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Rice that Filipinos Grow and Eat

John C. de Leon

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES
Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas

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Abstract

This paper introduces rice to the reader and analyzes the changes it has gone through the past 100 years in the hands of varietal improvement science. Here, the richness of the crop as a genetic material and resource is revealed. Over time, its many types included landrace rice, pureline-selection rice, cross-bred rice, semidwarf rice, hybrid rice, new-plant-type rice, and designer rice—choices ranging from the traditional to the modern and the futuristic. There is rice for lowland, upland, and cool-elevated areas; for irrigated and rainfed areas; and for saline-prone, drought-prone, and flood-prone areas—each kind serving as a wonderful display of biodiversity. Rice for dry or wet season farming and rice for double-cropping per year also exists. Of course, there must be rice for daily consumption and rice for important occasions. There is nonsticky rice or the glutinous opposite; well milled or brown rice; red rice; aromatic rice; rice rich in micronutrients; golden rice; the generic fancy or specialty rice; and even rice with healing wonders or medicinal properties.

Through purposeful research and development, rice ably provides for various needs. And although already very much transformed, rice remains culture friendly, like the science that does not tire to improve it. Viewed in this sense, rice continues to be very precious and indispensable to Filipinos.

1 Introduction

The history of dryland rice culture in the Philippines, as in the case of rice in mainland Southeast Asia, is believed to be older than the wetland system of cultivation. Rice was originally grown under upland conditions as a component of shifting and subsistence farming. Not long after, lowland rice culture began to spread along coastal areas and riverbanks.

Archaeological evidence unearthed in 1978 at the Andarayan site in Solana, Cagayan Valley, suggested a dryland rice strain in use in the province as early as 3400 ± 125 years before present (B.P.) (Snow et al. 1986). A previous determination of the recovered rice husk and stem fragments indicated a sample age of 3240 ± 160 B.P. These extremely concordant dates are equivalent to the periods 1522 B.C. to 1077 B.C., suggesting the presence of rice in the Philippines as early as the second millennium B.C. Other records similarly indicated that rice arrived in the Philippines sometime after 1500 B.C. (e.g., Teubner et al. 1997). The initial construction of the famous rice terraces in the Cordillera region is also believed to have taken place some 2,000 to 3,000 years ago.

The cultivated rice species in Asia and the Philippines (Figure 1), called *Oryza sativa* Linn., is an annual grass that natural and human selection transformed to become an important food crop of the world. A wild perennial rice called *O. rufipogon* and a wild annual rice known as *O. nivara* were the successive progenitors following evolutionary time. Cytogenetic evidence on the close affinity between these ancestors and the annual cultivated forms of rice is well established (Chang 1975; Watanabe 1997). Another cultivated species of rice grown in some parts of West Africa is called *O. glaberrima* Steud. Recently, promising upland selections from numerous crosses between *O. sativa* and *O. glaberrima* varieties have been reported. This breakthrough was achieved through a multi-institutional research undertaking called New Rice for Africa (NERICA). The project aimed to combine the hardiness of the local African rice species with the

Figure 1. Rice plants grown in a breeding nursery (a); farmer's field transplanted to rice (b); demo field ready to be harvested (c) (photos by J.C. de Leon)

high productivity of the Asian species.[1] There are 20 other species of rice that remain undomesticated or wild.

There is a great diversity of form within the cultivated species of rice in Asia. Each form followed a different evolution and dissemination process. An extensive dispersal of this species occurred in places with tropical, subtropical, and temperate climates. The process ultimately produced the so-called ecogeographic races of *O. sativa*—referred to as Indica, Japonica, and Javanica. Varieties grown by our farmers mostly belong to the Indica classification, although some farmers purposely cultivate a few Japonica varieties from Japan or Korea for the high-end consumer market.

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[1] Tokyo International Conference on African Development (TICAD). http://www.ticad.net/nerica.html.

Javanica or "bulu" rice is still being grown in the mountain provinces of northern Philippines.

At present, more than 100,000 accessions of cultivated and wild species of rice from at least 100 countries are conserved in the Genetic Resources Center (GRC) of the International Rice Research Institute (IRRI). The GRC serves as the main "bank" for all the known rice seeds of the world, including all the genes that these different collections carry; hence, the "genebank" terminology. Old varieties that have been out of circulation for a long time are kept in the GRC. The Philippine Rice Research Institute (PhilRice) maintains a duplicate collection of Philippine traditional rice varieties in its genebank facility in the Science City of Muñoz in Nueva Ecija.

A melting pot of many fabulous varieties

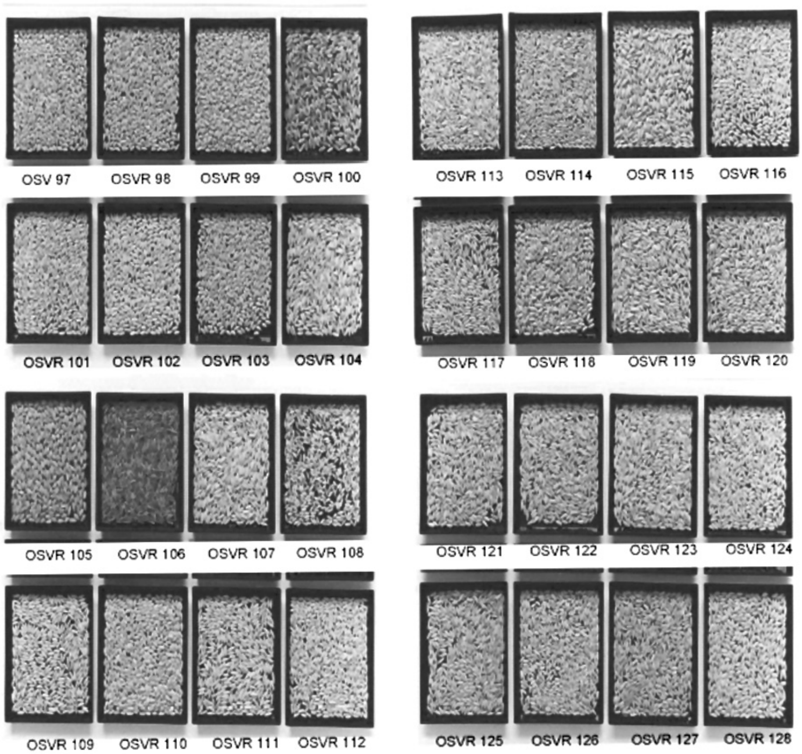
Despite the numerous cultivars spawned by homeland climate and preferences, the Philippines is also a melting pot of many rice varieties from abroad. Alien variety documentation, especially of the more adapted and fabulous ones, can be gleaned from the pages of scientific and popular literatures. The University of the Philippines (UP)-College of Agriculture (established in 1909) and the Bureau of Plant Industry (BPI, created in1930) contributed immensely in perpetuating these seeds and knowledge. Among the successful cosmopolitan varieties were Ramai from Cantho, Vietnam, introduced into the Philippines in 1919; Kra Suey from Thailand and Malagkit Sungsong, a glutinous or sticky variety from China, both introduced in the 1920s; Peta from Indonesia, introduced in 1930; Seraup Kechil 36 and Seraup Besar 15, both from Malaysia and introduced in 1936; and Fortuna from the USA, introduced into the country after the Second World War (Masajo et al. 2004).

Of the endemic traditional varieties, on the other hand, the more popular names include Elon-elon that was already being grown in 1914; Apostol and Milagrosa in 1915; Wagwag in 1936; Buenavista or Kasungsong in 1939; and some products of cross-breeding developed from the late 1930s such as Raminad Strain 3, selected from the progenies of Ramai and Inadhica cross or Ramai x Inadhica; Ramelon from Raminad x Elon-elon; Buenketan from Buenavista x Ketan Koetoek; Milketan from Milagrosa x Ketan Koetoek; and Milfor from the Milketan x Fortuna cross. A few retail and grocery stores today in the cities of Muñoz and San Jose in Nueva Ecija still sell Milagrosa- and Wagwag-labeled rice regularly.

After the war, the BPI and UP-College of Agriculture led the effort to retrieve many prewar varieties left physically mixed in the field. Panicles of the aforementioned varieties and those from Azucena, Dinalaga, Guinangang, Khao Bai Sri, Macan I, Macan Bino, Macan Tago, Macan Sta. Rosa, Mangarez, and Thailand were secured and carefully sorted in the laboratory. Foundation seeds of the following varieties were also produced: Agoyor, Binirhen, Calwis, Canoni (Red), Carreon, Carti 42, Caydaog, Criollo la Fria, Dinitaan, Dorado Agulha, Gumuyod, Inabaca, Jaguari, Kaawa, Kinanda, Kinandang Pula, Kinandang Nagpulot, Kinawayan, Lady Wright, Lubang Puti, Lubang Pula, Luteang, Magsanaya, Macapilay Pusa, Mangarez, Moratuto, Nagdami, Nira B, Palawan, Pilit Kalabao, Pinulot, Portoc, Remelletes, Rexoro, Salog, Salumpikit, Suacong, Tapukoy, and Twalibon for the uplands; Cotsiam, Guinata, and Sinaba for the elevated areas; Baiang, Ballatinao, BE-3, Bengawan, Brondal Putih, Bulao, Bulastog, Concejala, Inumay, Intan, Khew Khao, Macaraniag, Macan Compol, Macaneneng, Malaman, Mas Java, Milfor 6, Nagadhan, Salak, Skrjmankote, Tjahaja, and Tjere Mas for transplanted lowland (Octubre 1956).

Traditional rice varieties gave low but dependable yields under minimal input and management practice. Many were tolerant to variations in water level and competed reasonably well with weeds. Some varieties were fairly resistant to insect and disease attacks, while others possessed excellent cooking and eating qualities besides being aromatic. Among the traditional varieties, Apostol, Azucena, Binirhen, Delhlinla, Elon-elon, Fortuna, Kasungsong, Macan I, Macaraniag, Magsanaya, Makapilay Pusa, Milagrosa, Milbuen, Milfor, Milketan, Palawan, Raminad Strain 3, Seraup Besar 15, and Wagwag (Figure 2) were reported to have very good to excellent table qualities.

Figure 2. Seeds of some prewar varieties of rice in the Philippines



Seeds shown include those of Wagwag (Official Standard Varieties of Rice [OSVR] 113-115), Fortuna (OSVR 116-120), and Peta (OSVR 121-128), among others. Obtained originally from IRRI through a Material Transfer Agreement. (Photo by R. Baclit and J.C. de Leon)

2 Current Varieties

The formal system of rice varietal release in the country is preceded by rigid selections done by the Rice Technical Working Group (RTWG) of the Philippine Seed Board (PSB) through the National Cooperative Testing (NCT) program. The PSB was later renamed National Seed Industry Council (NSIC). In the NCT program, test entries nominated by different public breeding institutions and private seed companies are evaluated over several combinations of test locations and seasons for yielding ability and general agronomic performance. All test entries are compared to so-called check or standard varieties identified by the NCT. The same entries are also evaluated for resistance to major insect pests and diseases, physical and physicochemical properties of the grain, milling potential, preference and acceptability by trained and consumer panels.

Entries with combined superiority for high yield and other traits and parameters examined relative to the standard varieties are recommended by the RTWG to a Technical Secretariat for review and submission to the NSIC. The NSIC convenes its members as a final screening committee that will deliberate and approve the commercial release of new varieties.

The history of the NCT can be traced to the cooperative undertaking initiated by the UP-College of Agriculture, BPI, and the Bureau of Agricultural Extension (BAEX, which was abolished in 1992) between 1952 and 1954 that eventually led to the establishment of the PSB in 1955 (Table 1). From 1955 to 1991, all new varieties for commercial release had to be approved by the PSB. The PSB was superseded by the NSIC under Republic Act (RA) 7308 (or the Seed Industry Development Act of 1992).

From 1992 up to 2004, the NSIC approved the release of 77 rice varieties for commercial production. Of this total, 42 varieties were intended for the irrigated lowlands, 15 for the rainfed lowlands, six for the uplands, eight for the saline-prone irrigated lowlands, and six for the cool-elevated areas. Among the varieties approved for the irrigated lowland ecosystem, seven were F_1 hybrid varieties.

Table 1. Rice varietal improvement timeline in the Philippines, 1901–2002

Time	Event / Milestone
1901	**Bureau of Agriculture (BA) created under the Bureau of Interior.**
1901	Beginning of rice improvement by selection among endemic varieties and by plant introduction.
1907	Central Luzon Agricultural School[a] created.
1909	**University of the Philippines (UP)-College of Agriculture created.**
1909	Rice improvement by head-to-row started to isolate productive strains from propagated varieties.
1916	BA transferred to the Department of Agriculture and Natural Resources.
1920	Rice improvement by artificial hybridization initiated.
1924	Baybay Agricultural School[b] created.
1928–31	Strains of Ramelon (from Ramai x Elon-elon hybrid) and Raminad (Ramai x Inadhica) developed.
1930	**Bureau of Plant Industry (BPI) created;** plant tissue culture demonstrated abroad.
1931	Maligaya Rice Experiment Station established.
1935	Plant Breeding Section in the BPI organized.
1938–39	Initial observations on hybrid vigor and recognition of the commercial potential F_1 rice reported.
1941–45	World War II years.
1952	**Bureau of Agricultural Extension (BAEX) created;** a rice institute for the Philippines proposed.
1952–54	Cooperative Rice and Corn Improvement Program established; for the first time, there was an interagency program for rice and corn improvement.[c]
1955	**Philippine Seed Board (PSB) created.[d]** Tissue culture of rice initiated in Japan.
1957	Start of development of BPI-76 by the BPI.
1959–60	Mutation breeding using X-ray radiation explored; first dwarf plant mutants obtained from Milfor 6(2).
1960	**International Rice Research Institute (IRRI) created.**
1962	Start of development of C4-63 by the UP-College of Agriculture
1966	IR8 released by IRRI.

[a] Now the Central Luzon State University (CLSU); [b] It became ViSCA, then Leyte State University and now Visayas State University; [c] A cooperative program jointly undertaken by the UP-College of Agriculture, BPI, and BAEX with the assistance of the International Cooperation Administration (ICA), the predecessor of USAID; selection and breeding of new varieties assumed by the UP-College of Agriculture and the BPI; program expanded later and involved several agricultural schools as cooperators for testing or seed propagation; [d] The PSB passes upon and approves recommendations for increase and distribution of improved varieties.

Table 1. continued

Time	Event / Milestone
1968	BPI-76, C4-63, IR8 released by the PSB.
1971	Disastrous crop year[e].
1972	**National Grains Authority[f] created.**
1973	Masagana 99 Program (M 99) launched.
1985	**Philippine Rice Research Institute (PhilRice) created.**
1979	Hybrid rice research initiated at IRRI.
1989	Hybrid rice research initiated at PhilRice.
1992	**National Seed Industry Council (NSIC) created and replaced the PSB.**
1994	First hybrid variety PSB Rc26H (Magat) released by the PSB; NPT prototype harvested at IRRI.
1995	First anther culture-derived variety, PSB Rc50 (IR51500-AC11-1), released by the PSB.
1997	PSB Rc72H or Mestizo hybrid rice variety released by the PSB.
2001	PhilRice leads the National Hybrid Rice Commercialization Program.
2002	NSIC 114H (Mestizo 2) and NSIC 116H (Mestizo 3) hybrid rice varieties released by the NSIC.

[e] Cropping years 1971–73 "plagued by typhoons, floods, tungro, and drought"; [f] Reconstituted to National Food Authority (NFA) in 1981.

Most popular varieties to farmers

In 2002, the Rice Program of the Department of Agriculture conducted a survey to verify the top five varieties planted by farmers in 79 provinces of the country.[2] An analysis made on the dataset generated indicated that some 34 varieties of rice constituted the top five choices of Filipino farmers. Interestingly, these varieties represented a mix of old and new official cultivar releases by the NSIC. IR42, the oldest of the varieties, was approved for commercial cultivation by the PSB in 1977. The other varieties were released in 1983, 1984, 1985, 1988, 1991, 1992, 1994, 1995, 1997, 1998, 2000, 2001, and 2002.

Based on this survey, PSB Rc82, PSB Rc18, PSB Rc80, PSB Rc78, PSB Rc28, IR64, PSB Rc74, PSB Rc64, PSB Rc14, and IR60 were the

[2] Data from this survey were obtained from Dr. Frisco M. Malabanan, the DA Rice Program director.

top 10 most frequently grown varieties by farmers (Table 2). PSB Rc82 and PSB Rc18 are among the check varieties for grain yield and general performance in the NCT. On the other hand, IR64 has remained the standard variety for grain and eating quality since 1985. IR64 replaced the well-known variety C4-63G from the UP-College of Agriculture, which was released in 1968.

Using the 34 varieties in Table 2 as reference and plugging in the information on variety release year, it was possible to analyze farmers' propensity to try out new seeds or varieties. This probing showed a variety replacement rate of 3.1 years across the 15 regions surveyed with a range of 1.7 to 5.3 years. In some regions or constituent provinces, therefore, the farmers' variety replacement rate can be as fast as the rate of releasing new varieties, estimated in this case to be every 1.8 years sans IR42. In other words, farmers' reaction to new seed technologies can vary from immediate adoption to one that gives ample time for observation (may be related to the wait-and-see attitude) and variety diffusion.

Breeder and foundation seed production and distribution records at the PhilRice-Central Experiment Station (PhilRice-CES) at Maligaya, Muñoz, Nueva Ecija until the third quarter of 2004 showed that seed growers and farmers' demand for PSB Rc82, PSB Rc18, PSB Rc28, IR64, PSB Rc14, IR60, and IR42 had not waned. However, other varieties released in 2002 and 2003 such as NSIC Rc110, NSIC Rc112, and NSIC Rc122 had also started to attract attention. Seeds of these newer varieties, along with other cultivars, were requested by and distributed to members of the Rice Seed Production Network (SeedNet) in provinces of at least 10 different regions during the dry season of 2005. For NSIC Rc122 alone, more than 800 kilos of breeder seeds were disposed by PhilRice-CES between January and September of 2004.[3] This variety is more popularly known as Angelica.

PhilRice established the SeedNet in 1994 to facilitate the seed distribution of new varieties to more farmers in the country. In the wet season of 2004, the SeedNet had 70 members located as follows: 27 in Luzon, 21 in the Visayas, and 22 in Mindanao.

PhilRice was created in 1985 to be the national agency to undertake and coordinate rice research in the Philippines (Table 1). The former

[3] Data, which served as basis for this information, were obtained from Engr. Ricardo F. Orge, head of the Seed Production and Health Division of PhilRice.

Table 2. Rice varieties considered popular to farmers across provinces and regions of the country as of 2002

Variety	Popularity *	Rank	Variety	Popularity	Rank
PSB Rc82	14.8	1	PSB Rc98	1.0	18
PSB Rc18	14.5	2	PSB Rc84	0.8	19
PSB Rc80	12.7	3	PSB Rc104	0.8	20
PSB Rc78	8.8	4	IR62	0.5	21
PSB Rc28	8.0	5	PSB Rc10	0.5	22
IR64	6.2	6	PSB Rc30	0.5	23
PSB Rc74	4.7	7	PSB Rc46	0.5	24
PSB Rc64	3.4	8	PSB Rc100	0.5	25
PSB Rc14	3.1	9	PSB Rc4	0.3	26
IR60	2.6	10	PSB Rc36	0.3	27
PSB Rc66	2.6	11	PSB Rc44	0.3	28
IR74	2.3	12	PSB Rc56	0.3	29
PSB Rc54	2.3	13	PSB Rc58	0.3	30
PSB Rc34	1.8	14	PSB Rc90	0.3	31
PSB Rc52	1.8	15	PSB Rc94	0.3	32
PSB Rc72H	1.6	16	PSB Rc96	0.3	33
IR42	1.3	17	PSB Rc102	0.3	34

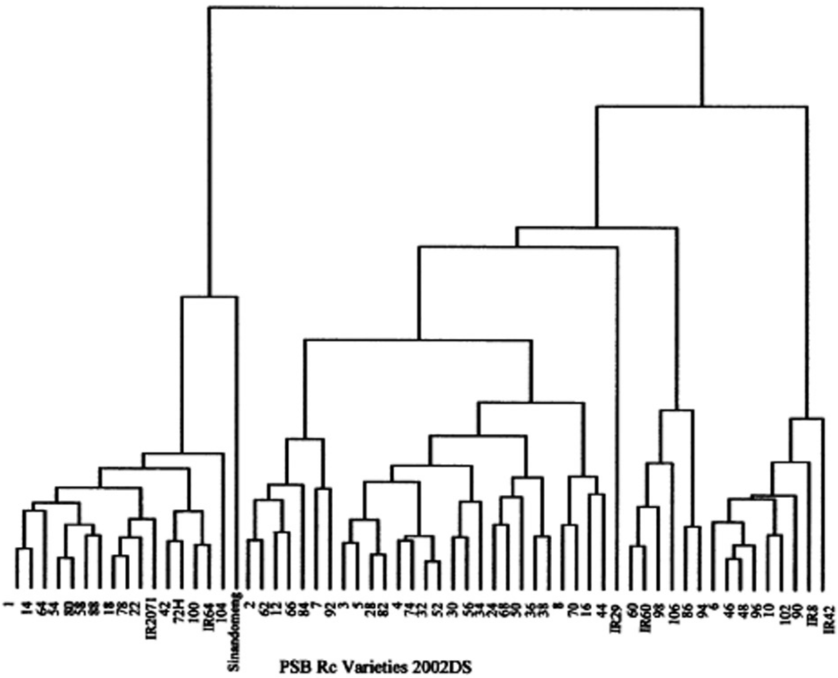
* Popularity (%) estimated from 386 cases obtained from the original survey data by the Rice Program of the Department of Agriculture.

Maligaya Rice Research and Training Center (MRRTC), the famous rice breeding station of the BPI, established originally as Maligaya Experiment Station in 1931 became the PhilRice-CES, which has been completely modernized and expanded since 1990.

IR64 and the myth of ramble varieties

The variety IR64 commands a premium price almost exclusively in the local rice trading scene. The study done by Roferos et al. (2004; also in Juliano et al. 2004) compared the grain quality of IR64 with the other commercial varieties known until 2002. They employed the method of cluster analysis to classify these varieties based on the head rice, physical attributes, and physicochemical characteristics of their grains. Physicochemical characteristics, which include moisture content, gelatinization temperature, gel consistency, amylose content, and crude protein, are known indicators of cooking quality and texture in rice.

Figure 3. The comparability of premium rice IR64 with the quality of other varieties based on physico-chemical characteristics (original data from Juliano et al. 2004)



The findings suggested that many varieties, including several of those that Filipino farmers prefer to grow, are similar to IR64 in grain quality. PSB Rc78, PSB Rc18, PSB Rc80, PSB Rc54, PSB Rc64, PSB Rc14, and PSB Rc72H or Mestizo 1 hybrid (Figure 3) are among the notable examples of varieties that rice traders and millers should also be buying from farmers at a premium price. In other words, traders have little basis to classify these other varieties as "ramble" or inferior to IR64 in terms of their translucency, milling properties, and texture of cooked rice (Juliano et al. 2004). Currently in Muñoz, farmers can sell their newly harvested palay at P11.00–P11.20 per kilogram. This is a welcome departure from previous prices that were lamented by farmers as below what they had hoped for. In relation to this, an interesting study on the rice marketing chain and how it affects farmers' profitability was made by Yorobe and his group in 2004.

3 Dramatic Changes: Postwar

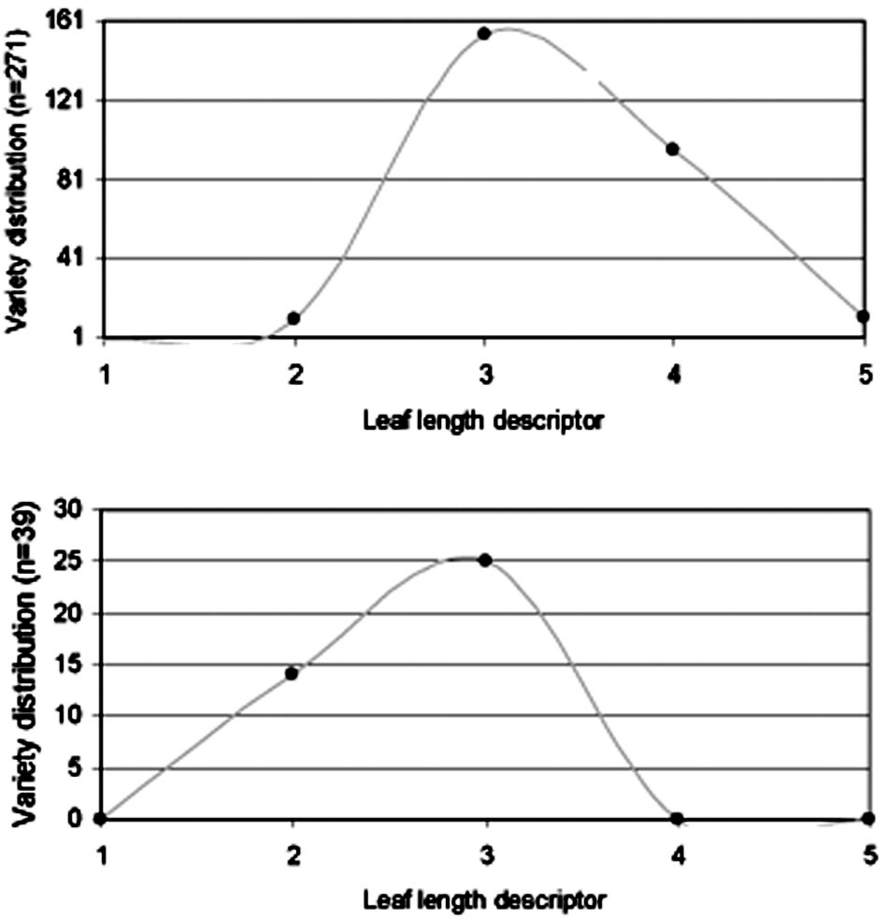
Of the plant characteristics where there had been rice varietal changes in the Philippines these past 100 years, the most dramatic were undoubtedly those on yielding ability, plant stature, maturity duration, and the weakening or elimination of photosensitivity. The utilitarian shift from tall rice varieties to semidwarf cultivars started in the country in the mid-1960s. Unlike the tall traditional varieties that were prone to lodging or toppling over, the shorter selections responded favorably in terms of harvestable yield formation to higher rates of nutrient applications (i.e., more than the usual prewar rate of 30 kilograms of nitrogen fertilizer per hectare). Consequently, these were recognized as the new high-yielding varieties (HYVs) of rice, the so-called modern varieties.

The same HYVs were also maturing early and no longer limited by sensitivity to photoperiod. Such improvements therefore permitted the growing of more than one crop of rice per year, especially in irrigable and drainable fields, and bestowed fuller control of planting time to the farmer-adopter. Modern varieties of rice particularly selected for the less favorable environments—e.g., those often stressed by salinity or brackish water intrusion, by drought due to insufficient amount of rainfall, or by low temperature spells—also started to spread in affected localities. HYVs and intensified cropping therefore boosted the gross productivity of rice cultivation in many parts of the country.

In relation to lodging, the bending moment and breaking strength of the culm and sheath are normally considered when determining a variety's resistance. Bending moment increases with increments in panicle and grain weights. The breaking strength of a tiller is related to the length of lower internodes, the thickness of the culms, the tightness of the leaf sheath, and the rate of senescence of older leaves. Interestingly, prewar studies on rice in the Philippines missed plant height as an important attribute that affected lodging (Masajo et al. 2004).

The pleiotrophic or associated effect of genes responsible for plant height on leaf length is known and the correlation is positive. Long and wide, drooping leaves in the plant canopy, typical of most traditional rice varieties (Figure 4), decrease the efficient interception of light due to mutual shading. Mutual shading at the reproductive and ripening growth stages of the rice plant can reduce the number of spikelets developed and filled. This phenomenon is somewhat similar to what happens to grains

Figure 4. Long, wide, drooping leaf trait of traditional varieties (a) was replaced by the short, narrow, and erect leaf characteristic of modern, semidwarf varieties (b). (Original data from J.C. de Leon)



in rice plants during the rainy or wet season cropping, when overcast clouds "shade" the crop from the incident solar energy, thereby lowering the crop's production of dry matter and grain yield.

From the establishment of the insular Bureau of Agriculture in 1901 until World War II broke out in 1941, Filipino farmers were able to choose from the following general types of rice varieties:

1) Traditional endemic;
2) Traditional introduced;
3) Strains selected from endemic varieties;
4) Strains selected from introduced varieties; and
5) Improved, uniform selections following hybridization.

Many prewar varieties were still released by the PSB for cultivation until the late 1950s. When it comes to rice hybridization for varietal improvement in the Philippines, the one done by Torres and Borja in 1920 at the Alabang Experiment Station (now defunct) was among the pioneering works on record (Torres 1923).

IR8 and the modern plant type era

The first semidwarf rice variety known to Filipino farmers was formally released by the PSB in 1968. The pedigree line IR8-288-3 was simply called IR8 following the designation given by the IRRI in 1966 to cross number IR8 made by its breeders in 1962. (Plant breeders at IRRI achieved another milestone in 2002 by completing and designating cross number IR80000.) The IR8 is a cross between the tall local variety Peta and the short-statured variety Dee-geo-woo-gen (DGWG), an early-maturing semidwarf Indica from Taiwan. Taiwanese farmers have known the variety DGWG since 1939.

Considering that plant breeding in practice is also propelled by artistic imagination, the creative stroke behind IR8 may be drawn from the thinking that IR8 is actually the tall Peta variety made smaller.[4] The IR8 is considered as the first high-yielding and semidwarf indica rice variety adapted to tropical climates. It "initiated the era of modern plant type for irrigated rice." Tests at IRRI showed this variety yielding 6 tons/hectare

[4] This idea came up in a discussion with Mr. Hilario C. dela Cruz, former rice breeder of the Maligaya Rice Research and Training Center and former head of the Plant Breeding Division of PhilRice.

in the wet season and up to 9 tons/hectare in the dry season. Its yield occasionally exceeded 10 tons/hectare during the dry season (Yoshida 1981).

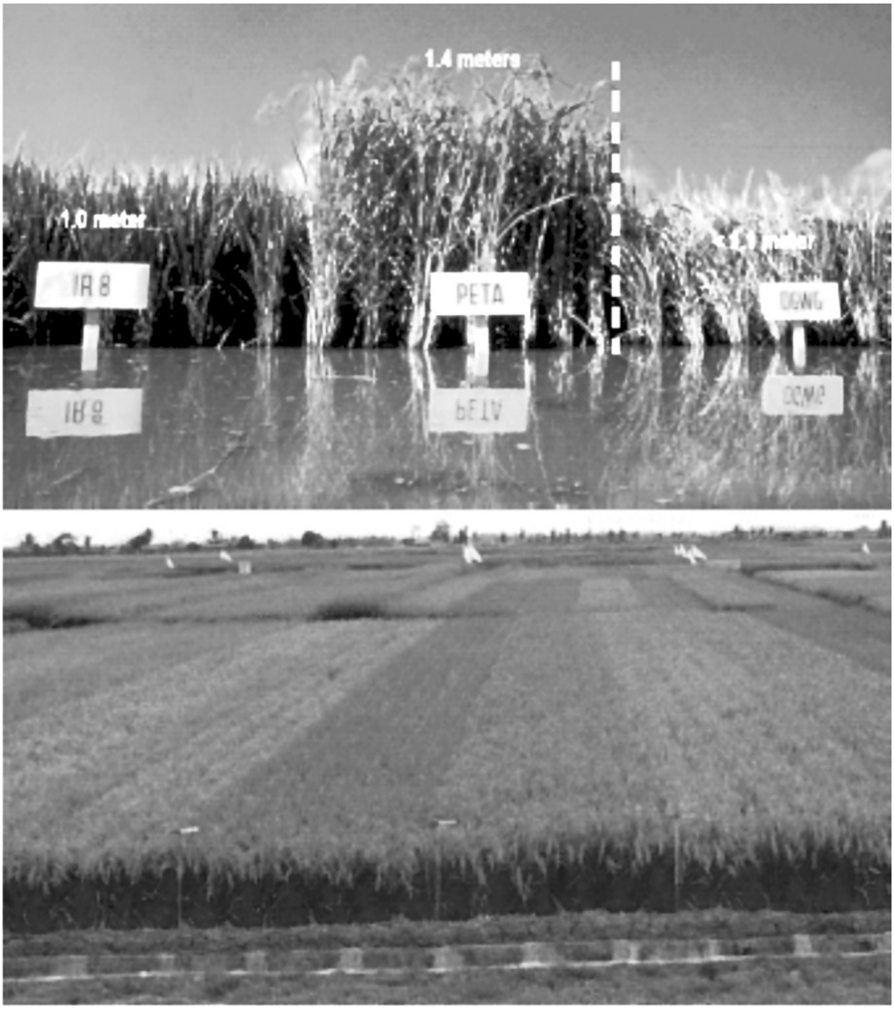
The IR8's novelty, positive reaction to fertilization, and ability to produce high economic yield without lodging made it attractive to plant breeders. Consequently, this variety and other selections derived from it were extensively used as parent materials in the breeding programs of the BPI, University of the Philippines Los Baños (UPLB), and PhilRice, in addition to IRRI. For example, a published study in 1995 shows that 92 percent of all the 67 official varieties released in the Philippines from 1960 to 1994 were directly related to IR8 as one of their parents, or to IR8 through the variety Peta (de Leon and Carpena 1995). This study reveals that varieties developed under different breeding programs in the country became related to each other because they share common donor parents—about 57 cultivar sources of important genes for successful adaptation, with acceptable agronomic performance and plant features. At the core of this ancestry are 19 landraces that provided the basic template—the "genetic design"—to breed these varieties.

Plateauing yield and some countermeasures

The yield potential of inbred cultivars that succeeded IR8 has not significantly departed from the IR8's 6 tons/hectare to 9 tons/hectare level (Figure 5). The high genotypic and morphological similarity of these varieties to the IR8 ancestry may be the fundamental cause of "plateauing yields." In this regard, the implementation of alternative strategies in breeding new rice varieties can be appreciated. They are important countermeasures to break what seemed like a "yield barrier" that developed in the last two decades. The alternative ideas currently include the exploitation of the heterosis phenomenon through hybrid rice breeding, and the development of a new plant type (NPT) of rice, which has been initiated by IRRI scientists.

The NPT will bolster the productive capacity of rice for direct seeding and rainfed culture through plants with very different architecture from the IR8 idiotype and the so-called "Green Revolution" varieties. Contrasted to existing HYVs, the NPT rice has fewer number of tillers, but all its tillers are productive or panicle bearing. In addition, the tillers are bigger and more robust. The NPT plants also produce bigger panicles that are more densely packed with grains (Figure 6). Experiments and simulation tests using the NPT model indicated a yield potential improvement of about 25 percent over the typical semidwarf varieties.

Figure 5. The breeding of IR8 and other high-yielding semidwarf varieties (lower photo) (photos from IRRI and J.C. de Leon)



Heterosis in rice has been locally reported as early as 1938 (Capinpin and Punyasingh 1938). The "fifth invention," as one noted writer perceives hybrid rice to be (and in the same league as the other great Chinese inventions such as the gunpowder, paper, printing, and compass), is indeed an idea whose time for productive use by Filipino farmers has finally come (Hilario 2005). In 1981, the success of the development and extension of

Figure 6. One of the early NPT prototypes with grain-dense panicles (photo from IRRI)

the Indica hybrid rice was considered one of the most important achievements in the science and technology of China.[5] Hybrid rice technology was developed in China in 1974, following the initiation of concerted research on hybrid rice in 1964.

Reports of more than 10 tons/hectare yields (about 200 cavans of threshed palay per hectare) from farmer cultivation of hybrid rice in the Philippines are now being repeatedly heard. In fact, one report from the field had one farmer in Barangay Tondod, San Jose City, Nueva Ecija, breaching the 300 cavans-per-hectare mark with the hybrid varieties he planted.[6] The highest hybrid rice yield recorded in the country so far stands at 258 cavans of dried weight palay from one hectare.

On the other hand, trials on NPT rice in China have also reportedly hit the 12 tons/hectare target. In the Philippines, however, no NPT variety has so far been released. Promising NPT prototypes were first harvested at IRRI in 1994.

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[5] In Yuan Longping, China National Hybrid Rice Research and Development Center, 1999, p. 17.
[6] Engr. Rogelio Malunay, the city agriculturist of San Jose, Nueva Ecija, shared this information to the author firsthand in a farmers' field day in April. Bayer Crop Science and the Department of Agriculture subsequently awarded on May 5, 2005 the 2005 Higanteng Ani Top Award to Mr. Fernando Gabuyo of Nueva Ecija "who harvested an impressive 17.047 metric tons of palay per hectare." The two other top awardees from San Jose City and Bula, Camarines Sur also produced yields of 15.499 metric tons/hectare and 15.184 metric tons/hectare of palay, respectively. (Source: *Philippines: record breaking yield using Arize™ Bigante hybrid rice.*)

4 A Thousand Years in the Making

The development of modern-day HYVs already spans more than a thousand years if one were to trace its roots. Current HYVs could be associated with the early-maturing varieties called *Champa* popular among Vietnamese and Chinese farmers even before 1,000 A.D. In East Asia, particularly in Japan, the selection of high-yielding, fertilizer-responsive varieties, although generally not of the semidwarf type yet, began in the 1800s with the introduction of fertilizers. The earliest known semidwarf rice was recorded in 1871 in Taiwan. It was called Woo-gen. In the Philippines, dwarf plants of rice resulting from mutation experiments were reported in 1959 and 1960. The breeding of day-length and temperature-insensitive Japonica rices also started in Taiwan in the early 1920s (Table 3). Rice as part of the Asian heritage becomes evident even in this aspect of rice's technocomplexity.[7]

The improvement in the yield performance from the early 1900s up to the present is around a fourfold increase in average productivity. Average yields increased from about 15 cavans/hectare in the early 1900s to 17 cavans/hectare in 1920; 22 cavans/hectare in 1940; 24 cavans/hectare in 1960; 41 cavans/hectare in 1980; and 59 cavans/hectare in 2000. The Food and Agriculture Organization (FAO) reported that the average yield of rice grown in the Philippines and in its neighboring countries until 1958 was only around 1.4 tons/hectare or about 28 cavans/hectare.

Such improvement in Philippine rice production can be attributed to the following developments:

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[7] The author wanted to add this dimension to the "legions of commonalities" and "varied items of technocomplexes of rice," alluded to by Dr. F.H. Hornedo as an Asian heritage in his Overview (p.8) for the ARF publication, *Rice in the seven arts*, edited by Dr. Paul B. Zafaralla.

Table 3. Historical development of modern-day high-yielding cultivated rice varieties

Period (A.D.)	Rice Variety or Type Known to Farmers and Plant Breeders*
1000s	• Early maturing
1800s	• Short stature • High tillering • High yielding • Fertilizer responsive
1900s	• Semidwarf • Early maturing • Disease resistant
1920s–1940s	• Day-length and temperature insensitive • Short culmed to medium height • Fertilizer responsive • High yielding • Early maturing
1950s	• Improved indica • Short stature, semidwarf, tall • Insect resistant • High tillering • Responsive to high N-fertilizer • Varieties from indica x japonica crosses • Early to medium maturing

* By context, farmers and/or plant breeders in Vietnam, China, Japan, Italy, Philippines, and India.

1) Opening of new rice lands;
2) Cultivation of varieties with higher grain yields;
3) Use of high-yielding and early-maturing varieties that promote growing of two rice crops per year; and
4) Expansion of rice areas with reliable irrigation and drainage.

The dramatic increments in yield after the 1960s have been attributed to the increase in area planted with semidwarf varieties or HYVs.

In 1970, the area harvested for rice in the Philippines was 3.1 million hectares. About 1.5 million hectares of this was planted with modern varieties. The national output from rice cultivation that year reached 5.32 million metric tons. In 2003, the rice area harvested, modern variety coverage, and aggregate production reached 4.06 million hectares, 3.7 million hectares (91%), and 14.2 million tons, respectively. Comparing with the 1970 data, the total harvestable area for rice, area planted with modern varieties, and overall production had increased by 30.9 percent, 146.6 percent, and 166.9 percent, respectively.[8]

The shift in strategy from one which is land frontier-based to one which is technology-based (e.g., use of HYVs, irrigation, and fertilizer) became necessary when competition for human settlement spaces in land originally considered as agricultural intensified in the country. The closing out of the land frontier became apparent after 1960. Today, it is not only to human settlements that the cultivation of rice must give room to. Rice lands in the countryside are slowly being cemented or concretized. These are being allocated to a variety of commercial business establishments instead, which increase the pressure on the rice's research and development (R&D) sector to produce more rice from a shrinking rice land.

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[8] *Rice statistics manual* (1970–2002). PhilRice- Bureau of Agricultural Statistics.

5 Intensive Land Use Strategy

Unlike the experience in the Philippines, other countries at the onset pursued intensive land use to induce growth in the production of rice and other crops. The wide adoption of early-maturing rice varieties promoted multiple cropping in the same piece of land, which was consistent with the overall policy on cultivating arable lands intensively. In the country, a reference to locally grown varieties that reached maturity in only three months dates back to 1893.[9] Late-maturing varieties face the danger of yield loss when the seasonal rainfall ceases as early as September or October. Rice is traditionally a wet season crop in the Philippines. It is normally grown in June and typically harvested in late November or December, when rainwater in the fields start to recede. Short-duration varieties increase the chance of escaping such drought problem, especially in rain-dependent ecosystems.

In the past, however, farmers tended to believe that early-maturing varieties do not produce as much yield as the late-maturing ones. Umali and Tepora showed in 1955 that early-maturing rice types could outyield late-maturing ones. Early varieties were those that matured in 100–150 days after sowing based on the 1914 classification by Crisostomo (1914). Nowadays, early maturity implies growth duration of up to 115 days from sowing date.

Modern HYVs of rice are attractive because many possess early maturity and nonsensitivity to photoperiod properties. Improvement made on the latter trait prevents the occurrence of yield penalties on the crop due to untimely planting. If flowering occurs before the sensitive variety has

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[9] This old reference was cited in Uichanco, L.B. 1952. A history of rice and corn improvement in the Philippines. *The Philippine Agriculturist* 36:283–289.

accumulated adequate carbohydrates, then grain yield may be reduced. Conversely, if flowering is delayed due to early planting, then the sensitive crop will be exposed to biotic (insect pests and diseases) and abiotic (drought, typhoons, and floods) hazards in the field, thereby destabilizing its expected yield.

6 Rice Grain and Eating Quality

The presence of rice defines the significance of a meal in the Philippines. This is the psychology behind Filipinos' resilience to produce rice sufficiently every year. Rice as food correlates the taste, cooking, and material culture of the various ethnic groups in the country (Fernandez 2002). As one historian vividly pointed out, rice is the balancer of taste in the Filipino meal. It is a bland background for the main dish (Veneracion 2001).[10] For table rice, Filipinos prefer the type that is long grain, translucent, white, well milled, high in head rice, aromatic, and soft on cooking (Juliano et al. 2004). Rice for normal consumption is simply boiled until it is cooked dry and fluffy. Fried rice is often resorted to and is equally satisfying, especially if prepared from rice that does not harden upon cooling, storage, and reheating.

Studies on the physicochemical properties of Philippine rice varieties as well as the sensory properties of their raw and cooked forms suggest that breeding for milled rice quality should target intermediate amylose content (AC) of 20 percent to 25 percent, and intermediate gelatinization temperature (GT) of 70°C to 74°C. The AC refers to the linear fraction composition of starch, in contrast to the branched fraction called amylopectin. The AC of nonwaxy rice ranges from a low of 5 percent to 12 percent, to a high of 25 percent to 33 percent based on a dry milled sample and measured by iodine colorimetry. On the other hand, GT is the temperature at which more than 90 percent of the starch in the grain has irreversibly swollen in hot water. This temperature ranges from 55°C to 80°C. The increase in hardness of cooked rice during storage has been attributed to

[10] In Veneracion, Jaime B. 2001. *Philippine agriculture during the Spanish regime*. Diliman, Quezon City: University of the Philippines.

amylopectin staling. Regardless of AC, lower GT-cooked rice showed less staling (and therefore more suitable for fried rice preparation) than the intermediate and high GT-cooked rice.

Traditional rice varieties such as Peta and Wagwag have been analyzed with high AC and intermediate GT. This quality of high AC-intermediate GT combination produces rice that is soft upon cooking. On the other hand, IR8 and other early semidwarf rices were analyzed with high AC but low GT. This high AC-low GT combination results in a hard cooked rice.

Most rice in the market now belongs to the intermediate AC classification to satisfy the dominant consumer preference for soft-textured cooked rice. Rice that is "more filling" (high AC) is still available, however, in many retail stores and supermarkets. For waxy or glutinous rice (1–2% AC), pure opaque grains with low GT are the preferred grain characteristics because of the tendency of cooked high-GT waxy rice to harden fast. Glutinous or sticky rice of either the white or the brownish varieties are used in preparing native rice cakes and sweets. Incidentally, the allele genealogy of the waxy gene controlling the glutinous endosperm appearance indicated a probable Southeast Asian origin (Olsen and Purugganan 2002).

In terms of the quality of glutinous rice, Malagkit Sungsong remains as the standard variety for comparison. Malagkit Sungsong or its improved plant version is still being grown today. Among the numerous HYVs made available to farmers, IR29, UPL Ri-1, BPI Ri-1, BPI Ri-3, IR65, NSIC Rc13 (Malagkit 1), NSIC Rc15 (Malagkit 2), and NSIC Rc17 (Malagkit 3) had been released as glutinous varieties until 2004. The three new NSIC varieties were found superior to the check variety IR65, which was released in 1985.

7 Scented Varieties and their Export Potential

Historically, rice was not an export crop of the Philippines, although reports that describe the prior abundance of rice in the islands and the export of its excess to China (c.1842) or of local varieties to Sevilla, Spain (c.1855) could be found (Veneracion 2001). Sugar cane, coconut, tobacco, and abaca became major export crops while "rice had to be imported in large quantities every year" (Constantino 1975). In contrast, India, Thailand, and Vietnam have developed export-winners from their rice, which they anchored essentially on the scent trait and its strong expression in the grain. The FAO forecast in 2003 showed that prices continued on a steady upward trend for the aromatic rice market.

Published accounts on Philippine aromatic varieties of rice are scanty. Aromatic or fragrant rice belong to the so-called specialty type rices that can be sold at more expensive prices in the market. Usually, the aroma of such varieties is better recognized when the grain is boiled. Guinata and Kinandang Pula have been reported to be scented or aromatic. Other traditional varieties described in passing to be aromatic are Azucena, Binicol, Milagrosa, Milfor 6, Mimis, and Sinampablo.

In cooking nonaromatic varieties, aroma is commonly introduced by steaming with a few leaves of the *pandan* (screw pine) plant, which also acts as a flavor enhancer. The presence of the major aroma compound 2-acetyl-1-pyrroline (AcPy) in 18 Philippine rice germplasm accessions[11] (Table 4) was confirmed in a study by de Leon et al. in 2005. Its laboratory analysis utilized the GC-MS technique.

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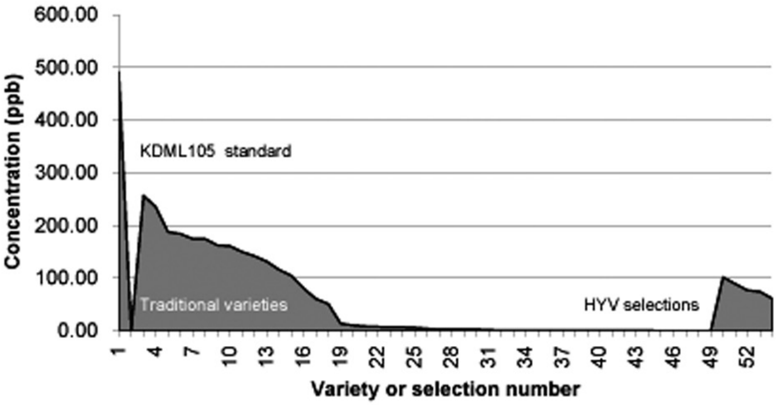
[11] Seeds of 355 traditional varieties noted down from an extensive review of literature were obtained from the Genetic Resource Center of IRRI through a Material Transfer Agreement under IRGC Request No. 20030901.

Table 4. Selected information on some traditional Philippine rice variety accessions identified to be aromatic (compiled by J.C. deLeon)

Variety Name	IRGC Acc. no.	Country Source	Period Cultivated	PSB Release Year	Culture	Yield (cav/ha)	Maturity (days)	Aroma, Table Quality Reports
Azucena	328	Philippines	c. 1922 / 1950	1955	Upland	59	127	Aromatic; VG TQ
Azucena	47124	Philippines						
Azucena	47125	Philippines						
Azucena	52861	Philippines						
Binicol	4021	Philippines	c. 1914 / 1921		Upland	39	141	Aromatic
Binirhen	4022	Philippines	c. pre-war		Upland			VG-E TQ
Elon elon	5193	Philippines	c. 1914	1955	Upland/palagad	44	138	VG TQ
Mimis	52937	Philippines	c. 1915 / 1922					Aromatic
Mimis	97905	Philippines						
Magsanaya	725	Philippines	c. 1893 / 1921	1955	Upland	44	123	VG TQ
Magsanaya	4019	Philippines						
Milagrosa	5159	Philippines	c. 1915		Lowland	55	142	Aromatic; E TQ
Milbuen	4029	Philippines	c. post-1939		All			E TQ
Milfor 6	4026	Philippines	c. post-1939	1955	All	48	136	Aromatic; VG-E TQ
Milfor 6-2	52	Philippines	c. post-1939	1962				VG-E TQ
Palawan	4020	Philippines	c. 1922	1955	Upland/palagad	46	129	VG TQ
Palawan	53047	Philippines						
Quezon Rice	47453	Philippines	c. 1939	1955	Lowland	65	194	E TQ

Notes:
G, VG, E TQ refer to descriptions of good, very good, or excellent table quality in reports. Seven of the 12 variety names listed in the table became Philippine Seed Board (PSB) varieties. Milagrosa was one of the official standard varieties of rice until 1954.
1 cavan = 44 kilograms.
Varieties that mature up to 150 days were still considered as early maturing in the past.

Figure 7. Aroma compound AcPy concentration in brown rice of some Philippine traditional rice varieties and HYV selections (original data from de Leon et al. 2005)



The aroma compound concentration in these traditional varieties (Figure 7) exceeded the AcPy concentration in the aroma standard variety Burdagol by up to 150 percent. Compared to the renowned KDML105 (Jasmine) rice of Thailand, however, the 18 accessions analyzed had lower AcPy concentrations, less than 50 percent of the Thai variety aroma in general (de Leon et al. 2005). IR841 is another improved rice selection recognized locally for its aroma.

AcPy is the primary odorant in popcorn and has also been associated with the potent pandan smell (Buttery and Ling 1982; Buttery et al. 1983; Schieberle 1991). Several methods have been developed to quantitatively analyze the AcPy formation during cooking and to discriminate the potency of this flavor/odor compound in different varieties. Using a combination of techniques, it has been shown that the concentration of AcPy is higher in brown rice than in milled rice. Moreover, the concentration of AcPy appears to be higher still in the husk or hull and shoot (Yoshihashi et al. 2003).

In addition to aromatic rice, waxy varieties and the red and black varieties or colored rice (which have more protein, crude fiber, lysine, vitamin B1, and other minerals) also belong to the so-called specialty rice. Specific varieties used for rice wine and wild rice such as *Zizania aquatica* are considered as specialty rices as well—clearly distinguished by a substantial price difference in the rice market.

At present, the aggregate area under aromatic rice cultivation in the country is uncertain. Extensive information on the status of R&D on specialty rices around the world was compiled by the FAO in 2001 (Tran and Chaudhary 2001), but none mentioned the Philippines' case. However, if one were to focus on the country's exportable rice, one may realize that excess rice from HYV cultivation is not the country's only hope. Aromatic rices exist among the modern inbreds, hybrids, and traditional varieties of the Philippines. Some only require valuation for market competitiveness. In this regard, a comprehensive rice program should be able to assess the potential of this genetic resource and to formulate a strategic plan for its integration to mainstream research, production, and commercialization.

8 Micronutrient-dense Rice

Protein content and micronutrients left in the grain after it is milled mainly determine the nutritional value of rice. The heritability of protein content in rice varieties is generally low, and environmental factors significantly affect this character. The considerable genetic variation for iron (Fe) and zinc (Zn) content in brown rice samples suggests that conventional plant breeding approaches could be used to boost these micronutrients (empirical results show doubling) in the rice grain.

Increasing further the Fe content of rice through conventional breeding appears to be more feasible compared to the experience with vitamin A. This is due to the naturally existing high-Fe rice and aromatic line IR68144-3B-2-2-3 selected by plant breeders at IRRI from the cross of IR72 x Zawa Bonday. The brown rice grain of IR68144 has a reported iron concentration of about 21 mg/kg. This line can certainly be useful to the food-based improvement of human nutrition, especially in high-risk communities or countries. One of the clues that led to its discovery was when aromatic varieties such as Jalmagna, Zuchem, and Xua Bue Nuo were found to consistently exhibit higher grain Fe concentrations than nonaromatic materials (Gregorio 2001).

Existing information suggests that rice does not contain any vitamin A, C, or D. In the endosperm of rice, for example, the precursor of vitamin A (retinol) called ß-carotene is not naturally present. This inherent limitation in the nutritional value of rice was the basis for a seven-year genetic engineering research that introduced the prototype of a ß-carotene-producing Japonica rice to the world in 1999. This was dubbed the "golden rice" (Figure 8). The potential of the prototype golden rice as donor for pro-vitamin A biosynthesis in the rice plant system paves the way for future breakthroughs. The usual cross breeding approach followed by rigid selection can now be utilized to transfer this important trait to popular commercial rice varieties. Historically, developing countries solved the vitamin A deficiency problem through periodic dosing, education on food selection, and food fortification (Murphy 1995).

Figure 8. Golden rice, T309, was genetically engineered to promote beta-carotene presence in the grain. Similar work has been done on the popular variety IR64. (photo from IRRI 2003)

9 Medicine Called Rice

Philippine flora is medically enriching. At least 1,500 of the 13,000 plus plant species are medicinal plants. A little over 800 of these have already been described in a book. However, only around 120 have been validated for safety and efficacy, while only five species have found business applications.[12] These are the untapped potentials of genetic resources. One may not believe it, but the very crop or grain each person so casually eats has also been cited for its healing properties.

Though slow to be proven scientifically, rice is believed to have medicinal properties. Consider the rice bran-derived B vitamin called tiki-tiki. It is purported to prevent or cure beri-beri. A more sophisticated product called stabilized rice bran has been found to have promising uses against diabetes, arthritis, peripheral neuropathy, high cholesterol, liver abnormalities, and cardiovascular diseases (Kamen n.d.). Many of these chronic conditions are assumed to have their indirect origins from oxidative damage.

Rice bran is better known as a milling fraction in the rice polishing process. In the health and medical research realms, on the other hand, rice bran enjoys close association with rather unfamiliar but healthy-sounding words such as antioxidant, phytonutrients, nutraceuticals, and food supplements. Inositol hexaphosphate or phytate (IP6), the major form of phosphorylated inositol, which is a water-soluble alcohol often grouped with vitamins present in food, is another rice-based product currently gaining attention in biomedical researches for its preventive actions

[12] In Highlights of the Seminar-Workshop on the "State of the art of medicinal plant research and business plant research and business opportunities." UP Los Baños. 2003. http://www.pchrd.dost.gov.ph/.

against such diseases as kidney stone formation, cholesterol deposition, and even cancer. It occurs at 9.5 percent to 14.5 percent by weight of the rice bran (Jariwalla 2004).

In one place in India, over 50 rice varieties are reportedly known for their medicinal properties. Particular varieties are given to women after delivery to bring back their strength within a short time. A different variety is recommended for lactating mothers. There is even a variety mixed with other seeds and best given to a cow after parturition or calving (Menon 2003; Oudhia 2003; Ulpotha Heritage Rice 2004). At the recent International Rice Congress, Balachandran et al. (2006) emphasized that even the system of Ayurvedic medicine practiced over thousands of years in Kerala had established the multiple medicinal property of a variety called Navara. In the Philippines, the variety Annanaya is believed to have extra-energizing effects on the body, while the variety Minaangan is considered useful in alleviating ulcer problems and dizziness.[13] Therefore, rice varieties' medicinal properties are one area worth exploring and directing R&D activities to, if necessary.

[13] This information was sourced from T.F. Padolina of the Plant Breeding Division of PhilRice in 2004 through her personal communications with Dr. M. Cadatal and F. Buyayo.

10 Future Challenges

At least 90 percent of all rice production and consumption in the world continues to take place in Asia. In the future, breeding new varieties of rice shall continue to be the focus of many generations of breeders and researchers from countries in this part of the world, including the Philippines. This endeavor will challenge the technical skills and creative faculties of those involved. Variety development activities will only end once rice breeders and farmers who retire are not subsequently replaced. It will also cease in the Philippines if rice's importance in the Filipino meal drastically changes or simply diminishes.

The challenges related to yield remain manifold, considering the following: Between 1901 and 1970, rice was sufficiently produced in the Philippines only in 1953 and 1968. Here, one can find another "tragic contradiction."[14] In the very year the Bureau of Agriculture was created, the Philippines imported some 170,648 metric tons of rice worth P10.217 million. As per record, the total volume of rice hauled annually into the country up to 1923 reached 3,753,049 metric tons with a combined value of P280.761 million (Wester 1924; Torres 1956). Over the next 20 years (i.e., 1971–1990), the import-export scene was comprised of 13 years of milled rice importation as compared to seven years of limited rice exportation, which was realized from 1978 through 1984 and again in 1987. The volume of rice exported during these surplus years ranged from 10,000 to 236,000 metric tons (PhilRice 1992).

On the other hand, there were disastrous cropping years that took their toll on production. For example, the years 1971, 1972, and 1973 saw the fields besieged by typhoons, floods, drought, and tungro disease. Quite

[14] The author shares the opinion of F. Sionil Jose in this sense, in *Rice in the seven arts*.

understandably, this period had been described as “a century of very low productivity levels and of recurring shortages, importations, and annual crises”(Castillo 1983).

The challenge, therefore, is to repeatedly realize the yield potentials of existing varieties in as many farmers’ fields as possible. Varieties can be the modern inbred HYVs or the F_1 hybrids, which are starting to increase in number. While these varieties may not attain their yield potential in the less productive provinces or regions due to factors such as the inherent limitation of the soil, it is still reasonable to expect an improvement over prevailing yields if one were to widely adopt the most appropriate HYVs, including those conducive for rainfed, upland, and adverse environments. Ultimately, the increased productivity in the customarily low-yielding localities will help hike the baseline yield and average rice yield of the country.

Another challenge is the ability to sustain the current yield potential under reduced water conditions in many farms. Water availability in the irrigated fields is getting more difficult even on a seasonal basis. Because the HYVs’ success is partly attributed to the expansion of areas with improved irrigation and drainage facilities, varieties that cannot perform well under upland-like management of irrigated lowland fields may be eliminated and the breeding of so-called aerobic rices expanded. Varieties with shorter growth durations also become more suitable when there is a looming water shortage in the cropping season. High-yielding and early-maturing varieties that continue to do well under direct seeding culture will be desirable since direct seeding can further reduce by several days the cropping duration of early-maturing varieties.

Because strategic R&D plays a key role in the challenge, it must be strengthened and invested in so that one could empirically show how much yield can be added to the current potential given the local cultivation conditions, the crop management practices of Filipino farmers, and the genetic resources available and accessible to breeders and researchers in the light of recent developments in intellectual property rights and plant variety protection. This challenge essentially constitutes the “Malthusian dilemma,” whose partial solution will rely on measures that could “curb and stabilize population growth” (Lantican 2005).

The recent popularity of practices such as the integrated crop management (ICM) system and the PalayCheck model (an adaptation of the Australian RiceCheck) highlights the many different ingredients that can make rice farming successful. In Europe, for example, varietal choice only appears in more than 50 percent of the observed ICM practices. Fertilization and plant protection are virtually more universal, appearing in 95 percent and 93 percent of the schemes, respectively. Farming measures related to soil management, tillage practices, and crop rotation appear in more than half of the examples while more than one-third refer to harvest, postharvest, and irrigation (de Leon 2004).

The sufficiency of the country's rice needs, therefore, is not entirely due to the seeds. But good seeds are essential to good crop production. And good rice production must be sustained because rice, the Filipinos' most important food item, can only be eaten if it is there.[15]

[15] Modified from "Food and the Filipino" by D.G. Fernandez, in Philippine world-view, p. 20-44, edited by V.G. Enriquez. 1986. Singapore: Institute of Southest Asian Studies.

11 Conclusion

Superior varieties of rice are important contributors to the productivity and sufficiency objectives. Together with area expansion, cultural management, and intensive cropping, these new varieties help achieve these goals. Such contribution of modern rice varieties to the growth of rice output in the country, particularly over the last 30 years, cannot be denied. However, the battle for rice sufficiency rages on, particularly with a changing landscape. Rice varietal improvement and R&D combined can help Filipinos cope with such change and enable them to pursue opportunities beyond high grain yield.

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