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BACKGROUND TO THE INTRODUCTION OF HIGH YIELDING VARIETIES OF RICE IN THAILAND

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This paper describes Thailand's experience to date with new technology in rice, namely new high yielding varieties with associated inputs, which forms one part of the "green revolution." First, the historical background in exports, production, and domestic marketing and pricing is presented. Next the significant developments in rice research in Thailand are described, followed by a brief outline of the adoption of new varieties. In the final section, some implications are drawn for future developments, based on the experience gained until now.

The considerable attention paid thus far to the green revolution and high yielding rice varieties has dealt only with two categories of countries. One category consists of those developing countries which were food deficit, and are trying to reduce food imports or even gain self-sufficiency. Their problems with the new technology include production and marketing as direct effects and employment and income distribution as indirect effects. The second category consists mostly of developed countries which are historically large exporters of food grain, plus Japan which has recently switched from a rice importer to a rice surplus producer, and the EEC which is nearly self-sufficient. These countries face problems of shrinking commercial export markets and/or surplus

disposal problems. Thailand represents a third and largely neglected category, namely historically food surplus, rice exporting, developing countries, which in a sense now face, because of the green revolution, all of the problems faced by both of the first two categories of countries. This paper is intended to bring some of these special problems to light in the Thai context.

EXPORTS

Thailand has been an important exporter since 1855 when the Bowring Treaty with Great Britain opened Thailand up to international trade on a significant scale (Corden and Richter 1967, p. 128). By the early 1930's Thailand was exporting one-half of its annual production. The volume of exports from 1857 to 1944 is shown in Table 1. World War II greatly disrupted rice production and trade in Southeast Asia. However by 1949 Thai rice exports had come back up to 1.2 million metric tons of milled rice, or 27 percent of annual production, as shown in Table 2. Exports reached a peak in 1965, when 1.9 million tons, or 30 percent of total production, were exported. Exports then declined to about 1 million tons per year, or 10 to 12 percent of production by 1970. Increased production as a result of favorable weather and aggressive exporting brought exports back up to 1.5 million tons in 1971.

The countries to which Thai rice exports went and their relative shares during the period 1957 to 1969 are shown in Table 3. In 1965, rice was exported to 59 different countries, but only nine countries each took 5 percent or more of the total. The distribution among major export qualities is shown in Table 4 for the period 1966 to 1970. There are 38 distinct and clearly defined grades of milled rice in Thailand.

Table 1: Volume of Rice Exports from Thailand, 1857-1944

Period	Average Value Per Year (thousand metric tons)
1857-60	59
1860-64	110
1865-69	98
1870-74	112
1875-79	212
1880-84	215
1885-89	319
1890-94	435
1895-99	480
1900-04	668
1905-09	886
1910-14	913
1915-19	947
1920-24	1,061
1925-29	1,043
1930-34	1,543
1935-39	1,522
1940-44	795

Source: Ingram, J.C., Economic Change in Thailand: 1850-1970 Stanford: Stanford University Press, 1971, Table III, page 38.

Table 2: Volume and Value of Rice Exports from Thailand, 1946-1971

	Volume (million metric tons)	Value (million baht)	Exports as Percent of Production (percent)
1946	0.455	0,267	19
1947	0.392	0,385	13
1948	0.812	1,255	22
1949	1.216	1,869	27
1950	1.418	1,672	32
1951	1.474	1,824	33
1952	1.549	2,629	32
1953	1.359	3,747	31
1954	1.001	3,087	18
1955	1.237	3,133	33
1956	1.265	2,861	26
1957	1.570	3,622	29
1958	1.133	2,968	31
1959	1.092	2,576	23
1960	1.203	2,570	27
1961	1.576	3,598	30
1962	1.271	3,240	24
1963	1.418	3,424	23
1964	1.896	4,389	29
1965	1.895	4,334	30
1966	1.508	4,001	25
1967	1.482	4,653	19
1968	1.068	3,775	17
1969	1.023	2,945	14
1970	1.047	2,520	12
1971	1.554	n.a.	18

Sources: 1946-1949; Ingram, J.C. (1971) Economic Change in Thailand: 1850-1970 Stanford University Press, Stanford, California, Table III, p. 38.

1950-1967; Agricultural Statistics of Thailand 1967 Division of Agricultural Economics, Ministry of Agriculture, Bangkok. Table 81, p. 127.

1968-1970; Bangkok Bank Monthly Review, Vol. 12, No. 5 (May, 1971) p. 177.

1971; Unpublished data from Board of Trade, Bangkok.

Exports as percent of production calculated from this table and Table 5, with exports lagged one year behind production, i.e. exports of 1970 divided by production of 1969, with production in paddy converted to milled basis by multiplying 0.66.

Table 3: Thai Rice Exports by Country of Destination, Percent of Total Quantity Exported Each Year, 1957-1969

Country \ Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Southeast Asia													
Hong Kong	12.3	15.1	14.9	14.9	12.4	17.2	13.5	10.8	10.8	14.2	14.5	12.3	16.9
Malaysia	14.3	17.0	24.4	19.9	15.7	15.6	17.7	15.4	14.3	10.2	13.7	17.8	14.7
Singapore	17.2	19.6	20.0	17.4	12.3	13.5	12.4	12.1	9.1	9.5	8.1	12.3	13.1
Indonesia	11.4	11.6	6.8	11.4	23.8	21.0	23.9	23.8	5.7	11.1	12.0	4.2	7.9
Philippines	6.6	4.1	a	0	8.9	a	5.1	5.7	6.8	3.2	6.7	0	0
Subtotal	61.8	67.4	66.1	63.6	73.1	67.3	72.6	67.8	46.7	48.2	55.0	46.6	52.6
East Asia													
Japan	9.3	6.4	8.5	7.5	3.2	5.0	7.5	6.7	8.1	6.1	9.3	9.3	6.2
Taiwan	0	a	0.4	1.6	4.8	0	0.1	1.2	0	0.1	0.4	a	0.7
Subtotal	9.3	6.4	8.9	9.1	8.0	5.0	7.6	7.9	8.1	6.2	9.7	9.3	6.9
West Asia													
India	0.2	a	a	a	0	a	0	1.8	11.3	12.1	12.4	19.5	11.2
Ceylon	2.9	a	a	0.7	3.9	3.5	2.5	1.6	9.8	7.4	6.5	5.4	3.0
Subtotal	3.1	a	a	0.7	3.9	3.5	2.5	3.4	21.1	19.5	18.9	24.9	14.2
Middle East	5.4	5.9	10.9	9.3	4.6	7.4	6.6	5.5	5.2	4.7	5.5	7.8	7.6
Europe	4.9	7.8	5.0	2.8	2.9	4.4	1.5	2.8	2.0	2.2	0.5	0.4	1.0
Other	15.5	12.4	9.0	14.4	7.4	12.3	9.1	12.5	16.8	19.1	10.4	11.0	17.6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

a less than 0.05 percent

Source: Department of Customs, Annual Statement of the Foreign Trade of Thailand, Bangkok, calculated from annual issues.

Table 4: Thai Rice Exports by Grade, Percent of Total Quantity Exported Each Year, 1966-1970

Grade [a]	Year				
	1966	1967	1968	1969	1970
	percent of total export volume				
1. Rice White 100%	14.2	13.4	17.3	21.2	23.8
2. Rice White 5 & 10%	6.4	3.2	1.8	2.0	1.9
3. Rice White 15, 25, 35%	14.0	10.2	11.9	7.5	22.3
4. Rice Broken	19.7	22.9	19.4	18.3	16.8
5. Rice Glutinous	5.2	8.1	8.9	12.7	8.2
6. Rice Parboiled	26.4	23.1	22.0	31.7	25.3
7. All Others	14.1	19.2	18.7	6.6	1.7
Total	100.0	100.0	100.0	100.0	100.0

Source: Annual issues of Annual Statement of Foreign Trade of Thailand, Department of Customs, Bangkok.

[a] Standard International Trade Classification (SITC) code 0420200 series through 1969.

1. Code 0420210
2. Code 0420211, 12
3. Code 0420213, 15, 17
4. Code 0420230, 31
5. Code 0420242, 47, 49
6. Code 0420251
7. Code 0420229, 01, 09, 14, 16, 18, 19, 20, 32, 33, 34, 35, 36, 38, 39, 02, 03, 04, 05, 06, 07, 08, 50, 52, 53, 54, 43, 44, 45, 46, 48.

After 1969, based on the Brussels Tariff Nomenclature, Chapter 10.

Weekly export prices are reported for each grade. The grading system was instituted and is maintained and policed by the private sector. The major categories of grades are white, broken, parboiled, and cargo (which are all non-glutinous) and glutinous. White rice 100% (no broken kernels) is the highest quality of rice, for which Thailand has a reputation in world markets, and is usually traded only by the private sector. Hong Kong, Malyasia, and Singapore are the major buyers. The chief competitor is the People's Republic of China, and Thai exporters claim that quotas set by the importers which split the market between Thailand and China are politically determined. The largest export grade is parboiled rice, with India the major buyer, followed by Ceylon and Mideastern and African countries whose inhabitants have a taste for parboiled rice. This type is frequently traded government to government. Broken rice is another major grade. Hong Kong, Malaysia, and Singapore are the principal buyers, usually through private channels. White rice 5% (5% of the kernels are broken) and white rice 10% are the most important grades in domestic consumption and the grades on which the local consumer price index is based. White rice 15%, 25% and 35% are normally traded only government to government, with Indonesia the major purchaser. Glutinous rice faces a very thin market, based on special tastes. Japan has been the major buyer in the past, with Laos as second, although there is probably considerable unrecorded export of this type of rice in Laos. In any given year, the proportions being exported as white rice 100%, broken rice, and parboiled rice depends partly on the weather and partly on external demand. Adverse weather conditions during harvest can lead to more cracks than normal in the dried paddy, which in turn results in more brokens (less "head" or whole rice) during milling. Parboiling of such paddy before milling will usually result

in less brokens (higher recovery of head rice). So the relative strength between the broken and the parboiled markets partially determines the relative proportions going to each.

PRODUCTION

Rice is grown in every one of the 71 Changwats (provinces) in Thailand, with the most concentrated area in the Central Plains, particularly on the Chao Phya delta. About 75 to 80 percent of the Thai people live in rural areas and are involved in some aspect of agricultural production. Probably 80 to 90 percent of the farm firms produce some rice. Rice is the staple food, with per capita consumption steady at 155 kilograms (NEDB 1971).

Rice production data for the whole Kingdom during the period 1907-1970, by year and 10 year averages, are shown in Table 5. Although there may be valid questions raised about the data from earlier years, this table illustrates the problem of stagnation in yield per unit area in Thai rice production (see Ruttan 1966, Trescott 1968, and Ruttan 1970). Some work has been done to separate the yield depressing effect of extending production to areas marginal for rice production from the aggregate data in order to measure yield improvement in areas well suited to rice. Hsieh and Ruttan estimated that the 2.9 percent per year growth in total rice production from 1907 to 1964 consisted of a 2.5 percent per year increase in area harvested and 0.4 percent per year increase in yield (Hsieh and Ruttan 1967). Silcock estimated the components of the increase in output of rice from 1951-53 to 1962-64 as 13 percent increase in area and 15 percent increase in yield (Silcock 1970, Table 8.2, p. 180).

Table 5: Rice Area Harvested, Area Damaged, Production and Yield per Hectare Harvested, Thailand, 1907-1970.

Year	Harvested Area (1,000 ha.)	Area Damaged (% of Planted Area)	Production (1,000 metric tons)	Yield (m.t./ha. harvested)
1907	1,385	7.2	2,582	1.86
1908	1,253	14.4	2,368	1.89
1909	1,753	1.3	3,044	1.74
1910	1,452	3.2	2,953	2.03
1911	1,512	3.8	2,881	1.91
1912	1,972	0.1	3,670	1.86
1913	2,008	7.1	2,853	1.42
1914	2,018	1.0	3,102	1.54
1915	2,057	0.7	3,267	1.59
1916	2,079	4.2	3,786	1.82
Average 1907-16	1,749	4.0	3,051	1.74
1917	1,757	21.0	2,989	1.70
1918	2,009	6.9	3,384	1.68
1919	1,404	43.4	2,270	1.62
1920	2,239	8.4	4,266	1.91
1921	2,356	9.2	4,235	1.80
1922	2,402	4.9	4,340	1.81
1923	2,365	12.0	4,399	1.86
1924	2,558	7.9	4,942	1.93
1925	2,387	12.8	4,193	1.76
1926	2,785	3.8	5,226	1.88
Average 1917-26	2,226	12.8	4,024	1.79
1927	2,554	12.8	4,564	1.79
1928	2,386	16.3	3,882	1.63
1929	2,445	19.5	3,875	1.59
1930	2,909	8.5	4,826	1.66
1931	2,581	16.5	4,068	1.58
1932	3,011	6.3	5,116	1.70
1933	3,014	7.1	5,008	1.66
1934	2,933	12.1	4,598	1.59
1935	2,971	12.0	4,727	1.59
1936	2,226	31.7	3,380	1.52
Average 1927-36	2,703	10.7	4,404	1.63
1937	2,943	12.7	4,556	1.54
1938	3,129	10.8	4,524	1.44
1939	3,072	11.8	4,560	1.48
1940	3,235	15.0	4,923	1.52
1941	3,628	8.6	5,120	1.41
1942	2,876	34.3	3,854	1.34
1943	3,813	8.1	5,536	1.45
1944	3,813	6.1	4,928	1.29
1945	2,847	24.3	3,572	1.26
1946	3,509	11.9	4,442	1.27
Average 1937-46	3,286	14.5	4,602	1.40

Table 5 continued

Year	Harvested Area (1,000 ha.)	Area Damaged (% of Planted Area)	Production (1,000 metric tons)	Yield (m.t./ha. harvested)
1947	4,304	10.8	5,506	1.28
1948	4,930	5.4	6,835	1.39
1949	4,963	5.8	6,684	1.34
1950	5,295	4.4	6,782	1.28
1951	5,736	3.7	7,325	1.28
1952	5,130	4.4	6,602	1.29
1953	5,931	3.9	8,239	1.39
1954	4,524	18.6	5,709	1.26
1955	5,376	6.8	7,334	1.36
1956	5,762	4.3	8,297	1.44
Average 1947-56	5,195	6.7	6,931	1.33
1957	4,287	15.5	5,570	1.30
1958	5,169	10.2	7,053	1.34
1959	5,263	13.2	6,770	1.29
1960	5,643	4.7	7,835	1.39
1961	5,656	8.5	8,177	1.47
1962	5,191	7.0	9,279	1.50
1963	6,354	3.7	10,029	1.58
1964	5,971	8.7	9,559	1.60
1965	5,960	9.1	9,199	1.54
1966	6,878	5.9	11,846	1.73
Average 1957-66	5,737	8.4	8,532	1.49
1967	5,601	12.6	9,595	1.71
1968	6,259	12.4	10,771	1.72
1969	7,246	5.1	13,346	1.84
1970	7,131	8.6	13,401	1.88

Sources: 1907-1964; Israrkura, Vanrob, "A Study on Rice Production and Consumption in Thailand," Masters thesis, Ohio State University, 1966, published by the Division of Agricultural Economics, Ministry of Agriculture, Bangkok, 1967. Data also available in "Annual Report on 1962 Rice Production in Thailand" Rice Department, Ministry of Agriculture, Bangkok (in Thai) for 1907-1962.

1965-1967; Agricultural Statistics of Thailand, annual issues. Division of Agricultural Economics, Ministry of Agriculture, Bangkok.

1968; Unpublished data, Division of Agricultural Economics, Ministry of Agriculture, Bangkok.

1969-1970; Unpublished data, Department of Agricultural Extension, Ministry of Agriculture, Bangkok.

There are both conceptual and methodological problems involved in these estimates (see Ruttan 1966, Trescott 1968, and Ruttan 1970). The data indicate a steady increase in area harvested, with considerable increase in the past several years. Yield steadily declined until World War II, and then started a steady increase in the mid-1950's, reaching in 1970 the level of the 1920's.

Data for each of the four main geographical regions are shown in Table 6. These data illustrate the wide regional variation in yield, with yields in the North being more than double those in the Northeast. If data were available by agro-climatic or agronomic zones, they would show an even greater difference in yield among zones. Yields were highest in the North, at 2.9 metric tons per hectare, with yields by Changwat in the North ranging from 2.4 to 3.7 metric tons per hectare. Yields in the Northeast and the Central regions were the same, 1.6 tons per hectare, with ranges of 1.1 to 2.9 and 1.2 to 3.6 tons per hectare, respectively. Ranges in yield in the South were from 1.4 to 2.8 tons. It is becoming increasingly clear that environmental factors, particulary water control, are among the most important factors affecting increase in yield per unit area. Adoption of the high yielding varieties of rice and wheat (the green revolution) has occurred almost entirely on land with good water control. Conceptually one can classify rice areas as irrigated, rainfed, and upland. On the first two, rice is grown in a submerged conditions, with the paddys bunded on all sides to maintain at least a certain level of water. Irrigated usually means that a supplementary source of water is available, while rainfed usually means that the only source of water to the individual paddy is rainfall, plus perhaps a little runoff from the immediately

Table 6: Area Planted and Yield per Hectare Planted, by Geographical Region, Thailand, 1950-1970

Year	Area Planted (1,000 Hectares) North	Northeast	Central	South	Yield (m.t./ha. planted) North	Northeast	Central	South
1950	368	2,031	2,679	462	1.4	0.9	1.4	1.3
1951	374	2,364	2,758	464	1.5	1.0	1.4	1.3
1952	367	1,882	2,675	444	1.5	1.0	1.4	1.4
1953	379	2,538	2,778	476	1.8	1.1	1.5	1.4
1954	376	1,951	2,743	487	1.7	0.8	1.1	1.3
1955	388	2,323	2,632	428	1.9	0.9	1.4	1.6
1956	378	2,483	2,706	457	2.1	1.1	1.6	1.4
1957	387	1,659	2,600	430	2.1	0.9	1.0	1.2
1958	393	2,159	2,730	476	1.8	0.9	1.4	1.3
1959	410	2,467	2,732	456	1.9	0.8	1.2	1.4
1960	419	2,329	2,723	450	1.9	1.0	1.5	1.4
1961	412	2,465	2,822	479	2.1	0.9	1.5	1.5
1962	411	2,851	2,892	504	2.1	1.1	1.6	1.5
1963	424	2,715	2,961	501	2.6	1.1	1.8	1.6
1964	434	2,475	3,126	504	2.3	1.1	1.7	1.2
1965	437	2,453	3,129	534	2.4	0.9	1.6	1.4
1966	438	3,116	3,268	553	2.6	1.2	1.9	1.5
1967	439	2,255	3,165	552	2.9	1.0	1.7	1.3
1968	440	2,860	3,278	567	2.9	1.2	1.6	1.8
1969	458	3,245	3,353	581	2.7	1.5	1.9	1.9
1970	470	3,390	3,383	559	2.9	1.6	1.6	1.9

Source: 1950-67: Agricultural Statistics of Thailand 1967, Division of Agricultural Economics, Ministry of Agriculture, Bangkok. Table 12, p.48.
1968 : Unpublished data, Divison of Agricultural Economics, Ministry of Agriculture, Bangkok.
1969-70: Unpublished data, Department of Agricultural Extension, Ministry of Agriculture, Bangkok.

surrounding area. Upland rice is produced as an upland or dryland crop, i.e., it is not grown in a submerged condition. Data on production and area are not readily available for comparing yields on irrigated and non-irrigated or rainfed land in Thailand. The production and area data on irrigated land are collected by a different method than "all rice" data, and therefore calculation of non-irrigated yields by a residual method is questionable. The top section of Table 7 shows that percentage distribution among the four geographic regions of the area that the Royal Irrigation Department considers irrigated. The low proportion irrigated in the Northeast and the South is likely a partial explanation of the low yields of these two regions relative to the North as shown in Table 6.

"Irrigated" is also not really a very specific term. Dwarf varieties, with a height of around one meter, require a rather carefully controlled water level. This requires not only a supplemental source of water so that water can be brought in when needed, but also an adequate drainage system such that excess water can be taken off of the paddy, i.e., the water level must be controllable. Vast areas of the Chao Phya delta (in the Central region) of Thailand however have no provision for drainage. Water may reach depths of one to three meters, and depths of five meters have been observed. In these areas, floating rice, which is usually defined as a type of rice possessing the genetic ability to elongate rapidly under rising water conditions, is planted (Yantasast et al. 1970). Most floating rice is broadcast in late May and early June following the first few showers that mark the approach of the monsoon season. The rice seeds germinate and grow as the monsoon showers increase in intensity and frequency. Water levels usually do not increase rapidly until late August or early September at which time the level may change as much

Table 7: Area Planted, Area Irrigated, Method of Planting and Type of Rice in Thailand, By Geographic Region.

	North	Northeast	Central	South
	---------- percent ----------			
Area planted as percent of total kingdom (1966) [a/]	6.0	42.0	44.0	8.0
Area Irrigated as percent of total kingdom (1966) [b/]	10.0	10.0	77.0	3.0
Area Irrigated as percent of area planted [c/]	40.4	7.9	45.0	9.5
Method of Planting as percent of area planted (1959) [d/]				
Transplanted	99.6	98.4	54.8	71.3
Broadcast	0.4	1.6	45.2	28.7
Type of Rice as precent of area planted (1959) [e/]				
Non-Glutinous	8.5	28.2	96.7	95.7
Glutinous	91.5	71.8	3.3	4.3
Type of Rice (1970) [f/]				
Non-Glutinous	15.2	36.3	96.0	96.1
Glutinous	84.8	63.7	4.0	3.9

a/ Agricultural Statistics of Thailand 1967 Bangkok: Divison of Agricultural Economics, Ministry of Agriculture, Table 12, p. 48.

b/ Agricultural Statistics of Thailand 1967 Table 113, pp. 174-175. Included are State Irrigation Projects, People's Irrigation Projects, and Tank Irrigation Projects, irrigation area only.

c/ b/ divided by a/

d/ Kulthongkham, Sawaeng and Shao-er Ong, Rice Economy of Thailand, Bangkok: Division of Agricultural Economics, Ministry of Agriculture. 1964, Table 1.7, p. 7.

e/ Kulthongkham and Ong, op. cit., Table 1.6, p. 6.

f/ Unpublished data from Department of Agricultural Extension, Ministry of Agriculture, Bangkok Thailand.

as 3 to 5 centimeters per day. The fourth section of Table 7 shows the proportion of broadcast and transplanted rice in each of the four geographic regions. These data however cannot be interpreted as an exact measure of the floating rice area, because some farmers routinely broadcast some of their non-floating rice also, usually because of labor restrictions during planting time (NEDECO 1969). Transplanting takes much more labor to plant than broadcast, perhaps 20 to 30 times as much. So farmers with fairly good water control may start transplanting, and whenever they reach a point in time at which they feel that they must finish planting, they stop transplanting and broadcast the rest.

The area in the Central region planted to the true floating varieties has been estimated at 800,000 hectares. An additional one million hectares are planted to tall non-floating varieties that are not sensitive to water depths of one meter and occasional flooding (Yantasast et al. 1970).

The last two sections of Table 7 show the relative proportions of area planted to non-glutinous and glutinous rice in 1959 and 1970, respectively. The proportions in the Central and South remained constant, with glutinous being only a small fraction of the total. This reflects the nature of glutinous rice as a specialty in consumption in those two regions. However glutinous rice is the staple food in the North and part of the Northeast. The increased proportion of non-glutinous, especially in the North, can be interpreted as increased production for sale and export out of the region, rather than a change in taste.

MARKETING

The internal distribution system for rice in Thailand is remarkable. It takes part of the production from most of the 3 to 3.5 million farms that produce rice, distributes it among the 35 million consumers, who are very discriminating in their tastes and preferences for rice, at the rate of 155 kilograms per person per year, and channels the surplus of over one million tons per year into world markets. And it does this with marketing margins that are low by international standards, with farmers receiving something over 70 percent of the retail price paid by domestic consumers (Division of Agricultural Economics 1970).

The rice marketing system as it now operates in Thailand is essentially private, although in the past there have been some important government activities, particularly in pricing. The physical task of carrying out the marketing functions is private with three exceptions of a small government concern which is in the rice milling business, a small amount of storage operated in conjunction with a minor price support program, and a retail outlet intended for low income consumers in Bangkok.

The first steam powered rice mill was built in Bangkok in 1858, and by 1877 mills were being located in the rice growing area (Ingram 1970, p. 70). By 1910, there were about 60 mills in Bangkok, and this number remained nearly constant until after World War II, when it began to decline. In 1956 it was estimated that there were 6,067 mills in the whole Kingdom, with 3,518 of these with a capacity of less than 5 tons per day, 2,179 of 5-30 tons, 273 of 31-65 tons, 56 of 66-100 tons,

and 41 of over 100 tons per day capacity (Kulthongkaham and Ong 1964 p. 64). The mills are generally scattered throughout the country and fairly well located on the basis of production. Most are conventional under-run disc sheller rice mills with cone polishers. Steam engines burning rice husks for fuel are a common source of power. A common milling arrangement is for the milling to be done for the bran. The farmer brings the paddy and receives all of the milled rice, with the miller keeping the bran, and sometimes the smallest brokens, as a milling fee. Thus, millers frequently also have a pig feeding enterprise along with their milling business (Welsch and Tongpan 1971b). Most mills also have equipment to separate the rice by grade. Japanese-type rubber roller mills have been tested but are not economic at this time because the cost of rollers is greater than the added value of whole rice recovered from the rubber roller type mills. Another factor contributing to the low cost of the present steam powered mills is that they have few parts to wear out. The millers usually make their own rotary abrasive stones, and one frequently finds operating mills that are 30 to 40 years old or older.

Rice is usually stored in paddy form because milled rice does not keep well and must be reconditioned if it is not consumed within several months after milling. Small amounts of paddy are usually stored on farms and larger amount of paddy are stored at the mills. Most of the milled rice that moves to Bangkok for consumption or export comes by river barge at low cost. Grading equipment is used to blend grades to specification for export. Retail shops commonly offer a wide range of grades to consumers.

Internal pricing of rice from the end of World War II to April 21, 1971, was by a constrained free market system. Internal prices at all points in the market channel were set by normal market forces, and generally moved up and down in concert with world rice prices. However, they differed from world prices by the amount of the rice export tax, called the "rice premium." The history of the rice premium and its economic effects have been well documented and analyzed by Silcock and Ingram, so only a brief summary will be given here (Silcock 1970 and Ingram 1971).

Because of circumstances regarding Thailand's status during World War II, Thailand was required to provide the United Nations with 1.5 million tons of milled rice at a price considerably below world levels at that time. A Rice Bureau was set up and made the only legal exporter of rice. To avoid heavy treasury costs, domestic prices of rice were kept very low. By the end of 1949, the U.N. allocation of rice ended, but the system was maintained because a rise in domestic prices to world levels at that time would have reduced real incomes of urban consumers to politically intolerable levels (Silcock 1970, p. 217). The high world prices during the Korean conflict enabled the government to obtain considerable money by buying at the low domestic price and exporting at world price. However, a spurt in world production resulted in a buyer's market for rice from 1954 onwards and the Rice Bureau had difficulty in exporting. So private traders were allowed to export, but were required to pay a premium for the privilege. The rate of that premium was roughly set at the difference between world market price and Thai domestic price. At the beginning of 1955, the government

turned all of the rice trade back to the private sector. The "rice premium" was retained as the mechanism for keeping domestic price at the desired level below the world price. It is therefore essentially an export tax (Corden 1967).

The level of the rice premium was set by the government as a fixed amount per ton of milled rice loaded aboard ship, and the level varied for different grades of rice. The exporter procured his rice in the domestic market and made his own sales negotiations abroad. When the rice was loaded aboard ship and certified by customs inspectors, the exporter then paid the premium to the government. The level of the premium was supposedly flexible to take into account changes in world price levels. In practice, it rarely changed more than once or twice per year, and in fact, remained constant from May, 1963, to January, 1967. Also, only small changes in the level of the premium were made during the period 1956-1966. In 1967 the premium was changed from a specific rate to an ad valorem rate.

An example of the sluggishness of the premium is as follows. White rice 100% is considered as the top quality Thai rice. At the peak in world rice prices in October, 1967, it sold for US$250 per metric ton, F.O.B. Bangkok. The rice premium on white rice 100% at that time was US$82 per ton. During the week ending April 5, 1971, for the same grade, F.O.B. price was US$120 per ton, and the premium was US$38 per ton. Numerous statistical studies have shown that domestic wholesale prices usually are very nearly equal to F.O.B. prices less the rice premium and exporting costs (Chuchart and Tongpan 1965).

Another export tax on rice in addition to the premium is a 5.7 precent ad valorem tax which is collected on all agricultural exports.

The Thai Government also exports rice on a Government to Government (G-G) basis. The government negotiates the terms with the foreign government, and then calls for bids from the private sector to provide the agreed upon quantity and quality aboard ship. The difference between cost of procurement to the government and what it sells the rice for is also called "rice premium" and is paid to the treasury. Since 1963, the proportion of rice exported under G-G has fluctuated from 25 to 50 percent of total exports.

Over the years, the rice premium has been discussed, researched, and debated more than any other economic topic in Thailand. The proponents claim 7 benefits to Thailand. It:

1. Is a major source of government revenue.
2. Is the only effective method of taxing agriculture.
3. Promotes agricultural diversification by making the returns from other crops more attractive relative to rice.
4. Maintains domestic food price stability.
5. Aids low income groups by keeping prices of rice low.
6. Promotes industrialization by keeping cost of living and thereby labor costs low.
7. Provides bargaining power in exporting.

To review the literature on the premium, or even to summarize the pros and cons would reqire a paper in itself. Therefore the reader is referred to Ingram for a detailed analysis and discussion of each

(Ingram 1971, pp. 243-261). However the slump in world rice prices and consequent drop in domestic paddy prices resulted in the government removing the rice premium on all grades except 100% and 5% white, parboiled and cargo on April 21, 1971. Although the premium on parboiled was later removed, it still remains on white rice 100%, which represented one-quarter of 1970 rice exports. This would appear to be a disincentive for quality rice, particularly to millers. Exporters however argue that it will not be, and that their price competition comes with lower grades, not 100%.

RICE RESEARCH IN THAILAND

The first rice research station was established in Thailand in 1916 at Rangsit, about 30 kilometers northeast of Bangkok. Head selections and variety yield trials were started, with emphasis on grain quality and yield. This work, plus normal selections by farmers, resulted in a large number of traditional varieties, each best suited to the specific conditions of a local area. The stress on quality is illustrated by Thailand's winning the first honor and ten other prizes for high quality long grain rice at the World Grain and Seed Exhibition in Regina, Canada in 1933 (Dasananda 1968).

Rice breeding work began on an intensive scale in 1950. Initial work involved the identification of superior types from the existing material collected from farmer fields. Concentration was on pure line selection, based on the identification of high yielding, high quality, long grain types adapted to local conditions. A big boost to rice research occurred in 1954 with the establishment of a separate Rice

Department within the Ministry of Agriculture. Hybridization breeding and mutation breeding were both initiated in 1954. Research in soil fertility, plant protection, and mechanization were also started or intensified during this period. Work on blast disesse (Piricularia oryzae), bakanae disease (Gibberella fujikuroi), yellow-orange leaf virus (tungro), bacterial leaf blight (caused by Xanthomonas oryzae), and gall midge (Pachydiplosis oryzae) was also started. During this period, varietal selection was based, in addition to the quality criterion, on the ability of a variety to produce higher yield without the addition of fertilizer.

The decade of the 1960's turned out to be a significant period of change for rice in Asia and in Thailand. The International Rice Research Institue (IRRI) was established in 1960. Thailand entered into full fledged cooperation with IRRI. Thai rice breeding objectives and methods were re-evaluated, and new lines of work were started, taking advantage of the training, facilities, and germ plasm becoming available through IRRI. Hybridization efforts were revived, and a number of crosses were made, three of which turned out to be very important.

1. In 1964 a cross was made at IRRI between the Thai recommended glutinous variety, Gam Pai-15 and Taichung Native-1. (Jackson, et. al. 1969).
2. Also in 1964 at IRRI a cross was made between the Thai recommended floating variety, Leb Mue Nahng-111 and a dwarf experimental line originating from Peta/2 x Taichung Native-1 (IR95). This cross was designated IR442 (Yantasast, et.al. 1970a).

3. In April, 1966, a cross was made in Thailand between the Thai recommended non-glutinous variety, Leuang Tawng and IR8 (Jackson, et.al. 1969).

A new glutinous variety, RD2, was developed from the first cross listed above and was approved by the Variety Release Committee in December, 1969. At the same time, the Committee approved two new non-glutinous varieties, RD1 and RD3, that were developed from the third cross mentioned above. "Their release marks a new era in rice breeding (in Thailand) because they are the first hybrid varieties possessing the short, stiff straw and plant type, the main characteristics of IR8 variety" (Jackson, et.al. 1969, p. 33). Although experimental lines resulting from the second cross mentioned above are still under evaluation, results thus far indicate that "the ability to withstand deep water and occasional flooding can be incorporated into future stiff-strawed short height varieties much in the same manner that disease and insect resistance is being developed. The successful incorporation of this character could open up large areas prone to flooding which presently prevent the production of dwarf varieties" (Yantasast, et.al. 1970b).

The reader will recall that, after several years of testing, the famous rice variety, IR8, was released by IRRI in November, 1966, followed by IR5 in December, 1967. Thailand participated in the early testing of IR8, and extensively tested it in both the dry and wet seasons of 1967. (Sopanaratna 1968). Generally IR8 performed well under Thai conditions, exhibiting high yield, fertilizer responsiveness

and good plant type. However, its grain quality was so poor compared to Thai standards that merchants were reported to discount its price by 30 to 40 percent (Jackson et.al. 1969). IR8 has been available to farmers who asked for it, but it was not taken to the Variety Release Committee, primarily because of the quality factor.

This committee is composed of Thai Government officials and persons in the private rice trade, primarily millers and exporters. Although the committee uses several criteria, exhaustive quality tests appear to be the most important measure for approval. The situation in Thailand, a rice surplus and major exporting country, was quite different from that in some of the food deficit countries whose decisions to push IR8 led to one part of the green revolution. As mentioned previously, Thai consumers are very discriminating in their taste for rice. With per capita consumption already at high levels, it appears that increased incomes result in increased expenditures for the same quantity of a higher quality of rice. Due to normal weather and other factors, Thailand already had ample quantities of low grades of rice. In world trade, Thailand has a reputation for high quality long grain white rice, which usually commands a substantial price advantage over lower grades. A second reason was that, through the extensive cooperation with IRRI, the potential of IR8 and other materials as parent stock in the hybridization program was recognized, and progeny from the crosses using these materials with high grain quality Thai varieties were already in the testing stage.

One further high yielding variety should be mentioned. The variety, C4-63, developed by the University of the Philippines, was tested in Thailand at about the same time as the tests of IR8. Although C4-63 was resistant to Tungro, RD1 and RD3 were already in the testing stage, they produced somewhat better yields, and possessed superior grain quality. Therefore C4-63 was not submitted to the Variety Release Committee, but it has become moderately popular with farmers in limited areas with good water control.

DISSEMINATION OF NEW VARIETIES

The main research units of the Rice Department are the Breeding, Technical, and Engineering Divisions. Extension was an integral part of the Rice Department until 1968 when it was spun off into a separate department. The main units of the Breeding Division are the Breeding, Statistics, Seed Multiplication, and Regional Yield Trial Sections (Jackson n.d.). The Breeding Division is also responsible for maintenance and supervision of 21 rice experiment stations, which are located in all major rice growing areas of the Kingdom.

The Rice Department identifies four classes of seed: Breeders, Foundation, Stock and Multiplication seed (Pookamana and Jackson 1970). Each class of seed is limited to one generation. The Seed Multiplication Section is responsible for the production and maintenance of the Breeders and Foundation seed of all recommended varieties, promising experimental hybrids and old varieties which continue to be valuable for special areas of research. The network of rice experiment stations is used for this production. Extension workers assist farmer associations at the village level to promote multiplication of Stock and

Multiplication seed. This system of classification and the program to carry it out was first organized in 1954 and is still in operation.

The Regional Trial Section conducts yield trials tests in farmers' fields using the most advanced experimental lines. The section is also responsible for assisting the extension workers by preparing seed for yield trials and inspecting their yield trials at least once during the growing season.

Pathologists, entomologists, and agronomists in the Technical Division have extensive research programs underway in those subject matter areas. They also assist in the testing and evaluation of new experimental hybrids both in the laboratory and in the field. Thus weaknesses are rapidly identified and the information incorporated into the breeding program.

The Rice Department has also started other programs which directly and indirectly contribute to the spread of new varieties (Dasananda 1968). Pest control units, which were transferred to the new department of extension when it was formed in 1968, are maintained in major growing areas to monitor and assist farmers with insect and disease problems. Soil fertility experiments are conducted at the outlying rice experiment stations, and fertilizer trials are conducted in farmers' fields in at least 200 locations each year. In large scale demonstration plots, initiated in 1964, the Rice Department undertakes to assist selected villages for a three year period. Technical advice, fertilizer on credit, and in some cases chemicals, are provided for farmers who wish to participate. After three years, the farmers,

with the assistance of the local extension worker, are expected to continue on their own. A yield contest among farmers was initiated in 1963, with the winner receiving a special award from the King during the annual Plowing Ceremony. Since 1964, the winners have all achieved yields of 7 tons per hectare or more. A rice grain quality contest among farmers is also conducted annually.

The Engineering Division is also active in research and development of mechanization. Machines which they have developed include a special outboard motor for boats in shallow water, a water pump for shallow water and low lift, a rice soil puddling machine, and a small tractor. Centrifugal rice hullers, small threshing machines, and a harvestor are under development. Experiments on aerial seeding of clouds to control rainfall are also underway.

ADOPTION OF NEW HIGH YIELDING VARIETIES

With approval of the three new varieties in late 1969, the 1970 wet season (June to November) was the first opportunity for most farmers to adopt them. Only 25 tons of Foundation seed were available to the Extension Department in February, 1970, and another 30 tons in June (Rice Department 1970). Regular rice statistical data collection procedures do not permit identification of variety, so that only extimates by experienced observers are available. The best guess is that 100,000 hectares were planted to the new varieties, primarily RD1, in the 1970 wet season and 250,000 hectares in the 1971 wet season. These plantings are primarily in the western and northern parts of the Chao Phya delta, and in localized areas in the Chiang Mai valley in

the far north of Thailand. Those farmers who are able to grow RD1 successfully report approximately double the yields over conventional varieties. RD2 has not been superior to the old type varieties in the North and has not been adopted in that region. High prices for fertilizer, depressed prices for glutinous paddy since its introduction, and lack of a dependable water supply have limited adoption of RD2 in the Northeastern region.

Evaluation of the adoption thus far presents a mixed picture. The reader should keep in mind two crucial points. First, the new varieties were introduced at a time of the lowest rice prices and the highest fertilizer prices in Thailand since 1950 (Welsch 1971a, Welsch and Tongpan 1971b). As a major exporter, Thailand experienced directly the decline in world rice prices, and with an export tax (the rice premium) that further kept farm prices for paddy at about one-half of world levels, farmers just did not receive much for their rice. At the lowest point, in early April, 1971, farm prices for non-glutinous paddy went as low as US$35 per ton, and for glutinous paddy below US$25 per ton (farm price for corn at the same time was US$50 per ton). Paddy became a feed grain for some hog producers. On the other hand, cash price for ammonium sulfate in rural areas was US$0.10 per kilogram or about US$0.50 per kilogram of elemental nitrogen, which must be nearly the highest price for nitrogen in the rice growing world. Fertilizer--rice price ratios are very important in the adoption of the new varieties, and thus the Thai experience cannot be compared directly with food deficit countries in which

rice prices are kept above world levels and fertilizer is subsidized.

Second, the new varieties may occupy nearly 5 percent of the rice area in Thailand, but perhaps only 10 percent of the rice area has the degree of water control necessary for the short, stiff-strawed plant types.

CONCLUSIONS

It seems that the Thai experience with new high yielding varieties should be evaluated in the context of "The Evolutionary Nature of the New Rice Technology" (Barker 1971). As such, it would receive a high score. A solidly based national research program with multi-disciplinary teams working on a single commodity with a clear problem focus is hard at work (Welsch and Sprague 1970). An open flow of information and training with regional and international rice research is maintained. High yielding varieties are available that have the IR8 yielding potential but with the preferred Thai grain quality. A scientific breakthrough with dwarf varieties that can tolerate deep water or occasional deep flooding is imminent, and could have Asia-wide impact. However, there are several policy measures that need to be taken if Thai farmers are to gain the full potential of the rice technology that is now available and even newer technology that will be forthcoming from the research program.

The first has to do with input price policies. The present high fertilizer prices are a direct barrier to the gaining of the full benefits of the new varieties on areas to which they are suited. Second, rice can not be expected to carry all of the development burden in Thailand. If yields increase as rapidly and to the level

that they are capable of doing on land suited only to rice, then market realities will require some contraction of the area now in rice but which could produce something else(Welsch 1971c). Other farm enterprises will be needed to improve farm income in the areas coming out of rice, and an expanded research effort will be needed to develop such enterprises. Third, the level and the distribution of income, both regional and personal, are of increasing concern in Thailand. In some agro-climate zones, rice may be the development tool to solve these income problems. But high yielding rice varieties have their limitations, and policy makers should not be surprised if the new varieties have no impact on the poorest agro-climate zones. The problems in such areas are severe, and it will take a number of coordinated policies to solve them. Fourth, research is a long-run proposition. Although much has been accomplished in developing high yielding rice varieties specific to certain Thai situations, the task is not finished. RD1 and RD3 are not the final answer for Thai rice growers, but merely represent the prototype upon which improvements can be made. Continued strong support for rice research is required.

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