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Having Your Rice and Eating It too: A View of Thailand's Green Revolution

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ABSTRACT: The great achievement of the green revolution has helped to feed billions and lifted many out of poverty over the last half century. Thailand is one of the countries in Asia that have benefited, but the country's green revolution is a little different. This paper describes some unique features of growth in Thailand's rice production system. Productivity gains have been wrought from deployment of modern rice technology, but in combination with home grown knowledge and innovations. Improvement in Thailand's rice farming has emphasized quality, along with somewhat moderate yield gains. Utilization of the country's genetically rich local rice germplasm has helped to meet the need of those not reached by modern varieties, because of some biotic or abiotic stresses or social and economic constraints. Heroes of this particular revolution include the country's rice farmers, those involved in rice processing and trade in the private sector, and the public sector's rice scientists. The emerging problem of weedy rice is also discussed.

KEYWORDS: Biodiversity, Green revolution, Jasmine Rice, Parboiled Rice, Weedy Rice.

GREEN REVOLUTION WITH A DIFFERENCE

Central to the technology contributing to rice yield growth throughout Asia in the last 50 years is the modern plant type that enables the rice crop to best utilize optimal conditions provided by increased inputs of irrigation, fertilizer and pest control. However, Thailand's adoption of this modern rice technology has been somewhat less complete than in other major rice growing countries. A survey at the end of 1990's found modern rice varieties planted on only 18% of the rice land in Thailand, although modern varieties could have been planted in all irrigated area that cover about 25% of the country's rice land. Three closely related varieties with traditional plant type, KDML 105 and its sisters by mutation, RD 6 and RD 15, together took up 54%. The 28% balance was planted with local varieties

Modern rice varieties have, however, contributed to Thailand's rice production in a major way through the development of *Na Prang* (off-season or dry season rice) and year round rice cultivation. This has been made possible by their insensitivity to day length, another key innovative characteristic of modern rice, which has made possible double to triple cropping of rice on the same land in one year, instead of the traditional once a year wet season crop. Thus, combined with major public investment to provide irrigation in dry season, modern rice varieties are now grown on some 1.5 m. ha of *Na Prang* each year, adding about 6 million tons of rough rice to the country's annual harvest, from virtually nil up to the early 1970's.

QUALITY AS WELL AS QUANTITY

Even in the early years of 1920's, Thailand was already exporting more than one million tons of milled rice each year[1]. Since then the country's rice farmers have not only been able to feed a population, which has more than quadrupled, but also increased the rice export volume several times (Figure 1). The export growth, however, did not take off until after the green revolution was under way. Coinciding, and most likely significantly contributing to these developments, was liberation of the rice trade from government control and removal of the rice export tax. An interesting

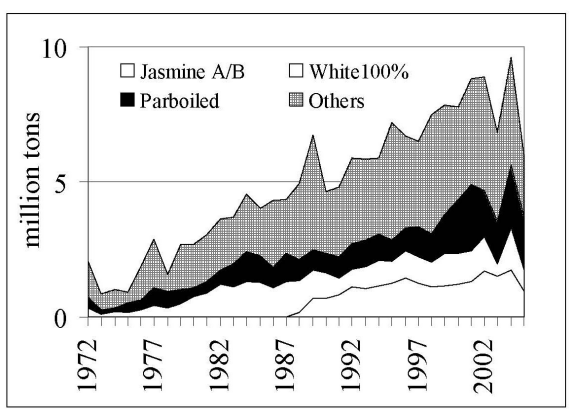

Fig 1. Thailand's rice export, by volume of different types of milled rice. (White 100% and Parboiled were sold at about two thirds the price of Jasmine; Others include all rice sold at half or less than half Jasmine price). (Data from www.riceexporters.or.th).

feature of this export growth is the growth in volume of rice with better quality that is sold for 50% more to twice as much as lower grade rice. The main types of these are the aromatic jasmine and parboiled rice.

Since 1988, when statistics for jasmine rice export began to be kept separately, export volume of aromatic rice from Thailand has been growing by more than 100,000 tons per year (Figure 2). Highest quality Thai Jasmine rice is produced from special traditional Thai varieties, KDML105 and RD15, which are sensitive to photoperiod, so they can only be grown once a year and have lower yield potential than modern semi-dwarf varieties. The aroma level, which determines the premium price, is highly dependent on the environment, and tends to be inversely correlated with yield. Jasmine rice is generally produced with moderate to minimum inputs. With everything else being equal, the price that farmers get for rice produced from KDML105 with the aroma can be twice as much as that without.

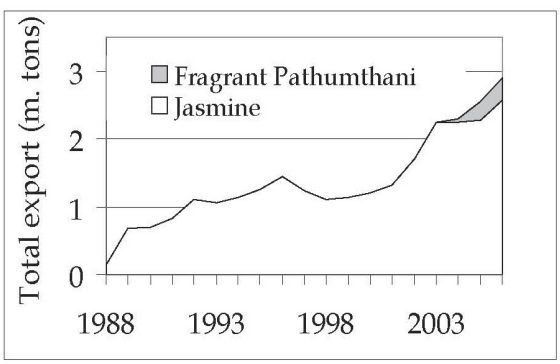

Fig 2. Thailand's aromatic rice export growth averages at about 100,000 tons per year. Fragrant Pathumthani which is also marketed as aromatic rice fetches 20-30% lower prices than Thai Jasmine.Source: (Data from www.riceexporters.or.th).

Jasmine type rice is now also produced from aromatic modern rice varieties (semi-dwarf, photoperiod insensitive). Pathumthani 1 (PTT1), released in 2000, now makes substantial contribution to production and export, while two earlier releases (1997) of modern jasmine, Hom Supanburi and Hom Klong Luang 1, have remained largely unrecognized. The rice grown from PTT1 is traded as Thai Pathumthani Fragrant (TPF), and contributed more than 300,000 tons (11%) to the jasmine rice export in 2006. Although priced at 70-80% of the premium Thai Jasmine in the export price listing, TPF has an advantage in being insensitive to photoperiod, so it can be grown at any time of the year including dry season.

Compared with the famous Thai jasmine rice, parboiled rice (*Kao Nueng*, produced from ordinary, non-glutinous rice; which is quite distinct from glutinous or sticky rice also called *Kao Nueng* in the northern Thai dialect) is almost unknown in Thailand, except amongst those involved with its production and export. Yet, parboiled rice currently accounts for almost 40% of Thailand's total rice export volume, while top quality jasmine rice accounts for 23% and top grade white rice only 15%. Between 1973 and 1988, when the green revolution rice was spreading in the Central Plain, export volume of parboiled rice was doubling every three years. From 1989 parboiled rice export has still been growing by a healthy 13% per year, compared with 6% for jasmine and 2% for ordinary white rice and a contraction of about half a percent per year for lower grades rice (Figure 1).

This development of parboiled rice has brought benefits to both farmers and mill operators, as well as contributing to the national export earning. For farmers in irrigated area, where rice is grown all year round, wet harvest is the norm. Milling such rice into ordinary white rice normally produces very low yield of whole grain (known in the trade as % head rice yield), which is translated as very poor quality. Traditionally parboiling, i.e. steaming of wet paddy and then drying it before milling, is to prevent the grain from sprouting and spoiling. Parboiling also fuses together starch in the grain and so helps to prevent milling breakage to quite a significant degree. Farmers are able to sell rice with moisture content of 20% or higher, instead of the standard requirement of 14%, to parboiling mills without being penalized for poor quality. On the other hand, the 1.5 million ha of off-season rice crop which produces more than 6 million tons of paddy rice per year has enabled the parboiled rice mills to keep operating all year round. Success of the parboiled rice business is evident in the number and capacity of the parboiled rice mills that have sprung up around irrigated, year-round rice production areas in the Central Plain and Lower North. Many of these mills are equipped with highly sophisticated processing facility, complete with modern optical sorting machines that flick out discolored and blackened grain.

In countries where rice growing has a shorter history, e.g. Australia and the USA, the application of science and modern technology can contribute much to the production of high quality rice. After several decades of centrally controlled prices that did not distinguish between good and bad quality rice, China has greatly improved its rice quality through investment in research and in drying and milling facility, that accompanied price differentiation brought about by the freeing up of the rice market. China now exports rice to countries with strong emphasis on quality like Japan and South Korea. In Thailand, some gains have been achieved by simple management changes. In the old days, overripe rice crop had to wait until labour was available for

cutting, gathering and threshing, so rice quality often suffered as the grain became brittle and broke upon milling This problem has now been solved by timely harvest brought about by mechanization. Other aspects of Thai rice quality are, however, more complex. Grain quality is one of the main breeding objectives of the Thai Rice Department, and its predecessor Thai Rice Research Institute. But it is still not possible to breed for quality with any degree of precision. Many elements of rice quality, from the aroma in jasmine rice to resistance to milling breakage, are also strongly influenced by the environment and farmer's management.

Most fortunately, although without design or anyone actually controlling it, a system of rice quality control seems to have been in existence for a long time in this country. Some of the characteristics that determine rice quality today were described as common knowledge in the early 1900's[1]. From the farm gate to milled rice in retail outlets to current FOB Bangkok prices posted on the webpage of the Thai Rice Exporters Association, different grades of rice are clearly distinguished by their prices. The main characteristics of the rice grain that are determinants of rice price include grain shape and size, translucency, absence of chalkiness (opaque region), pericarp glossiness, aroma, and above all potential to resist milling breakage. Except for aroma, which is determined by smell (requiring jasmine rice buyers to have the nose for it, like those working with perfume and wine), a simple routine for evaluating rice quality is to de-husk (normally under a roller) a small sample of paddy that reveals these characteristics all at once (Figure 3a).

Where rice is grown primarily for home use, local taste dictates acceptability of a variety, or its rejection, which has happened to some of Thailand's first green revolution rice varieties (e.g. RD 2, RD 4). On the other hand, farmers are given a strong message not to plant a certain variety or seed source again next season, when local buyers reject their rice harvest on evidence of the grain crumbling under the roller into small piles of rice flour. This decentralized quality control system has been effectively screening for rice varieties on the basis of their grain quality. Thus, some modern rice varieties from the national breeding program have been accepted, while others that might be even higher yielding have been rejected. The same standard has been applied to local varieties. Many of these have been recognized for high quality rice varieties for specific uses, including for processing into parboiled rice (see below).

Putting All the Rice in Different Baskets

Thailand's rice export market is highly diverse, and export destinations include almost all countries in all continents. Of the top 12 importers of Thai rice (Nigeria, Senegal, South Africa, China, Iran, Iraq, Indonesia, Benin, Côte d'Ivoire, Malaysia, the USA and Hong Kong, in that order, based on 2001 to 2006 average import volumes) which together take two thirds of the total annual export, each accounts for a share of only 4-8%. Virtually all of the parboiled rice produced is exported, mainly to the Middle East and Africa. Even though China has been so successful with its own green revolution that the country now exports some 2 million

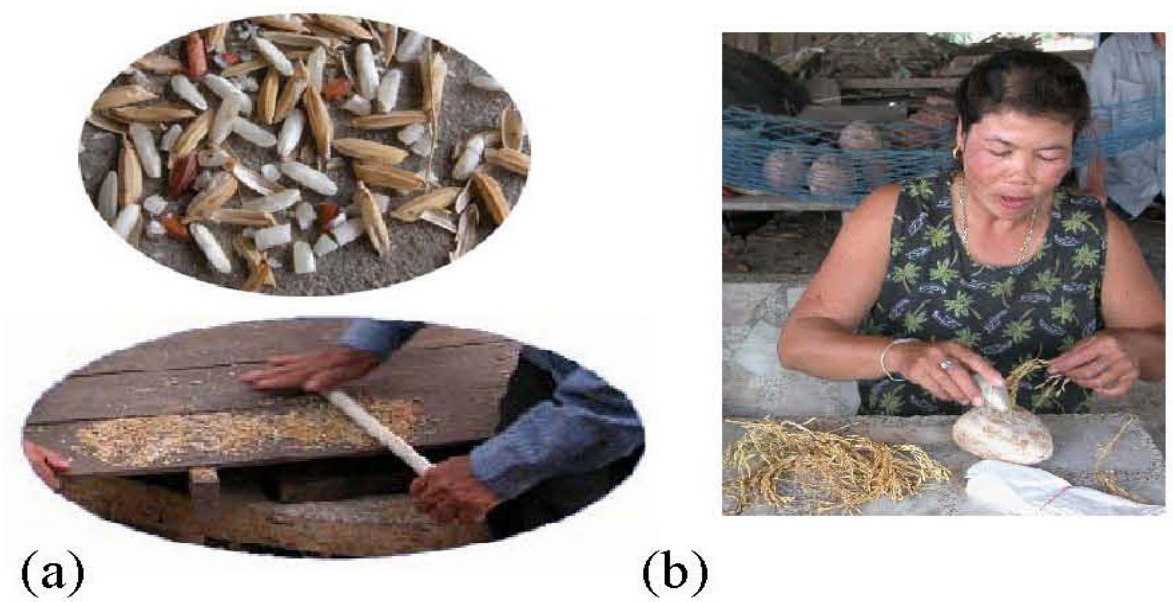

Fig 3. Evaluation of rice quality by (a) paddy crushing, and (b) examination of representative grains in each panicle for seed selection.

tons of rice a year, China's import of Thai rice has been growing rapidly. The USA is another major rice exporting country that also imports substantial volumes of rice from Thailand.

This apparent anomaly of rice import by rice exporting countries is explained by the fact that there is more than just one kind of rice, both in terms of how and where it is grown as well as in market preferences. Asian rice is recognized by taxonomists as one species, *Oryza sativa* (there is also the entirely different African rice, *O. glaberrima*). *Oryza sativa indica* (commonly called indica rice) and *O. sativa japonica* (japonica rice) are, however, two subspecies that are genetically and historically distinct. Molecular evidence now points to japonica rice having been domesticated from the northern population of wild rice, *Oryza rufipogon* and indica from the southern population (south of the Himalayas and the 22½°N) of the wild ancestral species[2]. Although there are minor exceptions and their genes are beginning to be somewhat co-mingled by modern rice breeding, japonica rice is grown mainly in the temperate region and indica in the tropics.

Rice eaters and thus markets are also divided into those who prefer indica and those who prefer japonica. Traditional indica eaters are in South and Southeast Asia and southern China, while traditional japonica eaters are in Korea and Japan. Traditional European rice consumers also prefer japonica which is more suitable to the European method of cooking like the Arborio rice, the special rice for making Italian Risotto, Spanish Paella, Greek Dolmades and other Mediterranean dishes. However, new markets and opportunities have emerged from recent changes. Along with major yield increases, the quality of japonica rice has been greatly improved so that China has captured a significant portion of import market in Japan and South Korea. Japonica rice has even replaced wheat as the staple food for many in China's northern cities. Even the best quality japonica rice, however, does not meet the growing demand for high quality indica rice from China's rich, southern and coastal provinces. China's import of high quality indica rice has been increasing, almost all of it from Thailand.

Diverse Niches Require Genetically Diverse Rice

On good soil, well endowed with good water control and irrigation, free from devastating pests and diseases, modern rice varieties will always out yield local varieties. However, only one quarter of Thailand's rice land is irrigated. Vast areas of the Chao Phrya Plain above Bangkok, the country's major rice area, are on acid sulphate soils, with extreme acidity and deficiency of many essential nutrients. Some of this and other areas are prone to flooding that can be up to six meter deep. Those who live on rice in the northern mountains face another set of problems. In many of these situations, rice production is so marginal that people are unable to make a living from rice farming, but this is not always the case. Even now, genetically diverse local rice varieties can be found that sufficiently meet the needs of rice farmer in some of these difficult places. Apart from certain specific constraints, for which technical solutions are still somewhat elusive, variability in the stresses themselves sometimes makes it difficult for a centralized rice breeding program to reach such environments with single genotypes. Two examples illustrate this.

Deep water rice on acid sulphate soils used to be one of Thailand's least productive rice farming systems, with very low yield of poor quality, feed grade rice. The flood regimes vary in any combination of water depth, duration and the rate of flood rise and fall. The national breeding program has released a couple of improved varieties of deep water rice, but they are adapted to water depth of about one meter only. Local varieties adapted to different flood regimes have, however, been produced from the long and continuing history of seed selection by farmers. Painstaking selection for quality (in each seed selection cycle many farmers go through tens of thousand panicles, to select for quality of the endosperm by tapping a few grains at the tip of each panicle to break off the husk, Figure 3b) has resulted in some varieties with the best quality. Together with soil fertility improvement by judicious application of marl and fertilizer and combined harvesting that greatly reduces damages and losses, the area now produces yield of 2-4 t/ha (from barely half a ton per ha about 30 years ago) of rice judged to be of superior in quality by parboiled rice mills and market sectors that prefer rice with high amylose contents. In addition to local varieties that are recognized by name for their adaptation to specific flood regimes, variation has also been found in seed lots recognized by the same name that are maintained by different farmers and within seed lots with uniform outward appearance. In the big flood of 2006, some accessions of popular deep water rice *Lueng Yai* and *Khao Banna* died when the flood water exceeded their normal depths, while some survived and some had plants that died and plants that survived.

Another example of diversity in the agro-ecological niche that is filled by genetically diverse rice may be found in small foothill valleys in the north, that are highly variable in microclimate, while sharing a common problem of a devastating insect pest called gall midge. Even in the absence of the gall midge, standard lowland varieties like RD 6 or Sanpatong 1 can be so poorly adapted in some of these valleys that they yield only half of their potential. With the gall midge, whose

larvae eat the rice growing point, robbing it of opportunity to produce any grain, rice production in such areas would have been impossible without resistance, which has yet to be satisfactorily incorporated into modern varieties. Fortunately, for as long as the oldest farmers can recall, gall midge resistance is commonly recognized in these areas in a 'variety' of glutinous rice named *Moey Nawng*. Although generally recognized by the common features of bold grain with straw colour husk, the one name covers an enormous range of genetic diversity[3]. When planted together at the same location, accessions may differ in flowering time by more than one month, as well as in degree of gall midge infestation and grain yield. The different accessions also react differently to gall midge from different locations. Microsatellite analysis confirmed this, and also revealed that most of the molecular variation is found within seed lots maintained by individual farmers.

The structure of genetic diversity, described in molecular markers as well as in agronomically useful traits, found in *Moey Nawng* has also been found in all of Thailand's local rice varieties so far studied that include upland rice, highland paddy varieties, as well as in deep water rice discussed above. This is good news for *in situ* conservation of local rice germplasm, as genetic diversity is already being maintained by farmers. The challenge is how benefits from modern rice science might reach these farmers while conserving the genetic diversity of the local rice germplasm.

Emerging Threat of Weedy Rice

Along with its not so insignificant achievement, Thailand's rice farming is now facing one of the most critical and immediate threats in the emergence of weedy rice[4]. The weedy rice, hybrids between cultivated and common wild rice (*O. rufipogon*), has always existed in rice fields especially where natural populations of the wild rice are present nearby. Its rise as a noxious weed in the rice field in the last 6-7 years, causing severe losses in yield and grain quality, has resulted from several changes in management of the rice crop that have been advantageous to the weedy rice. These include direct seeding instead of transplanting, combined instead of hand harvesting, year-round rice cropping that accelerates the build up of weedy rice seed bank in the soil, chemical weed control that kills off all other weeds but not the crop rice nor weedy rice, and so on. From the first recorded observation in the Central Plain in 2001, it has spread to other irrigated rice areas, and has now reached the rainfed rice area, including the premier jasmine rice area in the Northeast. The total area infested, estimated at over 300,000 ha in 2006, is expected to keep growing unless it is brought under control. While a suite of integrated control measures has been put together and continues to be improved and added to[5], weedy rice is one of those complex problems that require concerted efforts of many. The problem is unlikely to be solved with less than a national program that effectively integrates all aspects of control together, from stringent control of weedy rice contamination in the rice seed sold to farmers, to close cooperation with farmers, communities and extension personnel and others who are involved with control and spread in the field, to operators of combined harvesters who can spread the weedy rice seed from field to field and across the country.

In conclusion, judging from its continuing growth in rice surplus and export, Thailand's rice farmers have not done so badly although they have not embraced the mainstream green revolution quite so completely as their counterparts in many other rice growing countries. Having the world's lowest rice yield, instead of being a source of embarrassment imagined by some Thais, actually means that there is plenty of room for growth. Numerous efforts have been directed towards realization of this potential. For example, investment and efforts to develop hybrid rice technology by the private sector is expected to raise yield in irrigated areas by 10-15%. Noted future challenges are (a) how to make benefits from modern rice science reach more of the country's rice farmers without destroying genetic diversity of the local rice germplasm, and (b) the immediate need to control the weedy rice on the national scale.

Further Reading

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