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A Century of Rice Innovations

Saturnina C. Halos

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For comments, suggestions or further inquiries please contact:
The Research Information Staff, Philippine Institute for Development Studies
3rd Floor, NEDA sa Makati Building, 106 Amorsolo Street, Legaspi Village, Makati City, Philippines
Tel Nos: 8924059 and 8935705; Fax No: 8939589; E-mail: publications@pidsnet.pids.gov.ph
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Saturnina C. Halos, PhD Chair, Department of Agriculture Biotechnology Advisory Team and Executive Vice President, Arnichem Corporation

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Saturnina C. Halos, PhD Chair, Department of Agriculture Biotechnology Advisory Team & Executive Vice President, Arnichem Corporation

ABSTRACT

Rice innovations are technologies and practices extensively adopted so as to change production practices and productivity. This paper documents the changes in rice productivity, policy and institutions in the last 100 years and identifies the technological change that may have affected rice productivity. One hundred years has totally changed rice production practices and improved productivity. Technical innovations that helped improved rice productivity include irrigation, pest management notably, the management of locust outbreaks, fertilization, modern varieties, farm mechanization, improved rice milling and crop rotation. Irrigation increased productivity and the total annual area planted to rice. More technologies associated with irrigated lowland rice cropping were developed and disseminated subsequently rice productivity in irrigated areas is higher than in other areas.

The rice innovation system comprised of technology developers, innovators or promoters of technologies and their delivery systems. Technology developers include public institutions like BA/BPI, UPCA/UPLB, IRRI, PhilRice, other SUCs as well as agri-input companies. NGOs are recent technology developers as well as innovators. The major innovator is the government, the Department of Agriculture with its rice programs. Of its various rice programs, the Masagana 99 Program revolutionized rice production with its legacy of farmers receptive to technological change.

Rice productivity slowly rose from 0.832 MT/ha in 1903 to 3.28 MT/ha in 2002, this latter represents only half of possible maximum yield. This slow rate of productivity increase is due mainly to slow adoption of new technologies rather than lack of new technologies. Of the critical technologies contributory to yield, only the use of modern varieties is extensively adopted whereas irrigation, fertilization and pest management practices are yet to be extensively applied. Further improvements in the government rice program, in the extension system and new technology designs are needed to improve technology adoption. Technology developers should include in the design of technology its acceptability and its delivery strategy to rice farmers. Other considerations in technology design should include global warming, decreasing water supply, and environmental protection. Needless to say, investments in RDE must be increased and improvements in the R & D climate to retain rice scientists versed in new methodologies in the country must be made.

Keywords: rice, innovation, productivity, innovation system, rice policy

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SUMMARY

Innovation is inventiveness put to use- Evans, 2004

Innovation from the evolutionary standpoint is the ability to improvise, to experiment, to change – to radically question what is familiar and to look at things in a new light… In turn, history teaches us that societies often resisted precisely the innovations (and often enough the innovators) that later formed the basis of a better future - Hintereder, 2004

-the essential quality of an innovator lies less in the cortex than in the epidermis – Evans, 2004

Innovations in society are the products of new ideas, technologies and policies. To study the interaction of these factors, this paper documents the changes in rice production, policy and institutions in the last 100 years. This paper is based on a review and analysis of publications on rice statistics, policies and scientific reports from 1903 – 2002. This paper has five parts. The first part describes rice culture at the start of the 20th century. The second part describe the innovations related to the broad changes in rice production: the expansion of the rice area and increases in rice productivity. The expansion of the rice area is discussed in relation to policies, the social milieu and the technology involved. The third part discusses the innovations that brought about increases in rice productivity including the role of institutions. The fourth part discusses the rice innovation system and the last part discusses the future in rice innovations.

There are five types of rice culture at the start of the century: clearing or *caingin,* upland or *secano,* "sabog" or broadcast method, lowland, paddy rice, transplanted or Chinese rice culture and the Ifugao rice terrace culture. Whatever it is rice culture was laborious. Rice varieties are tall, poor yielders, many sensitive to daylength and susceptible to lodging. No fertilizer is applied except some seedbeds may be applied with manure. Manuring is practiced in the rice terraces. No after transplanting care is practiced except for the Ifugao rice culture where weeding and pest management is practiced. There was limited irrigated areas where a second crop of rice, "palagad" is planted. Productivity is low at 0.832 MT/ha in 1903.

The area harvested for rice expanded from ~0.6 Million has in 1903 to 4.0 Million has in 2002. Two periods of rapid expansion has occurred, one at the start of the century from 1903 – 1909 – the area harvested increased by more than 500,000 has within 6 years and between 1952-58 when another increase of 500,000 has occurred. These two periods were preceded by wars. Hence, these rapid expansions could be due to bringing back into production previously cultivated lands made idle by the wars. Expansion after these periods resumed at a slow pace and by 1970's, the physical area devoted to rice has remained stagnant. All increases in area harvested to rice can be attributed to the second cropping in irrigated areas. With an expanded

role and resources of the National Irrigation Administration, rapid expansion of irrigation occurred after this period.

Rice productivity also rose within the last 100 years from 0.832 MT/ha in 1903. Several innovations contributed to this: irrigation, effective pest management practices notable is the management of locust outbreaks, fertilization, use of modern varieties, limited farm mechanization, improved rice milling and crop rotation all helped improved rice productivity.

The innovation system comprise of technology developers, innovators and their delivery system. Technology developers include public institutions like BA/BPI, UPLCA/UPLB, IRRI, PhilRice, other SUCs as well as from the private sector e.g. agri-input companies. MASIPAG and its network of NGOs are recent technology developers as well as innovators. Innovators are agencies and individuals that bring technologies into use and ideas into practice by the rice industry. Agri-input companies are innovators. But the biggest innovator is the government, the Department of Agriculture with its rice programs and the National Irrigation Administration with its irrigation projects.

Introduction

What is innovation? Innovation is not simply invention, something to be measured by the number of patents or shrieks of "Eureka" in the lonely lab. Innovation is inventiveness put to use (Evans, 2004). Innovation from the evolutionary standpoint is the ability to improvise, to experiment, to change – to radically question what is familiar and to look at things in a new light… In turn, history teaches us that societies often resisted precisely the innovations (and often enough the innovators) that later formed the basis of a better future (Hintereder, 2004). Innovations have the capacity to transform society as genetic engineering is doing today. Genetic engineering not only is producing novel products we could not even imagine 50 years ago, changing production systems in pharmaceutical production, in industrial processing and in agriculture but it has also raised questions about how we define life or about why we accept certain foods as safe.

Innovation always starts out with a new idea or concept. The idea or concept may lead to understanding a natural phenomenon or solve a particular problem. A solution to a problem may be an invention. A new variety of rice designed to solve the problem of lodging is an invention. Until this variety has been adopted by rice farmers in a massive scale so that yields have increased because the losses from lodging has been avoided then it is not yet considered an innovation. Thus for an invention to effect a change, it must be delivered to its users. In rice, the delivery system depends upon the source of the new idea or technology. If the idea or invention comes from a public institution, the government plays a key role in bringing the idea or invention to be able to affect rice production or productivity. If the technology developer is a private individual or a corporation, the technology is brought into the market as a commercial product or process which should lead to improvements.

Innovations in society are the products of new ideas, technologies and policies. To show the interaction of these factors, this paper documents the changes in rice production, policy and institutions in the last 100 years. This paper is based on a review and analysis of publications on rice statistics, policies and scientific reports from 1903 – 2002. This paper has five parts. The first part describes rice culture at the start of the 20th century. Innovations are related to the broad changes in rice production: the expansion of the rice area and increases in rice productivity. The expansion of the rice area is discussed in the second part in relation to policies, the social milieu and the technology involved. The third part discusses the innovations that brought about increases in rice productivity including the role of institutions. The fourth part discusses the rice innovation system and the last part discusses the future in rice innovations.

Rice culture at the start of the Century

The Bureau of Agriculture upon its establishment in Oct 8 1901 has one of its functions to study the methods of cultivation then in practice. It has recognized four types of rice culture (Copeland, 1926): clearing or *caingin,* upland or *secano,* "sabog" or broadcast method, lowland, and paddy rice, transplanted or Chinese rice culture. A fifth type should be added, the Ifugao rice terrace culture as it has been existing in the past 3,000 years. Typically these systems except the Ifugao rice culture system did not fertilize, weed or manage pest until the population has reached a highly damaging population of such pest like locusts and rats. Most rice lands were rainfed both lowland and upland and there was a limited irrigated area. A second crop of rice known as "palagad" is sometimes grown in irrigated areas. Farming was dependent on manual labor from dike-building, land preparation, broadcasting, transplanting, harvesting, winnowing to milling. In the caingin, rice seeds are planted directly on holes made by pointed sticks. The carabao is used in all farms except in the caingin to draw the plow and the harrow during land preparation and to pull the cart to transport the harvest and people. Harvesting is by hand cutting with a blade called "yatab" (rakem-Ilocano) of individual panicles especially caingin-grown rice or by a sickle cutting armful of palay. Rice harvested by sickle is threshed by trampling the rice with the feet or by the carabao, or by bashing the rice against a box-like contraption made out of sacks. Rice harvested by yatab is pound with a wooden pestle to remove the grain from the panicles. Milling is generally by mortar and pestle except in a few areas where rice mills are found. Planting, harvesting, threshing are often community affairs that may be accompanied by music. Labor exchange is common. However, in cases when payment is made planting/harvesting/threshing are linked. The privilege to harvest is given to those who planted and are paid a portion of the harvest. The Ifugao rice terraces considered the Eighth Wonder of the Ancient World are fully irrigated by a sophisticated system of canal networks and permanent dikes with water drawn from upstream. The fields are manured, weeded and periodically visited. The community adopts a land-use pattern that designates forest preserves and camote areas vis-à-vis the rice terraces (Beyer, 1980). Like the rest of rice culture, everything is manual. But unlike the others, rice culture in the Ifugao is steeped in religion and culture (Brisket-Smith 1952).

Expansion of the rice area

A major change in the last 100 years is the expansion of the rice area. Within 100 years, the area harvested for rice expanded from 0.6 Million hectares in 1903 to 4.0 Million hectares in 2002 (Fig 1). Before World War II, this change is brought about mainly with the clearing of forest land for farms and settlements, an activity encouraged by the American regime as it promoted agriculture for the production of export crops.

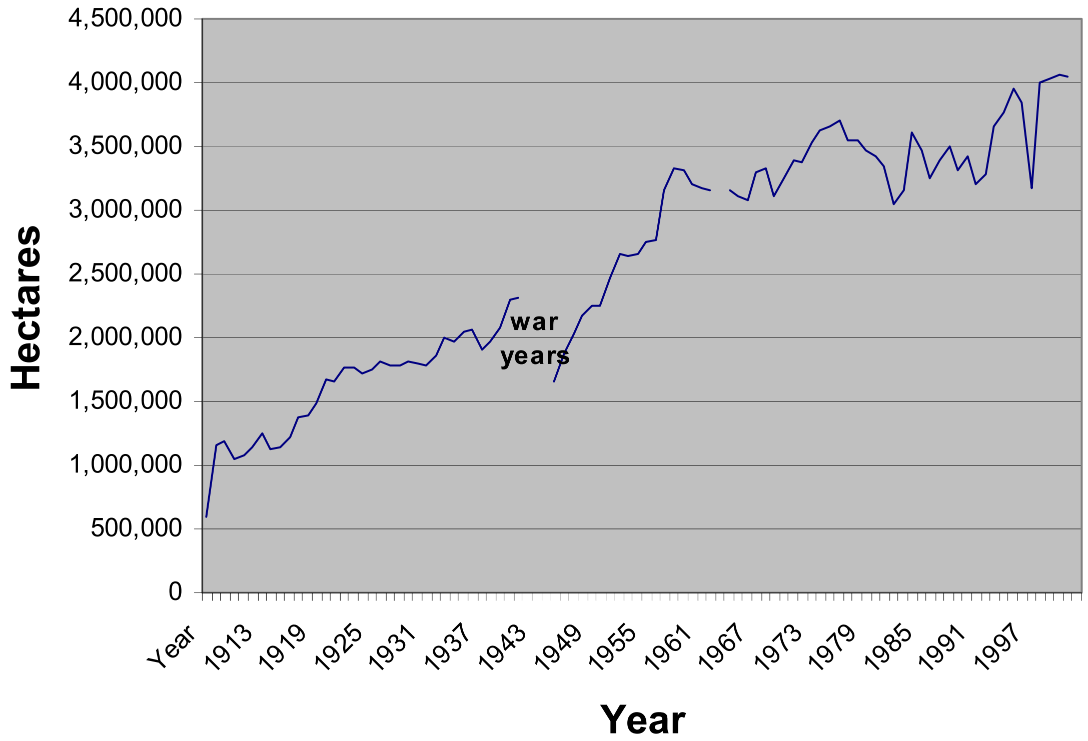

Fig 1. The expansion of area harvested for rice in the last 100 years

Fig 2 summarizes the expansion in areas harvested for rice in banner years when area increases showed 500,000 has increments from the previous banner year. The rapid expansion of rice land from ~ 0.6 M has in 1903 to ~1.2 Million has in 1909, a 100% increase in area in only 6 years could be attributed to bringing back into production some 345,000 has previously cultivated but made idle by the Filipino-American Wars from 1986-1903 (Corpuz, 1997) and the clearing of additional land for agriculture.

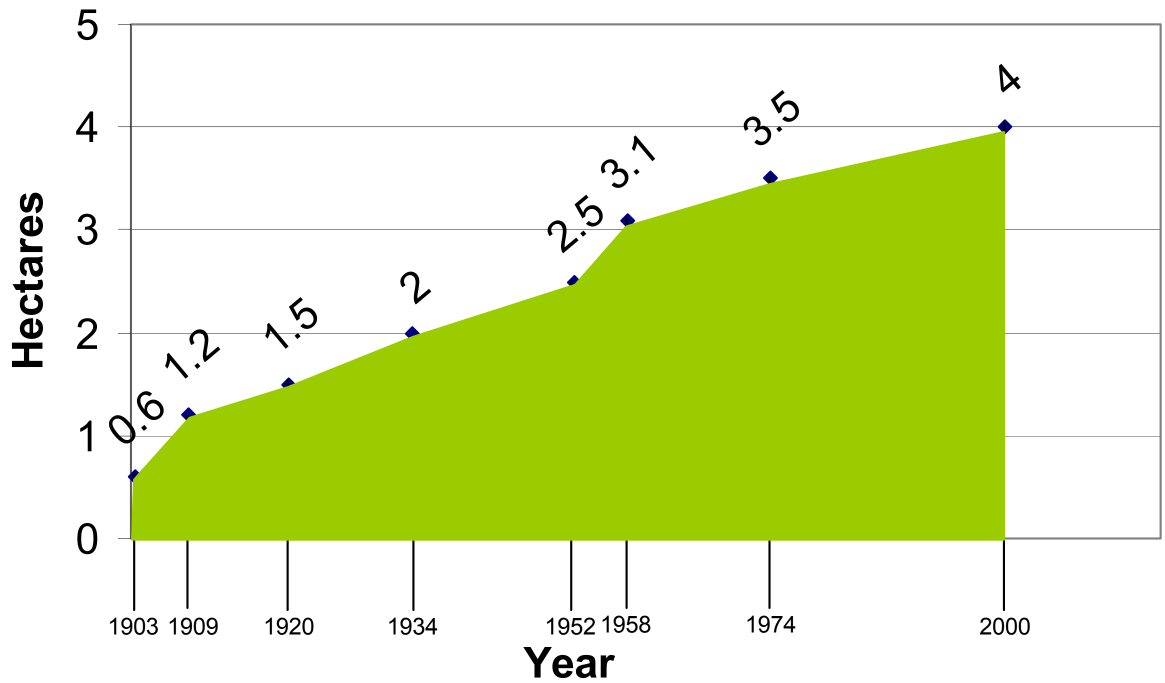

Fig 2 The banner years of increasing areas harvested for rice

The US occupation government in Manila or the "insular government" as it was called has for its principal economic policy to expand American trade in the Philippines (Corpuz 1997). The strategy was to make the Philippines a market for US exports and a source of cheap raw materials for US industry. In agriculture, this meant that any government support was focused on the export crops: sugarcane, coconut, abaca and tobacco. Hence, rice land was converted to export crop: tobacco, sugarcane, coconut, abaca production. This practice of converting rice areas into export crop production would then explain the slow expansion in rice areas after 1909 and before World War II. It took 11 years to expand the rice lands from ~1.2 Million has in 1909 to ~1.5 Million has in 1920 and 14 years to again expand from ~1.5 Million has to ~2.0 Million has in 1934. A change in policy in rice production appears to have occurred in 1929 when a special Rice and Corn Fund was established and rice self sufficiency became a goal. The Fund appropriated loans to Agricultural Credit Cooperative Associations to encourage and stimulate the cultivation of new rice and corn lands and to purchase cattle and farm implements. The War could explain the slow rate of expansion of 18 years from ~2.0 Million has in 1934 to 2.5 Million has in 1952.

Another rapid expansion is seen between 1952 and 1958 when it took only 6 years to attain another 500,00 has expansion. This could also be due to bringing back into production land idled by the War. More than 5 Million hectares have been planted to crops in 1940 but only about 3 Million were planted in 1946 (Merino, 1952). The opening of Mindanao, Palawan, Mindoro and Cagayan Valley for settlement, the building of national irrigation systems and the start of commercial logging may have also added to this rapid expansion. After 1958, the expansion of land area resumed its slow pace. Most likely, majority of lowland areas suitable for lowland rice have already been settled and the expansion is due to double cropping. Between 1958 and 1974, the irrigated areas have significantly expanded and early maturing, photoperiod insensitive varieties have been developed and disseminated. These technological breakthroughs expanded the areas that can support rice production twice a year.

Fig 3 supports this contention as it shows that based on the wet cropping season, the largest area planted to rice is only about 2.5 Million has from 1970 to 2002. The wet cropping season allows for all areas suitable be planted with rice because water is then available. The maximum land area devoted to rice in the country is about 2.5 Million hectares. As of 2002, 66.9 % of these are irrigated. Apparently, all of the irrigated area is tilled for a second crop which would explain the total area harvested of about 4.1 Million has in 2002. Essentially, the land area devoted to rice has remained constant at less than 2.5 Million hectares since the 70's and that expansion in area harvested is attained through second cropping in irrigated areas.

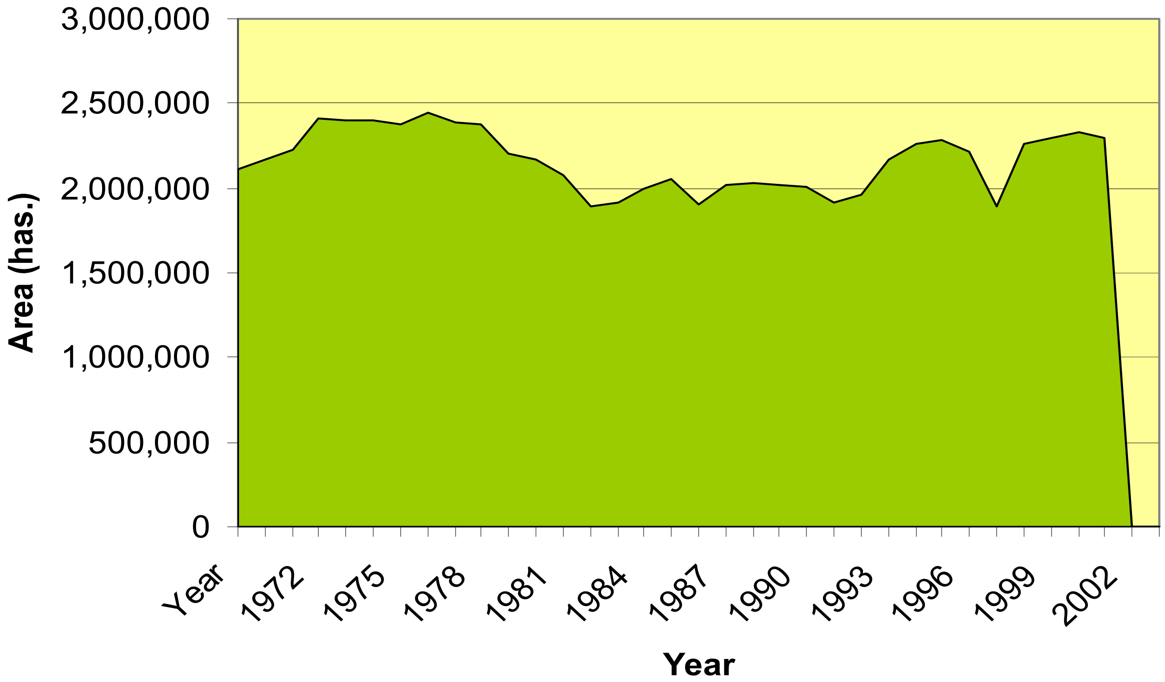

Fig 3 The total land area cultivated for rice during the wet season cropping.

The expansion of irrigated areas

State construction of irrigation systems began during colonial Spanish rule in 1840 and continued under the American regime. About 30,000 has was irrigated during the Spanish regime. The Irrigation Act, Act 2152, authorized the construction of irrigation facilities throughout the country with a target of about 100,000 has (Camus, 1929). Since 72% of rice production was in lowland areas, irrigation was to promote second cropping of rice in these lowland areas. Irrigation and varietal selection were expected to improve rice production. Construction was limited to ~ 50,000 has in 1912 and the system was by gravity diversion. Pump irrigation was introduced in 1915 (Merino, 1952). Research of the Bureau of Plant industry showing the increased yields with pump irrigation led to the establishment of the Pump Irrigation Administration. The building of national irrigation systems with large and multifunctional dams is carried out by the Irrigation Projects of the Bureau of Public Works with assistance from the Mutual Security Agency (now USAID) of the USA. The National Irrigation Administration (NIA) was established in 1964 as a part of the nation's goal of achieving national self-sufficiency in rice production. Hence, the expansion of irrigated areas dramatically rose since 1964 (Fig 4). Three modes of irrigation systems are in place pump, communal and national system servicing a total of about 1.4 Million hectares.

In 1974, NIA embarked on an ambitious program to reach the minimum and normal rice requirement of the nation through irrigation alone (Raby 2000). The expansion of irrigation service areas together with the advent of more early maturing varieties has resulted in a more widespread practice of second cropping, thereby expanding the area harvested for rice.

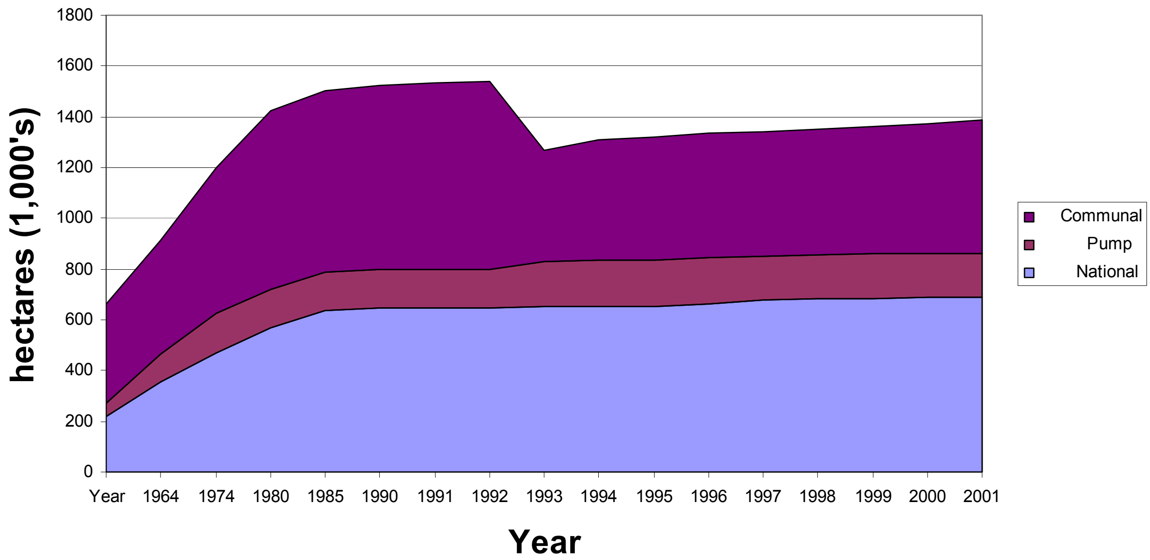

Fig 4. The expansion of irrigated areas

Rice productivity, policy and technological innovations

Rice productivity or yield per hectare has also increased albeit very slowly from 0.832 in 1903 to 3.275 in 2002 (Fig 5). The annual change is not consistent and there are years when harvests are lower than the previous years. These decreases in productivity could be attributed to locusts, rats and other pest epidemics and natural calamities such as floods, drought or El Niño. For example, the decrease in productivity in 1915 could be due to the drought that occurred that year (Mendiola 1926). Locust outbreak cycles occurred in 1919 - 1926; 1932 – 1939 and in 1941-1949 (BPI,1980). The 1971-72 drop in productivity has been attributed to drought and tungro infection (Chandler, 1979).

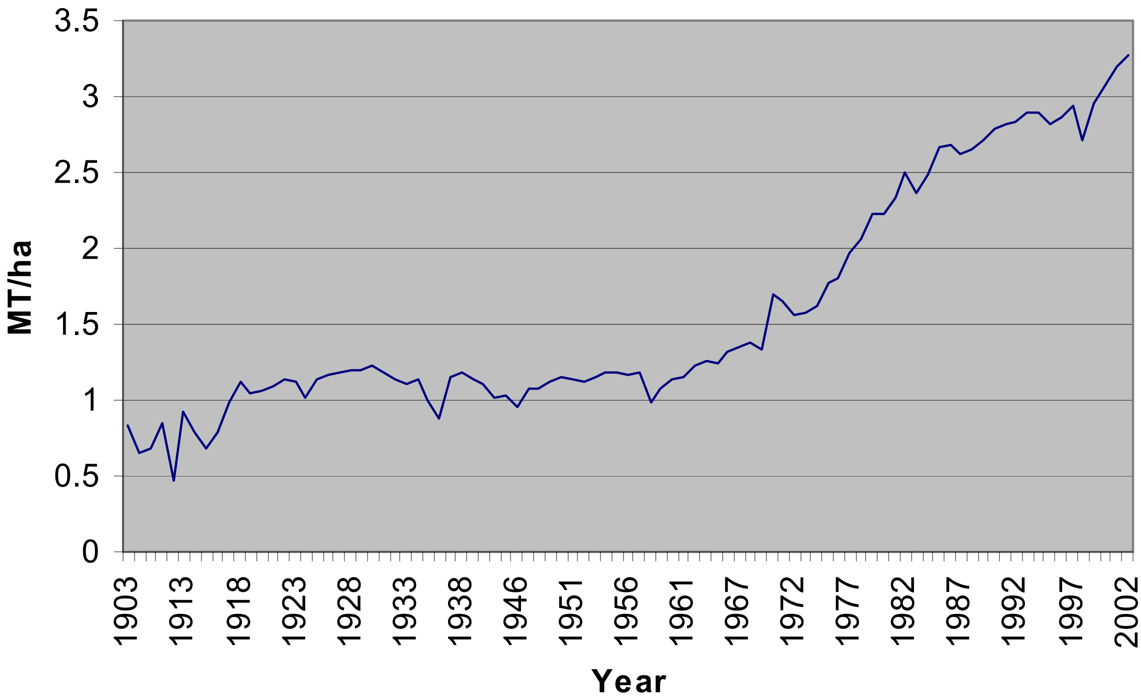

Fig 5. The average annual yields of rice in the last 100 years

The low productivity of 0.832 MT/ha at the start of the century is due to the level of rice production technology as well as planting of innately low yielding varieties susceptible to lodging during typhoons and monsoon rains. A look at average changes in productivity in 10 year increments (Fig 6) shows that the years before the War has not seen a consistent increase in productivity. Net decreases are evident at the start of the century and the decade prior to the War. However, after the War there has been a steady but slow increase in net productivity. Technological breakthroughs and new policy initiatives may explain the consistent net increase in productivity after the War.

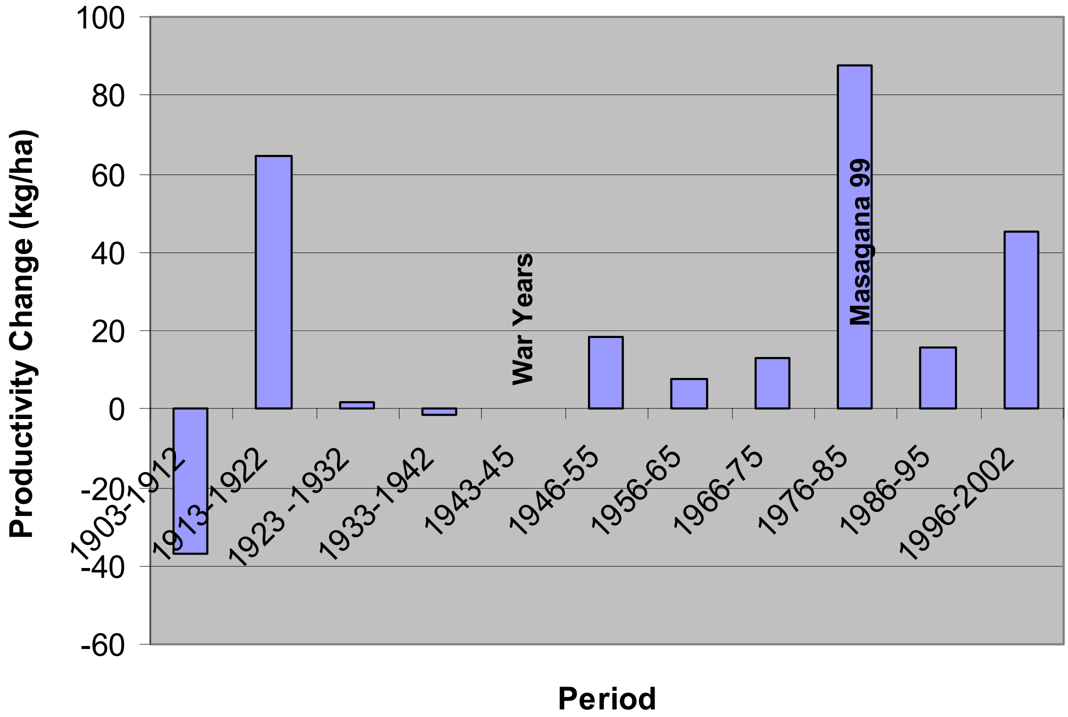

Fig 6. Net annual changes in rice productivity for 10 year periods

During the American regime, rice was the major crop in terms of value, hectarage and labor engagement. Yet, the major rice policy was to keep the prices artificially low through annual rice imports until 1935. The government entered the rice market to prevent dealers from charging exorbitant prices and to ensure sufficient supply in case traders failed to import on time. Not much effort was expended to study closely methods to increase local rice production. The major research effort at the time was first to characterize existing production practices and monitor production. Productivity-enhancing activities include the introduction of new varieties and in 1928, the Bureau of Agriculture started the breeding of Raminad Strain 3 (Quezon), the first variety developed from hybridization and released by the Bureau of Plant Industry in 1937 (BPI, 1980). Technologies that improved productivity were disseminated and entrenched after Filipinos took over their own government. In 1935, the Commonwealth government adopted a policy of self-sufficiency for crops that can be grown locally (Merino, 1952). Apparently, this includes self-sufficiency in rice. This policy was retained during the Japanese occupation but also included the production of two export crops: Virginia tobacco and cotton.

Further technological and policy changes occurred after the War that must have promoted the increases in productivity and each of these are discussed below. Note that the highest net productivity increase in seen in the period 1976-1985, years after the start of the Masagana 99. Masagana 99 actually started in 1973. It is the first extensive rice production program that addressed the problems of the rice farmer: access to improved technology, credit, price and high cost of fertilizers. It has four elements: credit, training and supervision for the adoption of the new package of technology, price support for rice and provision of low cost fertilizer (Chandler, 1979). The package of technology is basically adapted to irrigated rice culture.

Irrigation

Apparently, irrigation not only expanded the rice production area but also increased rice productivity. Although pump irrigation was introduced in 1915, the first dry season rice harvest made possible with pump irrigation yielded 100.8 cavans per ha in a field in Bambang, Pasig, a remarkable yield at the time (Merino, 1952). For any given year from 1970 -2002, the average yield per hectare is always higher from irrigated areas compared with yields from rainfed lowland areas and upland areas (Fig 7). Actually, the lower national average yields per unit area is due to the low productivity of rainfed and upland areas. Since majority of rice breeding efforts is also focused for breeding rice in irrigated environment, increased productivity could be due to both irrigation and new varieties of suitable higher yielding rice.

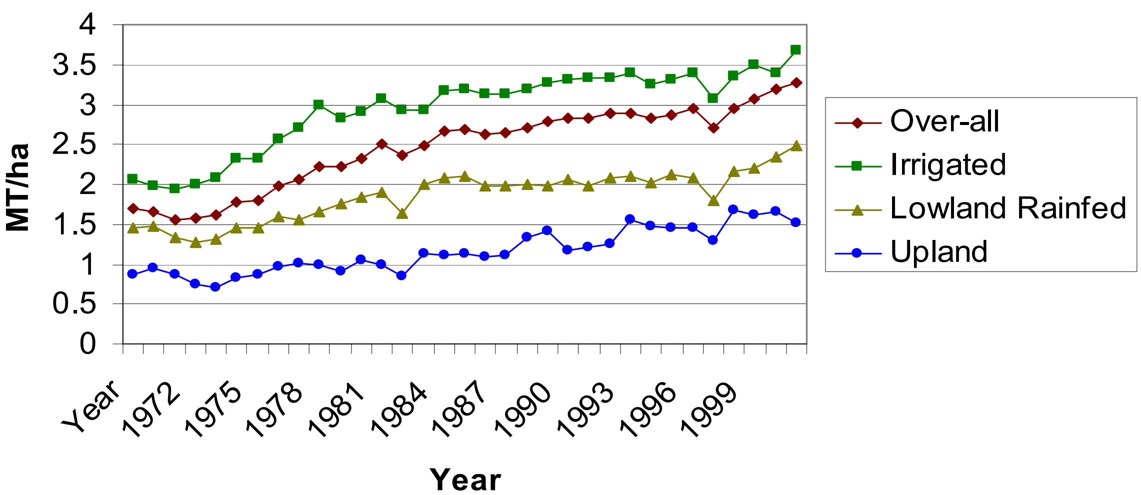

Fig 7 Average rice yields under different environments

On the other hand, the increasing irrigated areas vis-a-vis rainfed lowland and upland areas (Fig 8), a significant reduction of upland areas and increases in productivity in rainfed lowland and in upland areas appear to have all contributed to the increases in average national productivity.

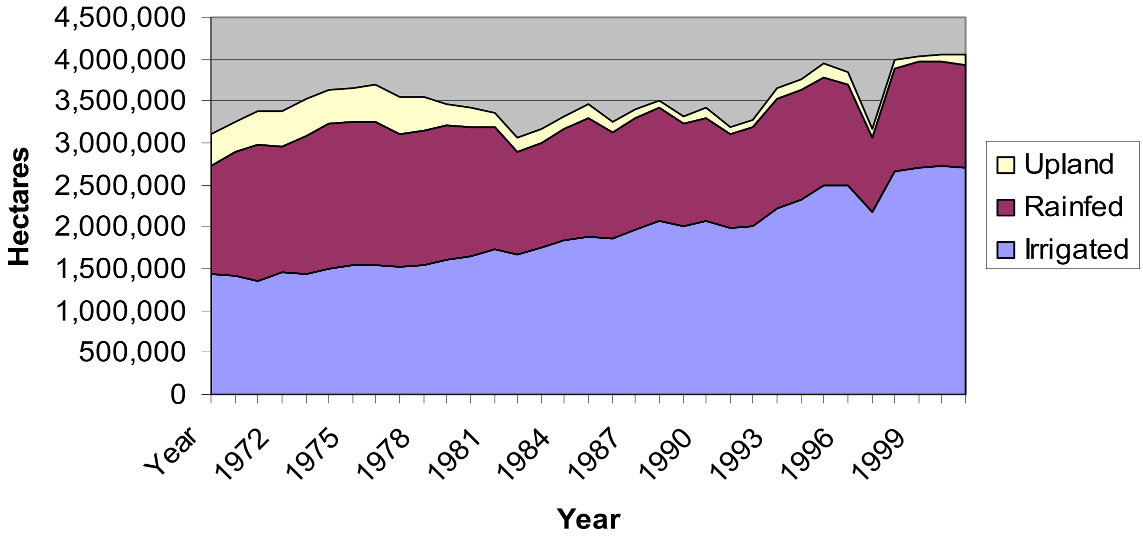

Fig 8. The relative proportion of rice environments in the last three decades

Pest management

Another rice innovation after the War is the widespread adoption of pest management practice. The most successful effort is the development of a management strategy for locust outbreaks. Before the War, three locust outbreak cycles have occurred: 1919 -1926; 1932 – 1939 and 1941-1949. During a locust outbreak, locust swarms feed on plants that they happen to land on. Plants thus fed upon ended up with only their hard stems, all soft tissues gone. Locust attack on rice results in no harvest at all. Hence, locust swarms are known to cause famine during the Spanish times. Laws, orders, decrees defining the function of the clergy, individuals, army and royal treasury have been issued to manage locust outbreaks but to no avail. The American regime superseded all these Spanish laws with the Locust Act of 1915. This Act provides that all males from 16 -60 years old must devote at least 2 days a week, 9 hours per day to the killing of locusts. Again, this Act alone was not able to contain locust outbreaks.

At the early part of American regime, the control measures of locust swarms included catching the locust fliers, driving hoppers into pits and using chemicals to kill the insects such as white arsenic, soap solution and rotenone. These methods proved ineffective until a series of findings resulted in a more effective management strategy. Findings by the Bureau of Agriculture indicated the presence of outbreak cycles and that presence of transient swarms can predict devastating outbreaks. An effective method of control was to time the scouting work at the start of infestation and destroy incipient swarms to prevent outbreaks. BPI entomologists located the origin of locust outbreaks to areas in Central and Southern Cotabato. This facilitated control measures by concentrating scouting activities within these areas and spraying such areas with more effective chemicals after World War II like DDT, Dieldrin, Aldrin, Methyl Parathion and BHC.

With the threat of locust outbreaks effectively extinguished, pest management today focuses on other rice pests such as weeds, rats, insects, and diseases. The major method of controlling agricultural pest today is the use of synthetic chemicals, a practice introduced after the World War II. There are six classes of chemical pesticides commonly used: herbicides, insecticides, molluscicides, fungicides, nematicides and others like rodenticides. A new pest was introduced 1982 – 1984 by a well-intended livelihood urban program, a rapidly growing and reproducing snail "Golden kuhol". This snail, a native of South America, feeds on young leaves and shoots of the rice plant. By 1986, this pest was reported to have damaged 300 hectares of rice fields in Cagayan Valley (www.philrice.gov.ph). This snail continues to infest 11% of the irrigated rice fields and appears to have displaced the native species. Farmers spent US$23 Million worth of imported molluscicides from 1980-98 for controlling this pest (Guerrero, 2001). All molluscicides imported and used in the country are for managing the Golden Kuhol. Herding ducks in rice fields during fallows is recommended as a control measure. Another method of managing the snails is the transplanting of more seedlings per hill. This change in farmer practice has increased the use of seeds from the pre-War rate of 50 -75 kgs per hectare to the current rate of 83-200 kgs/ha. Farmers explain that by planting more seedlings, at least one or two will be left to mature after the snails have fed on the fields.

The indicative amount of pesticides used in rice show the decreasing trend on chemical pesticide usage(Fig 9).

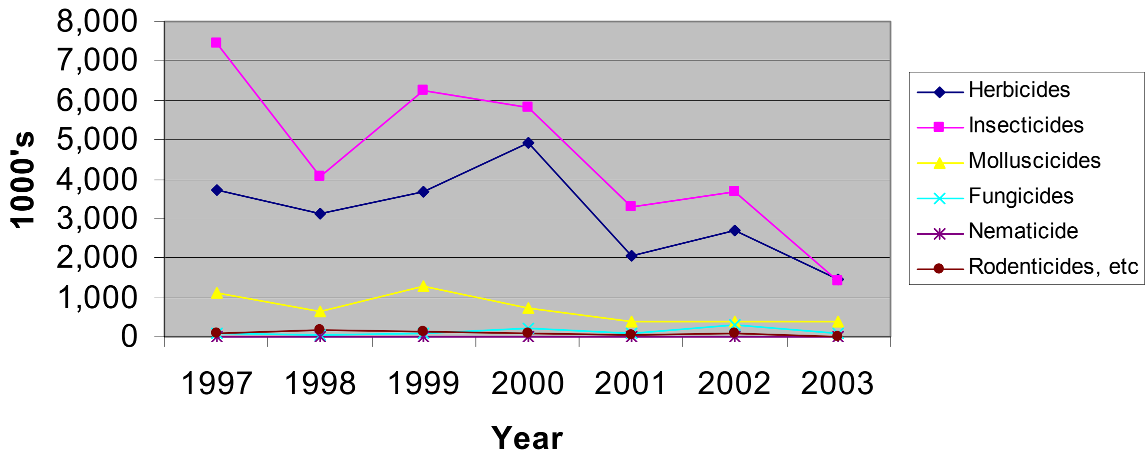

Fig 9. The decreasing amount of chemical pesticides used in rice production

This trend could have been brought about by the inability of farmers to buy pesticides or it could also indicate that the campaign to practice IPM is gaining headway. IPM or Integrated Pest Management was declared the core of crop protection policy in agriculture in May 1986 by then President C. Aquino. Subsequently on 3 May 1993, then President Fidel V. Ramos launched a revitalized National IPM Programme as the Philippine government's commitment to Agenda 21 of the *United Nations Conference on Environment and Development* in promoting sustainable agriculture and rural development.

Like other rice production practices, pest management has undergone an evolution within the last 100 years. Physical measures to kill insects and rodents were practiced at the start of the century. Under the newly established Bureau of Agriculture, a Plant Pest Control Section within the Plant Industry Division was organized. Prior to 1924, this particular office organized and supervised campaigns against major pest outbreaks like locusts and rats. It also undertook field observation and compiled relevant information about pest to Philippine crops locally and from abroad. In1924, the Plant Pest and Disease Control Division was organized into the Plant Quarantine Section, Entomology Section and Plant Pathology Section, the two latter sections started research on crop protection. The establishment of the BPI in 1930 included in its function the conduct research on and promote methods of efficiently prevent, control and eradicate pests and diseases injurious to plant and plant materials.

After World War II, chemical control agents to control not only insects and rodents but also diseases were introduced extensively by the private sector and the research community. The major institutions involved in refining the technology of using synthetic chemicals were the BPI, UPCA, IRRI, SUCs and private companies particularly transnational corporations. The latter imported and distributed these inputs.

The pest monitoring activity that started with the Bureau of Agriculture later evolved into a Surveillance and Forecasting Monitoring System in 1972 to detect at the earliest possible time the presence of pest or disease incidence, warn farmers of an impending outbreak and thus initiate control measures. A network to monitor pest and disease outbreaks or resurgence led to the organization of the Surveillance and Early Warning System (SEWS) in 1975. This evolution was supported by the German government to the BPI (Fifty years of the BPI, 1980)

The period of 1970s in Philippine agriculture was identified with the effective control of ricefield rats, brown planthopper resurgence, pesticide resistance and invigorated effort to establish national self-sufficiency in rice through the Masagana 99 Program (Cuaterno, 2000). Under the Masagana 99 Rice Production Program (M-99), pesticide provision came along with a package of technology (POT) as a condition to avail production loan. The technoguide recommended that rice farmers apply pesticides 6–9 times per cropping season as a preventive measure on a calendar basis. Subsequent research found that this practice is expensive and unnecessary. Moreover, following the introduction and increased demand for agro-pesticides after World War II, many issues were raised concerning ecological balance and human health. This was because pesticides misuse have resulted in widespread loss of beneficial and non-target species and increased the buildup of pesticide resistance and incidence of pest resurgence. All these have led to major pest outbreaks in rice and vegetables (Sumangil *et. al*., 1991). In addition, the adverse effects of synthetic pesticides on wildlife as initially documented by Rachel Carson in her book, "Silent Spring" have been observed not only on birds but on frogs as well as other organisms in the environment.

Following these findings, international efforts and joined in by the Philippines Fertilizer and Pesticide Authority classified pesticides according to their capacity to cause harm. A number of pesticides have since been banned like DDT because of their persistence and capacity to be built up in food chain. Strategies to reduce pesticide use in agriculture have been forwarded. IPM or Integrated Pest Management has been borne out of these efforts.

In 1952, the national rat control drive unknowingly started Integrated Pest Management (IPM) in the Philippines using control strategies with a wide range of methods (Cuaterno, 2000). It was in 1978, however, that the Department of Agriculture (DA), through the Bureau of Plant Industry (BPI) formally introduced IPM to educate the farmers on the concept and practice of need-based insecticide spraying. This radically departed from the dominant crop protection method of calendar spraying since the IPM program was information-based and decision-intensive. IPM or integrated pest management is a concept and practice of keeping the damage from insects to a minimum by using technologies compatible with supporting the population of natural enemies at a magnitude capable of keeping the insect pest population below a level that causes economic injury. In 1986, the Philippines adopted IPM as the core of crop protection policy in agriculture. Subsequently a revitalized National IPM Programme was launched in 1993 through Memorandum Order No. 126 dubbed as *Kasagaan nang Sakaban At Kalikasan* or KASAKALIKASAN.

The National IPM Programme aims to make IPM the standard approach to crop husbandry and pest management in major areas of rice, corn and vegetables in the Philippines. KASAKALIKASAN trains farmers and empowers them to become experts in their own fields by developing their ability in making critical and informed decisions, including making crop production systems more productive, profitable and sustainable. The training approach is essentially andragogic. Hence, it is experiential, discovery-based, group-oriented, involves critical thinking and adopts a horizontal relationship among learners and trainers. Its learning process revolves around the following basic practices:

- Growing a healthy crop by using resistant varieties, better seed selection process and efficient nutrient, water and cultural management;
- Conserving beneficial insects like predators and parasitoids; and
- Observing fields weekly to determine management actions necessary to produce a profitable crop.

These practices do not disrupt the agroecosystem, allowing natural pest control to take place. They also minimize pesticide usage such that it is economical and is relatively safer for humans and the environment.

The training component of the IPM program differs radically from previous extension approaches used until the late 1980s which followed the concept of pedagogy, or the art and science of teaching children, using the traditional lecture or didactic approach to learning. The IPM training approach was patterned after the Indonesian National IPM Programme. It is discovery-based, experiential and participatory in nature. It applied the art and science to help adults learn or what extension experts refer to as essentially andragogic. The training process is based on farmers' experience and their capabilities to discover and master scientific crop management skills. The training process involves a season long immersion in an area referred to as Farmer Field School (FFS) that brings farmers and trainers together to carry out an intensive training on IPM methods and issues over the life cycle of the crop. The FFS trains farmers to become IPM experts in their own fields.

FFSs are based upon a solid, field-tested curriculum and material package that cover an entire crop production season(14-16 weeks) and directly incorporate key IPM principles. This particular approach to IPM requires an intensive capability-building among players of the extension system. There are four types of IPM training courses: (i) Specialized Training Courses for National Trainers (NTs) and Research and Extension Specialists (RES); (ii) Subject Matter Specialist (SMS) Training Course; (iii) Training Courses for Municipal Experts and Village Extension Trainers (MEVET); and (iv) Training Courses for Farmers and Farmer-Leaders (FFL). Between 1993-June 2004, 406 IPM specialists, 2,138 field trainers and 291, 181 farmers have been trained in IPM for rice.

Evaluations have shown that farmers involved in the IPM pilot project held in Antique in 1991 used significantly less pesticide, obtained equal or better crop yields and earned higher incomes from their crops. Of even greater significance in the long term was the awakening of farmers' interest in crop ecology. This enabled them to quickly adapt into their local conditions any new agricultural innovations that they perceived to be beneficial (Philippine National IPM Programme, 1993). An evaluation of the KASAKALIKASAN done in 1997, 5 years after its implementation indicated that the training approach has effectively enhanced farmers’ ecological knowledge and skill in growing healthy crops. Farmers started using less insecticides and the less toxic of them. Yields generally increased and were attributed to improved decision-making by farmers as a result of practicing IPM. Farmers perceived that their incomes were higher and their health better.

Fertilization and nutrient management

Inorganic fertilization is another practice that boosts productivity and was introduced sometime in the second decade of the 1900's. Inorganic fertilizers are imported into the country then as it is now and the practice followed the practice of rice culture in the USA. Fig 10 indicates an increasing amount of fertilizers applied per hectare of irrigated rice land from 1988-2002. However, this amount is still below the average recommended rate of 8 bags per hectare. The most common form applied is urea (46-0-0). However, there is a trend indicating that farmers have been increasing their use of complete fertilizer (14-14-14). A similar trend has been found in rainfed lowlands (Fig 11). This may indicate that farmers are now more aware of the need to balance the nutrients available to plants or that urea is more expensive than complete fertilizer and all the others.

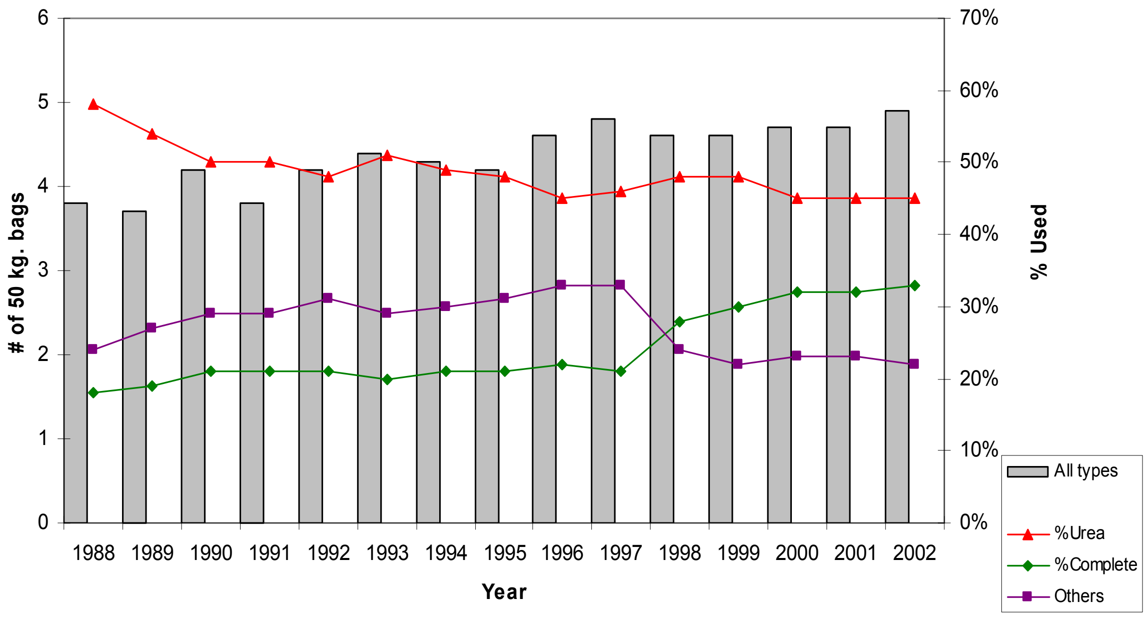

Fig 10. The types and amount of fertilizer applied to irrigated rice lands in about two decades

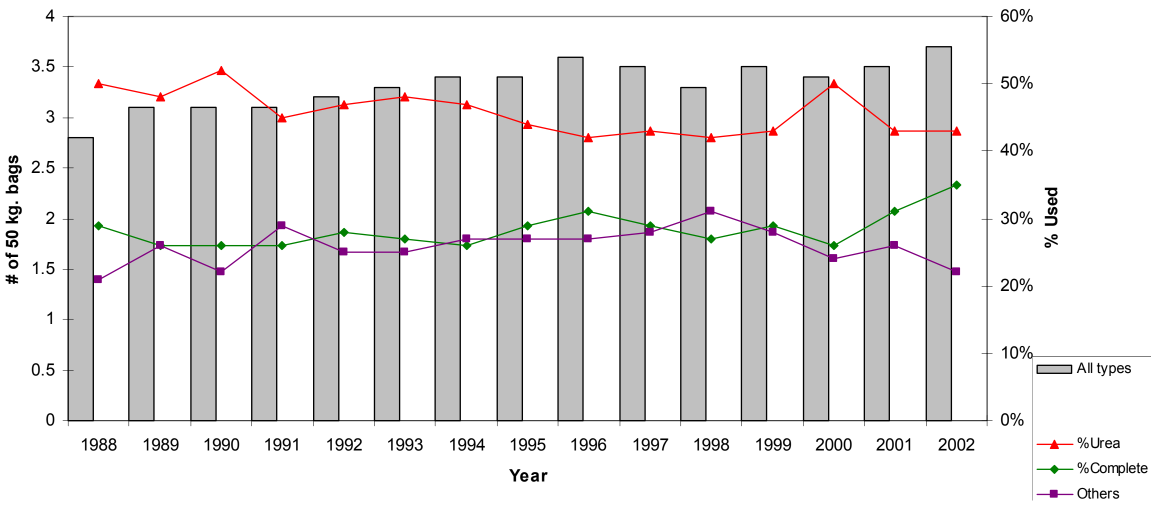

Fig 11. The types and amount of fertilizers used in rainfed lowland rice areas

Green manuring is already practiced prior to the American regime apparently in the Ilocos region. Indigo (*Indigofera tinctoria*) and mungbean biomass are plowed under prior to land preparation (Borja et al 1952, Garrity et al. 1994). Green manuring with wild sunflower has been also practiced in the Ifugao rice terraces.

The development and widespread use of modern varieties and changes in breeding strategies

One of the problems early recognized that causes low average national productivity is the use of hundreds of low yielding or mixed varieties (Gutierrez 1918, Mendiola, 1920). Most of the rice improvement activities of the Bureau of Agriculture and later the Bureau of Plant Industry centered on the introduction and adaptation of foreign rice varieties, breeding and selection of local varieties and nationwide replacement of inferior varieties with better/superior varieties (Borja, and Torres, 1952). The first foreign variety was introduced from Japan in 1902. As of 1929, it has noted 2,430 names of rice varieties, collected and tested 828 varieties (Octubre, 1929). Gutierrez (1918) recommended a Seed Improvement Program that provides farmers with pedigreed seeds noting that the Bureau of Agriculture has existing experiment stations not only in Manila but also in the major rice producing provinces of Pangasinan, Nueva Ecija, Tarlac, Iloilo and Capiz. This idea could have started the Cooperative Rice and Corn Seed Improvement Program initially constituted by the Bureau of Plant Industry, UP College of Agriculture and the Bureau of Agricultural Extension and started in 1953. IRRI and other concerned agencies later joined in this Program. The Program was aimed at breeding, producing improved high yielding varieties and maintaining their genetic identity for distribution to farmers to replace inferior varieties (BPI, 1980).

The Cooperative Rice and Corn Seed Improvement Program expanded to include a seed quality certifying function established in 1954 with the BPI given the supervision and control of seed testing and field and seed inspection. There are four types of seeds developed from a breeding program: breeders seeds, foundation seeds, registered seeds and certified seeds. These types of seeds differ mainly on their purity i.e. contents of contaminating seeds of other varieties. Breeders seeds are the seed directly produced by the developer of the variety and are limited in quantity. These seeds are multiplied in the experiment stations of the Bureau of Plant Industry. As of 1980, there were 47 experiment stations serving as seed farms. The first generation or seeds produced by plants grown from breeders seeds are referred to as foundation seeds and the second generation produced from the foundation seeds are registered seeds. Registered seeds are distributed to farmer cooperators to produce certified seeds. Certified seeds are distributed to farmers for palay production. The participation of farmer/seed producers in the Program spawned the establishment of a certifying agency to ensure seed quality. Another related innovation is the registration of improved varieties with the Philippine Seed Board which set the guidelines on variety testing and registration and approves varieties for general increase and distribution. The Philippine Seed Board established in 1954 has now evolved into the National Seed Industry Council (NSIC). The Philippine Seed Board now NSIC also supervises the National Cooperative Trials (NCTs) where newly developed varieties are tested on a nationwide scale. Results of these trials are used as the basis for variety registration. As of 2003, there are 165 varieties registered (Table 1).

Table 1. Number of varieties approved by PSB/NSIC for release by each agency 1955-2003

Period	Total	BPI	UPLB	IRRI	PhilRice	Others
1955 – 1964	32	28	4			
1965 – 1974	23	7	7	8		1
1975 – 1984	32	6	7	19		
1985 – 1994	23	1	3	15	4	
1995 - 2003*	55	-	4	32	18 plus 25 co-registered w/ IRRI, 3 co-registered w/ UP & 1 co-registered with Cargill = 47	1

As result of active breeding program and the facility with which seeds could be obtained and exchanged among farmers, the spread of modern varieties has been very rapid (Table 13) . There has been a rapid adoption of modern varieties since their introduction in 1967. Within three years, 56.7% of the rice area was planted to modern varieties. Today, 96% of the rice area is planted with modern varieties. Apparently, the spread of these seeds were mostly done by farmer to farmer seed exchange. This demonstrates the facility with which a good variety of a self-pollinating crop spreads through the farming community. The downside of this spread is the loss of diversity in the farms. The number of varieties planted at the start of the century is about 2,000. Today, there are probably less than 165 varieties being planted. The 165 refers to varieties registered with the Philippine Seed Board/ National Seed Industry Council.

The problems solved with the use of modern varieties include low yields, lodging, late maturity, seasonality of production solved by photoperiod insensitiveness and less damage from insect pests and diseases. However, the use of certified seeds encouraged by the Department of Agriculture and for which the Philippine Seed Board and Seed Certification Service of the Bureau of Plant Industry were set up is not widespread . To this day, farmers' seed remains the most prevalent seed type being planted (Table 14), more than 50% of rice farms use farmers' seeds in rice production and less than 10% use certified seeds. Most seeds purposely produced for certification cannot attain the standard quality set and are thus classified as good seeds. The major contribution of improved varieties to rice productivity is undeniable. Improved varieties in 1956 gave average yields of 1.4 MT/ha over the 1.06 MT of standard varieties (Cruz, 1956) whereas modern varieties in farmers fields yields ranges from 3 – 7 MT/ha.

Farm mechanization

From 1928-32, large tractors for tilling the land were introduced and tested. In 1947 BPI Maligaya Rice Experiment Station implemented a lowland rice mechanization project. The realization that rice farms are small, led to the design and testing of locally fabricated farming implements. BPI, IRRI and UPLB are the major sources of new ideas and design. The free use of IRRI design by local fabricators facilitated the adoption of new farming implements. The large tractor today has been replaced by the "kuliglig", a small mechanized hand tractor with its hand pushed rotavator and similar implements designed to be pushed rather than pulled. Threshers introduced during the American regime also underwent reduction in size after the implementation of the land reform. The breaking of large to small farms has resulted in threshers with smaller capacities. Threshers underwent different designs, before the war, a foot operated one-man rice thresher was introduced from Japan. Several small engine threshers were designed by BPI and PhilRice. Nevertheless, the current capacity (Table 15) of threshers and mechanical dryers are not yet sufficient to process the total palay harvested. Apparently, there is also a decreasing number and capacity from 1999. Hence, it is assumed that threshing palay, by feet, arms and animals and drying palay by the sun are extensive practices to this day. This could be due to the traditional practice of linking transplanting, harvesting and threshing together in a single contract for farm workers. That is, workers who have helped transplant the rice and who are usually given only a free meal during transplanting are given the privilege of harvesting and threshing the palay. They are then paid a portion of their harvest. Mechanized transplanters and harvesters are not yet extensively adopted despite new designs offered by research institutions. The adoption of weeding whether manual or mechanical has led to the extensive practice of harvesting of rice by "gapas" - using the sickle and the use of the "yatab" (rakem-Ilocano) is probably confined only in small upland rice farms. The use of yatab is preferred when the rice is infested by weeds because it allows the selection of an individual rice panicle among weed heads. Harvesting by "gapas" does not allow for such individual selection but allows for more rapid harvesting and thus higher productivity.

Rice milling

Another productivity enhancing technology that has been fully adopted is rice milling. Sometime after harvest, most of the country side at the start of the century would often reverberate with the rhythmic sound of wood pounding rice to remove the grain from the panicle. The few rice mills (kiskisan) are found only in Tarlac, Pangasinan and Bulacan (Corpuz, 1997). In the last 100 years, not only has the number of rice mills increased but their designs have evolved from the kiskisan to the cono type and to rubber roll hullers. The evolution in design resulted with improved milling recovery efficiency, the kiskisan has a milling recovery efficiency of 48%, the cono 53% and the rubber roll huller 55% (Cruz, 1957). The native "lusong" has a milling recovery efficiency of 41%. In 1957, 50% of rice was milled with the kiskisan, 30% with the cono and 20% with the lusong. Today, lusong is probably used in hinterlands in processing limited quantities of upland rice since the total capacity of rice mills is more than sufficient to process the rice harvested (Table 16). In 2002, for example, if all mills operated at 8hrs/day for 250 days a year, 14,654,000 MT of palay would have been milled whereas the total palay production for the year was only 5,672,369 MT.

Table 16. The total capacity per hour (MT per hour output) of various rice mills and the proportion (%) processed by three mill design

Year	Total capacity (MT)	Kiskisan (%)	Cono (%)	Rubber roll (%)
1987	6,161	27.2	34.1	38.6
1988	6,877	25.7	34.2	40.1
1989	6,834	24.0	32.7	43.3
1990	7,356	21.5	34.8	43.7
1991	7,494	19.0	36.0	45.0
1992	7,683	17.3	35.8	46.9
1993	7,626	16.1	35.4	48.4
1994	7,757	13.8	34.6	51.6

1995	7,664	12.2	34.4	53.4
1996	7,682	11.0	32.6	56.5
1997	7,683	10.6	33.2	56.2
1998	7,493	9.6	30.9	59.4
1999	8,227	10.0	31.2	58.8
2000	6,982	8.0	32.0	60.0
2001	6,932	6.5	33.4	60.0
2002	7,327	6.0	30.4	63.0

The data also indicates a trend towards greater adoption of rubber roll hullers, the most efficient mill which have further improved to 65-68% recovery efficiency. Given that rice mills are imported, this trend of increasing rubber roller capacity and decreasing use of kiskisan and cono type mills probably reflects more of a world trend rather than a local innovation. That is, kiskisan spare parts are no longer available in the market and therefore these mills having been around for decades are decommissioned. New models of rice mills available in the market are probably only rubber roll hullers and for millers to expand their capacity, these are the only models available.

Crop rotation

Rotation cropping practice involving indigo, rice, corn tobacco in the Ilocos region dates back to the Spanish period (Borja et al 1952, Garrity et al. 1994). Rotation cropping with mungo, corn and peanut has been reported as early as 1909. The Bureau of Plant Industry lays claim to the spread of rotation cropping in rice lands (Aquino & Subido, 1952). BPI has conducted several studies on the appropriate crops that can be planted after rice. It reported on the increased yields of rice following a crop of legumes. The variety of crops planted after the first crop of rice has since increased and the incomes of rice farmers are increased significantly with the harvest of high value crops such as onions, garlic and the like. The income from these other crops is so lucrative that some farmers in the Ilocos region today claim to plant rice only so they can have straw to plant garlic and onions in the dry season.

The rice innovation system

The whole innovation system with the farmers as the final implementers includes the farmers themselves, technology developers, idea progenitors, innovators and the service delivery system. The rice technology developers in the country as the name indicates are the sources of new technologies whether these are technologies they have developed themselves like new rice varieties or these technologies were acquired elsewhere but were refined/validated locally to suit the conditions in the country. Farmers, NGOs, individual inventors and public research institutions comprise the technology developers in this country. The innovator is the person or the agency that establishes a system that delivers the technology to its final users. Innovators comprise of farmers, farmer organizations, NGOs, and the extension program and system of the government

The technology developers

The farmer as a technology developer is a novel concept in Filipino culture. Rice in the Filipino culture is associated with religion and God. The origin of the white and red varieties of rice is described in a myth among the Boholanos as follows:

"*When the people pounded the harvest, most of the grains were milky white. These came from the ears which Sappia filled with her milk. Some grains were red, and these came from those that were filled with her blood.*"(Eugenio, 2002)

Similarly, the Igorot rice farming system is believed to have been taught by the Gods.

" *Lumawig before his departure to heaven, taught many things to the people of Bontoc. He taught the art of making rice paddies that can produce large yields. He instructed them how to irrigate their fields, how to cut the rocks in order to build ditches (*Eugenio, 2001).

"Wherefore Kabunian showed him how to make and irrigate the rice paddies, how to plant rice in a seed bed then how to transplant the seedlings and care for them until harvest."(Eugenio, 2001.)

Developing new varieties or tempering with the established technology would have been like "playing God." It does not help either that the Spanish friars introduced lowland rice culture using the plow and the carabao. Mendiola (1926) described a program of mass selection for rice as taught to farmers. There were posters in English and Spanish and in five of leading dialects placed in public areas where people tend to congregate. Students in public schools were also taught. Mass selection was expected to give slight and slow improvement in the variety. Apparently, farmers have not sustained the practice.

On the other hand, there are farmer practices that have become innovations. One of the more recent innovations is the use of more planting stock to manage the damage from various pests especially the Golden Kuhol. Whereas farmers at the turn of the century used only 50 kgs of seeds to plant one hectare of transplanted rice or 75 kgs to broadcast, today 100-200 kgs of seeds are used to plant one hectare so that there are more seedlings planted to a hill to allow for the destruction of some seedlings by the Golden Kuhol and eventually leaving two or three seedlings to grow and mature into grain production. Thus the recommended practice by PhilRice of using 20-40 kgs to plant one hectare of rice is being resisted. A variety referred to as 7-tonner in Mindanao is supposed to be selection made by a farmer from a modern variety.

The major public Philippine institutions in developing rice technologies prior to the establishment of the Philippine Rice Research Institute (PhilRice) in 1987 are the Bureau of Agriculture/Bureau of Plant Industry (BPI), the UP College of Agriculture and the International Rice Research Institute (IRRI). The Bureau of Agriculture established in 1901 by Act 261 of the US-Philippine Commission under the Department of Interior and organized in 1902 is the first government agency within the century that was mandated to introduce new agricultural technologies and study and improve existing agricultural production practices (BPI, 1980). Within the Bureau is the Division of Plant Investigations responsible for rice hybridization, varietal testing, testing of cultural management practices such planting distances, field preparation, weed control, pest control, fertilization tests, etc. (Manas et al., 1929). This division was later reorganized in 1930 by Act 3639 into the Bureau of Plant Industry responsible for plant research and crop production. Although the resources expended for rice research could have been higher, accomplishments of the Bureau especially in the introduction and dissemination of improved varieties and cultural management practices are notable. The Philippine Rice Research Institute (PhilRice) took over the rice research and seed multiplication/dissemination functions of the BPI including its network of experiment stations devoted to rice research and seed multiplication. Nevertheless, it can be seen that after 1964 and prior to 1987, the ability of the BPI to develop new rice technologies diminished as indicated by the fewer number of new rice varieties released. The new functions of seed certification and variety registration as well as plain seed multiplication could have taken away the resources previously expended for rice breeding. The establishment of the IRRI in 1960 could also have affected the decision of the government to invest less in rice research at the BPI.

The UP College of Agriculture (UPCA) has been very active in rice research since established in 1909. Rice research undertaken are similar to those of the BA/BPI such as rice hybridization, varietal testing, testing of cultural management practices such planting distances, field preparation, weed control, pest control, fertilization tests, etc. UPCA through the years has also undergone organizational changes. It has now developed into a full university offering other degrees in addition to agriculture. Aside from individual faculty research, collaborative programs with BPI, IRRI and PhilRice in rice technology research and development as well as seed quality regulation have been maintained through these reorganizations. Specific rice technologies developed solely at UPLB include several varieties notable of which is the very popular C4-63 variety, soil test kit, and the Trichoderma-based compost activator.

PhilRice was envisioned as a key player in building a self-sufficient and competitive rice economy with a to sustain rice self-sufficiency and build a competitive rice economy through research, technology promotion, and policy advocacy.

partners: Food and Agricultural Organization
Asian Development Bank
International Atomic Energy Agency
International Food and Policy Research Institute
Rockefeller Foundation
International Rice Research Institute
CREMNET
Fujian Agricultural University
Guangxi Academy of Agricultural Sciences
Jiangxi Academy of Agricultural Sciences
Bureau of Agricultural Research
University of the Philippines Los Baños
17 State, Colleges and Universities
15 DA research centers
Philippine Nuclear Research Institute
Private companies like SL Agritech, BM Domingo and Monsanto
NGOs like ICDAI, Philippine Rural Reconstruction Movement
International Plant Genetic Resources Institute
Phil-Sino Center for Agricultural Technology

The International Rice Research Institute (IRRI) is an autonomous, nonprofit agricultural research and training organization with offices in more than ten nations (www.irri.org). The Institute's main goal is to find sustainable ways to improve the well-being of present and future generations of poor rice farmers and consumers while at the same time protecting the environment.

Most of IRRI's research is done in cooperation with national agricultural research and development institutions, farming communities, and other organizations of the world's rice-producing nations.

IRRI was established in 1960 by the Ford and Rockefeller foundations in cooperation with the government of the Philippines. Its research activities began in 1962 and are now estimated to have touched the lives of almost half the world's population.

The Institute's research headquarters has laboratories and training facilities on a 252-hectare experimental farm on the main campus of the University of the Philippines Los Baños about 60 kilometers south of the Philippine capital, Manila. Besides doing rice research, IRRI is also very active in local communities providing educational scholarships, organizing income-generating training activities, and arranging other community projects that will help improve living conditions in the poor communities that neighbor the Institute.

Publicly funded like institutions BA/BPI, UPLB-CA, IRRI, PhilRice, and SUCs like MMSU, CMU have actively developed rice technologies since their establishments. These institutions have themselves evolved affecting their rice programs.

Recently, a NGO established in 1987 is MASIPAG (Magsasaka at Siyentipiko Para sa Pag-unlad ng Agrikultura - Farmer-Scientist Partnership for Development Inc), a farmer-led network of people's organizations, non-government organizations and scientists working towards the sustainable use and management of biodiversity through farmers' control of genetic and biological resources, agricultural production and associated knowledge.

For the last 17 years, MASIPAG has been at the forefront of development struggles in the Philippines pursuing, among other things, a holistic approach to development, community empowerment, and people's control over agricultural biodiversity as a contribution in the over-all effort of improving the quality of life of small farmers." Its first project was designed primarily to break the control of local and multinational fertilizer and pesticide companies, multi-lateral rice research institutes and distribution cartels over the rice industry. At present, MASIPAG has a total of 456 base POs, 42 NGOs, and 15 scientists who composed the General Assembly which serve as the highest policy and decision-making body of the network. An elected Board of Directors acts as an advisory and policy-making body ensuring that decisions in the General Assembly are enforced/implemented. A Secretariat based in Los Banos, Laguna assists the coordination of activities of Regional Project Management Teams (RPMT) in every region. The RPMTs spearhead the program implementation in Luzon, Visayas and Mindanao. Two major programs related to rice technology development being implemented are the CIMME and the rice breeding program.

The CIMME program refers to the Collection, Identification, Multiplication, Maintenance and Evaluation (CIMME) of traditional lowland and upland rice and corn varieties on a national scale and in a cooperative manner. Seeds are maintained in a back-up seed bank, in PO/NGO/church-managed trial/research farms in Luzon (48 farms), in Visayas (46 farms), in Mindanao (91 farms) and in-situ in the genetically diverse farms of farmers and farmer-breeders. The rice brteeding component seeks to sustain collection and improvement of traditional rice varieties and seed exchanges, upscale organic adoption, production and conversion and intensify soil fertility management practices.

The innovators and their systems of innovation

Innovators in rice are private individuals and corporations, MASIPAG and other NGOs but the biggest innovator is the government. Private individuals and corporations have established distribution networks to sell farm implements, pesticides, fertilizers and farm machinery to farmers. The Department of Agriculture through its Rice Program establishes the delivery system for new technologies to reach farmers. Other agencies like the National Irrigation Administration and the Department of Agrarian Reform have their technology delivery programs as well.

The most significant service delivery system for improved rice production designed by the Department of Agriculture is the Masagana 99 Program. Dubbed by then President F. Marcos as a program of national survival, Masagana 99 came at a time when the country was reeling from the effects of a series of calamities. In 1971, the rice crop was devastated by 28 typhoons that battered the country within four months during the rice cropping season. This was followed by a severe outbreak of tungro in the 1972 crops and in 1973, a killer flood inundated most of the rice pplains of Central Luzon (Alix 1978). Masagana is the Tagalog term for bountiful and 99 refers to the target yield of 99 cavans per hectare or about 5MT/ha. The features of Masagana 99 launched in May 1973 includes credit, fertilizer subsidy, price support for rice and a delivery system for a package of technology describe in the technoguide as 'Sixteen Steps for Masagana 99 Rice Culture'. The Program mobilized an extension system involving thousands of rice technicians to acquaint farmers with the new technology as well as supervise its step-by-step implementation. Credit at low interest rates and without collateral was made available from more than 400 rural banks, more than 100 branches of PNB, and from field offices of the Agricultural Credit Administration. The palay price support program was instituted through the National Grains Authority (now NFA) guaranteeing farmers a floor price for their paddy, assuring a stable price and reasonable profit. The fertilizer subsidy was implemented to reduce the impact of the high fertilizer price that occurred in 1974. The Masagana 99 demonstrated that given all these support rice production can increase so that self-sufficiency in rice was attained in 1975-76 and rice was exported in 1977-78. The government unfortunately cannot sustain the program. However, the legacy of the Masagana 99 program are farmers acquainted with a science-based rice culture and are more informed. Compared with the rice farmer at the turn of the century, the rice farmer today knows more about his rice plant, its needs and its stages of growth and development when cost-effective measures can be used to attain maximum profits. It also demonstrated that technology can indeed raise yields to100 cavans per hectare and that these yields can further increase with further improvement in technology. On the other hand, it also taught them that technology is expensive and beyond their ordinary means.

After Masagana 99 at the start of the Aquino administration in 1986, there was no rice program (Panganiban, 1999). However, from 1987-92, a Rice Production Enhancement Program (RPEP)/Rice Action Program (RAP) was instituted and the also the Law on the Comprehensive Agrarian Reform Program (CARP) was enacted. Under RPEP I, certified seeds and fertilizer were subsidized for irrigated rice and the Department of Agriculture incurred debts from suppliers that were payable until 1999. An evaluation of the initial implementation of RPEP (RPEP I) noted that the average increase of 8.78 cav/ha was below the target of 13 cav/ha but an increase achieved nevertheless (Aragon et al 1990). Farmers participating in RPEP I increased their use of fertilizer. Despite the fertilizer subsidy under this program, the average use of fertilizers on a national level continued to decline from 1988 to 1992 (Fig 10) in irrigated areas. The decline continued up until 2002 through the Grains Production Enhancement Program (GPEP) of the Ramos Administration, the Agricultural Makamasa – Rice Program of the Estrada Administration and the Ginintuang Masaganang Ani – Rice (GMA Rice) Program of the current Macapagal-Arroyo administration. The Ramos and the Estrada rice programs did not have fertilizer subsidy but the 2001-2004 GMA-Rice Program had a subsidy of P500 per farmer.

Another constant feature of all government programs from the Masagana 99 to the current GMA-Rice Program is either subsidy or special loan program for certified seeds and hybrid seeds. However, the effect of these programs is too small with only 7-12% of rice farms using certified seeds. Thus, the increases in rice productivity could not be attributed to use of certified seeds. However, it is the widespread use of modern varieties which by 2002 was more than 95% of all rice planted that could help account for the increases in rice productivity.

NIA was established in 1964 as part of the nation's goal of achieving national self-sufficiency in rice production. In 1974, NIA embarked on an ambitious program to reach the minimum and normal rice requirement of the nation through irrigation alone (Raby 2000). It designed a 10 year irrigation development plan using an integrated agricultural development area approach to supersede the practice of simply making irrigation available to an area. In addition to the construction of the dam, the NIA also constructed adequate farm ditches, drainage facilities, farm-to-market roads, and indirectly engaged in training farmers in the use of water and in related agricultural practices, organization of farmers into irrigators associatios/cooperatives for them to fully realize the benefits of irrigation (Julian, S 1975). The 10-year program was envisioned to bring an additional 1.35 Million has into irrigation so that by 1985, 2.35 Million hectares would have been irrigated. Also, 342,700 hectares of existing systems would be improved. The NIA would also undertake concomitant projects such as flood control drainage, land reclamation, hydraulic power development, domestic water supply, road or highway construction, reforestation and projects to maintain ecological balance in coordination with other agencies. To promote the organization of Irrigator associations/cooperatives, the government through NIA delegates partial or full management of national irrigation systems to duly organized irrigators association or cooperatives. Increased attention was also given to the construction of small gravity and pump irrigation projects. These broad functions of the NIA might have dissipated its resources so that its objective of irrigating 2.35 Million in 1985 was not met. Only 1.424 Million has of irrigated area in 1985. The sustainability of the irrigation systems is also a problem due to a myriad of factors.

MASIPAG works with its member NGOs and partner institutions at the national and regional levels to promote a particular technology. It has established a network similar to the government and promotes technologies through training and demonstrations similar to the government mode except that the implementers are sometimes volunteers and farmers and not employees.

It should be noted that the rapid spread of modern varieties principally through farmer to farmer exchanges demonstrate the capacity of farmers as innovators.

Technology trends

Factors that currently affect the design and development of technologies include scientific advances, environmental concerns and resource limitations. Two world-wide phenomena: global warming and water scarcity are expected to negatively impact on rice production. Simulation and actual data from IRRI has already demonstrated that an 1^{o}C increase of night time temperatures as expected in global warming caused a 15% decrease in rice yield (Rice Today 3:7). Rice varieties with tolerance to high night time temperature may be able to address this problem. This contrasts with present breeding programs for rices tolerant to cold.

The expansion of human populations exerts tremendous pressure on water supply. There is competition for water use between households, industries and agriculture. Recent press reports highlighted this problem when officials of the Angat Dam decided that water supply for Metromanila takes precedence over the irrigation of Bulacan farms. Thus, water saving technologies most likely rapidly spread. Research on aerobic rice, a new term for upland rice, has already resulted in high yielding rice varieties. However, it should be noted that the area for upland rice is dwindling and may continue so. The more effective technology therefore would be those suitable for lowland farms. Intermittent irrigation uses less water than the traditional submerged rice culture. In areas where farmers have full control over the irrigation system such technology would be very useful during the dry season when fields are not submerged by flood or rain waters. On the other hand, new varieties with tolerance to broad water supply conditions from no water to submergence during growth and grain filling should be developed for rainfed areas. Although irrigated areas will continue to expand mainly by improving the efficiency of present irrigation systems, promoting small community-managed system and privately owned pumps, the rainfed areas will remain significantly large. Available information show that the country is realizing less than half of potential benefits from irrigation development (David, 2000). Irrigation systems will be limited by the productivity of watershed areas unless novel strategies for reforestation are adopted to maintain forest cover.

The extent by which technologies are adopted widely will mainly be affected by the farmer's capacity to access the technology and its benefits over an existing technology. Another factor that may affect technology adoption is perception of the technology in relation to moral values. Movements based on the exclusion of global business in agriculture appear to be grounded on this last factor.

Two technologies that have become controversial are SRI or System of Rice Intensification and GMOs or genetically modified organisms. SRI is a rice production system characterized by transplanting seedlings very young -- 8-12 days old, compared with the 18-28 day old seedlings, singly, only one per hill instead of 3 or more as currently practiced, widely spaced to encourage greater root and canopy growth and in a square grid pattern, 25x25 cm or wider , even up to 50x50 cm with the best quality soil. The soil is kept moist but well-drained and aerated, with good structure and enough organic matter to support increased biological activity. Only a minimum of water is applied during the vegetative growth period, and then only a thin layer of water is maintained on the field during the flowering and grain filling stage. Farmers are encouraged to experiment on how best to apply the principle of having moist but well-drained soil while their rice plants are growing. Soil nutrient supplies should be augmented, preferably with compost, made from any available biomass. Chemical fertilizer can be used and gives better results than with no nutrient amendments, but it contributes less to good soil structure and active microbial communities in the rhizosphere than does organic matter. It is desirable to build up soil fertility over time. Frequent weeding is necessary. (http://ciifad.cornell.edu/sri/methods.html).

SRI was developed in Madagascar 20 years ago by Fr. Henri de Laulanié of the Society of Jesus.

It is a low external input technology but labor-intensive that is believed to be appropriate among resource poor farmer. It appeals to cause-oriented groups as a technology that can resist the influence of global agribusiness by reducing dependence on chemical inputs. There are conflicting reports on its benefits. Increased yields have been claimed in various countries but data from IRRI experiments do not support this claim (Surridge, 2004). Possibly, the advantages of SRI could be realized only in particular soil types and certain locations and research should identify these parameters (Hengsdijk and Bindraban, 2004, Satyanarayana, 2004). A study made on SRI in Madagascar concluded that SRI is difficult for most farmers to practice because it requires significant additional labor input at a time of the year when liquidity is low and labor effort is already high. While SRI may be unique for its dramatic yield increases and relative complexity, the highly seasonal, labor-intensive nature of SRI is common to many LEI technologies, calling into question the common assumption of the appropriateness of such technologies for smallholders (Moser and Barrett 2002). Hence, the adoption of SRI is not expected to be extensive. PhilRice has been recommending intermittent irrigation and the planting of 1 seedling per hill for the past few years. New data on the use of biofertilizer also supports the practice of intermittent irrigation. However, intermittent irrigation is manageable only in areas where and when the irrigation water is easily controlled. Planting one seedling per hill will be feasible in areas of no "Golden kuhol" infestation.

On the other hand, the adoption of related technologies such as locally developed fertilizer substitutes like organic fertilizers and biofertilizers are expected to be more extensive mainly because of the increasing cost of imported inorganic fertilizer. Although organic fertilizer can be produced in the farm, apparently farmers find organic fertilizer production unattractive. The eventual decrease in the adoption of the *Trichoderma* compost activator, a fungal inoculant extensively promoted to facilitate rapid composting by the Dept of Science and Technology (DOST) Philippine Council for Agriculture and Natural Resources Research and Development
(PCARRD) some years back. The use of organic fertilizer to augment inorganic fertilization is promoted by PhilRice and its widespread adoption will depend upon its availability and cost. Organic fertilizer production is a low level technology that has many players in the market. The current policy of solid waste management where local government units are required by law to manage their waste will promote the production of organic fertilizers and thus will further push the adoption of organic fertilizers. Biofertilizer is a bacteria-based input that is also expected to gain widespread adoption. Biofertilizers supply part of the N requirement of plants in addition to supplying growth promoting factors and providing protection from soil-borne pathogens. The advent of dried microbial preparation allows for the delivery of biofertilizers to farmers in far –flung areas and its cost competes well with inorganic fertilizers. Two forms of biofertilizers one developed at BIOTECH-UPLB (Bio N) and the other at PhilRice (Vital N™/enhance[P]) are currently available. The manufacturing and distribution network of Bio N is supported by a government program whereas those of Vital N™/enhance[P] is wholly in private hands. These two systems present an interesting contrast and may ensure the spread of the technology.

Rice breeding will continue to dominate rice R & D because the seed is probably the best vehicle to spread a new technology using inbred seeds. The rapid adoption of modern varieties is due to the facility with which these seeds being inbred are multiplied and thus amenable to distribution as farmers' seed. The early efforts for rice improvement included the introduction of foreign varieties which started in 1902, mass selection and line selection to develop better or purify varieties (Mendiola, 1920, Manas Y Cruz, 1929), varietal selection and hybridization and inbred selection. The final product of these efforts is inbred seeds. Two new methods of varietal development are in practice today: ybrid rice seed production and genetically engineered seeds.

The use of hybrid seeds with 50% subsidy was included in the GMA-Rice Program in 2001. The production of hybrid seeds is a complicated and expensive process and unlike inbred seed production must involve a separate production system. The GMA-Rice Program also subsidizes private seed companies including multinational firms in the hybrid rice seed business. For the farmer, the hybrid seed is another input that requires financial capital. Given the tight fiscal situation of the government, it is doubtful if the current subsidy for the adoption of hybrid seeds can be maintained. Unless the economy grows to the extent that the non-agriculture sector can eventually subsidize the agriculture sector as can be seen in highly industrialized economies like the USA or Japan.

The controversial GMOs will include rice in the near future. Genetic engineering of rice at PhilRice is one of the major projects funded under the DA-PL480 Biotechnology Program and supported by IRRI. The research includes the development of rice containing precursors to Vitamin A and resistant to the major diseases like bacterial blight and Tungro. There are other projects such as rice resistant to rice blast and to major insect pests like the rice stemborer. At other institutions like IRRI, other traits are being introduced to rice other quality traits like high iron content, adaptation to adverse environments, etc.

However, an international anti-GMO campaign is trying to derail the adoption and commercialization of genetically modified food crops dubbed, GMOs in the popular press. This anti-GMO campaign is spearheaded by Greenpeace, a multinational NGO founded in Europe and has established offices in developing countries like the Philippines, Thailand and Indonesia. The campaign has effectively engendered public distrust of genetically engineered crops in many countries especially in the European Union and Africa using dramatic and scare tactics. The campaign focuses on the fact that the first commercially released crops are genetically engineered by transnational corporations, thus generating support from the Left. The laboratory-based nature of the technology is also highlighted as opposed to the back-to-basics/back-to nature trends in lifestyle. The precautionary approach of scientists that resulted in the rigid regulation of the technology has also backfired as indicative of high risks.

The Department of Agriculture Administrative Order No. 8 Series of 2002 has put in place a science-based, transparent, case-by-case, by transformation event, time-bound regulatory system for the import and release into the environment of genetically modified crops and their primary products. The system is administered by the BPI as part of its phytosanitary mandate. This regulation has allowed the first commercial release of genetically modified corn (Bt corn MON810) in 2002. As of today, BPI has approved for importation 19 transformation events for direct use as food, feed or processing and two events for commercial propagation, Bt corn MON810 (resistant to corn borer) and Corn NK603 (Round Up herbicide tolerant). Provided that all necessary information have satisfied the regulators, it takes 120 days to process an application for a permit to conduct field trials and 90 days to process an application for a permit to commercially release a GM crop. The process requires risk assessment harmonized with risk assessment principles and procedures in the Cartagena Protocol on Biosafety, Codex Alimentarius and recommendations of the Panel of Experts of the Organization for Economic Cooperation and Development.

Regulation has effectively increased the time and actual cost of developing new varieties using genetic engineering. Two regulatory frameworks apply to GM crop development: biosafety anjd Intellectual Property Rights (IPR). Yet, genetic engineering offers new solutions that are not feasible using traditional methods. Continuing research not only on the application of the technology to provide solutions to pressing rice production problems but also to address the issues of human health and environmental safety raised against the technology will ensure that GM rice will in time dominate rice farming, provided that these new varieties will come as both inbreds and hybrids as planned by PhilRice. For example, the use of genes from non-food organisms will decrease as we know more about the genomes and retrieve favorable genes from traditional food organisms for transfer to food crops. The development of Golden Rice or Vitamin A rice containing the precursors of Vitamin A started out using genes from the ornamental plant, daffodil but today the equivalent gene from maize is being transferred (Alfonso, 2005). Techniques to avoid the accidental spread of transgenes to non-GM varieties and other relatives are also being being developed. For example, a system of transferring genes into plastids, those small cellular components not carried by the pollen is being developed (Khan et al 2005). IPR has also added complexity to the development of GM rice because many of the platform technologies in genetic engineering are privately owned. For example, the technology to develop Golden Rice involved more than 40 patents which must be negotiated individually prior to research in the USA or Europe but only one patent is applied for in the Philippines (Kryder et al 2000). The assistance of IRRI in resolving the IPR issues and the establishment at PhilRice of an IPR office are seen to address the problem.

China announced the commercial release sometime 2005 of its Bt rice, an insect resistant rice containing a gene from the soil bacterium, *Bacillus thuringiensis* (CropBiotech Update Mar 4, 2005 knowledge.center@isaaa.org). The release of this genetically modified variety is expected to promote the adoption of GM rice in other countries. The first commercially released GM rice expected in the Philippines is Vitamin A rice since its development is fully supported not only by the Philippine government but also the International Rice Research Institute.

Pest management – IPM, future of biotech pesticides – NPV, Metarrhizium, varieties

IPM or integrated pest management or a more manageable version shall continue to gain adherents among rice farmers simply because chemical pesticides are imported and their prices shall continue to become prohibitive unless the Philippine economy takes a turn for the better. Nonetheless, with the strong environmental awareness campaign and the commercialization of alternative bio-control technologies, chemical pesticides may eventually wane from agriculture.

Foremost of these alternative technologies are pest resistant rices. PhilRice has developed using Marker Assisted Selection a rice variety resistant to bacterial blight. Tungro-resistance, fungal resistance and insect resistance are traits that are also being incorporated through genetic engineering. PhilRice intends to introduce these genes both in inbreds as well as in hybrids, hence, their spread is expected to follow the rapid spread of the modern varieties.

Active R & D with biocontrol agents have been going on since 1970's. Biocontrol agents are microbes and insect parasites capable of controlling insect pests and diseases. PhilRice currently recommends the fungus, *Metarrhizium spp*., to control the rice black bug (Anonymous1, 2002) and nuclear polyhydrosis virus (NPV, Anonymous2, 2003) to control armyworms and cut worms. However, for these biocontrol agents to become widely used, they must be packaged and delivered in convenient usable forms to farmers. Effort should be expended to get the private sector involved in the development, packaging and delivery of these biocontrol agents.

Decomposing plant materials like those of the wild sunflower are traditionally used in the rice terraces to control pests. PhilRice recommends the use of neem kernel extracts or the raising of ducks against armyworms and cutworms (Anonymous2, 2003). Ducks are also recommended for managing the very destructive "Golden kuhol".

An interesting development of extension materials is the options offered to farmers for technical problems in rice production. Brochures on rice production published during the Masagana 99 years list 10 specific steps using specific inputs at indicated amounts during certain stages. Today, leaflets describe various options that a farmer may adopt to control pests. Thus, farmers are expected to make decisions and are thus trained to do so.

Nutrient and soil management – green manuring, organic fertilizers, biofertilizers, slow release fertilizers, liquid sprayable fertilizers

The evolution of soil management practices like other production practices evolved from increasing scientific knowledge in this case of plant physiology and soil properties.

Direct seeding vs transplanting

The continuing loss of labor from the rural areas shall push rice towards labor saving strategies. Direct seeding is seen as one such technology, transplanting being a very labor intensive activity. The advent of herbicide tolerant rice should push direct seeding further. The loss of patent protection to the most environment friendly herbicide, glyphosate, has opened competition and has resulted to lower prices for the herbicide. Glyphosate tolerant rice would

Organic rice farming will remain to cater to a niche market rather a change in the production system However, price of inputs will continue to determine the rate of technology adoption.

Mechanization

Policy trends: Price support, rice programs, R & D support

Policy implications

The slow increase in rice productivity appears related more to technology adoption rather than generation. Increase in productivity due to adequate fertilization for example has yet to attain its maximum potential. Technology adoption is related to information, ease of technology, physical access to the technology and resource for adoption. Urban migration and overseas work will continue to reduce labor available for agriculture hence, mechanization should be encouraged.

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