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Survey Paper

Problems and Prospects of Agriculture in Thailand Report of SMKT88, 1988*1

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Chapter 1. General

1. The Mission, SMKT88, and Its Purposes

Kinki University sent a mission (SMKT88) to Thailand to carry out a joint investigation on the agriculture of Thailand with the Department of Agriculture (DOA), Thailand, and Chiang Mai University (Thailand), during the period of Aug. 9–18, 1988. The first objective of the mission was to outline the current state of the agriculture of the kingdom. The second objective was to identify possible subjects concerning the improvement of Thai agriculture. One promising subject was exploration of the most effective agricultural techniques to be adopted by small farmers, to be identified with Japanese participation.

Following a schedule arranged with the cooperation of the Regional Office for Asia and the Pacific of the Food and Agricultural Organization (FAO) of the United Nations, Bangkok, field tours were conducted between Bangkok and the Burma-Laos border, with special attention paid to the agricultural ecology of the tropical lowlands near Bangkok and that of the Chiang Mai and Chiang Rai valleys in the north.

We thank Dr. R.B. SINGH, Expert of the Regional Office for Asia and the Pacific of the FAO, for his kind support in arranging the tour. Special thanks are given to Dr. Sanchai TONTYAPORN and his staff of the Mycological Section, Plant Pathology Division, DOA, who prepared a detailed tour programme and accompanied the mission during its stay in Thailand.

2. Members of the Mission

Kenjiro KINUGAWA ; Mission leader. Dr. of Agriculture, professor, plant geneticist, plant breeder, and specialist in mushroom cultivation.

Hikaru TSUTSUI ; Dr. of Agriculture, professor, and specialist in strategies for world food and agricultural development.

Takao TERASHITA ; Dr. of Agriculture, associate professor, chemist mainly engaged in the chemistry of fruit-body development, and specialist in mushroom cultivation.

Akio ENOKI ; Dr. of Agriculture, associate professor, and chemist mainly engaged in the chemistry of wood decay by white rot fungi.

Shuzo FUKATA (invited member) ; Bachelor of Agriculture, director of the Institute of Biological Production, Sanyo Tokki Co., Ltd., chemist, and specialist in the mechanization of mushroom cultivation.

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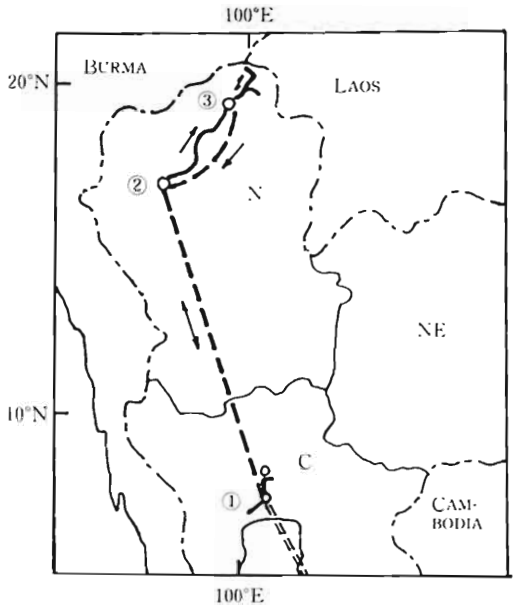

Fig. 1. Map of Thailand with the Agro-Economics Regions and the Itinerary of the mission. Agro-Economics Region: N, Northern; NE, North-Eastern; C, Central Plain. ①, Bangkok; ②, Chang Mai; ③, Chiang Rai. ———, by car; – – –, by air; ═══, by air (Bangkok-Osaka).

3. Programme

Fig. 1 is a map of parts of Thailand showing the itinerary of the mission. The programme of the August 1988 tour was as follows:

Date	Remarks
9 (Tue)	Lv. Osaka, Ar. Bangkok (by air)
10 (Wed)	Bangken, Bangkok Visit to the DOA, for a meeting with Dr. Sanchai TONTYAPORN (chief) and his staff of the Mycological Section.
11 (Thu)	Lv. Bangkok, Ar. Chiang Mai Visit to Chiang Mai University. Discussion with Dr. Nakorn NALAMPANG (dean) and his staff, and inspection of research facilities (meeting 1)*.
12 (Fri)	Chiang Mai Field visit to the Chiang Mai area to see paddy straw mushroom cultivation and the cultivation of various oyster mushrooms and of *Tricholoma giganteum*.
13 (Sat)	Lv. Chiang Mai, Ar. Chiang Rai (by car) Field visit to mountainous district between Chiang Mai and Chiang Rai to see villages of hill people and to inspect cultivation of *Lentinus edodes* by people of Chinese ancestry (meeting 2)*.
14 (Sun)	Lv. Chiang Rai, Ar. Bangkok (by air) (meeting 3)*.
15 (Mon)	Bangkok Courtesy call on Dr. Riksh SYAMANANDA (Director-General) and Mrs. Dara BUANGSUWON (director of Plant Pathology and Microbiology Division) of the DOA. Field visit to Nakhon Pathom to see rural villages where paddy straw mushroom and oyster mushrooms are cultivated.
16 (Tue)	Bangkok Field visit to Nakhon Hayok to see rural villages where paddy straw mushroom

is cultivated in the openfield and in houses (meeting 4)*.

17 (Wed) Bangkok
Visit to several orchid companies to see methods of orchid propagation (meeting 5)*.

18 (Thu) Return to Osaka by air.

* staff meeting of the SMKT88.

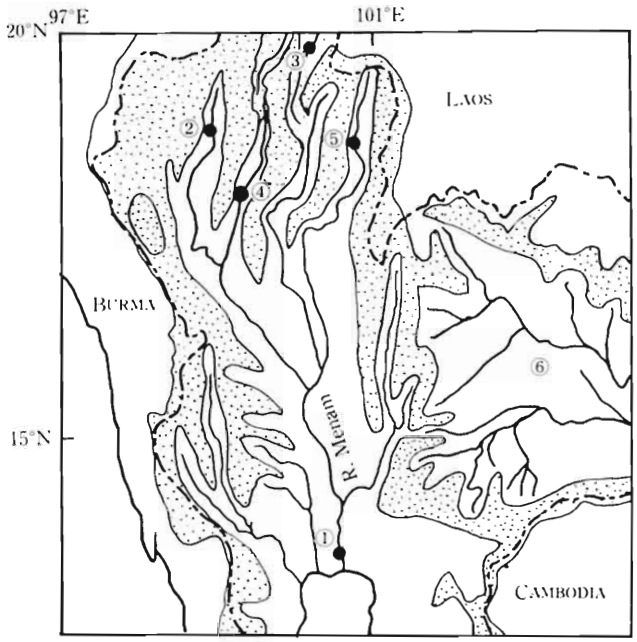

Fig. 2. Topographical map of Thailand.
①, Bangkok Plain; ②, Chiang Mai; ③, Chiang Rai; ④, Lampung; ⑤, Nan, ⑥, North-Eastern Plateau.

4. Brief Description of Thailand, its Natural and Social Situation[1].

The Territory of Thailand extends over 510,000 km², divided into four agro-economics regions: 1. North-Eastern Region, 2. Northern Region, 3. Central Plain Region, and 4. Southern Region.

Central and North Thailand are between 13° to 20° N and 98° to 102° E. As shown in Fig. 2[1], the Bangkok plain of Central Thailand spreads over the broad expanse of flood land of the Menam River. The Menam flows southwards from the junctions of four branch rivers in the north, each with a major alluvial valley of the North Thailand: Chiang Mai, Chiang Rai, Lampang and Nan. Between these valleys, there are mountain ranges oriented from north to south, where the hill people (Miao, Yao, and others) live.

The climate of Thailand is affected by two major air streams, the northeast monsoon and the southwest monsoon. The former begins in November and lasts till February with cool, dry winds from the north, and the latter from July until September with very wet winds from the southwest. With the movement of the Intertropical Convergence Zone (ITCZ), the climate of Thailand is divided into four different seasons[1]:

(1) November to February: The ITCZ moves from north to south in October, and dry, cool air from Siberia covers all of the territory north to Bangkok.

(2) March to May : The ITCZ moves from south to north. The climate is still dry in March, and wet in May, especially, on the southwesterly sides of mountains.

(3) June to July : The ITCZ moves more to the north, and the southwest monsoon has become active. The rainfall increases but varies from year to year.

(4) August to October : The southwest monsoon prevails throughout the kingdom, and rainfall is maximum in August and September. The movement of the ITCZ generally continues in the southerly direction, and it traverses the northern part of the kingdom in August, setting on the central part in September.

The Fig. 3[5] shows that, in most of the kingdom, there are the hottest days in April to May

Table 1. Annual mean precipitation at Chiang Mai (1931-1961)

Month	Precipitation (mm)
1	7
2	12
3	15
4	49
5	144
6	146
7	188
8	231
9	289
10	126
11	39
12	10
Year	1,254

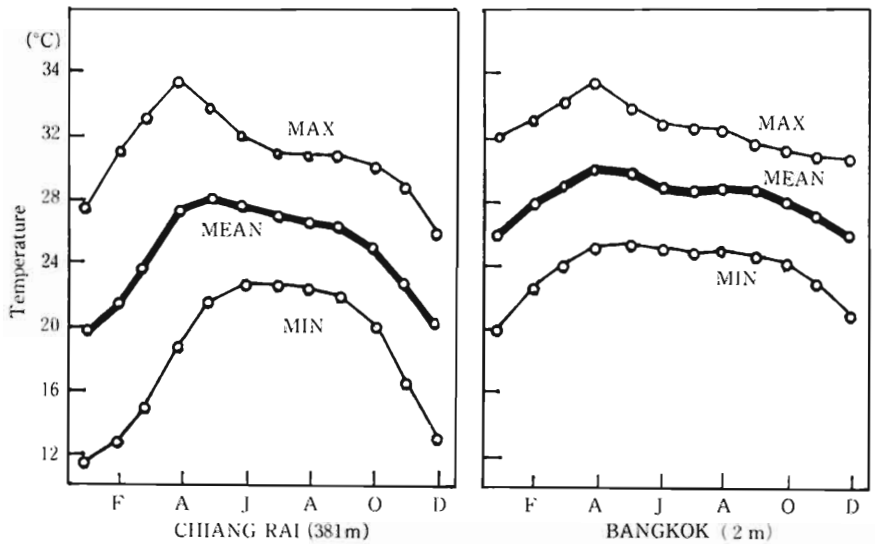

Fig. 3. Monthly temperatures at Bangkok and Chiang Rai (mean, maximum, and minimum).

(season 2), while as the wet season approaches, the temperature gradually becomes moderate. The coolest months are December and January (season 3).

The total solar radiation is highest (more than 550 cal·m^{-2}·day^{-1}) in April and May, concomittantly with the occurrence of the hottest days.

The population of Thailand was 52,094,000 in 1986, and the population density was 102.1 per km^2. These are 1.4 and 0.32 times, respectively, those of Japan. Forty percent of the total land surface of the kingdom is occupied by farm land, of which 57.4% is paddy fields. The average size of a farm is 4.21 ha (1986).

5. Difficulties in the Economy of Thai Agriculture[2,4]

The Gross Domestic Product (GDP) of Thailand of industrial origin in 1986 was 14.8 billion US dollars. The shares of the GDP and the size of population engaged in the three classes of industries, primary production, manufacturing, and services, clearly indicate that agriculture in Thailand generates less GDP with a larger working population than those of the other classes of industries (see Chapter 2-1).

Rice is the staple agricultural crop in Thailand. Maize and cassava are also important crops. They are common in dryland, mainly in the plateau of the North-Eastern Region, and rare in the lowlands of the Central Plain and Northern Region, except for that grown in the mountainous district by hill people, some of whom continue outlawed poppy cultivation[3].

The difficulties of Thai agriculture has come from the reduction of the price of rice and from an unbalanced relationship between the GDP and the population allotted to agriculture. These have brought the farm economy to a critical situation. The difficulties are worse in the less productive Agro-Economics Regions: the North-Eastern and the Southern Regions (see Chapter 2-1).

The rural village communities of the lowland where we travelled were surrounded by expanses of paddy fields, and seemed to be traditionally well-organized with an assembly of houses covered with tall trees on wide lots, where people live quietly and in peace. The farmers in a village are connected with each other by mutual aid during paddy cultivation.

The government of Thailand needs to work out an effective strategy to save these rural communities from destitution. There are several strategies:

a. Introduction of multicropping systems.

b. Introduction of more money-making crops.

c. Introduction of side jobs compatible with farm-working.

For *a*, it is difficult to find crops profitable enough. For *c*, it is still difficult for farmers to get employment in rural districts, because industry is not yet well developed in Thailand, except for the urban areas. For *b*, it is expected that mushroom cultivation will generate some income for farmers, because mushrooms are in demand in the surrounding urban society, and because the climatic and topological conditions described above are suited for their cultivation. The DOA and Chiang Mai University are keen on the improvement and extension of this kind of farming. Althouth most Thailanders do not have a custom of eating mushrooms, tourists and Chinese inhabitants in the cities do have a taste for mushrooms. For example, a larger demand has rised the price of shiitake (*Lentinus edodes*) to about ten times that of other vegetables. Thus, in the vicinity of Bangkok, many farmers are now cultivating paddy straw mushroom (see Chapters 2 and 4). In the vicinity of Chiang Mai and Chiang Rai, several species of oyster mushrooms (see Chapter 2 and 3), ear mushrooms, and *Tricholoma giganteum* are raised. Shiitake is also cultivated in the hilly area near Chiang Rai (see Chapter 2).

6. Cooperation of Kinki University in Stimulating Thai Agriculture.

There may be an area in Thai agriculture where we can cooperate with the institutions of

Thailand to promote agriculture, particularly in the field of mushroom production : for example, in the improvement of the quality of spawns and the process of cultivation. There are some indications in their current cultivation methods that suggest its recent introduction from Japan or Taiwan. According to our experience in the temperate zone, the farmers' handling of cultivation may have some problems. In spite of these difficulties and problems with transportation in Thailand, more production in the rural district and more consumption in the cities should be possible. Increases in the farmers' income are indispensable to save the community economy, concurrently with the increase of general purchasing power of the people of the kingdom. This may also stimulate the further development of modern manufacturing in Thailand (see Chapter 2).

7. Strategies to Intrtoduce New Techniques to Farmers

The system of exploitation studies in agriculture seemed to be complex in Thailand. The basic studies on mushroom cultivation are being done in the DOA and Chiang Mai University, and applied studies in the DOA. The extension services are handled by another government organization, the Agricultural Extension Department. It is reasonable to think that through the progress of basic and applied studies in these government institutions, and through adequate extension services, our cooperation will contribute to improve the farmers' techniques of mushroom cultivation.

(by Kenjiro KINUGAWA)

Chapter 2. Agriculture in Thailand

1. General Picture.

As seen in Tables 1 and 2, the percentage of agricultural population in the total population of Thailand (about 52 millions) is nearly 70 percent which is the highest among the ASEAN countries. However, the share of agricultural GDP against total GDP is merely 17%, the lowest in the ASEAN countries.

Table 2. Shares of Gross Domestic Product (GDP) of Thailand at current prices and persons working in industries (1986)

Classes	GDP	Shares of persons working	Production per person (ratio)
1. Agriculture & mining	18.8	67.0	1
2. Manufacturing & other production	37.5	10.4	12.9
3. Services & commerce	43.7	22.6	6.8

[1]Mining, 2.1% in GDP.

From Table 3 it can be seen that household expenses exceed cash farm income for the country as a whole, and the problem is particularly acute for the poverty-stricken North-Eastern and Southern regions[1]. This is a compelling reason for providing ways and means for increasing the cash farm income of small farmers.

Crop production accounts for more than 85% of the country's agricultural production. Among crops, rice paddy, which occupies more than half of the total agrilultural land, provides three-fifths of the total dietary caloric intake, and is the major export commodity of the country. During the past decade, rice paddy production increased from about 14 million tons to about 18 to 20 million tons, with an annual growth rate of 2.4%[2,4]. About two-thirds of this increase occurred through increased productivity. The National mean yield increased from 1.6 ton/ha to

Table 3. Agricultural population and Gross Domestic Product (GDP) in several ASEAN countries

Countries	Population (%)[1]	GDP (%)[1]
Thailand	67	17
Indonesia	48	24
Malaysia	34	28
Philippines	49	27
Japan	8	3

[1] Ratio of agriculture to the total

Table 4. Cash farm income and household expence per farm in U.S. dollars (1982). (1$=23 bahts)

Agro-economics region	Cash income	Expenditure	Balance
North-eastern	499.7	697.4	−
Northern	891.4	846.4	+
Central plain	1675.1	1366.2	+
Southern	739.8	1046.8	−
Mean for kingdom	844.4	902.6	−

about 2 ton/ha, but is still one of the lowest in the world[2]. Hence, there is ample scope for improving the yield level of rice production.

Maize is the second most important cereal crop. Its production has been more than doubled during 1977-87, from 1.7 million tons to about 4 million tons. The trend should be maintained, as there is increasing demand for maize as a source of animal feed and also because of its suitability for multiple cropping systems.

The third most important crop is cassava. Thailand, with an annual production of about 16 to 20 million tons, accounts for 42% cent of the Asian Region's cassava production. During the past decade, its production increased annually by 4%, and the entire increase occurred through area expansion, often causing deforestation. With the limited prospects of further increases in export of cassava, it would be advisable (i) to diversify out of cassava towards other upland crops, and (ii) to promote the domestic use of cassava.

The country has done well in plantation crops. For instance, its rubber production doubled from 431,000 tons in 1977 to 860,000 tons in 1987. Palm oil production is also increasing rapidly, multiplying from 5,000 tons in 1977 to 115,000 tons in 1987[2].

A large variety of fruits are grown, averaging 5.5 million tons per year with a very high potential for domestic as well as export markets. During the past 10 years, vegetable production has increased only by 1.6% per annum against a population growth rate of more than 2%. Thus the per caput availability of vegetables in the country, which has all along been below the recommended level, has further declined. Considering the supportive role of fruits and vegetables in nutrition, the per caput availability of these commodities should be increased. The agro-ecological as well as socio-economic conditions are conducive to increased production of fruits and vegetables, and this opportunity should be fully exploited.

Low yields of major crops in Thailand are attributed to the low and inefficient use of production input. For instance, Thailand uses less than 25 kg of NPK per hectare compared to about 90 kg of NPK per hectare for the Asian Region as a whole. The irrigation percentage, about 20%,

is also significantly lower than the Region's average. Despite recent developments in production and distribution of standard seeds, hardly 5% of the total crop area is put to certified seeds every year. Therefore, there is tremendous scope for increasing the level as well as the efficiency of use of the major inputs of production. Appropriate technologies for rainfed agriculture should be developed, keeping in mind the risk factor, the preponderance of small farmers and their low input capacities.

The government has announced a policy of crop diversification to be adopted for avoiding risk, increasing employment, improving nutrition, and increasing the socio-economic condition of Thai farmers. The strategy for crop diversification calls for critical assessment of the production potential of varyous crop blends, for research, extension, and development of infrastructures and capabilities, and the analysis of domestic as well as foreign market demands.

In the process of crop diversification, certain grain legumes, coarse grains, such as sorghum and millet, and several fruit and vegatable species should receive greater attention. Further, there is a high scope for intensifying the production of mushrooms to meet the fast increasing domestic demand. Mushrooms like shiitake have a great potential for meeting urban demands. The existing research capabilities are inadequate to develop appropriate technologies. Therefore, there is a need to strengthen research capability, including adaptive research by national institutions dealing with mushroom production.

2. Background and Scope of Mushroom Cultivation.

1). General Remarks

Mushroom cultivation in Thailand startarted in 1937, resulting from the pioneer works of Dr. KAHN, Jalavicharana. The first mushroom cultivated was the straw mushroom (*Volvariella volvacea*), which was native to this country. Techniques developed by Dr. Kahn were isolation of pure culture, preparation of spawn, and cultivation with rice straw as the substrate. Before his work, the straw mushroom was cultivated by immigrant Chinese using garbage piles or rubbish heaps as substrates in which the mushroom grew naturally. Evidently, there was no guarantee of success in this method of cultivation. Dr. Kahn's work totally changed straw mushroom cultivation practices and made it reliable occupation for the Thai people.

Following the success of straw mushroom cultivation, there have been many attempts to cultivate other native and introduced mushrooms as well. Mushroom cultivation has received serious attention again during the past decade and quite a few people are now earning their income from mushrooms.

Six kinds of mushrooms are commercially cultivated in Thailand. They are straw mushroom, ear mushrooms (*Auricularia polytricha, A. auricula-judae*), oyster mushrooms (*Pleurotus ostreatus, P. sajor-caju, P. salmoneostramineus*), abalone mushrooms (*P. cystidiosus, P. abalonus*), shiitake (*Lentinus edodes*), and common mushrooms (*Agaricus bisporus, A. bitorquis*). The straw mushroom ranks first in both total production and value. Others are produced in relatively smaller volumes. Most of the products are consumed domestically and the market demand has idcreased rather slowly during the past three years. However, the common mushroom is an exception, because the demand for this particular mushroom increased dramatically every year while supplies lagged far behind. This has resulted in an excessively high price for the mushroom. In the past, fresh common mushroom was sold at over Baht 40 per kg at the Chiang Mai market. This was approximately twice as much as the international price. Some canning factories are now operating mushroom farms to guarantee steady supplies to the industry, and it is believed that they also import common mushroom valued at over Baht 30 million annually (approximately US$ 1.1 million) for domestic consumption and re-export.

Apart from the common mushroom, demand for shiitake mushroom has been increasing greatly in recent years. This mushroom is particularly appreciated by the Chinese community and have

very important place in Chinese cuisine. It is thought that a large quantity of shiitake is imported from China and Taiwan (lower-grade items) and even from Japan (top-grade items).

2). *Volvariella volvacea*—Straw Mushroom

This mushroom is grown on rice straw and its culture is traditional to South-East Asia. Extremely simple techniques are used. Beds of wetted straw are placed in open fields or on shelves in growing houses made of bamboo poles and plant leaves. After inoculation with spawn, growth into the rice straw is rapid, and normally, mushrooms are produced some 8-10 days after inoculation. Mushrooms are harvested at an immature stage of development and are sold locally. Once harvested, deterioration is rapid and this restricts the scope of the market for this mushroom. Market demand greatly exceeds the supply, and generally, the cultivation of this mushroom is highly profitable to growers and complementary to the main rural activity of rice farming (cf. Chapter 4).

3). *Pleurotus* and *Auricularia*—Oyster and Ear Mushrooms

These mushrooms are adapted to grow on a wide range of substrates and many farms have appeared over the last few years that use sawdust substrates. Straw, after wetting and fortification with rice bran, or in some instances, a mixture of sawdust and straw, is used as the base substrate. The two dominant species of Pleurotus cultivated in Thailand are a white strain of *Pleurotus ostreatus* (fast-growing) and *Pleurotus cystidiosus* (slow-growing).

Most oyster mushrooms are sold fresh, but some *P. cystidiosus* are sold dry or canned. The ear mushroom *Auricularia polytricha* is also sold fresh, but more frequently sold dry, and the dried form is exported to Japan (3,000 kg, US $16,223 during Jan.-Aug. 1988). Oyster and ear mushrooms are technically the least demanding of all mushrooms to grow, but unfortunately consumer demand is low compared with other edible mushrooms. In Thailand, fresh *P. cystidiosus* is favoured, particularly in Chinese cuisine, but there are already indications that marketing may prove difficult if there should be a sudden increase or extension of production. The exportation of these mushrooms will only be possible if production costs are minimal.

4). *Lentinus edodes*—Shiitake

Shiitake is cultivated at the higher elevations of the northern province near Chiang Mai, where temperature conditions are more favourable. Traditional methods involve the inoculation of freshly cut hardwood logs with sawdust or wood chip spawn and incubation under natural conditions at appropriate sites in the forest. However, the system requires substantial tree felling and because the highlands are an important watershed, it is official policy to discourage the use of logs.

An alternative, artificial system based on the use of sawdust has been introduced, and an increasing number of farms useing sawdust are being set up in the Chiang Mai region. The procedures closely follow those adopted for *Pleurotus* culture; bags of inoculated sawdust substrate are incubated in growing houses constructed of bamboo and dried leaves.

This intensive system yields mushrooms quickly compared with the natural system. However, it is widely recognized that the quality of the *Lentinus* mushrooms grown under this system is inferior to naturally grown *Lentinus* and it is unlikely that an export market can be developed without improvement through breeding of the strains currently being used.

5). *Agaricus bisporus*—Common Mushroom

Successful production of the common mushroom requires high technology and a lower atmospheric temperature than for other mushrooms. The two factors have thus far limited its production to very few growers in the north of the country during the cool season. Most are

produced is the Chiang Mai and Chiang Rai areas, and productivity is low.

Current common mushroom production is far below the nation's demand. The annual consumption as estimated at 500 tons per annum, but production is estimated at 120 tons. Consumption could become higher than 500 tons if the price of the mushroom were lower. Growers receives Baht 30 per kilogram for ungraded mushrooms from the canning factories. The retail price at the market for fresh mushroom is between Baht 45-60 per kilogram. The price of the mushrooms could be brought down considerably and production stabilized by the application of better production technology. With lower prices, it is anticipated that more mushrooms will be consumed.

6). Future Scope

In Thailand, the consumer demand for mushrooms greatly exceeds supply, and there is considerable scope for the expansion and development of a large industry. Also, there is an active world trade in mushrooms that offers good prospects for developing an export market.

Mushroom production should play an important role in achieving the government policy decision to diversify agriculture. However, the rapid growth of mushroom industries and the diversity of mushrooms being cultivated for growers are far beyond the capacity of the research and extension activities of the University and the DOA. Conseguently, many technical problems appear, some of which are quite serious. Those who have suffered most have been the small farmers, because these problems are highly technical and some are intricately woven together. It is necessary to promote further integrated efforts among researchers and extension-workers to place farmers at the center of their consideration. Practical recommendations are given in the following Chapters 3 and 4.

(by Hikaru TSUTSUI)

Chapter 3 Cultivation of Oyster Mushrooms in Thailand

Oyster mushrooms (*P. ostreatus*, *P. sajor-caju*, and *P. salmoneostramineus* ; see Chapter 2-2) and abalone mushrooms (*P. cystidiosus* and *P. abalonus* ; see Chapter 2-2) are edible fungi with a wide distribution, being cultivated in many countries. In Thailand, these fungi are also cultivated in mixes, mainly in the northern area near Chiang Mai and Chiang Rai.

1. Growing Houses (Fig. 4)

Several mushroom growers in these areas were visited. Growers live in dwelling houses with a high floor in a wider lot covered with clusters of trees including such fruit trees and shade trees as *Cocos nucifere*, *Areca catechu*, *Carica papaya*, *Citrus* sp., *Euphoria logana*, *Ananas comosus*, *Musa paradisiaca* var. *sapientum*, *Ficus elastica*, etc. Many of the growers visited had mushoom houses of medium size (less than 20 to 30 m^2), built in a corner of their lots. These houses have poles of timber or of bamboo, and roofs and walls thatched with bundles of graminaceous straw, with palmate leaves (nipa) or with broad tree leaves that permit free ventilation.

In some growing houses, ventilation was accelerated by the provision of openings (with covers) between roof and wall and in the lower part of the walls (Fig. 4). Light poured into the house through these openings and through gaps of leaves thatching the wall. High humidity was maintained in ordinary growing houses by the earthen floors being sprayed intermittently with water.

2. Spawn and Sterilization

Spawn of oyster mushrooms were prepared with sterilized substrate. A farmer near Chiang

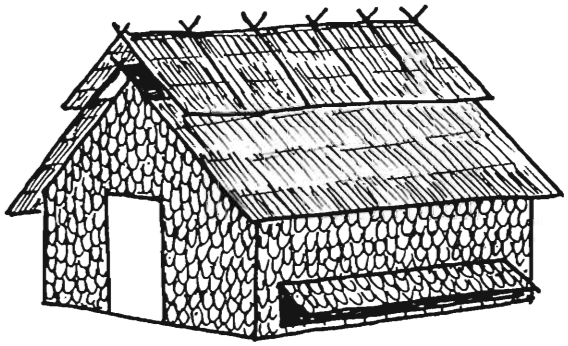

Fig. 4. Example of growing houses for oyster mushrooms.

Mai, who was exclusively producing spawns on a small scale, supplies spawns to many growers in the nearby area. Among the growers, a kind of differentiation sometimes occurs; a few growers become spawn-sellers as the number of growers in this district increases.

In the work-shack of this spawn-maker, after the substrate is placed in a whisky bottle, a young boy employee inserted a stick into the bottle, rammed the surface of the substrate repeatedly, added more substrate, and rammed the surface repeatedly again. Finaly, he filled the bottle to 2/3 to 3/4 of its capacity. As substrate, he mixed sawdust with an appropriate quantity of supplement nutrient and water to give a 62-65% in water content. Mr. Anon AUETRAGUL[5] recommended the following formula for the substrate:

Completely dry sawdust*	100 parts by vol.
Fine rice bran	8 parts by vol.
Ground maize**	5 parts by vol.
Bean meal**	2 parts by vol.
Flour or granulated sugar	2-3 parts by vol.
Limestone mixed with gypsum in equal proportions	1-2 parts by vol.
Moisture	

The bottle was plugged with cotton-wool, covered with a piece of paper, tied with rubber band, and then sterilized.

For sterilization, many growers and small spawn-maker used a kind of steamer (Fig. 5). It was composed of a 200-liter drum with a lid and a hand-made furnace of brick. A grower said that he kept fire in the furnace for about 3 hours until completion of the sterilization, using dried coconut shells and waste wood for fuel. The temperature of the substrate was probably kept above 95℃ at the least for one houre. The sterilizer of this kind may be the "country-style steamer" mentioned by Mr. A. AUETRAGUL[5].

3. Filling, Inoculation, and Cultivation

The substrate was prepared with use of sawdust of rubber wood (*Hevea braziliensis*) as a base material. Sawdust was stacked outdoor and fermented until it became loose and friable without a bad smell. The formula of the substrate recommended by Mr. A. AUELTRAGUL[6] is as follows:

Compost materials, ground and dried	100 kg
Fine rice bran	3-5 kg
Finely ground maize or corncobs	3-5 kg

* In a mushroom factory near Bangkok, spawns of oyster mushroom were produced. A mixture of grain sorghum and nutrient supplements was used as substrate.

** Fine rice bran may be used instead.

Lime	1-2 kg
Epsom salts	0.1-0.2 kg
Water	65-70 kg

The substrate was used to fill a heat-resistant plastic bag (about 20 × 30 cm) thicker and harder than those used in Japan, and pressed to become compact. A plastic neck (3-4 cm in diameter) was put in the mouth of the bag with a rubber band to fasten it tightly. The neck was then plugged with cotton-wool (Fig. 6). The bottles thus prepared were soon sterilized after being covered with a piece of paper. For the sterilization, steamer(s) as described above were also used.

When the sterilization ended, the bottles were transferred into the inoculation room and left until inoculation. Inoculation was done with spawn put onto the surface of the substrate at 25 to 30°C. The bottles were then left on shelves in the incubation room, and within 25 days, the spawn-run usually ended. It was the time to transfer the bottles to a growing house and to open the bottle. Many bottles were seen on shelves constructed with a variety of styles in growing houses (Fig. 7). Some bottles were hanging from strings and mushrooms grew out of slits on the side of the bottles (Fig. 8). Ordinarily, mushrooms grew out from the mouth of the bottle. Mr.

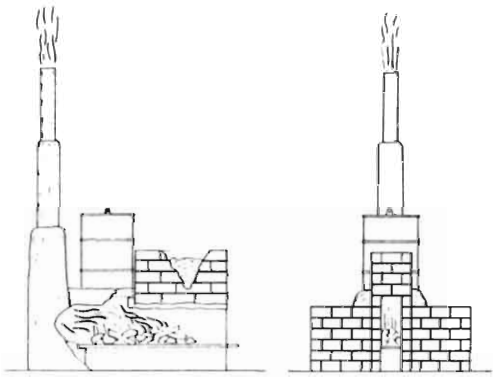

Fig. 5. Furnace and the steamer (200-liter drum) for sterilization.
a, side view ; b, front view.

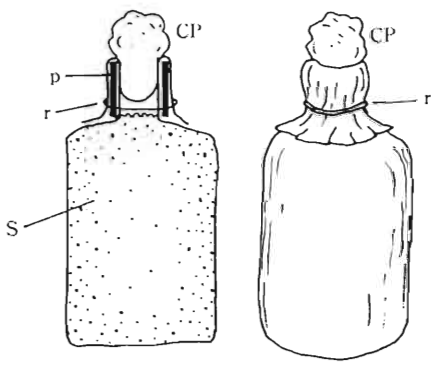

Fig. 6. Bottle (bag) for cultivation that contains substrate.
cp, cotton-wool plug ; p, plastic neck ; r, rubber band ; s, substrate.

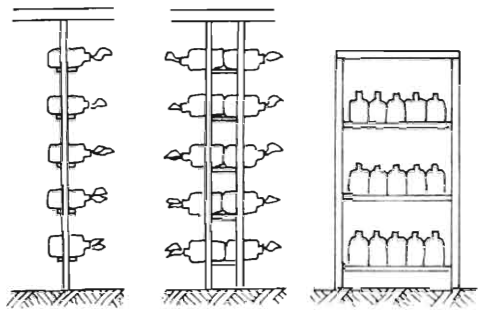

Fig. 7. Three kinds of shelves placed inside the growing house.

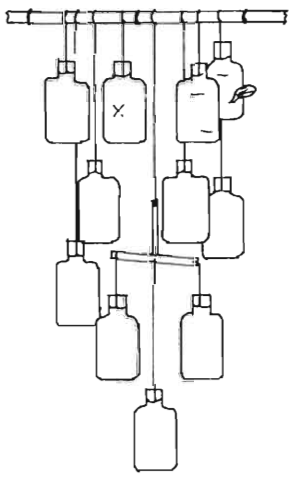

Fig. 8. Bags handing from strings from a shelf. This style was seen in growing houses near Chiang Mai.

A. Auetragul recommended three other methods: (1), opening and rolling down of mouth; (2), cutting off the mouth with a razor; and (3), slitting the sides of the bag[6].

Mushrooms grew out from the opening or from the slits, and matured. Mushrooms were harvested at the stage they started to produce spores.

The cultivation procedures in Thailand and those in Japan will be compared elsewhere.

4. Recommendations for Future Cooperative works

In most countries, the levels of the techniques used in individual industries cannot be determined in themselves, but only in connection with the levels of other industries coexisting in the same country. This is clearly seen in the goals of the modernization of the mushroom cultivation industry. Japanese-syle cultivation of mushrooms is characterized by modern growing houses equipped with highly mechanized utensils, the use of an orderly and set cultivation programme, and the ample supply of low-cost electric energy and oil. These characteristics exists due to the general level of high development of Japanese industries. The difficulty of mushroom cultivation in Thailand arises from the lack of such conditions, suggesting that the direct adaptation of Japanese-style techniques to Thailand is of no relevance.

Considering the conditions of Thailand, the followings seem to be appropriate as subjects of future cooperative studies (including those for oyster mushrooms):

a. Prevention of harmful fungus contamination to cultures (improvement of cotton-wool plugs, steamers for sterilization, pure culture spawns, etc.),

b. Selection of high-yield fungus stocks,

e. Exploitation of breeding practice, and

f. Training of extention workers as well as researchers about basic problems.

(by Kenjiro KINUGAWA)

Chapter 4. Cultivation of Straw Mushrooms in Thailand

1. Introduction

The straw mushroom (*Volvariella volvacea*; see Chapter 2-2) has been cultivated for many years in Thailand as well as in mainland Chaina, Taiwan, Indonesia, Philippines, and other Asian countries. This mushroom is a saprophytic tropical fungus, which requires relatively high temperature (28°-37°C), high humidity (65-85%), and weak light for normal growth.

In August 1988, a wide range of farms and research institutes for the straw mushroom in the Bangkok district were visited, including small straw-mushroom farms in Nakon Nayok. There, farmers used the traditional method for cultivation, and it appeared that more scientific and technical research was needed.

This report outlines the cultivation method and the possibility of improvement of yield by application of S-PI, substance that promotes fruit-body formation of mushrooms.

2. Outline of cultivation

1). Substrate

Rice straw is widely used in Thailand, because it is easily available in the country. However, several researchers have pointed out the possibility of using other materials such as the compost commonly used for *Agaricus bisporus*[7], a mixture of cotton waste and paddy straw[8], and a mixture of banana leaves, oat chaff, oat busk, sawdust, rice bran, and sucrose[9]. A mixture of guinea grass and sugar-cane bagasse, oil palm bunch waste, oil palm pericarp waste, and sisal tow is also a useful substrate[10].

2). Cultivation

(1). Open-air cultivation

In the farm we visited near Bangkok, dried rice straw was tied into small bundles and stacked into beds, and the beds were placed in open fields and in wet land. After inoculation with spawn, the mycelia grow rapidly, and normally produced mushrooms some 8-10 days after inoculation. This type of traditional open-air culture is important as a stable source of farmer's income, although the yield is not satisfactory.

(2). Shelves for cultivation under a roof

In an other farm near Nakon Nayok, Bangkok, rice straw with added cotton waste and fertilizers was used as substrate. The substrate was placed on bamboo shelves that were arranged in layers 4 to 8 high, in a simple growing house constructed with a bamboo or timber framework and broad tree leaves. Such houses provided protection from rain and a limited degree of control over pre-spawning pasteurization by live steam. Such procedures are said to improve the nutritional status of the straw substrate, resulting in higher yields and 3 or 4 harvests within 4 or 5 weeks. In this farm, the presence of competiting species such as *Coprinus* sp. was observed. Shelf cultivation may be a evolutionary step towards intensive methods like *Agaricus* culture in on a large scale.

3. S-PI application to cultures

The fruiting of edible mushrooms such as *Lentinus edodes*, *Pleurotus ostreatus*, *Flammulina velutipes*, and *Agaricus bisporus* is promoted by the addition of a carboxyl proteinase inhibitor S-PI[11] that is isolated from a culture filtrate of *Streptomyces naniwaensis* (Fig. 9). Application of S-PI shortened the time required for maturation of fruit-bodies, and increased both the number of fruit-bodies and the total yield on a dryweight basis. In addition to the improvement of substrate and cultivation procedures, the development of effective use of S-PI should increase mushroom yield in Thailand.

(by Takao TERASHITA)

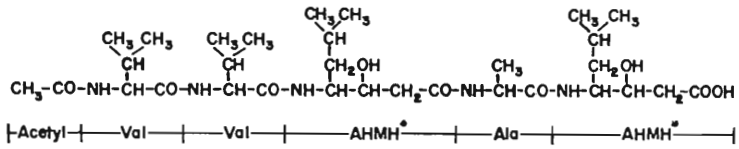

Fig. 9. Chemical structure of *Streptomyces*-pepsin inhibitor (S-PI).
* 4-amino-3-hydroxy-6-methyl-heptanoic acid.

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タイ国農業における問題点と展望
1988年，調査隊 SMKT88 の報告

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摘　　要

1988年，近畿大学がタイ王国のチェンマイ大学と姉妹校協定を結び，相互の研究協力を約束した事情をふまえ，学術調査隊（SMKT88）が派遣されて，タイ王国の農業事情を調査した．本報はその調査報告である．

タイ王国は，気候がモンスーン大気流の支配下にある熱帯に位置し，米作を主とする農業を営むが，米が現在非常に低価格であることと関連しながら，農業の GDP が農業人口に比しきわめて小さく，その比は，よく似た国情にある ASEAN 諸国中最低である．そこで，タイ国の農家経営は現在非常に困難な状況にある．政府は作物多様化の政策をとっているが，その中で，きのこ（ふくろたけ，ひらたけ類など）は最も有利な作目の1つである．すなわち，タイ国におけるきのこ類の価格は，他の野菜にくらべて著しく高く，発展する都市部にその需要の大部分がある．このようにきのこ栽培は将来に明るい展望をもつが，栽培技術に関してはなお改善の余地がある．その他，タイ国農業の現況を述べ，農業に対するきのこ栽培の寄与と研究協力の方向に関し考察した．