, about the end of July, The growing of rice and fish goes on simultaneously until harvest time in December or January.

The water is first let in up to a depth of 50 centimeters. The field, during this time, has no weeds because they have been cleared during the first period. Therefore, the farmer at this time does not have to use his buffaloes for ploughing, harrowing and puddling his field. If some weeds are still left, they are in small patches and the farmer can puddle them with a wooden puddler drawn by a buffalo. The soil is then soft enough for transplanting rice. The fish are released into the field after the farmer observes that his rice seedlings have ,started tillering which takes about two weeks. Some farmers may not wait this long if they are confident that the fish will not churn the rice seedlings to the surface of the water.

(2 21) Mr. Guan waited till the tillering of his rice seedlings had started and then released the 6–7 cm. common carp, 8000 in number, which he kept separately at the end of the first period, into his 20 rai rice field. He released also 16,000 small pla salid of 5–10 cm. in length and 30 parent pla duk into the same field. During the second period the cultivated fish were fed with rice milling by-products, totalling 200 kg. in weight. The rice milling by-products consisted of fine rice bran and fine broken rice. Mr. Guan believes that the rice milling by-products served as fertilizer to the rice plants as well as fishfood. The food was given raw daily at the corners and on the sides of the dike. In December 1961 the harvesting was done. The paddy yield was 1200 tang, giving an average of 60 tang per rai (against a yield of 45 tang per rai in Tambol Rang Chalong) Five hundred end forty six and eight-tenth kilograms of 1719 common carp, 200 kg. of pla duk and 100 kg. of others including pla chon and pla salid were obtained. The total weight of marketable fish was 847.8 kg. giving an average yield of 42.4 kg. of fish per rai. This did not include the young pla duk, which were considered as forage fish, even though some of them were sometimes taken out and sold as fish seeds.

(2.22) Mr. Chat Klinrod released 1,540 common carp of 6–7 cm. in length in August 1961, 3 days after the rice was transplanted. He gave the fish prepared food, a mixture

of boiled-broken rice and rice bran. The total weight af the food used was 1,500 kg. He harvested the rice in early January 1962 and havested the fish in the middle part of that month. His rice yield was 50 tang per rai. (The rice yield of other farmers in Tambol Chorake-bua was 35–37 tang per rai and if the field was fertilized, 45–48 tang per rai). He harvested 1120 common carp, weighing from 500–700 grams each, with a total weight 510 kg. This gave an average yield of 51 kg. of marketable fish per rai for the 6 months period.

(2.23) At Tambol Song Klong in Amphur Bangpakong of Chacherngsao Province, Mr. Sompoj Sirisoda in 1961 cultivated two rice fields of 10 rai each, one with pla salid and the other with common carp. Only the cultivation of common carp in the rice field will be related here, because pla salid have not yet been harvested even though the rice has been.

The soils in the Tambol Song Klong originated from Tachin soils. Nai Sompoj had to obtain local rice seedlings that could withstand the salinity. Rice transplanting was done in August 1961, and in September common carp were let loose in the field. These fish had been bought in July. There were 11,000 individual fish of 1–2 cm. in length and they were kept in a trench, temporarily surrounded by high dikes. It happened also in the month of September that one day the farm boy forgot to close the connecting pipe between the common carp field and pla salid field with the screens. Mr. Sompoj fertilized the field with chicken manure twice each time with 400 kg. of manure. Rice harvesting was done in December. Three hundred and seventy tang of rice paddy were obtained, giving an average of 37 tang per rai. In February 1962 the fish were harvested. Eight hundred and sixty common carp, weighing 429 kg. and 8000 pla salid, of about 50 grams each, weighing 416 kg., gave a total of 845 kg. The average yield of fish per rai was 84.5 kg.

(2.24) Mr. Ob Iamlai, another farmer of Tambol Song Klong, in 1960, used 35 rai of his field for rice and milkfish cultivation. Forty thousand milkfish fry, 1–2 cm. in length, were released. He obtained a rice yield of 1,300 tang, giving an average of 37 tang per rai. He left the fish in the field for ten months. He obtained 1250 milkfish weighing 500 kg., 850 kg. of pla chon, and 150 kg. of tilapia. The total fish yield was 1500 kg. Therefore, in 10 months the fish yield per rai averaged 42.9 kg.

In 1961, he used 50 rai of his rice field for the cultivation of rice, and pla kapong. Four thousand of the latter, 3 cm. in length, were released 2 months after stocking the field with 500 kg. of parent tilapia. He obtained a yield of 1,800 tang of rice paddy averaging 36 tang per rai. The number of pla kapong, tilapia and others, including pla chon, is not known as the fish have not been harvested yet.

(2.25) Mr. Chom Onlamai, another farmer of Tambol Song Klong, in 1960, used his 40 rai field for the cultivation of rice and milkfish. He obtained a yield of 1000 tang of rice paddy averaging 25 tang per rai, 100 kg. of milkfish and 300 kg. of tilapia. The average yield of fish per rai was 14 kg.

(2.26) Mr. Charoen Samli, a farmer of Tambol Bangapakong, has 12 rai of land. In 1959 only rice was planted. The total yield was 320 tang, or an average of 26.6 tang per rai. In 1960 only rice was planted, and he obtained 200 tang of rice paddy, giving an average yield of 20.8 tang per rai. In 1961, Mr. Charoen turned his rice fields over to rice-fish farming. In May he released 150 parent tilapia. In July rice seedlings were transplanted. Fifteen hundred small pla kapong of 4–5 cm. in length were released. The yield was 540 tang of paddy or an average of 45 tang per rai. The fish crop amounted to 200 kg. of 384 individual pla kapong, 629 kg. of tilapia, 170 kg. of pla chon and 70 of pla tapien, making a total of 1,069 kg. and giving an average yield of 89 kg. of fish per rai.

(2.3) In Tambol Bangpla of Ambhur Bangplee in Samudhaprakarn Province, Mr. Chiak Muangrerng cultivated pla salid in a field where rice was not grown, but the *Scirpus* weed was grown instead. The field is 10 rai in area. Mr. Chiak bred pla salid himself. He used 5 breeding ponds, each 100 square meters in area. The breeding of pla salid started in April 1961. Each pond had 100 pairs of pla salid spawners. Two-month old pla salid, about 5 cm. in length, were released into the 10 rai field. During the months of July and August he released young pla salid several times, making a total of 70,000 fish. After that, he also released 1,000 parent fish into the field with the expectation that these parent fish would produce more young pla salid in the field. Four thousand pla duk of 10–12 cm. in length were also put into the field. Mr. Chiak gave on additional prepared food. The tops of *Scirpus* weed were cut and allowed to rot in the water in the field. Mr. Chiak believed that the slowly decaying *Scirpus* weed would be the food of pla salid. In March 1962 the harvesting of fish was done. The length of marketable pla salid were obtained. The pla salid production averaged 400 kg. per rai. If 180 kg. of small fresh-water shrimp and 300 kg. of pla chon and pla duk were included, the average production of fish per rai would be 448 kg. This yield is the highest on record in the Area. It is regrettable that this farmer will not repeat this method of fish farming during the 1962–1963 season, because he wants to take up rice and fish cultivation as practised by other farmers.

DISCUSSION

The type of fish farming described briefly here is evidence that the farmers have realized that fish farming in the dry season followed by rice-fish farming in the rainy season will help them to increase their income. However, as this type of rice and fish farming is still new and not well established, it should be borne in mind that technical and farm management problems may arise, as is often encountered where there is innovation. The environmental set-up may be changed and the resulting effect may be either major or minor. It is, therefore, advisable to do follow-up studies on the effects and their causes. Generally, the farmers need advice which will enable them to understand more about the fundamental causes of their problems. If the causes were known, the farmers would try to solve some of the problems themselves.

The followings are observations and problems that merit consideration:

1. This type of farming is growing in popularity. It appears that many farmers are now ready to adopt a system of rice and fish culture which has been under experimentation on a small number of farms during the past 5 years. However, among the 300 farmers who are developing 10,000 rai of fields, there are not more than 10 farmers who have skill in fish culture or in the management of fish farms.

Moreover in 1962 some of the farmers in the Chacherngsao Province, which has Ongkarak soils, are beginning to take up the cultivation of fish in the rice fields. As the Ongkarak soils are not highly productive for rice cultivation, the Extension Service is encouraging the cultivation of fish on this type of soil. The Extension Service has encouraged the formation of local fish culture groups. However, the extension service men are limited in number and their responsibilities will be multiplied as farmers respond to their encouragement to develop better farming practices in this Irrigation Area of 950,000 rai.

2. If the crop of fish harvested from the farm during the rainy season is 40–50 kg. per rai, it should be considered satisfactory since this type of farming is still young. The yield in Japan is 44 – 300 kg. per rai, in Taiwen 55 kg. per rai, in Indonesia 9 kg. per rai and in India 19 kg. per rai.

3. Mr. Chiak Muangrerng's production of 400 kg. of pla salid per rai is interesting because it compares well with the production in Japan. Mr. J.A. Tubb, of FAO in Bangkok, advised the writer that Mr. Chiak's production, which was highest among those of other farmers, could be considered reasonable. Pla salid is tolerant of fairly acid water and can utilize the epiphyte algae on the acid-loving marsh plants.

There are some other aspects which should be investigated. For example, are the *Scirpus* weeds the direct food of the pla Salid? Does the decaying *Scirpus* weed help in the production of algae? Do algae and plankton occur in the fields in sufficient quantity to provide natural food for the pla salid? Does the locality have fewer wild pla chon so that they do not affect the production of pla salid?

The pla salid yield indicates the fertility of the Bangkok soils of the Irrigation Area. This yield figure would be the target in a dovelopmental program. Success depends only upon the farmers having the appropriate know-how.

4. Will fish culture in rice fields contribute to increased paddy production? There was a striking increase only in the case of Mr. Charoen Samli. What is the proper explanation of the fair to high increase in paddy yield? One explanation may be that it results from the control of noxious weeds before and during the rice-fish farming in the rainy season. On the other hand, the fish may contribute directly to this increase. These matters need more study.

5. In 1962 some of the Chacherngsao farmers, whose lands are of Ongkarak soils, are adopting this type of fish farming. It is, therefore, important that not only should the fish farming give the farmers increased

income but also that the farmers should understand how to use the rice fields for fish culture instead of making ponds for fish cultivation. As is known from soil samples in the Rice Department, the Ongkarak soils have a low pH, which becomes lower with increasing depth and it has been shown in South Vietnam that such acid sulphate soils have great reserves of aluminium sulphate. Consequently, the pond water in this type of soil will have high acidity and aluminium sulphate, which are toxic to fish.

However, this kind of fish farming in the Ongkarak soils will be affected in the same way as rice farming in the same soils is affected. That is, it depends upon how well the aluminium sulphate, which comes up and is deposited on the soil surface when the soil is dry and exposed to air during the dry season, is flushed out. The flushing has to be done until the aluminium substance reaches the point, where it is not toxic to rice plants or fish. The drawback is that this cannot be depended upon to happen. If the rainfall during the early of the season is sufficient or if the rainfall and run-off occur during the appropriate time, the yield of rice and fish during the year will be good. If there is no rain at all or if the rain does not occur at the right time, the crop will fail. The farmers need be taught how to counteract these conditions if their fish-rice growing is to be successful on these Ongkarak soils.

6. Since there are more of the Ongkarak soils, about 1,450,000 rai (212,000 hectares), lying to the north of the Area, the run-off from this area will bring acidity and aluminium sulphate down to the area. This should be borne in mind, even though the Royal Irrigation Department endeavors to release water to come down and replace the waste water so that the farmers will have a fresh supply of water. If there were a drought and this water were not available, the fish farming would be affected.

7. It has been observed that some farmers intend to use their fields, which are of Bangkok soils, for 12 months out of the year. Some farmers may think only of the increased income and forget the fundamentals of fish culture. They will need to be reminded of this.

An example of some of the complications that can occur was seen on the farm of Mr. Chat when it was visited in March 1962. Red flaming was noticed in one of the nursery fields for common carp. This redness indicated that a precipate of ferric oxide was forming. Some burrows on the dike of the field had a deposit of ferric oxide. This suggests that the seepage from the fish farm above this field contains iron substance in the ferrous form. Mr. Chat related that 2 months earlier he had made this nursery field for fish by making dikes around it and letting the water from the high field seep into this nursery field. He did not release common carp fingerlings into the field, because when he tried some in another nearby field, they died. Mr. Chat further told of the case where one of his breeding ponds which was made in the same manner as that of the Bangkhen Fisheries Station, did not give as good a yield of common carp eggs as before. He had not dried this pond at all since 1957. The writer sought the advice of Dr. F. R. Moormann, FAO Soil Expert, and Mr. Sarot Montrakun, Soil

Expert of the Rice Department. According to both experts, if the Bangkok soils are not allowed to rest, i.e. to dry and be exposed to air, the iron in the soil is likely to become soluble ferrous iron. Also the soil will show a complete lack of oxygen. Therefore, fish farming should not be done at all one dry season and then the next year it can be done continuously both during the dry and the rainy seasons.

Dr. F.R. Moormann advises that soils need drying and aeration for at least 2 months out of the year, especially in the months of March and April, when there is little or no rainfall. If the soils are dried and exposed to air, the ferrous form will turn to ferric form, e.g., ferric oxide, which is not soluble and hence not toxic. If the soils have low acidity and contain the ferric form of iron, rice and fish will not be affected. However, if the fish farming is carried out continuously, during both the dry and the rainy seasons. the soils will not have an opportunity to rest. The water may serve as a barrier that prevents the soil from contacting the air. The aerobic bacteria will then not be sufficient to convert the farrous form to the ferric form, which is generally a slow process. Besides, the anaerobic bacteria will also be active in converting the ferric form to the ferrous foam by reducing the oxygen of the ferric iron.

It is known that ferrous iron starts to affect fish life st 100 ppm.

It may therefore, be said that fish farming creates chemical and bacterial changes in the soil. Will these changes affect fish and rice production, and, if so, to what extent? The answer to this question needs study.

8. The use of lime or limestone dust, which gives good results in ameliorating acid sulphate soils to a higher pH, has been tried out in experiments in Malaya and South Vietnam. Though this practice is possible but not economical at present, the matter should receive some consideration in order to find out other possible methods. At present there are two means of ameliorating the soils of high acidity which contain aluminium sulphate: flushing with water to reduce the toxicity, and applying either limestone dust or lime in combination with fertilizers.

The problems relating to soil and water are no less important. At present the study of these problems is limited. The problems can be divided into small subjects appropriate for study and research. If the basic knowledge of the soil and water in the area are studied and made known to the farmers they will understand the basic causes. They will be alerted and will try to solve some immediate problems themselves.

9. The kinds of fish used in fish farming at present are: common carp, milkfish, pla salid, pla kapong, tilapia, and pla duk. These fish can be considered as suitable. However, there are still more problems that need study, e.g., the pla chon problem. This fish predator is not cultivated but there is a demand for it in the market.

Thorny problems arise in the marketing of the fish. Take the common carp as an example. The market wants individual fish of 500 - 700 grams in weight, but the demand is only 300 kg. a day. If the production is more and more, the price of the fish in consequence will be lowered. The same problem also applies to milkfish.

Pla salid and pla duk (*Clarias*, catfish) are likely to provide lucrative farming in the future because they are esteemed by the Thai people. Pla salid could be dry-cured and exported. The chief defect is that there is a storage problem when pla salid is kept for a long time,

Tilapia is still consumed in the rural areas.

Pla kapong is a high grade fish which enjoys a good demand.

The question is, what kind of fish should be cultivated? Should it be one species or a combination of several species, e.g., the cultivation of pla chon or pla kapong in combination with tilapia and that of pla salid in combination with pla duk? If we choose the combination, we do not know what problems of fish management will arise.

10. *Macrobrachium* prawns, which, it has been proven in Malaya. May be reared from juveniles collected from natural waters, should also receive attention, because the prawn juveniles are commonly fould in Samudhaprakarn and Chacherngsao Provinces.

11. More studies should be done to discover the optimum application of chemical fertilizers, farm manures and composts in this type of fish farming.

12. Studies are needed on natural fish food and artificial fishfood.

13. Consideration of farm management and marketing should be included if the best results are to be achieved from fish farming.

As the problems presented here suggest, the breadth of their scope is worthy of study and research. The faculty of Fisheries and the Faculty of Agricultural Economics and Cooperative Science are in the process of preparing a proposal to be submitted to Kasetsart University asking for approval to study the technical and farm management problems relating to land and water use in the Lower Chiengrak-Klong Dan Irrigation Project Area. This will be a cooperative research project which can be further sub-divided into small projects appropriate for study, experimentation and research. The results derived will be used in the over-all planning of the management of land and water use in this Irrigation Area.

ACKNOWLEDGEMENTS

The writer wishes to thank several officials of the Royal Irrigation Department, the Rice Department and the Fisheries Department, who enabled him to present this introductory paper, especially Mr. Sarot Montrakun and Dr. F.R. Moormann who gave advice on the soil problems, and Mr. Chob Bunnag and Mr. Chanid Puranabura who kindly helped the representatives of the Faculty of Economics and Cooperative Science and of the Faculty of Fisheries to visit a number of fish farmers in Chacherngsao and Samudhaprakarn Previnces.

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