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Rice Production Practices

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

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Abstract

This paper presents the evolution of major practices in Philippine rice production over the last 100 years. These practices evolved out of the changes in the varieties introduced and planted by Filipino farmers, which subsequently altered the manner by which production and postharvest operations were done.

Varieties were introduced by rice scientists in three major periods: the pre-Green Revolution era, which was dominated mainly by traditional varieties planted once a year; the Green Revolution (1966–1988) period, which was characterized by the diffusion of modern high-yielding varieties that were planted for two seasons per year; and the post-Green Revolution (1989 to the present). As varieties changed over time, farmers' practices and technologies also changed so as to attain the maximum yield potential of the varieties and to realize the goals of higher productivity, greater efficiency, and recently, environmental sustainability.

1 Introduction

Rice production practices and technologies either directly increase yield or affect production costs. The use of modern high-yielding varieties (HYVs) and the management of nutrients, pest and diseases, and water are technologies that directly contribute to higher yield. On the other hand, farm mechanization and direct seeding do not directly affect production but significantly contribute to labor costs.

Rice production practices in the Philippines have been continually changing over time mainly due to new technologies and government programs that evolve to meet the dynamic challenges and needs of Filipinos. Most pressing among these needs are the growing population that has to be fed with the staple food and the clamor for cost-reduction measures to make rice farming profitable to most farmers.

Over time, tremendous strides have been made to improve the yield and reduce the cost of producing rice in the countryside. Rice was produced at 0.70 tons/hectare in 1909 and 3.08 tons/hectare by 2002—an improvement by almost 340 times! This success, although still lacking in terms of the means to realize full self-sufficiency in the country, has been attributed to the technological breakthroughs in rice science and practices of Filipino farmers.

2 Rice Production before the Green Revolution

Prior to World War II, rice farmers managed their rice production based on their past experiences and direct observations. Changes in total rice production over time involved changes in yield based on the location type (i.e., irrigated, rainfed, and upland areas), change of seasonal harvesting pattern, and variety planted. In 1909–1913, the average yield in the Philippines was only 0.704 tons/hectare while Japan was averaging 3.08 tons/hectare and Korea, 1.58 tons/hectare. New and superior rice varieties and the planting of better seeds led yield to increase to 1.06 tons/hectare and reached a high average of 1.25 tons/hectare in 1929. There was no growth in yield from 1955 to 1966 despite the increasing harvested areas (Figure 1). In 1968, the yield reached an average of 1.32 tons/hectare but

Figure 1. Harvested area and yield, 1903–1972

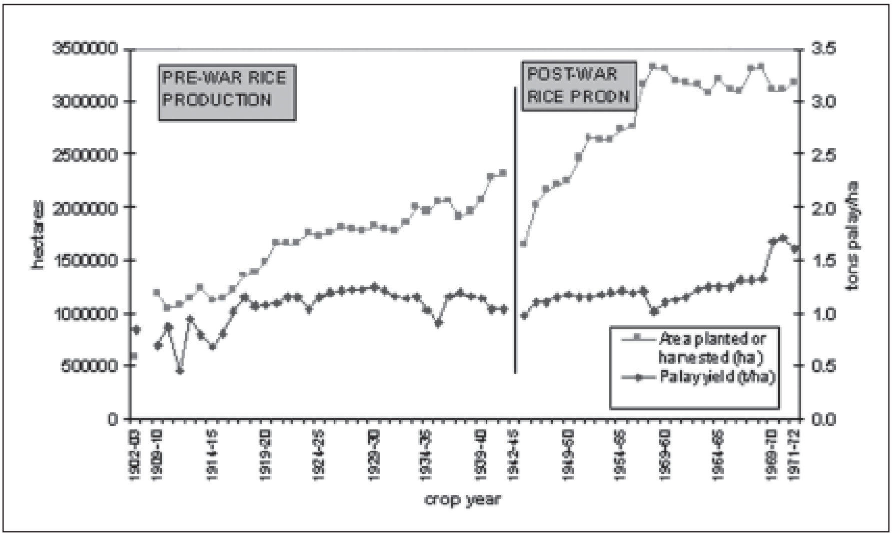
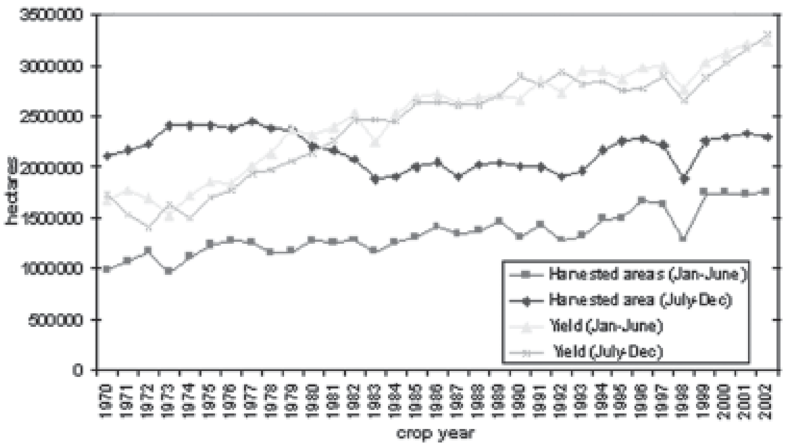


Figure 2. Harvested area and yield (1903–1972) in the Philippines across ecosystems



Sources:

1902–03	BAE, DANR, as reported by Ernesto C. Venegas and Vernon W. Ruttan, An analysis or production in the Philippines. *Eco. Rese. J.* XI No. 3 (Dec. 1964, 159-80)
1910–53	AED, DANR, Phil. Agr. Stat, I (Manila: Bureau of Printing, 1955) 26-27
1954–55	AED, DANR, Crop and Livestock Statistics, 1954-55
1958–59	AED, DANR, Crop and Livestock Statistics, 1958-59
1960–72	BAE, DANR, “Rice production, area, and yield in the Philippines” (mimeo)

the highest increase was observed in 1970 at an average of 1.76 tons/hectare (Figures 1 and 2).

The increase in rice production was attributed to the building of irrigation canals in the 1920s and the further construction of big dams and concrete canals in 1946. The availability of water and intensive campaign for new and better lowland and upland varieties of rice in 1946–1951, as Table 1 shows, drove up production from about 330,000 hectares (producing 495,000 tons) to about 1 million hectares (of 1.4 million tons). On the average, palay yield was only 1.10 tons/hectare (25 cavans/hectare). This was further increased to 1.25–1.34 tons/hectare when the new varieties were applied with chemical fertilizers (Galang 1952).

In the early years, several schools for agriculture such as the University of the Philippines (UP)-College of Agriculture, Central Luzon Agricultural School, and other provincial agricultural schools in the country were established. Agricultural (rural) high schools were also created to

Table 1. Average yield and area planted to rice

Crop year	Hectares	Total Production (cavans)	Production (computed into tons)	Average Yield (cavans/hectare)	Average Yield (tons/hectare)
1946–1947	329,686	11,207,005	493,108	33.9	1.4916
1947–1948	675,953	19,653,834	864,769	29.8	1.3112
1948–1949	675,639	20,535,206	903,549	30.4	1.3376
1949–1950	981,546	30,508,062	1,342,355	31.1	1.3684
1950–1951	1,024,277	31,099,479	1,368,377	30.4	1.3376

Previous average yield: 25 cavans/hectare
Source: Galang (1952)

boost agricultural knowledge and capabilities. Agencies related to the promotion of agricultural development were also established to address issues on irrigation systems, fertilizer administration, land settlements, weather, and soil conservation.

Despite these initiatives, the progress of the Philippine rice industry during this period was slow compared to other rice-producing countries such as Japan, China, and Korea. Serrano (1952) attributes this to the lack of support and facilities for rice research and organizations. The government support given then concentrated on mechanization and price control. Several proposals for the development of varieties and production technologies had been forwarded to the government; in contrast, changes in production techniques or management technologies were not as documented, which was ironic because one would have assumed that as new varieties are introduced, development of production technology for these new varieties would also be intensively researched and developed.

3 Rice Production in the Green Revolution

The Green Revolution and the scarcity and increasing cost of labor served as impetus for more R&D on the mechanization technologies, resulting in the adoption of some mechanized methods in farms.

Before 1967, the increase in yield was more attributed to the increase in production area (53%). After 1967, the total production was apparently due to the high-yielding capacity of the newly introduced varieties (76.5%). With proper seeds and cultural practices improved, the yield was boosted in 1975 from an average of 1.75 tons/hectare to 3.2 tons/hectare yield in 2002.

Rice production during this period is considered as most progressive because of tremendous growth in crop productivity and significant changes in terms of rice production techniques and management. In this period, the International Rice Research Institute (IRRI) spearheaded the technological change in the landscape in rice—from the development and introduction of modern HYVs to the intensive use of chemical inputs and machines to sustain high yields and double cropping system.

Generally, however, the development and adoption of new and modern varieties seemed to have more impact on the rapid yield growth from 1965 to 1980 than did the change in the production technology.

4 Yield-enhancing Technologies

Rice varieties

Rice production in the Philippines can be divided into three major periods: the period of the so-called traditional varieties that characterized the years before 1960s prior to the establishment of the Los Baños-based IRRI; the period from the 1960s to 1988, when IRRI and other breeding institutions introduced the so-called modern HYVs that were mainly for irrigated fields; and the present, when other rice ecosystems such as rainfed and fragile rice environments were recognized and given attention.

Traditional systems

The rice production system prior to the introduction of modern varieties and technologies is characterized by a single cropping per year, with yields ranging from 0.70 tons/hectare in 1900–1913 to 1.25 tons/hectare in 1966 (Serrano 1952). Rice management was less influenced by technology or chemical inputs than by farmers' direct experiences and field observation.

Filipino farmers planted traditional varieties that were photoperiod sensitive (i.e., sensitive to length of day and flower only when the days are short). The leading varieties then include the Milagrosa, Wagwag, Buenavista (Kasungsong), and those introduced from abroad, notably, Ketan Koeteok from French Indochina (now Vietnam) and Fortuna from Formosa. These varieties, although resistant to most pest and diseases and have excellent eating quality, yielded 0.88–1.32 tons/hectare only, matured late at around 150 days, and grew by as much as 160 cm. At that time, Milagrosa was the best quality variety but not a good yielder. Its grains were the smallest among other varieties. Wagwag, named by old farmers of Muñoz, Nueva Ecija from the Tagalog word "*wagwagin*" (meaning, to shake off), was another leading variety for almost three decades because of its superior quality and relatively good yields.

In 1928 to 1937, the Bureau of Plant Industry (BPI) successfully crossed the Ramai and the native Inadhica varieties and introduced it as Raminad Strain 3 (also known as Quezon Rice). This was dispersed for commercial cultivation before and even after World War II. The BPI also came up with a set of improved varieties that included Buenkitan (from Buenavista and Ketan Koetek), Milketan, and artificial hybrids such as the Milfor and Milbuen series (from Milagrosa-Formosa and Milagrosa-Buenkitan crosses) (Serrano 1975).

IRRI and its "miracle rice"

In 1962, the International Rice Research Institute (IRRI) was established through the Rockefeller and Ford Foundations because of concerns over the increasing world population and the need for sufficient food to forestall massive starvation. The initial breeding objective was to create a plant type that would be lodging resistant, nonphotoperiod sensitive, and efficient in using solar energy and fertilizer to achieve high yields. The IRRI immediately started crossing Philippine-grown Indonesian variety Peta with Taiwan's semidwarf Dee-gee-woo-gen and came up with IR8, the first of IRRI's modern HYVs (Huke and Huke 1990).

IR8 was short and sturdy, tillered well, had great seedling vigor, responded very well to fertilizer, had moderate seed dormancy and a reasonable degree of resistance to tungro virus, and was essentially insensitive to photoperiod. Unfortunately, it also had a bold and chalky appearance, was subject to considerable breakage during milling, and had high amylose content in its starch that caused the rice to harden after cooking and cooling. It was also susceptible to bacterial blight and to several races of rice blast. However, it was capable of yielding as high as 12 tons/hectare at a shorter duration of only 125 days.

At the same time that IR8 was being handed out in 1-kg packs and multiplied through the Rice and Corn Production Coordinating Council, two Filipino-bred varieties developed in the mid-1950s—BPI-76 and C4-63—were also released for multiplication and demonstration. The yield potential of BPI-76 and C-18 was lower than IR-8 but still much higher than local varieties. The BPI-76 yielded as much as 6.6 tons/hectare; matured in 120 days; responded to high nitrogen fertilization; was medium in height (125 cm) and resistant to lodging; was moderately resistant to rice blast, stem borer, and yellow dwarf virus; and was nonseasonal and dormant for four to six weeks. Its grain was slightly colored, fairly nonshattering with flinty kernel, has high milling recovery, and of very good eating quality. On the other hand, it could be seriously affected by bacterial blight.

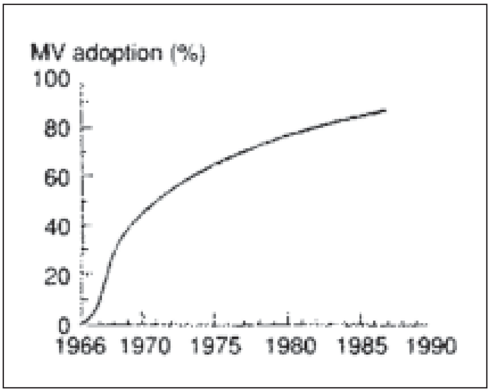
Meanwhile, the C-18 would yield 2.9–8.6 tons/hectare; matured within four to four-and-a-half months from seed germination; was best suited for moderately fertilized fields; had strong seedling vigor; was 110 cm tall; produced 12 productive tillers and resisted lodging under normal spacing; and had moderate resistance to common diseases and stem borers. Its grain was flinty and eating quality was excellent. However, farmers preferred the IR8 because of the higher yield potential in fields.

At the time of its release in 1966, IR8 was yielding as much as 10 tons/hectare in the dry season and 6 tons/hectare in the wet season at IRRI's farm in Laguna while farmers in the neighborhood were getting 2.0–2.5 tons/hectare of yield from traditional rice. The IR8's performance during the first year of introduction was its best form of advertisement. Its ability to adapt to different areas dispelled farmers' doubts against this "miracle rice" and its accompanying package of improved practices such as seedbed preparation, fertilization, spraying against pest and diseases, straight-row planting, and weeding.

The combination of good media coverage and a series of government policies such as organized extension efforts, fertilizer subsidy, and support for farmgate price led to rapid adoption of IR8 and succeeding varieties from IRRI. By the third year of seed availability, more than 40 percent of the Philippine rice lands was planted with HYVs (Figure 3). Of this, roughly 80 percent was for IR8 or IR5, while only 20 percent was for a mix of recommended varieties from UP-College of Agriculture and the BPI.

Some Filipino-bred varieties, on one hand, found their way in other locations that had been slow in adopting IR varieties for reasons such as eating quality or the need for a taller plant type. In Myanmar, the UP-College of Agriculture's C4-63 found its way in limited volume in farmers' fields in the late 1960s and was still planted in the

Figure 3. Adoption of HYVs in the Philippines



Source: Huke and Huke 1990

1990s. Even traditional varieties such as Dinorado, Wagwag, and Buenkitan are planted in provinces such as Nueva Vizcaya, Mindoro, and Palawan while retailers in urban areas brand their rice with these varieties owing to the excellent eating qualities. Such varieties are now assigned premium prices by Filipino consumers.

Modern-day varieties

In 1987, the national program for rice varietal development was taken over by the newly established Philippine Rice Research Institute (PhilRice), and all local-bred lines (from IRRI, UP-College of Agriculture, and PhilRice) underwent a collaborative field screening under PhilRice's leadership. Following PhilRice's establishment, IRRI's R&D shifted its focus on favorable rice environments to that of the ecosystems approach, where other ecosystems such as rainfed, upland, and fragile rice areas were given attention.

The Philippine Seed Board and the National Seed Industry Council started the Rc series of rice varieties in 1990. These varieties resulted from the collaborative undertaking among breeding institutions such as IRRI, PhilRice, and partner agencies and state colleges/universities, along with a few private companies. However, the most preferred rice variety at present remains to be IR-64, which was commercially released by IRRI in 1985. This variety yields an average of 5.3 tons/hectare, matures in 113 days, is 1.0 m tall, and is resistant to pests and diseases except tungro. Filipino consumers have favored the taste of the IR-64 such that it now commands a higher price from rice traders and millers than any other variety—even after newer, more disease-resistant, and similarly high-eating-quality varieties were introduced later.

Hybrid rice

Hybrid rice has been successfully introduced in China for nearly a quarter of century now. Many Asian countries, including the Philippines, have recently recognized the hybrid rice's ability to increase local rice production and its profitability. A hybrid rice cultivar is a product of natural cross-pollination of two genetically different parents with superior qualities that are passed on to the seed; this results in a phenomenon called "hybrid vigor" or "heterosis." The seed produces long roots and broad leaves that enable it to take up more nutrients and thus produce more grains. These factors result in higher yields than ordinary rice cultivars called inbreds. The IRRI and PhilRice researchers estimate a yield increase with hybrids of at least 15 percent over the conventional inbred cultivars. With proper management and favorable environment, farmers can raise yields by up to 12 tons/hectare/season.

The cultivation procedure of hybrids is basically the same as inbreds but the former cannot be used for replanting because hybrid vigor will be lost by then, resulting in lower yield and nonuniform crop stand.

At present, there are six commercial hybrids promoted by the government since 2000. PhilRice and IRRI developed three Mestizo hybrids while three private seed companies' own hybrid rice varieties are also being promoted through a government hybrid rice program spearheaded by the Department of Agriculture. Because of aggressive government support, hybrid rice cultivation in the country is increasing, starting with 5,000 hectares in 2000 to some 250,000 hectares targeted for 2005–2006 in selected provinces. Total target yield will be 5.15–6.75 tons/hectare.

Soil and nutrient management

Traditional practices

Lowland rice is best grown in easily drained heavy clay soils with not much nitrogen content while upland rice is best in loamy soils not too rich in nitrogen. Should there be high nitrogen content in the soil, rice plants would produce little grain and too much straw and grow tall, becoming prone to lodging (Camus 1921). As early as 1930, Central Luzon fields have been identified as best suited for rice because of their clay to clay-loam soil. Nueva Ecija became the highest rice-producing province.

Planting of rice in the early times was done once a year only due to the lack of irrigation water, thus causing the fields to fallow during the dry season. There had also been cases when rice had good yields for at least 100 years even without fertilizers. This was due to the effect of sun and air on the soil during the dry season.

In 1910 to early 1930, farmers in the lowland areas used mostly organic fertilizer such as farm manure, cogon and bamboo extracts, guano and rice straw, and Indigo (dye plant, commonly used in Ilocos). No inorganic fertilizers were used then. Early soil fertility management in the highland rice paddies included the incorporation of weeds and rice straw into the soil, and trampling compost, decayed litters, and azolla into the mud before transplanting.

The incorporation of wild sunflower (*Tithonia diversifolia*) in the seedbed has been also commonly practiced until the present times. The *fbuloj* (*Acalypha argatensis*) and *lamud* (weathered rock material and sometimes called “mountain urea”) are also used as topdress fertilizer applied to ameliorate zinc deficiency, which are prevalent in the rice terraces (Padilla 2000).

Village households do some composting by excavating pig pens deep enough to accommodate rice hull, straw, and panicle from manual threshing, as well as kitchen refuse and grass clippings. The decayed materials, enriched with pig manure and urine, are regularly collected and incorporated into the field during land preparation.

As the price of palay ascended in the 1930s, rice farmers resorted to the use of commercial fertilizer to increase production. Commonly used was ammonium sulfate and other fertilizers such as the Hoz™(13-6-2), Corona™ (10-6-2), Corona Arroz™ (9-9-4), Nitrophoska™ (15-15-18), ammonium phosphate (20-20-0), or the Nin-Plus-Ultra™(17-20-0) (Calma et al. 1952). Other fertilizers used since 1933 until the present times are the Superphosphate (0-18-0) or Solophos™ and the sulfate of potash (0-0-50). The latter has been recently improved to give higher percentage of potassium (Muriate of Potash™ 0-0-60).

With commercial fertilizers, better rice varieties, and irrigation, the production in the 1950s increased to an average of 1.24 tons/hectare in fertilized 257,046 hectares compared with the average of 1.10 tons/hectare from unfertilized areas (Galang 1952). Because of such increase, applying inorganic fertilizers became common in rice fields.

Green Revolution soil and nutrient management package

The Philippines’ Masagana 99 package also included basal fertilizer application. Several studies showed that the basal incorporation of fertilizer, done during the last harrowing and puddling prior to transplanting, is more efficient than broadcast. The adoption of the basal application, however, was very low since farmers stuck to their traditional method of applying fertilizers several days to two weeks after transplanting.

Modern soil and nutrient management

With the development of irrigation facilities and continuous supply of irrigation water to the farm, intensive rice monoculture (2–3 rice cropping systems) was started to be practiced. However, rice monoculture itself contributed to the degradation of paddy resource base and consequently resulted to declining soil productivities. The impact of the paddy resource base varied by agroclimatic and management factors and could be observed only over the long term. Thus, despite the influx of HYVs and increased fertilizer rates, rice yield declined during the late 1980s and in the 1990s.

Water management

Since rice is basically an aquatic crop needing much water for its growth and development, its cultivation during its early years in the Philippines took place during the rainy season only, when water was aplenty. Meanwhile, most of the land was left idle during the dry season.

To produce more rice in water-deficient areas, the government started to construct several irrigation systems. In 1840, the Spanish government started the construction of irrigation systems and succeeded in irrigating 27,798 hectares during the dry season. Under the American administration, its first irrigation system in Tarlac, the San Miguel Irrigation System, was built in 1913 (Camus 1929). Subsequently, the Irrigation Act (Legislature Act No. 2152) authorized the construction of more irrigation systems all over the country. Thus, 16 irrigations systems were completed and distributed in 15 rice-producing provinces. Additional areas were irrigated by these systems, reaching as many as 100,000 hectares. Rice breeders started working on varieties that could be planted during the dry season since almost all traditional varieties were photoperiod sensitive and could be planted only during the rainy season.

Intermittent irrigation

Lowland rice is usually flooded throughout its growth period. In 1939, only 30 percent of the total acreage planted to rice was served with irrigation systems while the remaining 70 percent was still totally dependent on rainfall. Out of the 30 percent, only few farms had sufficient water supply to support two rice crops per year (Alfonso and Catambay 1948). In areas with insufficient water, intermittent irrigation was practiced.

As early as the 1920s, some farmers in the irrigated areas of Nueva Ecija would let the rice field dry up for one to two weeks after transplanting to encourage development of roots (Aragon 1930). In the southern part of Luzon where water supply was sufficient, intermittent irrigation was employed in Calauan, Laguna, where four to eight irrigations were made during the entire rice-growing season (Teodoro and Bataclan 1931).

Pump introduction

In 1951, in response to the insufficient rice production, the Irrigation Service Unit (ISU) was launched as the pump irrigation program (Sta. Iglesia and Lawas 1959). It installed 211 pumps from 1952 to 1957, wherein an organized farmer irrigation association paid the installed pumps in 10 equal annual amortizations with 6 percent interest. Upon introduction of water pumps, the method of planting rice also changed. Out of 216 farmers in 1954–1955, 16 percent were transplanting rice while 84 percent were practicing hand broadcast seeding directly into the paddy field. In 1956–1957, 72 percent had shifted to transplanting method, broadcast farmers dropped to 11 percent, while the rest transplanted during the wet season and practiced direct seeding during the dry season.

This change in planting method due to season is still practiced at present mainly to reduce costs than for any other reason. More labor is required in transplanting than in direct seeding, in which seed bedding and seedling pulling are eliminated while the time to establish rice seedlings in the field was lesser with direct seeding. Rice transplanting is preferred by most farmers during the wet season since risks of poor crop establishment are higher during this period due to unpredictable rainfall occurrences. Direct seeding is done during the dry season, when water is more controlled and pests and diseases seldom occur. However, for less labor and costs, farmers in irrigated areas are increasingly adopting direct seeding irrespective of season.

Water management during the Green Revolution period

One remarkable change in rice production brought about by irrigation was the practice of second cropping rice during the dry season. As early as 1955–1956, a second crop was already considered but only given greater importance after 1967–1968, when irrigation systems were increased and old systems were rehabilitated. By then, nonphotoperiod-sensitive HYVs were already available, irrigated area expanded by 40 percent, use of fertilizer increased, and cultivation practices improved. However, the rate of yield increase (3.6% of annual rate) from 1962 to 1971 grew rapidly while the area harvested declined. Such drop was reversed only in 1967–1968, when profitable possibilities of high-yielding seeds and the large expansion of irrigated areas induced increased plantings (Mears et al. 1974).

Massive investments in irrigation infrastructure in the late 1960s became essential for the success of the Green Revolution and for rapid productivity. With the construction of the Pantabangan Dam and the Angat Irrigation Project in the late 1960s, rehabilitation of old irrigation canals, and establishment of the National Irrigation Administration-Upper Pampanga River Integrated Irrigation System (NIA-UPRIIS) in the late 1970s, irrigation water became abundant in Central Luzon.

At present, however, the increase in population, coupled with urbanization and industrialization, competes with agriculture for water resources. Subsequently, the supply of irrigation water started to decline as spending on irrigation infrastructure lessened, existing infrastructure deteriorated, and groundwater resources became overexploited (Pingali et al. 1997).

In 1997, the El Niño-La Niña phenomena greatly affected rice production. The National Irrigation Administration could not supply water to service areas because of the scarce or low water supply. Thus, alternative water management is now being studied. The intermittent irrigation schemes implemented back in the 1920s and 1930s are now reintroduced to farmers.

Crop establishment

Traditional methods

In the earlier times, rice was planted in four ways: *caiñgin* or mountain planting; the dry planting called "upland," also known as *secano*, *hasik*, or *dalatan*; the *sabog* (palay broadcasted on puddled rice paddies); and the *tubigan* (transplanted) (Camus 1921).

Caiñgin**,** the oldest method, is done on mountain slopes cleared and burned of underbrush and trees. Planting this area with rice is done at the onset of rain. Holes are made in the ground with a sharpened stick and 3–10 grains are dropped in each hole and covered with soil. Upland rice varieties are used in this method. For a particular area, the caiñgin method is used for three years or less, then left to fallow for another three to four years before planted with rice again.

Secano is the nontransplanted method in the upland areas or in a high rolling land. There are two methods of establishing rice: drilling in the seed and sowing, or broadcast seeding. In the drill method, shallow furrows are made by means of a plow or *lithao* (a comb harrow-like, animal-drawn implement that has wide wooden teeth for making shallow furrows in cultivated dry fields). The seeds are sown by hand, and the field is then harrowed with a native harrow to cover the seeds. This method makes weeding easier because of the spaces made between rows.

In the other method, the seeds are broadcasted in a plowed and harrowed area without any furrows. The seeding rate for this method is 70 kg/hectare (Camus 1929).

Sabog is a method for planting lowland rice paddies with existing dikes and done in areas where irrigation water is insufficient. Seeds are broadcasted by hand after the area is plowed and harrowed until the soil becomes totally puddled. The land is prepared with as little water as possible and the seeds are sown at the rate of 60 kg/hectare. Then, water is introduced in sufficient amounts to allow germination of seeds, and the field is maintained in submerged condition if rainfall is abundant or at just enough moisture for the entire rice-growing period. This method, however, risks not getting enough water to maintain the crop. Rainfall occurrence can save the plants but an irrigation pump, if available (this was only introduced in the early 1950s), can help draw water from nearby rivers or streams. The crop is harvested before the close of the rainy season, and the fallowed area is used as pasture land for animals during the dry season and then prepared again just before the next wet season comes.

Tubigan is the oldest planting method as this has been practiced in the rice terraces in olden times. This is also the most profitable planting method in areas where irrigation is abundant because the possibility of drought is less and planting two rice crops per year (i.e., the dry and wet cropping seasons) is possible. Paddy dikes are built to hold water as the area is prepared in “muddy” or wet condition. In the wet season, once the rain starts, the area is plowed once under water then harrowed thoroughly before leveling. Pregerminated seeds at the rate of 35–44 kg are first sown in 400 sq m of seedbed (to plant a hectare) and transplanted into the prepared fields when seedlings are already 30–40 days old. Transplanting is done by at least 12 hired transplanters paid at 40–60 centavos (circa 1920) plus free meal and afternoon snack per day. Guitar music at the background helps make transplanters speed up their work.

Transplanting is usually done by women and children or solely by men (depending on the region), who walk backward in the soft mud while poking three to five seedlings at 2-1/2 cm deep into the mud with their thumbs and the first two fingers, covering as much space as they can reach on either side (Figure 4). In the Ilocos provinces, where the land is seldom thoroughly puddled, sharp wooden sticks are used to make the holes where two to six seedlings are dropped.

Figure 4. Rice transplanting on bunded fields

Music from a guitar during the olden days is common in lowland areas.

As early as 1919, transplanting rice in the lowlands during the dry season (*palagad*) was practiced in places where there were irrigation systems. Early-maturing varieties were planted as the second crop so that they could be harvested early before the next or main cropping season. These varieties—when compared with medium-late or late-maturing ones—gave better yields on rainfed areas, especially when there were short period of rainfalls (Bautista 1949). In 1929, transplanted rice was found to be better than direct-seeded rice in the dry season (Camus 1929). In transplanted rice, farmers observed that seedlings grow faster than the weeds, unlike with the direct-seeded rice. Weeds were minimized in puddled fields (hence, hand weeding frequency was lessened) and soil fertility was allegedly better maintained.

With the advent of irrigation pumps, the method of planting rice rapidly changed from direct seeding to the more profitable transplanting

(Sta Iglesia and Lawas 1959), although in some areas where water is scarce, the secano or the sabog method is still practiced.

Seedbed management

Before 1921, farmers practiced the *punlaan,* the dry seedbed, or the *dapog*. In the punlaan, seeds were pregerminated before sowing into slightly elevated beds in a well-prepared flooded plot and allowed to grow for 35–50 days before transplanting (Figure 5). Leaves of pulled seedlings were topped or cut prior to transplanting to lessen transpiration while the newly transplanted seedlings were recovering and to prevent them from being blown down by high winds before they fully develop roots (Catambay and Jugo 1933).

The dry seedbed method uses an area that is prepared dry, not puddled nor flooded. A 1.5 x 10–20 m plot is constructed and the seeds sown and harrowed lightly, then watered; however, the seedbed risks getting too dry and the soil too hard for the young seedlings to grow and to be pulled later with minimum damage.

The dapog method is accomplished on a 1 x 15 m plot constructed after the soil has been puddled, harrowed, and leveled. Banana leaves are

Figure 5. Seedling pulling at *punlaan* 30 days after sowing

laid, with their edges toward the center of the bed, and allowed to sink and submerged into the mud by 2-1/2 cm deep. The banana leaves are also covered with a thin layer of clean rice hull or finely chopped rice straw. Fifteen to 30 liters (8.8 to 17.6 kg) of pregerminated seeds are spread into two 1 x 15 sq m seedbed plots, which will be enough to plant a hectare. Sowing is best done in the afternoon. Seedbeds are watered from time to time to avoid drying up. The banana leaf makes the new plant's roots run laterally to intertwine with other roots while keeping the seedlings in an erect position. The entire bed later forms a carpet-like sheet of young plants that can be easily lifted and removed for transplanting from the banana leaves after 12–15 days (and/or when plants are about 15 to 20 cm high). The seedling mat also provides easier handling and transport of seedlings from the bed to the field.

The dapog method became a common practice for growing dry-season crop because such crop matures earlier than ordinary transplanted rice. This has been a good alternative to broadcast seeding. Dapog-raised seedlings mature earlier by 20 days than those grown in ordinary seedbed (Camus 1921). On the other hand, with broadcast seeding, it is impossible to attain uniform and efficient seeding by hand and difficult to do the weeding process. Nonetheless, both the dapog system and the broadcast method are employed only where there is sufficient irrigation water during the growth of the crop. Nowadays, only Southern Luzon and Cotabato farmers have dapog-raised seedlings; the rest mainly use the punlaan method.

Seeding rate. Ordinarily, one hectare requires 32 kg of good bigger seeds and 22 kg of good finer seeds (e.g., Wagwag, Milagrosa) to plant a hectare (Catambay and Jugo 1933; Bautista 1949). The seeding rate, however, depends on the crop establishment method preferred by rice farmers, on the ecosystem, and on the percentage of germination rate. Pregerminated seeds are to be uniformly broadcasted into 400–500 sq m of preferably lighter soils for easier pulling of seedlings. The seedbeds are irrigated from time to time and fertilizer (ammonium sulfate) is applied to hasten the growth of seedlings whenever they appear spindly.

In the early 1990s, the 40 kg seeds/hectare seeding rate for wetbed method was demonstrated in the different rice areas through the government's rice program. This has lowered seeding rates for transplanting from 105 kg/hectare in 1998 to 86 kg/hectare in 2000; and the direct seeding in irrigated lowland areas from 150 kg/hectare to 129 kg/hectare. However, there was no significant change in the seeding rates used in the rainfed, direct-seeded areas from 1998 to 2000.

Seedling age. In general, farmers plant seedlings of traditional varieties at 30–40 days old. As reported by Camus in 1921, the age of seedlings to be transplanted depends on the maturity of the varieties to be planted: 25-day-old seedlings for the short-season crop (<120 days), 30-day-old seedlings for early-maturing varieties (120–145 days), 30- to 35-day-old seedlings for varities that mature at 145–170 days, 35-day-old seedlings for those that mature at 170–180 days, and 40-day-old seedlings after sowing for those that mature at over 180 days.

However, this classification of varieties based on maturity seemed to have changed in 1949. Seedlings of the early-maturing varieties are now those that mature at 140–160 days and should be transplanted at 20–35 days old while the late-maturing varieties are those that mature at 160–180 days and are transplanted at 35–42 days old. To date, late-maturing varieties that mature in more than five months are now classified as traditional varieties and usually planted in the upland ecosystems. Those classified as early-maturing varieties now have less than three months' maturity and can be planted from 18 to 21 days old after sowing. The medium-maturing varieties mature in more than three months and can also be transplanted when the seedlings are 21–25 days old. Both classifications are adopted to lowland rice ecosystems.

Distance of planting. Transplanting distances and planting density vary on a case-to-case basis. For better results and economy, three to four seedlings are used per hill at a distance of 20 cm to 25 cm. In low fertile soils, five to six seedlings per hill are planted in 18 x 18 cm up to 20 x 20 cm distances while seedlings are planted farther 20 x 30 cm apart in high fertile soils. Within five days, dead or weak seedlings are removed and replanted with better ones (Bautista 1949).

Although a similar planting distance (20 x 20 cm) is being recommended at present, most farmers still prefer other planting distances over that specified by the "straight planting" method. Commonly practiced are the "straight *kulong*" and the *waray* method. In the straight kulong method, a baseline of 20 cm planting distance is first transplanted with rice seedlings. Such baseline becomes the transplanters' guiding row as they plant by moving backward at undefined planting distance per hill. In the waray method, planting distance between row and hills are not defined, and no baseline is followed. These methods are faster than straight planting since transplanters plant according to their pace. Farmers also prefer these methods over straight planting method since their transplanting cost is lower.

In the straight planting method, farmers apply wider row spacing (20–25 cm) for better light interception and fertilizer application; easier incorporation of top-dressed fertilizer, weeds, and other dry matter; and easier weed management and cultivation when the rotary weeder is pushed along the space between plant rows. In Laguna, where straight planting is commonly practiced, some farmers allocate wider plant spacing (23–25 cm) during the wet season; during the dry season, the same field is planted using narrower spacing (18–20 cm).

5 Pest and Disease Management

Rats and rodents

Rodents have long been known to destroy rice. The most common is the Philippine field rat, *Rattus rattus mindanensis*, which constructs nests alongside dikes and irrigation canals, grass stands, termite hills, and bamboo clumps. A pair of adult rats can inflict more than 50 percent rice yield loss. As reported in 1921, the economical way to control these is to set their hiding places on fire and kill them. Field application of poisonous chemicals such as white arsenic, barium carbonate, or strychnine sulfate is also recommended (Camus 1921) although care needs to be exercised due to such chemicals' possible effects on other animals and humans.

Community-wide activities are also organized to control rats. Before planting, a community-wide rat control is done by digging and flooding burrows. Tin sheets (*liso*) are used as barriers for the seedbeds. The Barangay Rat Program (BRAP), instituted as the RA 3942 Rat Law, requires males to participate in rat control within the community and provides rice incentives in community contests for the highest number of rat tails.

Another rat control method is by using plants. The fresh leaves of *lupa* (poison ivy) are spread alongside dikes so that rats that get in contact with the leaves will itch and develop lesions. *Fbuloj*, which produces dark-colored water when spread into the paddy, repels the rats away from the paddy. Grated coconut is also used to attract first the ants and then the rats. Ants' bites cause itchiness and, afterwards, infection on rats.

In present times, farmers mix some cement into the bait, believing that cement will harden rodents' stomachs and eventually kill them. In Laguna, farmers also use sticks or a kerosene-fueled flame thrower to scare rats out of other burrows while dogs or extra labor stand by, ready to chase and kill the rats. In addition, by synchronizing their planting schedules, farmers can collectively reduce rat damage on one field because rats will tend to spread out to a wider area.

Also, more and more farmers now eat the meat of field rats, which can be a good source of protein. Rice rats are often regarded as delicacies to feed on during harvesting and land preparation periods, when farmers destroy rat burrows as they clean their paddies and dikes.

Birds

Mayang pula and the *mayang paking* are birds that bring the most destruction to rice plants. Farmers nowadays scare them away all day using scarecrows, flags, tin cans on poles, and even firecrackers. However, mayas easily get accustomed to such scare tactics and are not easily driven from the rice field. Thus, other methods of catching birds include attaching Ficus gum on sticks placed around the farm as traps; using a net trap in the field; and manually net-sweeping birds at night time. Such catch can then be eaten by families.

In the Cordilleras, farmers use two methods to control birds that destroy rice plants, especially during the milk and ripening stages. The first method is by luring birds into traps made of flower peduncles brushed with the sticky wax (*paket*) prepared by cooking the sap of the *bebeng* or *pospos* tree. The trapper, hiding below the rows of traps, blows onto an indigenous whistling instrument called *ngik*, which is made of the node of the *tanobong* plant, to lure the birds into the traps. The other method is by scaring birds with loud shouts or sounds such as a clanging tin can, which is manipulated via a cord by a birdboy (a helper who helps scare birds away from the field). Pulling a string connected to a scarecrow to cause movement ("dancing") can also scare birds away.

Insect pests

In the past, one of the most important insect pests was the migratory locust, which was eradicated by driving swarms into pits. Other destructive pests reported by Camus (1921) were rice bugs, which were as destructive as the locusts but controlled by systematic crop rotation and clean culture. Other early means to control these were to put a putrifying meat in a bag as bait to attract and then trap and burn adult bugs; to simultaneously and synchronously transplant varieties with the same maturity; and to plant rice earlier than its usual season to serve as trap crop so that rice bugs will feed and live on them and eventually be burned together with the trap crop, before the actual rice crop is planted. Of the three options, synchronous planting was least acceptable to other farmers because additional hands were needed during harvest time as these rice plants mature simultaneously.

Next to rice bugs, rice stem borer also wreaked havoc on farmers' output. To destroy rice stem borers' eggs, farmers therefore cleaned the field before transplanting. Leaf folders and cutworms or army worms were also common pests, especially in places where continuous planting of rice was practiced. Clean surroundings and crop rotation were the suggested control measures at that time but farmers would also burn highly infected fields at the end of the rice season. As early as 1930, the case worm was already a common insect pests in rice aside from the rice leaf roller (*Cnaphalocrosis medinalis*), rice bug (*Leptocorisa acuta*), and stalk borer (*Schoenobius incertellus*) [Aragon 1930]. To combat case worms, complete drainage of the paddy field was resorted to (Bautista 1949).

In 1954, the brown plant hopper (BPH) was first observed in Calamba, Laguna. In 1973–1974, it became a serious pest when it destroyed thousands of hectares of rice in Laguna. In 1976, serious outbreaks were also observed in Mindanao. The grassy stunt virus transmitted by the BPH soon exacerbated the yield losses of rice farmers in Laguna. During the infestation, technical personnel, chemicals, and equipment were pooled to suppress the spread of the pest. Farmers organized into pest control groups to cover wider areas. Educational drives introduced modern crop protection methods to farmers. As initiated by the BPI, a rice planting ban during the 1974 dry season was instituted in Laguna in an attempt to break the BPH cycle with grassy stunt virus. Only rice variety IR-26 was used for planting (BPI 1981). For the first time, rice farmers became aware of the different methods to minimize plant pests and diseases.

Extensive use of chemicals or insecticides became a common practice; even calendar spraying was recommended in the Masagana 99 Rice Program in the 1970s (Figure 6). Farmers believed that all insects were harmful and were unaware about the friendly insects in the rice paddies that were destroyed alongside the harmful ones. Due to the continuous spraying of insecticides, harmful pests became immune to insecticides and increased in number while friendly insects were killed. The negative effects of chemicals on the environment and on human health prompted scientists to develop the Integrated Pest Management (IPM) that sought to control the harmful insects only.

Calendar spraying of chemicals have more harmful effects to the rice environment and humans than benefits to rice farming.

Figure 6. Calendar spraying of chemicals

Calendar spraying of chemicals have more harmful effects to the rice environment and humans than benefits to rice farming.

Diseases

One cause for the declining yield in modern rice varieties is the increase in diseases that the varieties are not resistant to. In 1939, Serrano first reported a viral pathogen causing stunt or dwarf disease locally known in Bulacan as *aksip na pula* and by the Ilocanos as tungro. Rice tungro is considered the most destructive disease in the Philippines. During the 1940s, the annual production loss due to rice tungro was estimated at 30 percent (1.4 million tons). In 1970–1971, it damaged hundreds of thousands of hectares of rice in Central Luzon, Bicol region, and other areas. Localized outbreaks in 1975 occurred again in Central Luzon. In 1977, a complete crop failure was reported in an area covering 180 hectares in Cavite. Tungro became more common with the introduction of HYVs. Farmers were suddenly unprepared to handle such a serious disease.

During these outbreaks, BPI aggressively waged campaigns to suppress the disease. Pesticides were distributed free to augment farmers' pesticide and to contain the fast spread of the disease. Through organized farmers' meetings, an educational campaign taught farmers how to use resistant HYVs as a preventive measure against the recurrence of the disease. More intensive campaigns were done in rice farming areas such as those in North and South Cotabato, Davao del Sur, and Zamboanga del Sur and in places where farmers still insist on planting disease-susceptible varieties.

In late 1976, a new rice disease called infectious gall disease was discovered in Mindanao. The disease was serious, affecting over 1,000 hectares of rice and destroying over 50 percent of the crops. Following the BPI's vigorous campaign to plant high-yielding, resistant varieties such as IR32, IR36, and IR42, the impact of BPH and the infectious gall disease was controlled (BPI 1981).

Weeds

In the irrigated lowlands of Muñoz, five common weeds in rice fields were identified: *Monocharia hastate*, *Pistia strationles, Eichornia crassipes, Cyperus iria*, and *Cyperus haspan*. Hand weeding (*gamas*) was employed in fields, and the weeds were fed to pigs (Aragon 1930). Aside from hand weeding, weeds were controlled by periodical application of water to suppress the growth. Those that survived were pulled out from time to time and trampled into the soil (Bautista 1949).

Until the mid-1960s, the predominant weeds were the sedges *Cyperus difformis* and *Fimbristylis milicea* and the broadleaves *Monochoria vaginalis* and *Sphenocloa crusgalli* while grass weeds, mainly barnyard grass (*Echnonocloa crusgalli*), were only of minor importance. Broad-leafed weeds and sedges thrived more in flooded soil condition than did the grass weeds. However, direct seeding required sowing in a saturated soil condition, which favored growth of grass weeds and sedges. Nowadays, grasses and sedges, particularly the *Leptochloa chinensis, Cyperus* spp., and *Fimbristylis milicea,* are the major weeds found in rice fields.

After World War II, a manually pushed rotary weeder patterned after a Japanese model became available in Southern Luzon and was adopted in some provinces (Nueva Vizcaya, Leyte, and Cotabato). The weeders required straight-row planting so as to allow cultivation of the spaces between plant rows without damaging the rice plants. Bicol farmers in the 1980s had a simpler row weeder version, which was a narrow plank of wood with nails and fitted with a handle to scrape through row spaces of straight kulong-planted fields.

Since the introduction of HYVs in the 1970s, however, chemical herbicides sprayed using knapsack sprayers before or after weed emergence have become common. Herbicides proved useful and effective particularly in direct-seeded fields. It is, in fact, one of the reasons direct seeding was easily adopted in Philippine rice fields.

Golden Snail

Between 1982 and 1984, the golden apple snail, locally known as "Golden *Kuhol*" (*Pomacea canaliculata* [Lamarck]), was introduced in the Philippines for food purposes. After a few years of production, however, the golden snail turned out to be a rice pest in paddy soils (Madamba and Camaya 1987). Rice seedlings at 14 days to 24 days after transplanting were found to be most susceptible to golden snail damage, which could destroy the whole young transplanted seedling.

Although there had been a campaign to use safe and natural pest control methods, farmers preferred to use chemicals (mollusticides) for their more immediate results; however, farmers also later found their nails damaged by the chemicals. Farmers also drain their fields after transplanting or use older seedlings to minimize snail damage to newly planted seedlings. Most resort to picking snails and eggs during land preparation while others allow ducks to graze through the fields prior to land preparation so as to lower the snail's population.

Integrated pest management (IPM)

Before the 1960s, farmers grew traditional varieties that were often heterogeneous mixtures and selected for their resistance to insect pests and diseases. Indigenous practices included the application of botanical and inorganic concoctions as pesticides and the removal of infected plants.

With the introduction of HYVs during the Green Revolution period, the new varieties—together with modernized technology packages—created favorable conditions for plant diseases to develop and insect pests to survive. The short-statured HYV, with its higher number of tillers, use of higher nitrogen rates, and continuous planting all year-round, created an environment for pathogens (that normally were not serious problems with the traditional varieties and practices) to thrive.

As early as 1926, the use of toxic substances had been recommended for disease control, primarily against fungal pathogens. The Masagana 99 program in the 1970s recommended as seed treatment such fungicides as Benlate™ and Dithane M-45™ for seed-borne pathogens. It also recommended calendar-based (i.e., five to six times per season) chemical application regardless of the level of infestation. Chemical control offered immediate solution to ensure high yields even for resistant varieties. Heavy reliance on chemical control, the host plant's resistance, and widespread cultivation of HYVs led to unexpected problems caused by weeds, insects, and diseases. The control approach was not systematic and any institutionalized and standardized pest control effort was highly unlikely to work over a large area. By 1986, the government finally declared IPM as the national crop protection policy.

The IPM became the cost-reducing technology for pest control in rice, emphasizing ecology-based approaches by using season-long farmer training (known in 1993 as farmer field schools or FFS). Among the control measures of IPM were the use of resistant varieties such as the Matatag lines, which were bred as stop-gap lines in tungro-infected areas; cultural methods such as sanitation, proper spacing, low use of nitrogen, and proper water management; synchronous planting on a large contiguous area; and, on need basis, chemical control.

Biotechnology

Biotechnology is one of the breakthrough technologies that offer a sustainable and practical solution to many problems in rice production, particularly on pest protection. Various plant breeding methods can speed up the development of new cultivars with higher yields as well as multiple resistance to major pests that continue to affect rice production in the country.

Through biotechnology, one or more genes resistant to a particular disease can reduce disease infection on a host cultivar. Resistance to bacterial blight, sheath blight, and tungro—three of the major diseases of rice in the country—is the focus of biotechnology research at IRRI and PhilRice.

6 Labor-saving Technologies

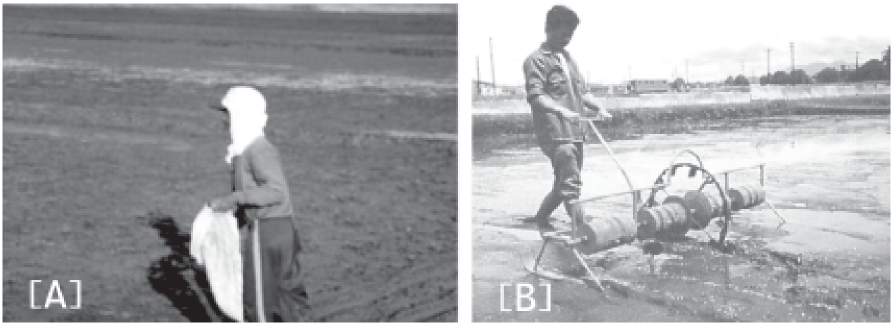
Direct seeding

Rice transplanting-dominated rice production during the Green Revolution and shortly after was one of the packaged recommendations of the Masagana 99 program. In Iloilo, however, broadcast seeding (combined with the introduction of early-maturing IR-36 as well as herbicides as a commercial product) were part of the package launched by a provincial rice program called *Kaumahan sa Pagsasaka* (Kabsaka). Rice seeds were broadcast manually into cultivated dry fields and germinate once rains come in. The program promoted this practice because of lack of gravity irrigation water in the area and of cost considerations. Farmers were then encouraged to broadcast mungbean prior to or right after harvesting while the soil surface is still wet for germination. Many farmers also broadcasted seeds on wet fields where water was plentiful, which resurrected the practice of wet direct seeding.

Initially, wet direct seeding was saddled by poor water management and weed growth caused by inadequate land leveling—both of which eventually led to poor yields. As farmers became skilled in proper leveling and water management, yields of direct-seeded fields no longer differed with those from transplanted fields. Nowadays, wet direct seeding of rice is advocated as an alternative planting method that answers the scarcity of labor during peak periods. It requires well-leveled puddled soil surfaces (to minimize water puddles that eventually reduce seedling recovery), good water management during the first week after seeding, and good weed control through the use of pre- or postemergence herbicides.

Direct seeding of rice is better established in the dry season, where there is minimum damage from rainfall, pests, and diseases, which are more prevalent during the wet season. At present, the combined method of transplanting (for wet season) and direct seeding (for dry season) is practiced in many irrigated areas. Some fields with good drainage,

Figure 7. The IRRI drum seeder facilitates wet seeding in neat rows with less seeds than do broadcast seeding



however, practice wet direct seeding of rice regardless of season to save on time, labor, and costs. A high seeding rate (150–250 kg/hectare) is used regardless of whether seeds are sown on irrigated or rainfed ecosystem. Such is to give allowance to plant damage due to rats, birds, and the Golden Kuhol.

Machinery for direct seeding

Beginning the late 1970s, IRRI has been developing simple hand-operated row seeders for direct seeding of pregerminated paddy grains into the soil surface (Wikramayake 1971) (Figure 7A). The most successful of these efforts is the IRRI drum seeder (Bautista et al. 1986) that was commercially released to manufacturers in 1989. The drum has a cylinder with perforations at both ends so that seeds could come out once the cylinders are rotated by a mud wheel as the operator pulls the machine (Figure 7B). Today, this seeder is gaining popularity since it allows neat plant rows at lower rates of 40 kg/hectare to 80 kg/hectare.

Farm mechanization

Mechanizing rice production came about due to such factors as: the drudgery of manual tasks; the intensive power required in operations such as land preparation; the increasing cost of manual labor; the significant amount of time devoted to a particular operation (Table 2); and the resulting better output when tools or machines are used.

Mechanization has always been associated with big or engine-powered machinery such as the hand tractor and rice thresher. However,

Table 2. Labor utilization in transplanted and direct-seeding culture in 1994

Operations	Transplanting (>4 tons/hectare yield)	Direct Seeding	
		Low Yield (< 4 tons/yield)	High Yield (> 4 tons/hectare)
Land preparation	104	112	80
Seedbed preparation,	8	—	—
pulling/bundling/transplanting	112	—	—
Broadcasting	—	16	24
Crop care and maintenance	24	40	64
Harvesting and threshing	480	288	408
Drying/storage	56	24	48
Total	784	480	624
Labor productivity, paddy kg/person days	83	64	88

Source: Takahashi (1995)

it can also include the use of tools and devices that ease and hasten the completion of field tasks. These tools can be in the form of hand hoes and carabao-drawn implements such as the moldboard plow and comb harrow.

Land preparation

Traditional practices. Preparing rice fields for planting is the starting point of mechanization for rice in the Philippines. It is one of the most labor- and power-intensive field activities. Rice in the olden days was cultivated only once a year, during the rainy season; hence, time and efficiency were less of a consideration than labor and costs.

In the early part of the century, farmers would heavily rely on hoes or groups of carabaos, supervised by one or two farmers, to trample and puddle submerged fields until the soil was soft enough for planting rice seedlings. This method is still practiced in the lower rice terraces of the Cordilleras and in Samar (where it is known as *payatak*). Before trampling, the field is soaked with rainwater or water flowing from the watershed above the rice plot. In elevated areas where carabaos cannot access the rice terraces, Ifugao and Kalinga women often prepare rice fields by manually inverting the mud and trampling the soil.

Moldboard plow. The first moldboard plow was introduced in the Philippines by a Spanish priest in the nineteenth century. In the 1920s, the carabao-drawn moldboard plows were already locally made by Chinese artisans and skilled Filipino blacksmiths out of scrap iron, white fine-grained iron, or discarded railroad rails. Other parts such as the beam, handle, and landside were usually fashioned by the farmer from buttresses, trunks, and branches of hard trees, although these may be occasionally purchased from plow dealers (Teodoro 1925).

The use of carabaos with moldboard plow persisted for many years but this also involved hard work and time. A farmer was estimated to walk for around 77 hours (an equivalent distance of 60 km) to plow a 1-hectare area. Harrowing using a carabao would require another 9 to 13 passes with a comb-toothed harrow when preparing the field for planting (Casem 1967).

Tractors. More powerful than animals, tractors achieve timeliness without sacrificing the quality of work. The first attempt to introduce tractors for plowing in the Philippines was done by the Spanish authorities in 1905. European-made cable plows pulled by two or three steam engines had been tried in Negros and Laguna but the plows' durability and performance were still unsatisfactory for the tough soils in the test sites.

From 1928 until 1932, the government's engineers at the Bureau of Agriculture tested and demonstrated several American tractor models in sugarcane fields in Negros Occidental. After World War II, mechanization of land preparation, with the government taking the lead, was more vigorously pursued because work animals had been destroyed by the war.

In 1953, a David Brown tractor equipped with a rotavator was tested for the first time on flooded paddy fields. The test results highlighted the tractor's potential problems on wet rice fields such as wheel slippage and bogging down due to the machine's excessive weight. It was these problems that BPI engineers, in cooperation with dealers of agricultural machinery, tried to solve through the introduction of extension steel wheels with angle lugs on the side of rubber-tired wheels (Cruz 1950). These enhancements provided the traction necessary in propelling the heavy tractor forward on soft, flooded soils.

In the 1950s, the ease in the way people adopted tractors might have been due to two reasons: (1) duty-free importation of tractors and subsidized credits for tractor purchase; and (2) the carabao shortage right after the war (Barker et al. 1969).

In the late 1960s, double cropping became possible with the introduction of early-maturing HYVs and irrigation. The turnaround time between the first crop and the second crop had to be shortened to allow two crops per year. Faster methods of land preparation, together with

Figure 8. Big four-wheel tractors with rotavating attachment and extension lugwheels for flooded rice fields

postharvest activities, became critical. Big, four-wheeled tractors with extension steel lugwheels (Figure 8) continued to dominate the irrigated rice areas in the Philippines, particularly in Central Luzon and near sugarcane plantations where tractors were already being used. In 1966, the government provided loans so farmers could buy big tractors and mechanize their production.

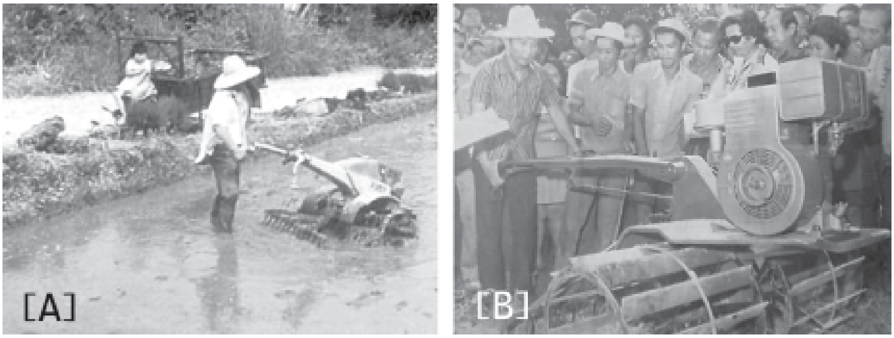
IRRI power tillers. Farmers in 1965 started to purchase and use imported tillers or hand tractors in rice paddies because it was difficult to take care of and maintain the carabaos under poor peace-and-order situations (Figure 9A). In 1968, most Laguna farmers already considered the hand tractor as faster, easier, and cheaper to use than carabao-drawn plows and harrows (Barker et al. 1969). Hand tractors were also known to make deep paddies shallower, were safer to use and keep than carabaos, had better rice crop stand, and would not need care and maintenance after use.

Because of early-maturing HYVs, land reform program, availability of credit support in the 1970s, and the outbreak of the foot-and-mouth disease, machine use was further encouraged. There were now labor shortages during peak seasons and greater need to accomplish land preparation within a much shorter period. For instance, in a Laguna village by the mid-1970s, hand tractors had almost completely displaced carabaos in land preparation (Hayami and Kikuchi 2000). Tractors could operate more efficiently in deep water fields adjacent to the Laguna de Bay owing to their floating wheels. The faster land preparation time was also beneficial for the dry season crop to avoid water shortages during the late dry months. The growing scarcity of grazing land areas (because rice cultivation expanded) might have also contributed to the replacement of carabaos by machines (Pablico 1968).

In 1972, a small, 5–7 hp, single-axle, lightweight power tiller was developed and released locally by IRRI at 50 percent lesser than the cost of imported tillers (Mahmud 1977) (Figure 9B). The IRRI tiller was simpler than imported models because it employed motorcycle chains and sprockets in its transmission that local manufacturers could assemble and repair. Small backyard shops also found the design compatible with their skill and limited resources. In just a year after its introduction, more than 2,500 hand tractors were sold in the Philippines. This number was 2.5 times greater in sales during the previous three years. Previously, imported tillers dominated the market. Later, more than 10,000 IRRI-designed hand tractors were locally produced until 1976.

Kuliglig era. The *Kulig-lig* (locally known as *kuliglig* after a popular hand tractor brand) era was the start of widespread mechanization (using

Figure 9. Imported hand tractors in the late 1960s [A] and a commercial version of the IRRI power tiller with then-President Ferdinand Marcos in the 1970s [B]



small hand tractors) of paddy land preparation in irrigated areas. The IRRI power tiller had been redesigned by local manufacturers through time. The split-type transmission casing was replaced with the box-type casing, the chains and sprockets enlarged, and the size increased with wider cagewheels, bigger engines, and longer handles for easy maneuvering.

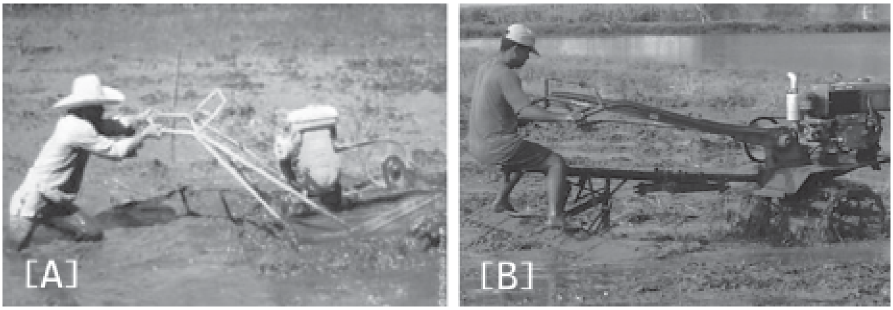
The use of hand tractors rose from 14 per 1,000 hectares in the Philippines to approximately 20 per 1,000 hectares in 1990 (Herdt 1983). Irrigated areas nowadays tend to be more highly mechanized, with over one hand tractor per 10 hectares of paddy land, while the less favorable areas continue to rely on animal power.

In most rice villages these days, the kuliglig hand tractor is used not only for custom land preparation but also for transporting people and products in and out of villages. In many villages in Central Luzon, its use has evolved into a passenger vehicle because it is the only vehicle rugged enough to maneuver through farm dirt roads (Figure 10).

In the 1970s, most kuligligs were manufactured in medium-sized Bulacan workshops. Nowadays, many are made and repaired in backyard shops of most towns or villages. Because it is simple to make, repair, and maintain, the kuliglig is widely used in irrigated fields, but its popularity had extended to rainfed areas. The design has not changed much from the original IRRI design of the 1970s although bigger chains and sprockets, coupled with more powerful gasoline (10–16 hp) or diesel engine (6–8 hp), are presently fitted. Common implements include the disc plow, which cuts through the soil surface as it is dragged at an angle; the comb harrow,

Figure 10. The hand tractor is useful in hauling products and people in farming villages

Figure 11. Local innovations like the turtle tiller [A] and riding attachments [B] are becoming common in some villages



which facilitates soil puddling in combination with wide steel cagewheels; and the trailer, which is a box-shaped platform fitted with surplus car wheels for hauling or transporting via roads.

In the 1980s, a manufacturer further adapted the kuliglig for deep, soft fields by putting a pontoon behind the transmission to come up with the turtle tiller, commonly called *pagong*. The pagong also became popular in Southern Philippines (Figure 11A). Recently, another manufacturer introduced riding attachments to the kuliglig for plowing, harrowing, and leveling (Figure 11B).

Palay harvesting

Manual reaping. In the 1900s, harvesting or cutting mature palay stalks in the field began in December and lasted until March in Central Luzon. There are several practices of harvesting rice. One is to cut off the rice heads of upland or bearded palay one by one or at most, three at a time, using a hand-held tool called *ani-ani* or *yatab*. The second most common method is to cut the straw midway above the ground with a sickle or serrated knife called *lingcao*. The knife is fastened at the back of a crooked tree branch and has a hook at the end for gathering the straw into a bunch (Figure 12). The hook is held in the right hand while the other hand holds onto the rice plant. The hook is then loosened and the straw cut with the knife and tied into bundles about 10–15 cm in diameter. The bundles are so uniform (each containing about 0.3 kg of threshed grain) they are sometimes used as a unit of measure. These are left scattered in the ground to dry and then piled into stacks on the dikes until the harvest is over.

Figure 12. Traditional harvesting using karet or kumpay

The lingcao was later replaced with the sickle called *lilik* or *karet*, a slightly hooked knife with serrations at the inside and fitted with a short, straight handle.

After cutting rice, the cut stalks are spread in the fields like mats to dry the grains. These are then gathered in heaps (*sipoks*), then hauled in carts to a well-drained place and piled as *mandalas*. In the 1950s, costs per hectare were ₱30 (or 1/5 or 1/4 of the yield) for contract harvesting (*pakiao*) by women and children; ₱8 for piling into sipoks; ₱5 for hauling and another ₱5 for mandalas; and finally 6 percent of the yield for threshing (Camus 1921).

Mechanical reapers. Toward the 1970s, both UP-Los Baños and IRRI actively tried out different harvesting designs. A significant achievement in mechanizing rice harvesting was when IRRI commercially released the reaper-windrower in the Philippines and Southeast Asia in the early 1980s. This reaper cuts rice stalks and lays them in neat windrows at one side, which will then be gathered by laborers after a few days of field drying prior to threshing (Figure 13).

Many small manufacturers started the reaper mass production in 1985 with IRRI's technical assistance (Stickney et al. 1985). Central Luzon farmers immediately adopted the reaper, which proved how receptive farmers and manufacturers were to mechanization of harvesting. However, problems such as poor durability/precision in manufacturing, poor after-sales service, and hired labor displacement stopped the local reaper adoption.

Figure 13. The IRRI reaper is faster and cheaper but its popularity was overtaken in the late 1980s with a lighter and durable model from Japan.

Meanwhile, a newly introduced Japanese reaper of similar design started to gain popularity. Although imported and more expensive, the model was more reliable and easier to handle especially in maneuvering headlands. The imported rice reaper continued to become popular in Central Luzon although adoption was slow mainly due to its high price.

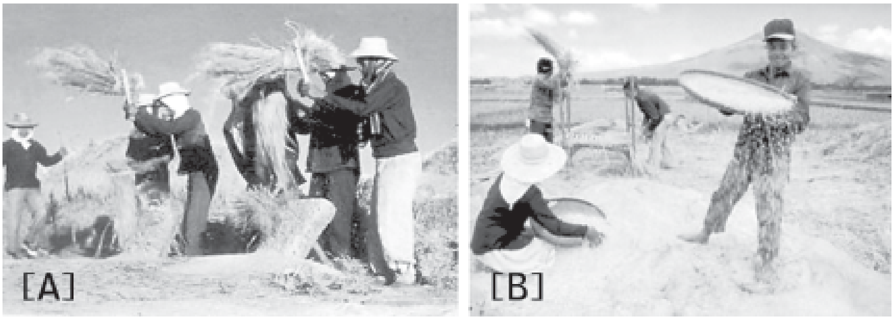
Overall, the sickle remains the dominant tool for harvesting rice nowadays.

Palay threshing

After harvesting, rice stalks with panicles are usually gathered and stacked high on dry ground for threshing. Threshing separates the palay grains from stalks and leafy materials. Small farmers normally thresh their traditional rice immediately after harvest, mostly by treading out the grain by foot, by using a team of carabaos, or by beating with flails against stones, hard wooden boards, or a bamboo stand (*hampasan*) (Figure 14).

With traditional treading, rice sheaves are spread on the hard earthen floor and the grain is trodden by four or five animals until almost all

Figure 14. The traditional hampasan for rice threshing made of stone and bamboo slats [A] and the traditional winnowing using bilao [B]



grains are threshed; any remaining grains left on the panicles are cleaned by hands or feet (Franco 1911). Winnowing to separate leaves and other impurities is done by the women using the *bilao*, a flat bamboo basket. Threshing is generally done by moonlight and becomes an important family activity. However, although threshing is a social occasion, many are all too eager to complete the operation as soon as possible because of its drudgery, the high labor required, and the long time needed to complete the process.

Before World War II, the Chinese and the Japanese introduced the foot-operated pedal rice threshers (Barber et al. 1985). The machine includes a bicycle chain and sprocket to transmit power from the human leg to the threshing drum. Formerly of wood with some metal parts, it is now made of steel frame and canvass to reduce weight and cost. Threshing efficiency was 98 percent and capacity was 120 kg/hour for two operators. However, the use of a pedal thresher, although widely used in some Asian countries, never spread in the Philippines since it offered no significant time and energy savings over hand threshing. Only in the Ilocos region, where the undamaged rice straw from the hold-on pedal thresher was useful on vegetables after rice, did locally made pedal threshers become popular.

The McCormick Deering thresher. In the 1920s, several hundreds of imported threshing machines were used by big farmers (*hacienderos*), mostly in Nueva Ecija, Bulacan, and Pangasinan (Camus 1921). These big threshers, locally known as *tilyadoras,* were the same McCormick threshers developed 50–70 years earlier in Europe and America. These were pulled by a 60-hp tractor or hauled by truck when moved from place to place and driven by the same tractor with long flat belts during threshing. Rice stalks were fed in sheaves on the elevator feeder of the machine, and rice grains came out in a separate outlet while stalks mixed with some grains were ejected out of a long spout at the back of the machine. McCormick threshers were sold in the Philippines at US$5,000. Later in the 1960s, exact copies of these threshers began to be manufactured locally.

Farmers would hire people to haul the harvest into dry ground and make big haystacks or *mandalas* of rice stalks. The mandalas were meant to minimize the movement of big tilyadoras in the field, to protect rice stalks kept in big mandalas from the rain, and to allow drying before threshing. Usually, a crew of 8 to 12 men operated these machines while a group of local women sifted through the straw to recover grain losses. About 20 to 30 tons of paddy could be threshed per day. Payment for work was in cash or as palay.

In major rice areas in the 1960s, the tilyadora started to replace foot or animal treading and hampasan since its use was considered of less cost to farmers. The tilyadora entailed an equivalent cost of 13 cavans for harvesting, stacking rice stalks, actual threshing as well as hauling of threshed paddy to the farmer's house using the truck used to haul the same tilyadora. With hampasan, 10 cavans were needed to pay for harvesting and threshing while prethreshing tasks (stacking and hauling) still required additional cost. However, the length of time from harvesting to threshing usually ranged from less than a week to three months (or an average of almost three weeks), depending on when the tilyadora could reach and service the area.

Small axial-flow rice threshers. In the late 1960s to early 1970s, HYVs with shorter duration allowed two cropping seasons in a year, and threshing operations became extremely time-bound, resulting in major labor peak. Farmers started to look for other threshing alternatives as the use of tilyadoras became impractical.

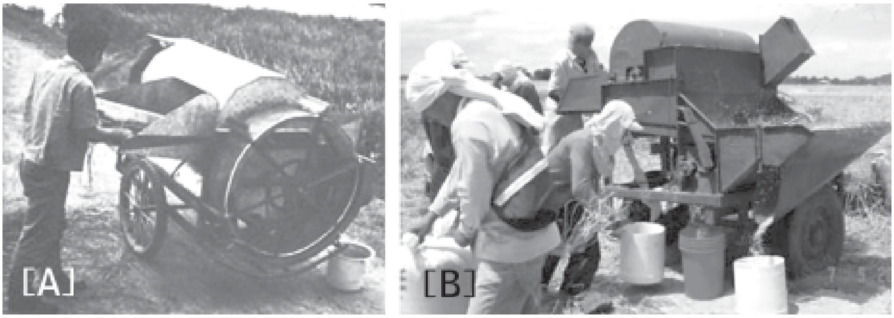
Because of the limitations of the bulky and big tilyadoras, IRRI in 1967 developed a smaller thresher suited to modern varieties. This thresher had to be low-cost, lightweight, fabricated locally, and more suited to small farmers' needs. Out of different alternative thresher concepts, a thresher that allowed operators to feed all of the stalks into the machine meant higher output than the type that required the operator to hold the stalk during threshing. Thus, the axial-flow principle was developed.

In this design, rice stalks are fed into a rotating drum housed in a chamber and equipped with peg teeth. Upon entry into the chamber at feed end, the stalks are hit by pegs against regularly spaced lateral bars around the rotating drum to separate the grains from the straw. The straw spirals a few times from the inlet to the outlet and ejects out and far from the machine. A fan underneath blows air to winnow the grain as it falls from the chamber. The grains are further cleaned by a rotary screen before they finally exit the machine. The thresher is mounted on small, narrow wheels for mobility and powered by a small gasoline engine (Khan 1971).

The axial-flow thresher was released in 1973, and local manufacturers further innovated the IRRI design for their commercial models (Figure 15). These modifications included the use of pneumatic car tires, spring-supported chassis, and a flat, oscillating screen beneath the threshing chamber prior to fan winnowing (Khan 1985). Provisions were also made to allow the thresher to be pulled by a carabao, hand tractor, or jeepney. Later, smaller models that could be carried manually by a group of men were introduced in Bicol and the Visayas (McMennamy and Policarpio 1977).

During the harvesting season, rice threshers with a crew of five to seven men, in addition to a group of women winnowers, are a common sight in rice fields. The thresher can thresh rice from a hectare of land in half a day to one day, depending on the thresher size. One or two of the crew members haul paddy stalks from a small haystack or *talumpok* next to the thresher; another member manually feeds the thresher, two attend to bagging while another recycles grains coming out of the screen for re-

Figure 15. The axial-flow thresher released by IRRI in the early 1970s [A] and a recent commercial model [B]



cleaning. Another person attends to bag closing and hauling of paddy bags into a hand tractor or a carabao-drawn cart. Custom fee is paid in kind at 6 percent to 8 percent of the paddy output.

By 1975, these mobile threshers have quickly spread in irrigated areas and became popular for contract operations. In 1982, 73 percent of the Central Luzon rice farmers were using them; by 1990, all other forms of threshing disappeared from the area (Pingali 1997). In some areas, however, the use of axial-flow threshers also changed the labor contract system, taking out the share of manual labor in favor of the machine (Juarez and Pathnopas 1981). Custom service operation allowed small farmers to benefit from the use of threshers and hand tractors.

The adoption of threshers also resulted in a decline in threshing labor requirements due to large gains in labor productivity: While foot threshing required eight labor days per ton of paddy, axial-flow threshers improved the time to one day per ton (Duff and Toquero 1975). In Nueva Ecija, Laguna, and Iloilo, postharvest labor in mechanized farms was around 25 percent lower than those in farms where rice was manually threshed (roughly 31 percent coming from landless households).

Threshers had considerably reduced the drudgery of postproduction tasks. They had made work lighter, making it possible for women and children to substitute men in the threshing operations. Where off-farm employment opportunities exist, thresher use could result in increased incomes for labor households since men may be released for heavier income-generation tasks while women and children could take on the threshing work.

It has been estimated that mechanical threshers reduce grain loss by 0.7 percent to 6 percent compared to manual threshing (Toquero and Duff 1984). However, the grains lost by the thresher are recovered by the winnowing women and used for household consumption or sold for outright cash.

Palay drying

Harvest time for traditional photoperiod-sensitive varieties used to fall at the end of the monsoon season (starting December). Any wet stalks were left in the fields for a few days or weeks to dry before being gathered for threshing. In those times, there was no need for drying since rice stalks in the mandalas had dried up by the time a tilyadora arrived.

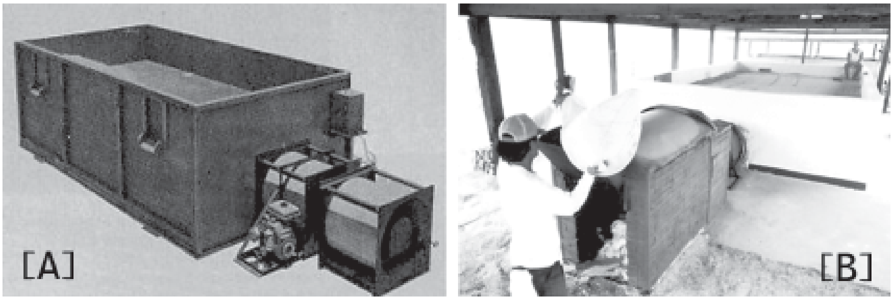
With the advent of HYVs in late 1960s, harvest of the first season crop began to coincide with the rainy months of August to September so that farmers could no longer dry harvested stalks in the field. Because of the high yields and large volume of paddy handled, farmers were forced to dry wet grains at any available pavement, including roads and highways (Figure 16). During the 1970s, the Philippines was considered to have the longest dryer in the world, since the roads from Bulacan to Cagayan were used heavily as drying pavements during the wet-season harvest.

Sun drying, although the cheapest and most practical among the drying methods, resulted in losses and poor grain quality and was not always possible during the rainy season. To discourage sun drying on roads, the government in the 1990s offered pavement dryers that were also used as basketball courts or dancing halls during festivals.

Mechanical dryers. The earliest mechanical dryer introduced in the Philippines was the UP-Los Baños box-type flatbed dryer in the 1970s (Figure 17). Air, heated by a kerosene burner at 40°C to 60°C, was blown by a truck radiator fan through the mass of wet grain placed above a perforated flooring and absorbed moisture from the wet grains as it evaporated into the atmosphere (Catambay et al. 1960). Cardino (1985)

Figure 16. Drying of wet palay on the highways and pavements is common but also results in accidents and losses

Figure 17. Flatbed dryer innovations from UP-Los Baños in the 1970s [A] and from Vietnam in the 1990s [B]



mentioned that although the technology was very simple, farmers did not adopt the flatbed dryer widely because of the unit's small capacity, high operational cost (for kerosene fuel), limited use when the climate was not favorable for sun drying, as well as other socioeconomic constraints. In the 1980s, Vietnamese engineers scaled up the model with their own flatbed dryer heated by rice hull furnaces. PhilRice successfully adapted the model and introduced its 6-ton version for cooperative- and village-custom drying of palay, corn, and other crops.

Modern dryers. The earliest design of a high-capacity dryer in the country in the 1900s was the LSU continuous-flow multipass system with tempering periods from the United States. This was later produced locally for government warehouses and some big millers. Presently, a more popular design is the batch recirculating dryers imported from Taiwan, Japan, and Korea, although their construction was not rugged enough for the operating conditions of most millers and traders. The Bureau of Postharvest Research and Extension also developed a small, mobile predryer called flash dryer to predry paddy to 18 percent moisture content and to go with in-store bins following the in-store principle of deep bin dryers from Australia. However, farmers quickly rejected the flash dryer because of its incomplete drying ability and high kerosene cost while millers preferred those with shorter drying periods.

Recently, government agencies collaborated through the Philippine Rice Postharvest Consortium (PRPC) to develop a batch recirculating dryer that can be locally manufactured but would incur lower dryer cost than its imported counterparts. The resulting PRPC dryer was expected to suit more the operating and local paddy conditions in the Philippines.

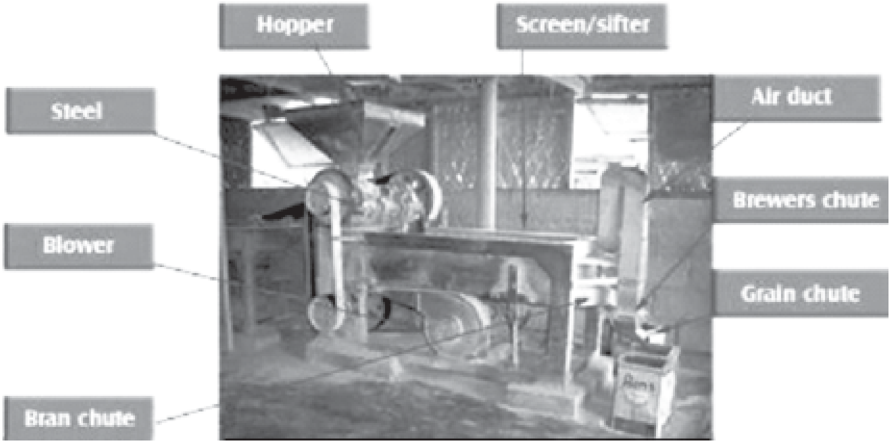
Rice milling

The rice grain is covered by a hard rough coating called hull or husk that must be removed by milling. Traditional milling was accomplished in the 1900s by pounding the palay with a wooden pestle in a stone or wooden mortar called *lusong (*Figure 18). The first pounding takes off the hull and further pounding removes the bran but also breaks most grains. Further winnowing with a bamboo tray (*bilao*) separates the hull from the rice grains. This traditional hand-pounding chore, although very laborious and resulted in a lot of broken rice, required two to three skilled men and women to work harmoniously and was actually a form of socializing among young folks in the villages.

Kiskisan. In the 1920s, rice mills along railroad stations started to become a common sight in rice provinces. Some were water-powered mills, normally found in Cavite, Laguna, and Tayabas, and charged 20 to 50 centavos for each cavan of milled rice or retained the by-product (*darak*) as payment. This rice mill was the Engelberg huller, popularly known as *kiskisan,* which utilized a one-step process of rice milling (Figure 19). The husks and bran layers were removed as grains rubbed against each other inside the chamber. The bran, useful as animal feed, was mixed with crushed hull and broken grains and exited from a screen below the milling rotor while milled rice came out at the other end for further sifting. Because of the large percentage

Figure 18. Manual pounding using mortar and mazo with bilao for winnowing

Figure 19. The village kiskisan provided milling services in the villages

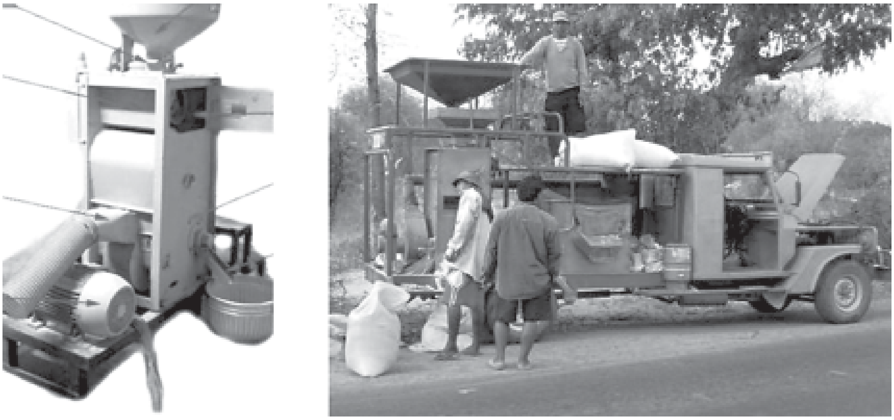


of broken grain, the total milled rice recovery from kiskisan was low (from 50% to less than 60% out of the potential 70%). This poor performance led the government in the early 1970s to discourage its use and further proliferation, which proved an advantage to more modern milling facilities that were introduced as the kiskisan's replacements.The kiskisan served its purpose for a long time until its use was discouraged by the government due to its low recovery.

A second mill type used by commercial millers in the 1970s had a disc sheller, giving it the name *cono* mill. It milled in two stages: The first was to remove the husk to produce brown rice through one or more sheller units of two metal discs coated with an abrasive material; and the second was to whiten or polish the brown rice through a cone polisher. Compared with the kiskisan, cono mills had larger capacities, higher milling recoveries, and high percentage of whole head rice. However, villagers still preferred the kiskisan because these could mill small quantities and were more accessible.

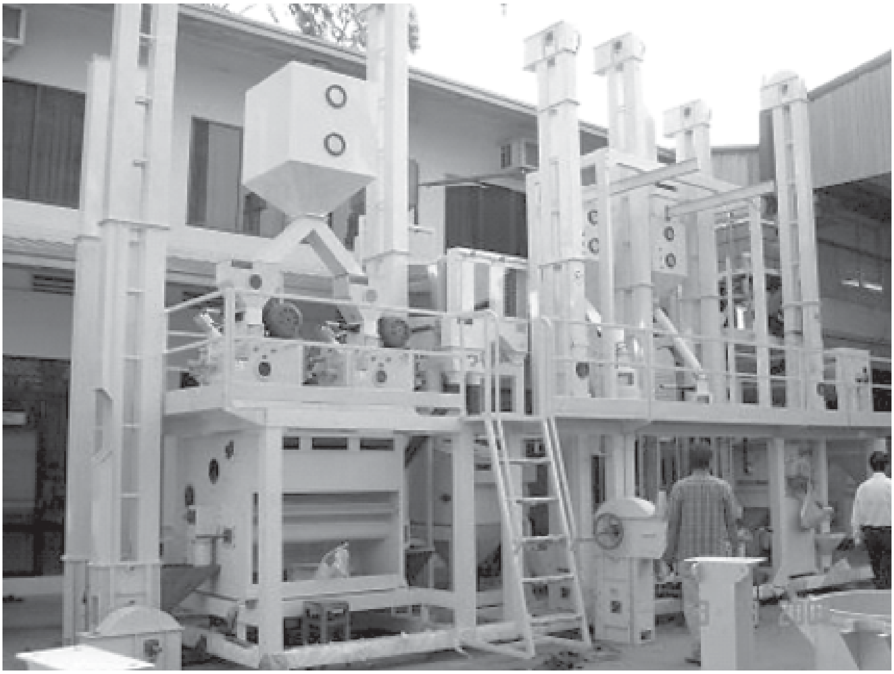
Modern rice mills. Japanese engineers developed a small two-stage rice mill called rubber-roll rice mill (also known locally as *baby cono* or mini *cono*) (Figure 20). Starting in the 1970s, this compact rice mill eventually replaced the kiskisan in providing milling services to rural areas. Its milling and whole grain recoveries are better than the kiskisan (above 60%). In addition to village mills that are permanently installed in

Figure 20. Single-pass rubber-roll rice mills as stationary units in village/town centers



These can also be mounted behind locally assembled jeeps to provide milling services in the villages.

Figure 21. Modern rice mill systems employ multiple passes of grains



village or town centers, these custom mills are also found mounted behind jeeps or small trucks that service villagers.

Big rice millers now adopt multiple milling units to improve milling and whole grain recoveries (Figure 21). These units separate the processes of dehulling or dehusking (i.e., taking off the hulls from the paddy grains), whitening (removing the bran layer from a dehusked grain), polishing (to give the grains a polish attractive to consumers), and separating broken grains from whole grains. In larger mills, the husked grains called brown rice are further stored temporarily in tempering bins to “rest” the grains before these are whitened and polished with spray water mists to produce glossy, whole grains. These technological improvements were developed abroad although local manufacturers were fairly successful in producing local versions.

7 Future Challenges

Improving farm productivity with increased yield while enhancing profitability by reducing input and labor costs remains as every Filipino farmer's twin goals. These goals will continue to challenge rice scientists and farmers to develop and innovate on the present rice production practices and technologies.

There is a growing concern over the decreasing availability of irrigation water in rice fields. The service areas of the irrigation dams set up during the Green Revolution of the 1960s to 1980s are becoming limited, forcing farmers to increasingly resort to shallow tube well pumps and small farm reservoirs. While plant breeders are still trying to develop drought-resistant varieties and agronomists are looking for methods to propagate these new cultivars, farmers will continue to share on whatever water is available in the farm.

Soil fertility is also becoming depleted in intensively cultivated rice areas. Because of the high costs of inorganic fertilizers, there is now a resurgence of organic fertilizer use in rice fields. As chemical fertilizers continue to become costly, farmers will resort to whatever sources of nutrients are already available in the farm. Agronomists, on one hand, will continue to seek and develop alternative means to improve fertilizer use efficiency so as to reduce the consumption of fertilizers and chemical inputs without adversely reducing yields. For instance, the Rice Check system, which aims to optimize the different operations in rice production so as to achieve the target yield without increasing costs, will become popular for many years to come.

The IPM, on one hand, is already successful. Many farmers now realize that the judicious use of chemicals is just one alternative toward a successful pest control system in the rice field. Biodiversity in the rice field is now contributing to a healthier and balanced ecosystem in the field, allowing farmers' families to reap more stable yields. Over the long term, however, the challenge will be how to avoid chemicals completely through better synchronous planting, biotechnology, and other IPM approaches.

Farmers will continue to seek ways to decrease the amount and costs of labor in rice production. Direct seeding, a labor-saving method, will be further refined with seed-saving ways such as practicing row seeding, using less herbicide, applying better land preparation techniques, and resorting to HYVs especially suited for wet seeding. Because direct-seeded rice already reduces growth duration by several days, there is a high potential to increase crop intensities in favorable areas if a shorter-duration variety is further developed.

Small-equipment mechanization will continue to be popular. Aside from machines meant for land preparation and threshing, those for harvesting (with small combines) are expected to grow. There will be heavy emphasis on equipment that increases farmer's convenience such as ride-on tillage attachments. The challenge for engineers and manufacturers is to continue to innovate on cheap but reliable equipment that bring about improved convenience, additional income, and grain loss recovery from harvesting up to drying.

The demand for global competitiveness among neighboring Asian farmers will continue to drive the Filipino farmer to produce more rice at lower cost and less labor. Research institutions such as PhilRice, IRRI, and other partners will continue to play critical roles toward the achievement of Filipino rice farmers' goals.

8 Summary and Conclusions

Major practices in rice production over the last 100 years essentially evolved out of the changes in the varieties introduced and planted by Filipino farmers, which subsequently changed the manner production and postharvest operations had to be done. Varieties were introduced in three major periods: the pre-Green Revolution era, which was dominated mainly by improved traditional varieties planted once a year only; the Green Revolution period of 1966 to 1988, which was characterized by the diffusion of modern HYVs that could be planted twice a year; and the post-Green Revolution period from 1989 to the present times. As varieties changed over time, farmers' practices also changed to attain the end-goals of higher productivity, greater efficiency, and recently, environmental sustainability.

From preparing the rice plots to rice milling, operations focused on greater efficiency and higher productivity. Although the early years were characterized by a single rice crop pattern per year and field operations were not necessarily done efficiently, farmers were already looking for better alternative methods to conduct field tasks that were done either manually or with the use of carabaos. Much of these practices were romanticized mainly because the social life of farmers and their communities revolved around the conduct of these tasks. There were fewer inputs needed as yield from the traditional cultivars was limited by the plant itself; labor productivity, time, as well as efficiency were of less concern compared to the drudgery in the conduct of manual tasks.

The period that saw the diffusion of short-statured, nonphotoperiod sensitive and early-maturing HYVs; and availability of irrigation water from newly constructed irrigation systems, was far different from the period of traditional varieties. Demands for efficiency and time became of greater importance to attain the high yield potential of these modern varieties. Tasks that were not given much attention earlier such as fertilizer management, chemical control, threshing, and drying suddenly turned relevant to small farmers who found themselves tillers and managers of their own land due to the newly passed land reform law. Techniques and equipment to accomplish these tasks were developed or improved upon. Research on land preparation, planting, fertilizer management, pest management, harvesting and threshing, as well as drying and milling were actively pursued and promoted although farmers were selective in adopting these new breakthroughs. The IRRI led the development of these varieties, management practices, and machinery to answer the needs of farmers at that time.

After the Green Revolution, concerns on costs and productivity, including sustainability, continued to hound Filipino farmers. While neighboring farmers in Southeast Asia adopted modern practices and big machinery to attain economies of scale, Filipino farmers continued to favor technologies that were efficient, inexpensive, and with high potential for income generation. The Green Revolution technologies continued to be practiced while some crop care measures such as the integrated pest and nutrient management were further refined. Practices that were previously used to efficiently manage the decreasing amount of water became relevant again. Direct seeding, a practice that was brought about by the early-maturing varieties and the development of herbicides, also continued to be increasingly popular in irrigated areas because these methods incurred less costs to farmers. Government programs also pursued the use of high quality seeds and hybrid rice cultivars from the public and private sectors as a means to seek the ideal rice self-sufficiency levels.

Rice production practices are expected to continue to evolve to the changing challenges and needs of the times—when both Filipino scientists and rice farmers come up with innovations that would pursue rice self-sufficiency and global competitiveness in farming. Direct seeding, mechanization, and integrated nutrient and pest management will continue to be refined and practiced on a wider scale. As new high-yielding inbred and hybrid varieties that cater to new environments and conditions are developed and introduced, farmers will continue to adapt improved methods and maximize the benefits from producing such crops. Research institutions such as PhilRice, IRRI, and other research institutions will continue to lead these innovations.

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