Status of Agricultural Production and Crop Variety Improvement in Thailand

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Abstract We introduced basic conditions of agricultural production in Thailand, and variety improvement of major crops, including rice, cassava, rubber, and vegetable, in the hope of providing reference for agricultural production and crop variety improvement in Hubei Province and even in the whole country.

Key words Agricultural production, Variety improvement, Thailand

At the request of 948 Project of the Ministry of Agriculture and International Cooperation Project of Ministry of Science and Technology, we surveyed agricultural conditions and scientific research situations in Thailand in October 2009. In particular, we surveyed production and variety improvement of major crops in Thailand, to find out agricultural production, resource utilization and new variety application in Southeast Asian countries, and to provide service for agricultural production and crop breeding in Hubei Province.

1 General situations of agriculture in Thailand

Thailand is a large traditional agricultural country with 15.3 million people (accounting for 80% of the total population of the whole country) engaged in agriculture. Arable land area is about 22.4 million hm^2, taking up 41% of the total land area of Thailand. Major crops include rice, maize, cassava, rubber, sugarcane, vegetable, mung bean, hemp, tobacco, coffee bean, oil palm, and coconut, *etc*. In agricultural land, about 59.12% is used for rice production, 23.18% used for high and dry land crops (such as maize, cassava, Chinese sorghum, *etc*), and 9.16% for fruit trees. The per capita arable land is 0.164 hm^2, favorable geographical location and climatic conditions offer superior natural conditions for agricultural production. Therefore, agriculture plays a decisive role in economic development of Thailand.

Thailand enjoys the reputation of the "Granary of Southeast Asia", and is the sole net exporter in Asia and one of export countries of major crops in the world. Rice and cassava export of Thailand ranks first in the world, rubber export ranks third, and export of aquatic products is only second to Japan in Asia. Among top ten export commodities of Thailand, 6 are agricultural products, accounting for 40% of the total export value[1].

So far, the newly developed aquatic products, livestock products, fruits and vegetables have increasingly become important pillars of Thai agriculture. At present, Thailand has become the third largest marine fishing country in Asia, and aquatic products have leaped to the fourth position in agricultural exporting products of Thailand. In animal raising industry, livestock and poultry products, such as chicken, duck, meat and eggs, can satisfy domestic market demand, and export quantum is bigger and bigger. Frozen foods, including frozen chicken, eggs and shrimps, have ranked among top ten exporting countries in the world. Besides, Thailand also has made outstanding achievement in tinned fruit and vegetable market. Its tinned pineapple has taken up 35% of the world market.

2 Major crop production and variety improvement in Thailand

In Thailand, major agricultural products include rice, sugarcane, cassava, rubber, maize, fruit and vegetable. With rice and cassava export taking up 25% and 95% respectively of the world total export, Thailand takes the lead in rice and cassava export. 60% of agricultural revenue comes from crops, and the rest comes from aquaculture, animal husbandry, agricultural product rough processing and agricultural services.

2.1 Rice Rice is an important variety of agricultural products in Thailand for foreign exchange earning. The paddy field covers an area of 10.78 million hm^2, accounting for about 20% of total land area and 50% of total arable land of Thailand. About 4 million farmer households (24 million people) are engaged in rice production, accounting for 75% of total agricultural population. The annual yield of rice is close to 30 million tons, 7 to 9% of the global total rice yield. The annual export reaches 7 million to 10 million tons, accounting for 25 to 35% of total volume of rice trade. The export amount is up to 1.8 billion to 3 billion USD. In sum, Thailand is the largest rice exporter in the world. Rice industry plays a significant role in Thai agriculture

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and its national economy[2].

2.1.1 Rice production. In 2006, the total rice planting area in Thailand was 10.784 million hm^2, including 5.334 million hm^2 in northeastern areas (50% of the total planting area), 2.575 million hm^2 and 2.504 million hm^2 respectively in northern areas and middle areas (23.9% and 23.2% of the total planting area), and the rest in southern areas (only 3.4% of the total planting area). Also in 2006, the planting area of single cropping of rice was 9.2 million hm^2 and double cropping of rice up to 1.584 million hm^2, separately accounting for 85.3% and 14.7% of total rice planting area. Main producing areas of single cropping of rice are northeastern areas (5.229 million hm^2), northern areas (2.042 million hm^2), middle areas (1.59 million hm^2) and southern areas (0.338 million hm^2); main producing areas of double cropping of rice are middle areas (0.914 million hm^2), northern areas (0.533 million hm^2), northeastern areas (0.105 million hm^2) and southern areas (0.003 million hm^2). In the same year, the total yield of rice reached 29.65 million tons, including 10.66 million tons (36%) in northeastern areas, 9.37 million tons (32%) in middle areas, 8.73 million tons (29%) in northern areas and 0.89 million tons (3%) in southern areas. The total yield of single cropping of rice was 22.9 million tons (77.2% of the total yield of rice in that year); the total yield of double cropping of rice was 6.75 million tons[3].

The per unit area yield of rice is not high in Thailand. Comparatively speaking, the yield in middle areas is higher than that in northeastern and southern areas. In 2006, the average per unit area yield of single cropping of rice was 2 487.50 kg/hm^2. Among this, the per unit area yield was 3 331.25 kg/hm^2 and 3 162.50 kg/hm^2 respectively in middle and northern areas, while that in southern areas and northeastern areas were 2 368.75 kg/hm^2 and 1 975.00 kg/hm^2. In 2006, the average per unit area yield of double cropping of rice was 4 262.50 kg/hm^2. The per unit area yield of rice production area is as follows: middle areas 4 450.00 kg/hm^2, northern areas 4 256.25 kg/hm^2, northeastern areas 3 031.25 kg/hm^2, and southern areas 2 968.75 kg/hm^2. Ecological production of rice includes 77% low-lying field rain-fed rice (water depth less than 0.5 m), 15% irrigated rice, 5% floating rice and deep water rice (water depth higher than 0.5 m), and 3% upland rice[4].

Thailand rice production has rainy season (May to October) and dry season (November to next April). The sowing time mainly depends on irrigation condition. In low-lying rain-fed field, the first season rice is sown in May to June; in paddy field with irrigated condition, it is sown in July to August, so the time of harvesting is long. In some places, the rice has to be harvested till December. Double cropping of rice is generally sown in the last ten days of December and harvested in the next March to April. In rainy season, about 50% rice farmers plant traditional long-stalked rice variety with average yield of 1 900 kg/hm^2; in dry season, most irrigated rice varieties adopt modified high yield short-stalked varieties with average yield of 3 700 kg/ hm.

Major variety in Thailand is conventional hsien rice. In northern areas, varieties promoted mainly include Phitsanulok 601, Phitsanulok 602, and especially Phitsanulok 2, which is a variety of fragrant rice and has cultivated area more than 50%. KDML105 is a variety of long and thin, transparent and fragrant grain of rice. In Chiang Mai, it has planting history of about 35 years; in the whole country, the planting area is large; it is excellent raw material for processing export rice[5]. Thailand farmers have strong market quality awareness, and they will not sow those varieties that have low quality and price. Scientific research institutions always take opinions of rice farmers as basis of evaluating rice quality. More important, Thailand insists on do a great job in seed production. In the whole country, it has established 23 rice seed production centers. Some varieties can be used for as long as 50 years in production, but still are favored by rice farmers and optimum raw material of export rice. At present, rice breeding in Thailand focuses on quality, yield, and resistance.

2.1.2 Variety improvement. Thailand rice is mainly conventional rice variety (more than 98%), while the hybrid rice is less than 2%. Thanks to high yield and economic benefit, hybrid rice is gradually popularized, but the popularization process is slow due to comparatively low quality. Before the 1960s, Thailand rice breeding mainly adopts pure line selection method to improve rice quality, especially rice grain length. In the middle of the 1960s, cross-breeding and mutation breeding methods were applied to rice breeding, especially to select non-photosensitive varieties that are suitable for irrigated rice regions, and to increase per unit area yield and raise ability of resisting disease and insect pest through using varieties developed by the International Rice Research Institute (IRRI). From the 1990s, it started to study hybrid rice, but the progress is slow. At the end of the 1990s, rice biotechnology started, and scientists tried to introduce into disease resistant gene through molecular technology. However, in consideration of safety, it still remains at the experiment and observation stages. Currently, main varieties popularized in Thailand are RD6 (bred in 1977), KDML105 (bred in 1959), SPR60 (bred in 1987), RD23 (bred in 1981) and RD10 (bred in 1981)[6,7]. In particular, KDML105 was selected from local farmer family lines in 1959. With hsien, drought-enduring, acid-base resisting soil, long and thin grain, transparent, fragrant characteristics, this variety sell well at international market. Although have been applied in production for nearly 50 years, it still takes up a larger portion because of high quality. Nevertheless, due to long time of repetitive planting, the variety degrades seriously and the ability of resisting diseases is declining. Thus, the importance should be attached to reinforce its disease resistance. In addition, due to small seed market and low profit, only a few agricultural companies are engaged in seed production and purification, and most seeds are purified by farmers themselves. Thailand is situated in a hot and humid climatic zone where there is serious problem of plant diseases and insect pests. Therefore, great importance has been attached to seed selection of resistant varieties.

In variety improvement, Thailand always takes precedence in quality. Only those varieties that meet quality standard can

be included into area test and approval. Varieties with merely yield increase will not be applied into production. Therefore, the high quality rice variety Hommali developed in 1959 is still one of the major varieties of Hom Mali Rice (Jasmine Rice)[7]. To prevent degradation of Hommali, Thailand Rice Research Center and Test Laboratory lay special stress on purification and rejuvenation, and upgrade it one time every two or three years, to ensure its high quality.

2.2 Cassava Cassava is the third largest crop, only second to rice and sugarcane, in Thailand. In 1786 to 1840, the cassava was introduced from Malaysia to southern Thailand, and then popularized in the whole Thailand. At present, the cassava is mainly planted in northeastern regions. The yield in Nahong District accounts for 57% of the total yield, and the next is Indo – Gangetic Plain, accounting for 31% of total yield. The cassava processing, at first, was a small-scale manufacturing technology introduced from Malaysia and Singapore. Later, along with constantly increase of market demand for tapioca, Thailand introduced advanced equipment from western countries.

Cassava is particularly drought-enduring, so it can grow up in nearly all types of soil. In addition to low requirement for nutrients, the planting area of cassava had risen to 1.5 million hm^2 in 1990 from 0.4 million hm^2 in 1973, and the total yield of fresh cassava rises to 20 million tons from 6.3 million tons. Thailand cassava has two periods of sowing: one is pre-dry season from November to next January, and the other is pre-rainy season from February to April. The production period lasts for 10 to 12 months. The cassava yield of Thailand ranks the second position, but its per unit area yield is the highest. In the 1960s to the middle of 1980s, the annual growth rate of cassava in Asia was 4.8%, mainly due to hard rice grain produced mutually by Thailand and Indonesia. In these two countries, the cassava yield takes up 75% of the total yield in Asia and 90% to 95% of export volume. From 1961 to 1986, the planting area of cassava in Thailand soared from 0.1 million hm^2 to 1.1 million hm^2, with annual increase of 13%. However, in the 1990s, the growth rate of yield declined due to the single variety RAYONG1. At present, Thailand is making effort to develop new varieties, such as RAYONG3, RAYONG60, RAYONG90, RAYONG5, KASET SART50, and SRIRACHAL, *etc*[8]. In the 1980s, cassava development was influenced by three factors: (i) Government factor. Government limits export of hard grain, and plants rubber, maize and other cash crops in areas where cassava should be planted. (ii) Factor of industrial development. Land is occupied by industrial development, so cassava planting has to extend to remote areas. (iii) Price factor. Hard-grain cassava price drops at Thailand-Indonesia market. Dry and hard-grain varieties of cassava in Thailand took up 88% of cassava consumption in 1982. However, in 1992, it dropped to 70% due to rise of tapioca industry. Thailand Agricultural Economic Research Institute founded the Cassava Development Commission, to formulate cassava development plan, raise cassava productivity and exploit market. The Commission estimates that the market demand for cassava in future years will rise to 34 to 37 million tons. At present, the annual yield of cassava in Thailand is 26 million tons, thus it is required to take measures to increase the yield, so as to satisfy the market demand. The Commission will also formulate three-term plan, to make farmers and distributors know functions of government and development trend of cassava market.

The industrial policy on cassava is formulated by the Agricultural Economic Office of Thailand Ministry of Agriculture and Cooperatives. The Ministry of Commerce and other organizations are responsible for assisting in cassava development and research, improving cassava variety and increasing per unit area yield. In 2007, 192 000 hm^2 land was improved, increasing the per unit area yield of cassava up to 31.25 t/hm^2, while in other unimproved land, the per unit area yield was only 21.25 t/hm^2. In this situation, it is proposed to strengthen research and development of cassava planting, enhance competitive power, cultivate new varieties, improve weeding technology, and research how to arrange morning, afternoon and evening, and adjust harvesting time.

Thailand cassava resource is very limited, and its genetic diversity is narrow. To improve local varieties and expand genetic foundation, Thailand has introduced many varieties from other countries, mainly from Latin American countries and Virgin Islands. Besides, International Center for Tropical Agriculture provides resources for Thailand every year, greatly lifting the genetic diversity of cassava in Thailand.

2.3 Sugarcane With sugar output accounting for 5% of the total world output, Thailand is the sixth largest sugar producing country, following Brazil, India, European Union, China, and the United States. At present, Thailand has 46 sugar refineries, including 10 in the northern areas, 18 in middle regions, 5 in northeastern areas, and 13 in eastern areas. Their production capacity ranges from 3 000 to 6 000 TPD. The per unit area yield of sugarcane is about 45 t/hm^2, and the sugar content of sugarcane is about 125. Sugar manufacturing period starts from November to the next January. The yield of sugarcane and output of sugar reached the all-time high in Thailand, 74.07 million tons and 7.28 million tons respectively. In 2005, the figures were 46.69 million tons and 4.835 million tons, 37% and 33.6% lower than that in 2002[9]. At present, there are about 107 000 small sugarcane planting households in Thailand. Sugar refineries do not plant sugarcane, but rather sign planting and purchasing contract with sugarcane farmers. In northeastern areas, sugarcane farmers plant sugarcane generally in October to November; in eastern Indo – Gangetic Plain areas, farmers plant sugarcane in November to December; in northern irrigated areas, farmers plant sugarcane in December to next April; in northern areas depending on rain, farmers plant sugarcane in May to June; in western Indo – Gangetic Plain areas and irrigated areas, farmers plant sugarcane in January to March, and in areas depending on rain, farmers plant sugarcane in May to June. Although the planting time and varieties are different in different regions, the growth period lasts for 10 to 14 months. Sugarcane is generated planted for one year (or two years for ratoon), so it is favorable to adjusting planting area according to change of sugar price. With sta-

ble development of its sugar industry in the past two decades, Thailand has become one of the major sugar producing and exporting countries in the world. Sugar industry has become a pillar industry of Thailand and plays a fundamental role in Thailand national economic and social development. The annual export and domestic sales revenue reach 1.25 billion USD, and sugarcane farmers and relevant people engaged in sugar industry reach one million.

Soaring of international sugar price stimulates enthusiasm of sugarcane farmers in Thailand for planting sugarcane. In 2009 to 2010, the sugarcane planting area rose to 979 200 hm^2 and the sugarcane yield rose to 70.53 million tons.

2.4 Maize Thailand is a major importer of maize in Southeast Asia. From the 1950s to 1980s, Thailand maize was used mainly for export. However, from 1990s, along with rapid development of domestic animal raising industry, the demand for maize grows constantly, so Thailand has to import maize from China, Argentina, and the United States. Maize is one of the major crops in Thailand and develops rapidly. In the 1950s, the planting area was only 780 000 hm^2; by the 1980s, it rose to 17.49 million hm^2[10]. In Thailand, about 80% maize is sowed in the early of rainy season (March to May); some is sowed in the later period of rainy season (July to August); and in the paddy field, it can be sowed in the dry season (November to next February).

Because maize variety Phraputtabat (PB) in Thailand is vulnerable to Downy Mildew, maize producers suffered a great loss in the 1970s. To select Downy Mildew resistant varieties, Thailand Agricultural University formed Suwan1 team in 1969. Under the condition of artificial inoculation, the team selected Downy Mildew resistant seed resource, and improve the variety by recurrent selection method. Through two times of recurrent selection, the team started to popularize the variety from 1975, and promote another early-maturing variety from 1979. In the 1980s to 1990s, another three varieties (Suwan3, Suwan5 and Nakhon Suwan1) were developed. At the same time, the Ministry of Agriculture and Cooperatives of Thailand promoted the Downy Mildew resistant variety ThaiDMR6. In the 1990s, total maize planting area had certain reduction, but there was nearly no change in the total yield, thanks to popularization of hybrid varieties. From the 1980s, the hybrid maize was planted in larger and larger areas. In 1981, the planting area of hybrid maize was 2 130 hm^2 (accounting for 0.1% of the total area); in 1996, the figure rose to 10.75 million (accounting for 77.5% of the total area) with an annual growth rate of 5.26%, and the yield rose from 2 356 kg/hm^2 in 1981 to 3 288 kg/hm^2 in 1995[10]. Seed selection for hybrid maize in Thailand was firstly taken by Thailand Agricultural University in 1978. Several years later, some private seed companies began to conduct research in hybrid maize, in the hope of selecting excellent inbred line and cultivating high quality, stable and high yield hybrid maize varieties.

In the 1980s, three-way cross hybrid, double cross hybrid and other non-conventional hybrid varieties took up a higher portion in maize production. However, in the middle of the 1990s, single cross hybrid varieties took up the major market share because of their high potential of yield and resistance to drought and plant insects. In 1995, the planting area of hybrid varieties was 926 000 hm^2, accounting for 69.4% of the total planting area. Among this, the planting area of single cross hybrid varieties reached 760 000 hm^2, accounting for 82.1% of the total planting area of hybrid varieties. In 1996, the planting area of hybrid varieties was 1.075 million hm^2, accounting for 77.5% of the total planting area. Among this, the planting area of single cross hybrid varieties reached 915 000 hm^2, accounting for 85.1% of the total planting area of hybrid varieties[10].

During the decade of 1987 to 1996, the yield of hybrid maize in Thailand, especially the single cross hybrid, had a significant rise compared with the last ten years. In the first two years of this decade, the highest yield came from three-way cross hybrid varieties; later, the highest yield came from single cross hybrid varieties all the time, with average yield of 9.0 to 9.5 t/hm^2. For single cross hybrid varieties, the seed consumption is little, but the yield is 35.4% higher than open pollination varieties, and 4.2% higher than other hybrid varieties. The net profit reached 6 445 Baht/ hm^2, 52.7% higher than open pollination varieties, and 7.3% higher than other hybrid varieties[10]. Besides, the single cross hybrid varieties also feature excellent germination percentage and seedling activity. Little weak seedling will appear if mechanical single seed sowing method is used.

2.5 Rubber Thailand is a major rubber producing country in the world. Among the whole 76 provinces in Thailand, 52 provinces plant rubber. In recent years, the planting area of rubber keeps 2 million to 2.3 million hm^2, about 5% of the total land area of Thailand, only second to Indonesia. Traditional rubber planting areas are mainly distributed in southern and middle areas. In recent years, they are gradually expanded to northern and northeastern areas. With annual output of 2.5 to 3 million tons (accounting for 1/3 of the total rubber output in the world), Thailand is the third largest rubber producing and exporting country in the world. The rubber export of Thailand takes up 40% to 45% of the global rubber export.

In 2006, rubber planting area was 2.294 million hm^2, 5.5% over the 2005. The largest planting area was southern areas, about 1.753 million hm^2, accounting for 76.4% of total rubber planting area in Thailand. In 2006, the rubber tapping area in Thailand was 1.744 million hm^2, 85.2% in southern areas, 10.5% in middle areas, 4.2% in northeastern areas, and 0.1% in northern areas[11].

Also in 2006, the total rubber output in Thailand reached 3.09 million tons, 4% over the 2005. Southern areas had an increase of 2.9% (2.66 million tons), accounting for 86% of the total rubber output in Thailand; middle areas had an increase of 5.8% (0.31 million tons); northeastern areas had an increase of 26.7% (0.12 million tons); northern areas had an increase of 27.1% (2 708 tons). The top five provinces that produce rubber are Suratthani, Songkhla, Trang, Nakhon Si Thammarat and Amphoe Mueang. Rubber output of these five provinces accounts for more than 50% of the total rubber output

in Thailand[11].

2.6 Vegetable Due to climatic factor, vegetable varieties in Thailand are single, and the yield is low and planting area is limited. Local vegetables in Thailand are mainly peppers, eggplant, cabbage, spinach, asparagus, young corn spear, cowpea, bitter gourd, pumpkin, cucumber, watermelon and so on. Crucifer cold-resistant vegetables, lotus root and some heat tolerant vegetables are mainly imported from China. At present, China takes the opportunity of zero tariff between China and Thailand. Yunnan rapidly increases its vegetable export to Thailand. More than 20 types of vegetables exported from Yunnan are popular in Thailand. Along with opening of Kunming to Bangkok highway, more vegetables will be exported from Kunming to Thailand.

Although the vegetable production is limited in Thailand, its vegetable resources are rich. Thailand Tropic Vegetable Research Center, subordinate to Thailand Agricultural University, is specially responsible for collecting high quality seed resources from the whole world, and evaluating and storing appropriate resources. Besides, it has established the Thailand largest vegetable seed resource bank, which has 117 types and 14 448 varieties of vegetable resources. In addition, it has established 50-year long term bank (−196 ℃ for seed storage) and 10-year middle term bank[12]. The vegetable research in Thailand is mainly in universities and scientific research institutes like Thailand Agricultural University, whose horticulture department has rich experience in organic cultivation and promotion of vegetable. Nearly 1/3 of organic vegetable planting technologies come from Thailand Agricultural University. Seed selection of new variety of vegetable mainly comes from Thailand Tropic Vegetable Research Center, Chia Tai Group (also called Charoen Pokphand Group), and other famous companies. Vegetable production has two types, farmers' spontaneous action and farm owners' contracting. And seed used by farmers is mainly purchased from seed companies.

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for giving play to these advantages, therefore, Guangdong Province, especially the western Guangdong sugarcane producing area, should give full play to its internal advantages; use the favorable external opportunities, and draw on the powerful technological support and service of research institutions, to vigorously develop the sugarcane industry.

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