KNOWLEDGE SHARING PROGRAM

2011 Modularization of Korea's Development Experience:

The Green Revolution in Korea: Development and Dissemination of Tongil-type Rice Varieties

2012

RURAL DEVELOPMENT ADMINISTRATION

Northern Agriculture Research Institute, INC

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Preface

The study of Korea's economic and social transformation offers a unique opportunity to better understand the factors that drive development. Within one generation, Korea had transformed itself from a poor agrarian society to a modern industrial nation, a feat never seen before. What makes Korea's experience so unique is that its rapid economic development was relatively broad-based, meaning that the fruits of Korea's rapid growth were shared by many. The challenge of course is unlocking the secrets behind Korea's rapid and broad-based development, which can offer invaluable insights and lessons and knowledge that can be shared with the rest of the international community.

Recognizing this, the Korean Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience and to assist its developing country partners. The body of work presented in this volume is part of a greater initiative launched in 2007 to systemically research and document Korea's development experience and to deliver standardized content as case studies. The goal of this undertaking is to offer a deeper and wider understanding of Korea's development experience with the hope that Korea's past can offer lessons for developing countries in search of sustainable and broad-based development. This is a continuation of a multi-year undertaking to study and document Korea's development experience, and it builds on the 20 case studies completed in 2010. Here, we present 40 new studies that explore various development-oriented themes such as industrialization, energy, human capital development, government administration, Information and Communication Technology (ICT), agricultural development, land development and environment.

In presenting these new studies, I would like to take this opportunity to express my gratitude to all those involved in this great undertaking. It was through their hard work and commitment that made this possible. Foremost, I would like to thank the Ministry of Strategy and Finance for their encouragement and full support of this project. I especially would like to thank the KSP Executive Committee, composed of related ministries/departments, and the various Korean research institutes, for their involvement and the invaluable role they played in bringing this project together. I would also like to thank all the former public officials and senior practitioners for lending their time and keen insights and expertise in preparation of the case studies.

Indeed, the successful completion of the case studies was made possible by the dedication of the researchers from the public sector and academia involved in conducting the studies, which I believe will go a long way in advancing knowledge on not only Korea's own development but also development in general. Lastly, I would like to express my gratitude to Professor Joon-Kyung Kim for his stewardship of this enterprise, and to his team including Professor Jin Park at the KDI School of Public Policy and Management, for their hard work and dedication in successfully managing and completing this project.

As always, the views and opinions expressed by the authors in the body of work presented here do not necessary represent those of KDI School of Public Policy and Management.

May 2012

Oh-Seok Hyun

President

KDI School of Public Policy and Management

Prologue

The history of Korea dates back to 5,000 years. Korea has endured through foreign invasions while maintaining the rich heritage. However, Korea could not free itself from the shackles of food shortage. Therefore, for Koreans, the volume of food production was a long cherished-desire. Starting from the early 1960s, Korea set out the first National Economic Development Plan in order to pursue self-sufficiency in food production, making it the priority in national agenda. Under the strong presidential leadership of the time, food self-sufficiency was one of the major challenges of state affairs. Hence, various policies to increase food productivity were actively promoted at the government level. As a result of these tireless efforts, Korea was able to achieve 100% self-sufficiency in rice production, the main staple in Korea since the late 1970s. Green Revolution refers to the Korea's achievement of self-sufficiency in rice production.

Self-sufficiency in rice production has been accomplished with R&D efforts in the agricultural sector and a new technology transfer system such as increased rice productivity through improved rice varieties and development of cultivation technologies, swift dissemination of new technologies to farmers. Harmonization of all the success factors above was critical to the success of the Green Revolution. In addition, this process was also possible thanks to the firm commitment of government policies and practices on building infrastructures related to rice production facilities construction, flexible production and supply chains for materials such as fertilizers and chemical pesticides. In the mid 1970s, there was a desperate need to secure investment resources for the National Economic Development Plan. Also, Korea was still able to achieve self-sufficiency in rice production at this critical juncture despite the fact that annual per capita income of Korea was only 200 to 300 US dollars and total export volume was 10 billion dollars. The self-sufficiency in rice production became a cornerstone to strengthening the basis of national economic development not only for procuring food security and boosting incomes of farm households, but also saving foreign currency required to import foreign rice.

How was it possible that Korea made such great expansion in rice production within a short period? What were the related factors? How was the technological innovations performed? How did government policies support this process? What were the achievements and impacts of the Green Revolution? This report describes in detail the process of achieving self-sufficiency in rice production in Korea; development of the high yielding rice varieties ("Tongil" and Tongil-type varieties), improvement of agricultural practices for the newly developed varieties, and the spread of rice varieties and technologies to farmers.

In addition, the governmental policies related to and the impacts from the Green Revolution are reviewed briefly. Finally, the implications of Green Revolution are discussed briefly to share the experience of Green Revolution in Korea with developing countries.

Abbreviations and technical terms are indicated in the list of acronyms. There were many government personnel, scientists, and specialists who participated in the government policies or programs related to the Green Revolution. However, their names are not mentioned in this report in order to free them from bias.

Importance of Rice in Korea

Rice is a staple crop and major food resource for Korean population. The amount of rice consumption takes up over 64% of Koreans' total consumption of grains. The people consume around 40% of their daily calories from rice. Also, rice production is the main source of income for the rural economy. Rice paddy occupies around 54% of the arable lands. Furthermore, 85% of farm households engage in rice cropping. The income from rice cultivation comprises over 49% of total income from agriculture and over 22.9% of the total farm household income.

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Summary

The history of Korea dates back 5,000 years. Korea has endured through foreign invasions while maintaining the rich heritage. However, Korea could not free itself from the shackles of food shortage. Therefore, for Koreans, increasing the volume of food production was a long cherished-desire. Starting from the early 1960s, Korea set out the first National Economic Development Plan in order to pursue self-sufficiency in food production, making it the priority in national agenda. Under the strong presidential leadership of the time, food self-sufficiency was one of the major challenges of state affairs. Hence, various policies to increase food productivity were actively promoted at the government level. As a result of these tireless efforts, by late 1970 Korea was able to achieve 100% self-sufficiency in rice production which is the main staple in Korea. The Green Revolution refers to the Korea's achievement of self-sufficiency in rice production.

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1. Development of Semi-dwarf New High-yielding Rice Varieties

The comprehensive work on improving rice variety was initiated with a systematic collection of native rice varieties and their pure-line selections, followed by exotic introductions and their adaptability tests during the early periods of the 20th century. These were replaced by domestic-bred varieties through hybridization within the traditional temperate japonica varieties since the late 1930s. During the 1970s, the indica and japonica types were hybridized and Tongil-types were developed with a view to achieve the Green Revolution in Korea.

A term of Tongil-type is derived from “Tongil”, the first variety developed from a selection of hybridization between indica and japonica in 1971. It was selected from the progeny of IR667, which was derived from 3-way cross (IR8//Yukara/Taichung Native 1) and released to the farmers in 1972. Afterwards, 25 improved Tongil-type varieties were subsequently released, rapidly increasing the area cultivating the breed. The acreage reached to 76.2 percent of the total rice farming areas in 1977, leading to the Green Revolution. Total 40 varieties of Tongil-type rice were developed and cultivated during the 1970s and 1980s. Successful cultivation of Tongil-type rice varieties was not only a new milestone for future improvements in rice varieties but also a practical opportunity to utilize indica germplasm in temperate environments. Tongil-type rice varieties’ major characteristics were their short- statured in their plant architecture with erect leaves, high yield potential, tolerance to heavy doses of nitrogen and lodging and resistance to major diseases and insect pests, particularly more or less neutral responses to photoperiod, and longer period of basic vegetative stage of rice growth. However, there were some shortcomings such as susceptibility to low temperature, easy shattering of grains and low grain quality and palatability to Korean consumers.

The milled rice yield potential of hybridized domestic-bred rice varieties that were cultivated since the late 1930s significantly rose to 4.06~4.57 MT/ha among the leading varieties such as Palkweng, Jinheung and Palgeum by 1970 and greatly soared to 3.3 MT/ha as the national average due to improvement in both varieties and cultural practices, resulting in 3.7 million MT/ha for total production. Although productivity of rice varieties increased significantly by the 1960s, it still fell behind in meeting self-sufficiency in rice production as a staple food crop in Korea.

The development of “Tongil” rice variety pushed up milled rice productivity to 5.13 MT/ha, which was 28 percent higher than that of the best japonica rice variety at that time. The productivity of subsequent Tongil-type varieties steadily increased to 5.76 MT/ha for Milyang 23 in 1976 and 6.05 MT/ha for Yongmubyeo in 1985. The national average of milled rice yield in farmers’ fields dramatically increased to 4.93 MT/ha, ranging 4.37~5.53 MT/ha in 1977 as compared to japonica varieties that yielded 3.37~4.69 MT/ha of milled rice. Total rice production reached 4.67 million MT in 1976, which was enough to meet the self-sufficiency of rice in Korea, and 5.21 million MT in 1977 and 6.01 million MT in 1978, which for the first time exceeded 5 million MT of rice production in the history, signifying the achievement of the Green Revolution in Korea.

2. Improvement of Cultural Practices for Tongil-type Rice Varieties

The modern rice cultivating techniques and practices were systematically established with a manual planting method, after the foundation of the first public organization of agricultural research station in Korea in the early 20th century (1906). But, currently it has evolved into today's scientific system after the Liberation from Japan in 1945 along with the intensive research works with traditional tall japonica. Particularly, the technology of rice cultivating practices has been greatly advanced by the cultivation of short-statured Tongil-type rice varieties since the early 1970s because they had some different characteristics in morphology as well as ecological responses compared to japonica varieties. Tongil-type rice varieties showed relatively longer basic vegetative growth with more or less neutral response to photoperiod and needed relatively higher temperature during the growth stage of grain ripening in the Korean climates.

It was certainly necessary to lengthen the growing periods of rice plant for safe production of Tongil-type rice variety. Until 1960s rice season began in the late April to early May when the temperature was high enough to germinate in natural conditions and transplanted in early to late June. The earlier production of rice seedlings needed to provide the critical temperature warm enough to grow rice seedling of Tongil-type variety. However, the recorded mean air-temperature is usually below the optimum for the growing Tongil-type variety during the early growing and late grain filling stages, resulting in leaf discoloration and growth retardation as well as poor grain ripening, particularly in habitual cold damage regions.

One of the most significant advances made in cultural practices with Tongil-type variety was the development of techniques for early covering of seedling nursery with PE film sheets. The new technology raising rice seedling covered with polyethylene (PE) film sheet, which enabled protection of rice seedlings from low temperature in rice seedling nursery, allowed earlier seeding in the early to mid April, and transplanting in the late May to early June. With the new techniques with PE film-covering seedling nursery for Tongil types, 30~35 days old seedlings were also available to be transplanted instead of 40~50 days old seedling prior to Tongil-type variety. It resulted in the extending rice growing period earlier by around 20~30 days as well as considerably preventing cold injury in rice growing of Tongil-type variety. This technique was a key factor of rice cultivation technology for stable production of Tongil-type variety that drove forward the Korean Green Revolution.

In morphological perspective, Tongil-type rice also made great advancements in plant architecture, which was considered as an important trait for high yield potential; erected-leaf type with heavy-panicle weight, short-statured with lodging resistance, and better responses to high nitrogen fertilizer and dense planting, which secured the number of spikelets per unit area as sink for increasing yield. In order to secure sufficient number of panicles per unit area, it fostered healthy seeding; transplanted proper density; facilitated tillering by applying both basal fertilizer and topdressing at tillering stage; secured sufficient number of effective tillering to avoid non-productive tiller at the early stage by mid-summer drainage in paddy fields. The split top dressing of nitrogen fertilizer were applied to paddy fields in a timely manner: for tillering at 15th day after transplanting, for panicle initiation around 20~25 days before heading and for the effective number of ripened grains per panicle at heading stage. The capacity of soil to hold applied nitrogen is a significant consideration in determining the efficiency of basal verse split applications of nitrogen fertilizer. The amount and time of nitrogen application may be highly dependent on the soil's capacity to hold nitrogen. Also, manure, silicate, soil dressing, and deep plowing were applied to enhance the fertility and physical structure of paddy soil. Rice was planted based on regionally specific weather conditions at the right time to reduce the risks of natural disasters such as the outbreak of disease and insects, lodging, and freezing, since those may occur frequently under the high fertilization and dense planting condition.

By successfully disseminating these high yield techniques, from 1973 to 1987, for 15 years, the national average yield on rice for Tongil-type rice surpassed that of japonica by 17%, 4.71 ton per ha and 4.03 ton per ha, respectively. The high yield farm's productivity (8.94 ton) increased by 2.22 times compared to that of japonica (4.03 ton), and by 1.9 times higher than that of other Tongil-type rice.

3. Dissemination of Tongil-type Rice Varieties and Technologies

In addition to the developing high yielding rice variety and new cultivation technology, Green Revolution would not have been successful without the effective system of dissemination to farmers' field and winning their acceptance.

The Office of Rural Development (ORD, currently RDA) is an entity that conducts research and extension activities as an organization within the agency. It develops new varieties and technologies and transfers them to farmers promptly through 9 Provincial ORD's (PORD) and 150 offices of agricultural extension in cities and counties across the nation. Difficulties associated with the field during the extension activities are identified and reflected on research activities in the related research institutes to solve the problems simultaneously.

Extension specialists from the ORD persevere in their efforts for disseminating new technologies to educate farmers on the newly bred and high yield variety, Tongil rice, whose characteristics were quite different from that of tall Japonica variety. It was up to farmers' preferences which varieties they want to grow in fields. The extension specialists disseminated newly developed high-yield technologies through Saemaul (new village) farm technology education program to farmers, along with the information on new technologies through newspapers, TV, radio, and local broadcast in the villages during the winter off season.

During the cropping season, the ORD released forecast information on plant disease and insect so that farmers can respond to the situation promptly. Agricultural extension specialists at the front line visited farms they were in charge of, to provide field extension. They also participated in rice production technology support groups to solve problems occurring in the farm field.

Furthermore, ORD executed each agricultural practice such as workload movement, rice planting and harvesting, policy delivery for Tongil rice production, and operation of the situation office for precise implementation of farming instructions in printing materials such as letters, prints and other media sources to increase productivity. Farmers exerted their utmost efforts to increase the rice production. Rewards for high rice yields encouraged competition and encouraged farmers to be motivated and increase productivity. Indirect supports from the administrative office, such as the rice-saving movement, made rice conservation feasible.

With the series of numerous efforts and contributions, Korea was able to achieve the goal of self-sufficiency in rice production with the availability of new technologies to farmers under the "research-extension-dissemination linkage system" developed by the ORD.

This effective linkage system was evaluated as the best management system in the world by the FAO with five other countries such as the U.S. and Great Britain in 1984.

4. Achievements and Impacts of the Green Revolution

In Korea, rice production stagnated during 1960s, at about 3.95 million M/T in 1964 to about 3.94 million M/T in 1970, which was 93 percent of self-sufficiency. However, sharply increased due to cultivation of semi-dwarf high yield rice variety-the Tongil-type-during 1970s, to about 4.45 million M/T in 1974, 4.67 million M/T and 6.01 million M/T in 1977; a 21 percent increase in just 7 years, driving forward the self-sufficiency of rice. This achievement was made possible by the Green Revolution, main components of which were development of semi-dwarf high yielding rice variety and cultivation technology, as well as effective dissemination. Tongil-type variety demonstrated 5.13~6.05 t/ha in yield potential, and 4.73~5.53 t/ha in the national average of the farmers field from 1973 to 1978, which is significantly more than that of japonica variety which yielded 3.49~4.35 t/ha. Cultivation of Tongil-type variety recorded the world's highest with yield of 4.93 MT/ha of national average in terms of milled rice yield in 1977. Through the Green Revolution Korea achieved not only rice self-sufficiency, but also increased farm household income. The farm household income surpassed that of the urban laborer since 1974 thanks to the high contribution from the rapidly expansion of farmland that cultivated Tongil-type variety, which in turn raised the quality of living in rural regions. The increase of farm household income allowed the farmers repay debts and to accumulate funds for re-investment to agriculture.

In line with the increase of rice production by means of expanded cultivation of newly developed varieties, the volume of government purchases of rice has continuously kicked up to a level capable handling the steady growth of farmers' earnings, stimulating farmers' incentive to increase production.

Rice self-sufficiency has played a great role not only in stabilizing food supplies in Korea, but also saving foreign exchange and contributing to economic growth and strengthening nation-wide confidence and active implementation of national policies, creating hopes for the future.

Self-sufficiency of rice also resulted in a changing the rice consumption pattern in Korea. Government policies of rice saving that encouraged cooking rice with other grains for meals and prohibited utilizing rice for processing such as brewing were replaced with a new promotion program that encouraged rice consumption. The wide dissemination of the seed bed technologies brought a number of alternative benefits such as higher production volume due to early planting and harvest, the possibility of planting barley in paddy fields after the rice harvest, reducing labor competition during the busy seasons, the careful treatment of rice plants and expansion of areas planted with barley. The early planting of Tongil rice varieties also enabled vegetable cultivation in areas near cities, particularly in southern part of Korea, which significantly improved farm management. The group farming in rice cultivation was the momentum for the cooperative production that initiated joint utilization of farm machinery, as well as joint purchase of farm materials and joint marketing of farm products among farmers in the same community. It played a core role in rural community development by making cooperation possible in every detail of farming.

5. Implications

5.1 Factors that accelerated the Green Revolution in Korea

In 1968, Korea succeeded in the first selection of semi-dwarf high yielding genotypes from the progeny of IR667, which was hybridized between indica and japonica in 1966. The variety was later named 'Tongil,' the first semi-dwarf high yielding rice cultivar (HYV), in February 1971. Thereafter, many semi-dwarf HYV, called Tongil-type rice variety were subsequently developed and released speedily to farmers during the early 1970s. As a result, Korea attained self-sufficiency in rice, called the 'Green Revolution in Korea' in 1977. There were several factors that contributed to the success of the Green Revolution in such a short period of time.

5.1.1 Efficient breeding system and cultivation techniques

The success of varietal improvement greatly depended on the efficient breeding systems in screening and/or testing to select prominent breeding materials.

In the early 1970s, a nation-wide network of research institutes were set up and functioned cooperatively to develop the new rice varieties in Korea. The optimum cultivation techniques for Tongil-type varieties were developed, such as PE-protected semi-irrigated nursery for early seeding and transplanting, safe high-yielding cultivation, regular and simultaneous pest control, improvement of soil fertility, etc.

5.1.2 International cooperation

RDA collaborated with domestic universities and international organizations such as International Rice Research Institute, which enabled acquisition of professional talent, facilities and technical information for breeding new varieties and tackling cultivation techniques. Such cooperative systems laid a strong foundation on which agricultural technology continuously developed. In order to distribute the newly hybridized varieties to farmers as quickly as possible, segregation materials were shipped to the Philippines for multiplication during the winter season for field experimentation. The multiplied seeds were immediately transported back to Korea early next year. By doing so, rice self-sufficiency was realized earlier than initially expected.

5.1.3 An exclusive extension services

Farm training in the winter season: Technical farm training was widely conducted during the winter season so that farmers could obtain the relevant techniques and information that can increase rice yield through understanding special traits of the new Tongil-type varieties. Since 1971, when the pilot farm planting started, a series of intensive technical training sessions were operated during the winter season for three months, from December to March of the following year not only for farmers who grew the newly developed varieties but also for those who had not yet attempted to grow them.

Farm training through mass media: Active farm technical training by means of radio and TV programs has been effective thanks to the cooperation of the radio and TV stations allotting time for the training programs. On every Saturday, a special radio program was issued on the following week's weather forecast, including an outline of the week's farm work and other farm information so that farmers could prepare for the required works. Information on rice diseases and insect pests was also broadcasted every Friday from March to September.

Accountable field extension service: Extension service agents persuaded farmers to grow Tongil-type varieties, which bore some risks at the time because farmers respond with strong resentment if slight crop failure occur, however diminutive. Thus, in order to reduce the possible crop failure, the service agents ceaselessly provided field extension service during the entire stages of rice cultivation, from seedbed preparation to harvest. The agents even assisted with marketing. It was not unusual for all the research and extension agents across the nation to give up summer vacation or even weekends due to their extraordinarily overwhelming workload. The Green Revolution was possible due to their noble service and sacrifice.

Distribution of agricultural information: On every Saturday, a special radio program was aired on the following week's weather forecast, including an outline of the week's farm work and other farm information so that farmers could prepare for the week's required farm work. Information on rice diseases and insect pests was also broadcasted every friday from March to September.

5.1.4 Great importance of leadership

The national leadership was vital to achieve food self-sufficiency. President Park pursued policies for self-sufficiency of national food supply through varietal improvement for three years from 1970 to 1972. Also, the president encouraged research and extension workers to work hard to facilitate the development of new varieties and dissemination of new technologies to farmers. The president said, for example, "At first, increase in food production! We import a great deal of food at present time, but we must reduce food import by increasing food production at home. At least we should achieve self-sufficiency in rice production (in the new year's press conference, 1974)." He demonstrated great concern and gave strong support to achieve self-sufficiency in rice production through the development of new rice varieties and immediate dissemination to farmers.

5.1.5 Strong recommendation and administrative support from the government

The systematic and unwavering support from the government was the most influential factor contributing to the success of the Green Revolution in Korea. The most significant administrative supports were the marketing policy targeting farm products, public guarantee of new R&D technology, timely and sufficient supply of productive materials, incentives for all of the involvers including farmers.

Government purchasing policy of food grains: The government induced growers to adopt Tongil-type varieties by setting the government's purchasing prices higher than market price. Beginning in the early 1970s, the government substantially raised the government price for rice every year. Under the government subsidy, the market price of rice rose 5.7% annual growth every year during the period from 1969 to 1979. In line with the increase of rice production, the volume of government purchases of rice was continually expanded to a level capable of accommodating as much as farmers wish to sell.

Government's strong recommendation: To enhance the adoption of the new rice varieties, a target level of adoption was assigned to local government officials as well as each extension worker in the provinces. The adoption of Tongil-type varieties was tied to the promotion opportunity of officials and extension workers. With strong persuasion from the government, Tongil-type rice varieties were planted in 76.2% of all rice cultivation area by 1978.

The administrative support of timely supply of the inputs for rice production: the increase in rice production could not have happened if not for the timely and sufficient supply of inputs for rice production. Government expanded construction plants for the domestic production of fertilizer and agro-chemicals which were essential to increase productivity of rice. The stable supply of fertilizers, agricultural chemicals, polyethylene film and other materials for seedbeds made critical contributions to rice production.

Cash incentives to high yielding farms: As an incentive to induce the adoption of Tongil and Tongil-type varieties and to increase their productivity, awards were given to farmers who produced the highest yield. The award was given to all whose yields of milled rice were over 6 tons/ha. To those farmers, 100,000 Korean won (ca. 250 dollars) was given as a prize. In addition to the awards for individual growers, there was another award for the joint cultivation districts. For the districts whose average yields were the highest in the country, one million Korean won (ca. 2,500 dollars) was awarded, and for those with the second highest yield, 500 thousand Korean won (ca. 1,200 dollars) was awarded.

5.2 Lessons

As reviewed above, there were many factors contributing to the Green Revolution in Korea. We were also able to get some significant lessons from the procedures and strategic implementations of the nation-wide program as well as from the beyond all expectation of the achieving Green Revolution.

Above all, the systematic and unwavering support of the government policy to sustain the financial and administrative supports was the key to success. In particular, the strong willingness of the national leadership of President Park for self-sufficiency in rice =influenced greatly the achievement of the Green Revolution in Korea. From the end of the 1960s to the early 1970s, the few industrial areas in which the government concentrated financial resources began to lead the industries in the sectors. The agricultural sector was awakened and funded substantially for the construction of agricultural infra-structures such as agricultural water resources, irrigation systems, land reclamation, and consolidation of farmland to build the basis for improvement of agricultural productivity. The governmental policies to supply appropriate agricultural inputs such as chemical fertilizers and agrochemicals for crop protection from disease and insect pests contributed greatly to the achievement of self-sufficiency in rice.

The Rural Development Administration (RDA), founded in 1962, played the major role for implementation of agricultural policies on development and dissemination of agricultural technology. The fact that the RDA had two main functions such as managing agricultural research and extension services under one umbrella made it possible to disseminate the newly developed technologies quickly and efficiently from the research institutes to farmers, and to receive feedbacks from the extension services to the related institutes, resulting in achieving the Green Revolution earlier than expected in Korea.

The main technology for Green Revolution in Korea was the development of semi-dwarf high yielding rice variety and its cultivation technology including fertilizer and irrigation system. In addition to the R&D technology, the rapid dissemination of the newly developed varieties and improved cultivating practices of farmers was a significant factor to Korea's Green Revolution.

In close collaboration with the university and the international research institutes such as IRRI, the RDA was able to make use of their professional knowledge, facilities and technical information in the process of breeding new varieties. Formation of such a cooperative system laid a strong foundation on which agricultural technology could develop continuously.

5.3 Adaptability of Korea's experience in Green Revolution to developing countries

The agricultural policies and experiences in achieving the Green Revolution in Korea are surely helpful to developing countries that are still suffering from food shortages, particularly countries in Africa and Asia. Koran agricultural systems are applicable to those countries that have small-scaled agricultural systems. The experience and knowledge obtained from the innovation of agricultural technology in Korea will be a good model for the developing countries in the world.

Financial resource might be a significant factor for the innovation of agriculture as it is in other industrial sectors. Two models are suggested for developing countries to achieve agricultural innovation and solve the problems of food shortage by increasing food production.

Countries that have some capabilities to invest in their agricultural sectors are able to build the basis for innovation of agricultural productivity within a short period. Meanwhile, countries that do not have enough financial resources must maximize financial resources by mobilizing domestic resources and foreign aid, and concentrate the resources on some targeted areas within agricultural sector at first. The targeted areas would eventually develop competitiveness through implementation of technology enhancement and financial support.

With the successful performance in the targeted areas, advanced technologies and available funds can be shared with the food security areas.

Regardless of context, national leader’s firm conviction on government investment in the agricultural sector, building the basis of infrastructures for agricultural production, creation of organization with an efficient operation system for development of new technologies and the rapid spread of these technologies to farms, and the close cooperation system with the related institutions of home and abroad are needed for the successful achievement of the Green Revolution. But most of all, farmer’s consciousness and national consensus would be prerequisite for the achievement of the Green Revolution.

Chapter 1

Background of the Green Revolution in Korea

1. Domestic and International food situation
2. The backgrounds of policy

Background of the Green Revolution in Korea

1. Domestic and International Food Situation

1.1 Domestic Food Situation

A sudden increase of population, due to the repatriation of overseas residents from Japan, China and Manchuria after the liberation from the Japanese occupation and the swarm towards the south by North Korean families due to the division of north and south, drove the bad food situation from bad to worse. Moreover, the Korean war (1950~1953) caused the chronic food problem to be prolonged seemingly due to supply of military provisions, inundation of North Korean war refuges and the devastation of farm lands. The repeated disasters such as drought and flood, lack of chemical fertilizers decreased the productivity of food grains, not only rice but other cereals. The domestic production could not cover the demand of food grains for the people. In 1960s, Korea was one of the poorest countries with GDP per capita of USD 83, making food import unsustainable. Lots of farmers in rural area and urban laborers were subjected to the severe food shortage, especially in the spring season just before the harvest of barley crop.

Fortunately, the national economy began to grow gradually every year starting in the early 1960s, fueled by the industrialization and increase of export based on the policies of National Economy Development Plans. The national economy grew drastically resulting in increase of export from USD 86 in 1968 to USD 1,067 million in 1971. However, the situation of food shortage prevailed and the government had to import lots of food from overseas which amounted to USD 26 million in 1971. Import of food grains was a big burden on the national economic development. Therefore, extraordinary determination and pursuit on a national basis was needed to speedily resolve the structural problem of the food economy, namely the chronic food shortage. The government put the increasing food production on the top of the policy agenda along with industrialization, and increased financial supports in the agricultural sector.

1.2 World Food Situation

During the past 70 years, world food situation fluctuated, showing abundance and shortage alternately. Due to the destruction of agricultural basis during the Second World War, the food shortage prevailed from the end of 1945 to 1953 in many countries except U.S.A. Thereafter, the food situation improved again all throughout the world by the impact of the increased production in Europe and Soviet Union. In the early- and mid-1960s, while agricultural production stagnated in Europe and Asia, food consumption increased sharply due to increasing population and the decreasing amount of food grain stock through the world. The Green Revolution proceeded successfully in developing countries around India after 1967 and overproduction of food grains occurred up to 1971. However, unstable supply and food consumption caused by the food crisis during 1973-74 continued until the early of 1980s in many countries. To cope with the food crisis, most of countries in the world strongly pursued the policy of food self-sufficiency. In fact, there were many difficulties in export and import of food because of complex political and diplomatic concerns. Occasionally food itself became a kind of weapon in the world trade. For these reasons, many countries prioritized safeguarding national autonomy by securing food security, rather than acquisition of food through the free trade based on the principle of comparative production cost or the theory of comparative benefit. They believed that food problem could adversely affect national autonomy.

Table 1-1 | Rice Production and Self-Sufficiency in Korea

Year	Population (000 persons)	Rice production (000 ton)	Rice self-Sufficiency (%)	Food grain self-sufficiency (%)
1962	26,470	3,015	102	91
1963	27,226	3,758	96	76
1964	28,181	3,954	101	94
1965	28,670	3,501	101	94
1966	29,160	3,919	99	95
1967	30,131	3,603	99	87
1968	30,838	3,195	94	81
1969	31,544	4,090	81	74
1970	31,435	3,939	93	81
1971	32,883	3,998	83	71
1972	33,505	3,957	92	71
1973	34,103	4,212	92	69
1974	34,692	4,445	91	70
1975	35,281	4,669	101	73
1976	35,845	5,215	103	74
1977	36,412	6,006	109	65
1978	36,969	5,797	104	73

Source: Kim, I.H.(1978), KREI(1992)

2. The Policy Background

2.1 Strengthening Administrative Organizations and Institutions

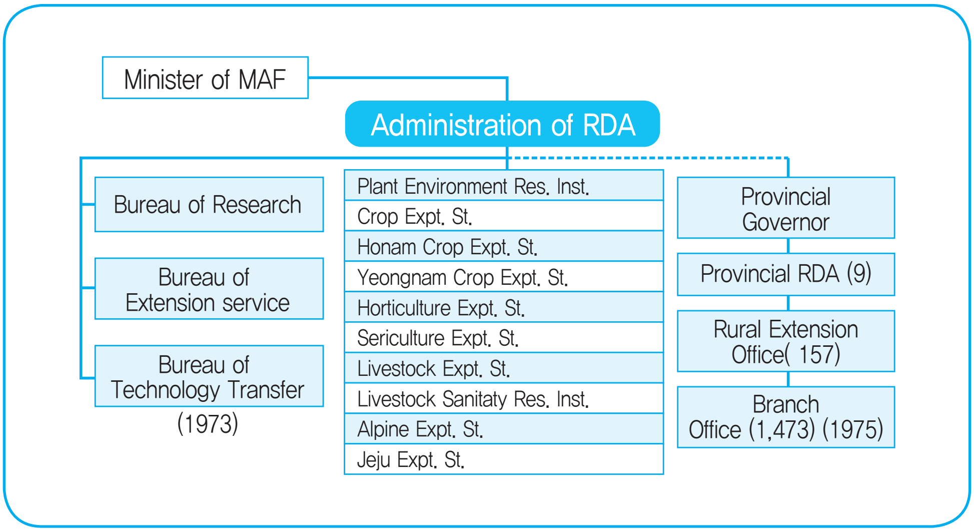
2.1.1 Ministry of Agriculture

When the Korean government was established in 1948 following the liberation from Japanese colonial rule, food shortage was the most urgent challenge. The agricultural policy attempted to face the challenge by controlling food prices rather than the expanding agricultural production which is essential for long-term stabilization of national economy. Policy for increasing food production was not implemented until 1960 when the first 5-year development plan of national economy began. The government set up the 1st 5-year plan that aimed at expanding food production and emphasized technology dissemination to aid productivity. The plan also supplied of agricultural inputs and improved seeds and crop cultivation methods. Also, the government directly managed food grain imports and tried to increase the domestic food cultivation. The government organization related to the agricultural production was reshuffled to strengthen these strategies in the Ministry of Agriculture and Fishery (MAF): The Division of Agricultural Inputs and the Division of Agricultural Education&Training were newly set up to support the strategies for increasing food production in 1955. In 1962 the Bureau of Agricultural Production was born, to administer good production expansion and achieving self-sufficiency for staple crop, mainly rice. In 1973 the Food Grain Policy Bureau and the Food Grain Management Bureau came into being to manage the government purchase system of food grains. In the late of 1970s when the national economy somewhat developed thanks to the progress of manufacturing industries, the government increased the invest in building the infrastructures for expanding rice production and set up the Farmland Development Bureau and the Farmland Management Bureau for these services.

2.1.2 Foundation of Rural Development Administration

The Rural Development Administration (RDA, former ORD) is a unique government agency under the MAF, playing a main role in conducting agricultural research and extension services as well as collaboration with international organizations and foreign research institutes. In collaboration with international research organizations, it aims to contribute to global development through sustainable food production, high-tech agriculture and vibrant rural areas. Agricultural R&D and technology transfer system has been known to be a successful model with integrated combination between research and extension services through the RDA during the last half century as revealed by the case as the Green Revolution and the white revolution. The administrator of RDA assists the Minister of MAF on matters of technical and extension work problems at the core of the nation's rural development policy, but he is the top officer responsible for planning and implementation of agricultural research and extension in the nation. The RDA mainly comprised of three bureaus such as the Research Management Bureau, the Extension Service Bureau, and the Technology Transfer Bureau in headquarters, and ten research Institutes which were responsible for the developing new varieties and technology suitable for different regions and/or different crops [Figure 1-1].

Figure 1-1 | The Organization of Rural Development Administration (1970. 4. 8)



MAF; Ministry of Agriculture and Fishery, Res.; Research, Inst.; Institution,
Expt.; Experiment, St.; Station

The nine provincial RDAs (PRDA) in each of nine different local areas were responsible for transferring new technology to the farmers and rural community through the adaptability test and extension services. The "Rural Development Law (1962)" entrusted the RDA Administrator with the duty on governance of the PRDA as concerns with agricultural productions including personal management even though they were belonged to the Provincial Governor in the Constitutional.

The "Rural Development Law (RDL, 1962)" describes the missions of RDA; to contribute to the development of farmers' welfare through conducting agricultural experiment and research, transfer of scientific knowledge and technology on agriculture and rural life, and training rural leaders and farmers. Specific obligatory missions of the Rural Development Administration are as follows:

- Conducting research and development for improving developing agricultural technology concerning food crops, livestock, veterinary medicine, horticulture, sericulture and farm machinery, etc., and for developing farm management.
- Transferring scientific knowledge and technology for improvement of agriculture and rural life, especially through informal education and demonstration and through fostering rural people's organizations.
- Training farmers, local leaders, rural youth, students and teachers of agricultural high school as a part of cooperative education, as well as research and extension officials in agricultural technology organizations.

2.1.3 Rice Research Organizations in RDA

There were three main organizations for rice research and breeding in Korea. The rice breeding organizations were located based on the rice eco-system such as varietal maturity and targeted breeding areas: Crop Experiment Station in Suweon for the middle part of the Country, Honam Crop Experiment Station in Iri(Iksan) for the south western part, and Yeongnam Crop Experiment Station in Milyang for the south eastern part, respectively. Each Station had substations for the selection and testing of the breeding materials in the environment of the targeted areas in the regional specific <Table 1-2>.

Table 1-2 | Research Institutes for Rice Breeding and their Research Areas

Institute†	Selection&testing for regional adaptability	Year of establishment	Specific criteria of selection&testing
Crop Expt. St.	Breeding for mid central region	1906	- Resiatance to blast disease and to cold temperature
- Cheolwon Br.	- Selection early variety for northern regions	1968	
- Chuncheon Br.	- Selection&testing on cold resistance	1978	
- Namyang Br.	- Selection&testing on saline resistance	1976	
- Jinbu Br.	- Selection of extreme early variety for mountainous region	1981	
Honam Crop Expt. St.	Breeding for west southern region	1930	- Resiatance to leaf blight and salinity
- Kyehwa Br.	- Selection&testing on saline resistance	1976	
- Unbong Br.	- Selection early variety	1981	
Yeongnam Crop Expt. St.	Breeding for east southern region	1965	- Resiatance to strip virus, dwarf virus and late transplanting
- Yeongdeok Br.	- Selection of extreme early variety for east southern coastal region	1981	
- Sangju Br.	- Selection of extreme early variety for east southern mountainous region	1981	

Expt.: Experiment, St.: Station. Br.: Branch station

2.1.4 Organization and Activities of Extension Services

a. Organizational development of agricultural extension services

The modern system of agricultural extension program, in the true sense of the word, was initiated with the foundation of the Government of the Republic of Korea in 1948, and developed into a national program for the first time in Korea under the "Agricultural Extension Law" in 1957. However, the programs of the agricultural extension and those of the community development by different agencies pertaining to rural development were overlapping and hence competed with each other.

The institutional integration of agricultural and rural extension service system was not conducted jointly until 1962 when the RDA was established under the Rural Development Law (RDL).

According to the RDL, Provincial RDAs and City/County Extension Offices were established respectively under each governor of local government at various administrative levels.

Since then, consistency began to arise in planning and implementing agricultural extension service in line with the overall agricultural policy and plan of the local government. And the budget for agricultural extension program has been shared by local governments as well as central government. This structure has greatly relieved monetary shortages. In 1964, branch offices of county extension for grass-root agricultural extension programs were established at township levels throughout the country.

Since both functions of research and extension were legally integrated so that the Administrator of the Rural Development Administration was responsible for these two very closely interdependent administrative functions, there were certainly clear-cut advantages for the extension service.

b. Extension organization

The extension organization of the RDA maintains various extension programs through the Extension Service Bureau, the Farm Management Office and the Public and Technical Information Office. There were four divisions under the Extension Service Bureau.

The Provincial Rural Development Administration (PRDA) represented the nine provincial organizations of the RDA. They were external arms of the provincial government and were consequently administratively controlled by the governors.

The 157 city/county "Rural Extension Offices" administratively and technically belonged to the hierarchical control of PRDA. But at the same time, each extension office formed an external arm of the respective city and/or county government. The county extension office, however, was considerably dependent on the county government in many ways, including financing, which was probably the most important aspect of agricultural extension work.

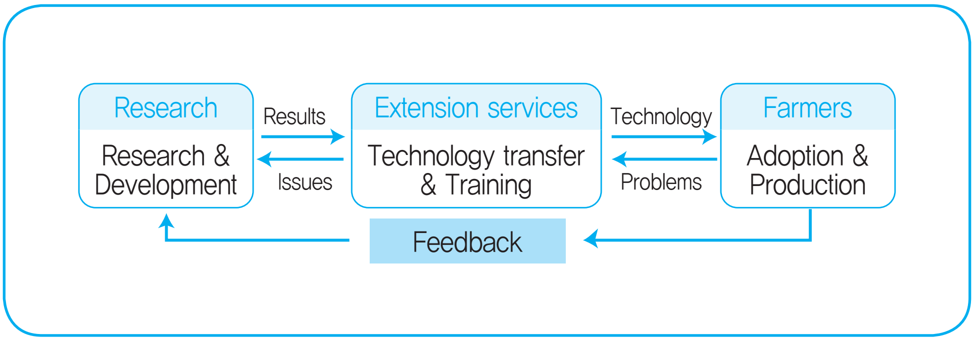
Finally, there were the real grass-root extension organizations under the jurisdiction of the county extension offices, which were named "Farmers Counseling Office" totaling 507 across the nation at the township level. Each office was geographically responsible for extension programs. These local extension offices made plan and carry out localized programs, and at the same time execute national extension programs financed by the government.

c. Characteristics of Organizational System

The characteristics of organizational system may be summarized as follows:

(1) Since both functions of research and extension are integrated under the same administrator of RDA, the results of agricultural research and newly-developed techniques could be more effectively, efficiently and timely disseminated to the farmers through the nationwide extension channels and networks. Any problems that occurred in the course of extension activities could be easily adopted as research projects [Figure 1-2].

Figure 1-2 | The Linkage of Research and Extension Services



Results of research are thoroughly examined, screened, and given to economic analysis by the research and extension joint evaluation committees. These results applied to agricultural policies and extension services. Related extension specialists are always aware of research programs going on and they actively participate in research planning and evaluation activities. Participation of researchers in extension programs is not only helpful for technical dissemination but also helps gathering very useful information for improving agricultural research programs. Researchers have opportunities to review the applicability of their research findings on the farm field through their involvement in extension activities such as field observation trip, training farmers, evaluation meeting, etc.

(2) The institutional cooperative relationship of the extension service system with provincial and local governments, generally known as general administrative agencies is another characteristic. With this relationship, the extension program is not only easily

integrated into comprehensive rural development policies, but also supported from the administrative agencies.

(3) Besides this close cooperative relationship between the extension program and administrative policies at all levels, the budget for agricultural extension services comes from central, provincial and city/county governments in collaboration with each other.

d. Extension personnel

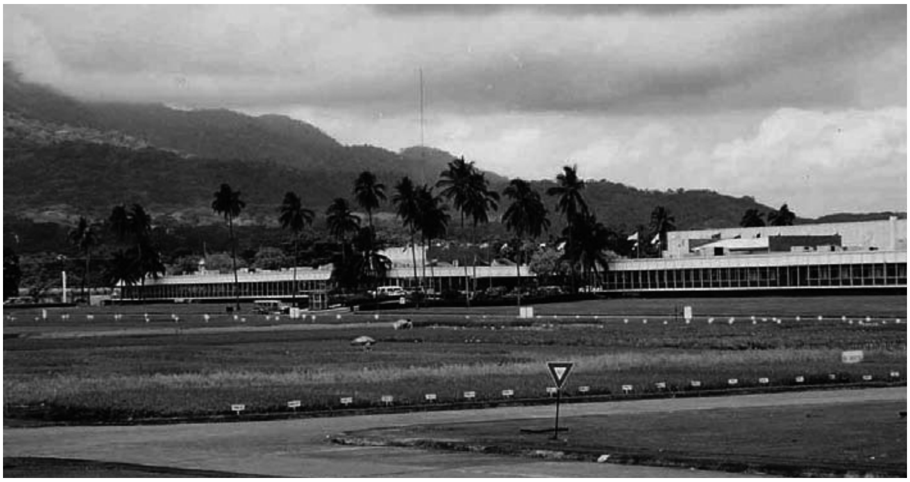
The extension workers are central or local government officials, and the Administrator of RDA was in charge of local extension personnel administration, directly or indirectly including appointment, positioning and promotion. A total of 952 extension personnel were made available for the Institute of Agriculture in 1958. The number of extension personnel has since steadily increased to reach total of 7,980 by the end of 1980 <Table 1-3>.

Table 1-3 | Number of Agricultural Extension Personnel

Year	Total	RDA	PORD	City · County Extension Office		
				Total	Headquarter	Br.
1957	952	82	177	693	693	-
1960	1,192	82	155	955	955	-
1962	3,173	75	180	2,918	2,918	-
1965	6,534	72	242	6,220	2,683	3,537
1970	6,360	73	236	6,051	2,882	3,169
1975	7,626	82	226	7,318	2,667	4,651
1977	7,628	84	226	7,318	2,667	4,651
1980	7,980	106	226	7,648	2,997	4,651

Source: The Manual of Agricultural Extension Service (1983)

Figure 1-3 | The International Rice Research Institute



2.2.1 Cooperation with the International Rice Research Institute (IRRI)

IRRI was established in 1960 and started research in 1962. The cooperative relationship between RDA and IRRI was initiated in July, 1963. Dr. S. Wortman, Assistant Director of IRRI, visited RDA in 1963. Subsequently, Dr. R. F. Chandler Jr., Director General of IRRI, visited RDA and proposed the training of RDA researchers at IRRI. In 1968, Dr. D. S. Athwal, Assistant Director of IRRI visited RDA and concluded a Memorandum of Agreement on collaborative research and training with the Administrator of RDA, which marked the beginning of a formal cooperative relationship. This agreement was regarded as IRRI's aid for Korea since the major program was the training of RDA staff. Since 1969, RDA staff began to visit IRRI for meetings, research activity, and on the job training programs. During this period, IR667 line from the cross of IR8//Yukara/TN1, which became the base of the Korean Tongil variety development and the start of Green Revolution in Korea, was discovered. Most of the RDA researchers sent to IRRI during this period, belonged to the generation that experienced the World War II as well as the Korean War and had insufficient linguistic and scientific knowledge base. However, they exerted every effort to compensate for such deficiencies, and came to be known as hard working scientists which contributed favorably to the development of cooperation.

Table 1-4 | RDA Personnel Participated in Cooperation Programs of IRRI (1961~1989)

Objectives		1960's	1970's	1980's	Total
Training course	Job-related	15	28	15	58
	Group	-	19	32	51
	Collaborative research	-	1	25	26
Thesis course	MSc.	4	9	4	17
	PhD	-	5	14	19
Conference		5	22	39	66
Project consulting		10	41	44	95
Materials collection		9	53	49	111
Seed multiplication		3	27	32	62
Dispatched scientist		1	1	7	9
Total		47	206	261	514

Before the RDA-IRRI agreement of cooperative works was signed in 1977, IRRI shouldered most of the cost of visits of RDA staff for meetings and trainings except for the visits of higher RDA officials and staff from seed multiplication project. The total number of RDA staff who visited IRRI for the period of 1960s~1980s was 514, and 36 of which were for degree course training at the University of the Philippines at Los Banos (UPLB) and other universities, nine were dispatched scientists at IRRI, and the rest of them were for trainings, meetings, and observation and study tours. 151 of IRRI specialists visited RDA for assistance or consulting of collaborative projects, crop breeding and genetics, and etc. The cooperation between the Plant Breeding Department of IRRI and RDA continued consecutively for generation advancement of breeding lines. RDA remitted USD 40,803 for the first time in 1975 for generation advancement and seed multiplication. This project is continuing up to present. From 1970 to 1975, multiplied seeds were sent to RDA at first by ship and then through airplane, and all the cost for shipping was shouldered by RDA. In the case of Yushin variety, in which the seeds were multiplied in 1974-1975, was sent to Korea by chartered freight airplane. A rented field was used for seed multiplication. RDA provided the cost for seed multiplication, and IRRI supported the cost for field arrangement, contracting, technology and facilities. In 1977, rice cold tolerance screening was established at the Chuncheon Branch of the National Crop Experiment Station (NCES). Thousands of germplasm from the IRRI germplasm bank were screened for cold tolerance at different growth stages. The outstanding selections were utilized for breeding cold tolerant varieties. RDA sent a number of researchers to IRRI to develop Tongil type varieties which led to the development of Yushin, Milyang 21, Milyang 23, Nopung, Raegyung, Suwon 258. The high yield potential, nitrogen responsiveness and lodging resistance of Tongil-type varieties were recognized internationally, and Korea recorded the highest rice production of about 6 million metric tons in 1977.

Table 1-5 | Visit of IRRI Specialists to RDA (1963~1989)

Objectives	1960's	1970's	1980's	Total
International collaborative research projects	-	2	7	9
Crop breeding and genetics	5	15	11	31
Crop physiology and cultivation technology	1	7	2	10
Cold tolerance of crops	-	4	12	16
Cropping system	-	2	7	9
Plant diseases and insect pests	-	10	20	30
Soil improvement	-	-	7	7
Agricultural machinery	-	3	3	6
Project consulting	9	9	7	25
Economics, extension, and public relations	-	5	3	8
Total	15	57	79	151

2.2.2 The Crop Improvement Project supported by the Agency for International Development (AID) of the United States

The government of the United States granted a loan of 500 million dollars to Korea for 5 years from 1974 to 1978 to assist the Crop Improvement Project. To achieve the Green Revolution earlier in Korea, the objective of this project was laid on building the basis for research through training of researchers and introduction of experimental instruments in six areas such as rice, wheat and barley, legumes, potato, cropping system, and agricultural machinery. Besides the loan, KRW 1,575 million was added to governmental budget for the project expenses. As a rule, training of researchers was carried out in the United States. The total number of participants in the oversea training was 215. During the period for the project, nine of long-term specialists and 78 of short-term specialists were invited to RDA and contributed much to improvement of the research system and the level of research in agriculture of Korea.

Table 1-6 | Number of Personnel Trained in AID Project (1974~1978)

Ph.D. course	MSc. Course	Short-term training	Conference&observation	Total
21	17	94	83	215

2.2.3 Korea-Japan Collaborative Research Project in Agriculture

Korean government and Japanese government signed the Agreement of Korea-Japan Agricultural Collaborative Research Project in June 1974 to promote technical cooperation between the two countries by joint working, exchange of technologies and experts, assistance of equipments, and exchange of seeds. The project continued for 15 years until 1994 in three periods and KRW 1,000 million of domestic capital and JPY 1,380 million of Japanese loans were used. The objective of this collaborative project was laid on the development of safety and high-yielding crop varieties (1974~1979), reduction of climate disasters in crops (1982~1987), and increase in farmland utilization (1989~1994).

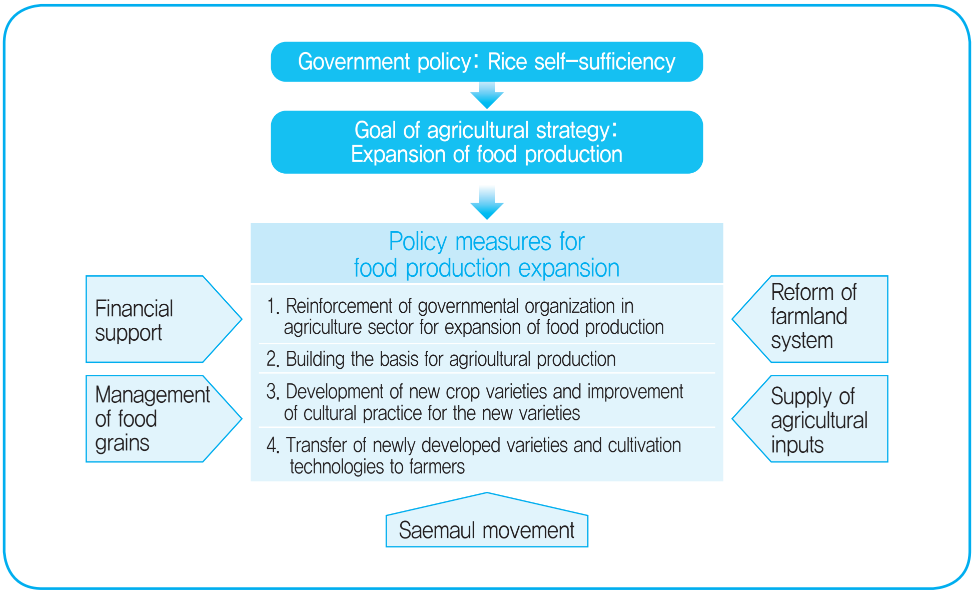
During the period for the project, 89 of RDA staffs visited research institutes and universities in Japan for training and observation, and 166 of Japanese specialists visited RDA for technical assistance and collaboration. New instruments, research references, and etc. were introduced from Japan for advancement of agricultural research in Korea.

2.3 Planning and Implementation of the Policies for Expansion of Agricultural Production

The "First 5-Year Economic Development Plan (5YEDP)", which began in 1962, was the first comprehensive economic development plan in the history of Korea. This plan and subsequent initiatives enabled Korea to achieve a rapid economic growth and modernization during the following 30 years. The main agricultural goal of the First 5YEPD was food self-sufficiency through the expansion of agricultural production. Specific plans included land reclamation and re-cultivation projects, land planning and improvement of irrigation systems, and research and training programs for increasing agricultural productivity. In the Second 5YEPD that began in 1967, boosting of the farmer's income and the parallel development of agriculture and other industries for the modernization of rural regions were added to the goals of national agricultural policy.

The national economy grew by an average of 10% through the duration of the two 5YEPD. However, uneven development that focused on industrialization still left deep gaps between agriculture and other industries, and rural and urban regions. Since the food problem resulting from industrialization remained serious, the goals of the government's agricultural policy were aimed at increasing food production and modernizing the production process. The means to achieve its goal were development and dissemination of agricultural technologies, provision of guidance to farming villages, enlargement and consolidation of farmland, development of agricultural water resources, seed improvement, and mechanization of agriculture. In addition to these, various policies were adopted: rural development through supply of electricity and expansion of roads, farm income assistance through a special project to increase farmers' income, and price support for agricultural products through a dual price policy of rice, in which the government paid higher price to the growers but offered lower price to the consumers in a market since 1971. As a result, rice production increased greatly and made self-sufficiency of rice possible and the Green Revolution was achieved in 1977.

Figure 1-4 | The Government Policies for Food Production Expansion and Related Policy Measures in the Late of 1960s to 1970s



2.4 Policies and Systems Supporting the Increasing Food Production

2.4.1 Financial Resources

Since the late 1960s, agricultural development plans were created every five years as a part of the government's 5-Year Economic Development Plans. Rice cultivation was at the center of farm policy during this period which focused on the increasing food production and providing stable supplies. The budget was predominantly used for farmland reform, irrigation system improvement, mechanization, fertilizer assistance and other programs for rice production. The government provided the secured financial resources with policy funds from the national budget to support the program of the increasing food production. Until the 1970s, when the government budget was insufficient, short-term loans formed the major part of policy loans for agriculture. The government policy loans for agriculture mostly supplied through the Nonghyup (NACF: National Agricultural Cooperative Federation) which was founded in August 1961 by merging the Agricultural Bank and Agricultural Cooperatives of those days. The Government allowed that NACF function as the sole supplier of policy funds for agriculture, resulting in contribution, resulting in contribution to the growth of NACF as a successful banking institution in rural areas.

In the late 1970s, when the financial situation of the nation slowly improved, the government began to increase the supply of mid- and long-term funds, such as the fund for agriculture <Table 1-7>.

Table 1-7 | Changes in Governmental Financing on Agricultural Sector

(Unit: million won)

Year	Investments and loans	Budget for food grain purchase	Total	Year	Investments and loans	Budget for food grain purchase	Total
1965	18,023	31,858	49,881	1973	111,556	230,242	341,798
1966	30,579	40,696	71,275	1974	148,100	295,784	443,884
1967	36,769	43,477	80,246	1975	224,384	486,488	710,872
1968	51,992	55,106	107,098	1976	292,250	806,100	1,098,350
1969	80,744	72,057	152,801	1977	362,413	922,521	1,284,934
1970	86,597	116,074	202,671	1978	448,020	1,361,892	1,809,912
1971	104,827	130,930	235,757	1979	627,418	1,484,031	2,111,449
1972	100,991	178,701	279,692	1980	1,212,878	1,680,397	2,893,275

Note: The governmental financing on agricultural sector was composed of national budget, funds, aids, funs of National Agricultural Cooperative Federation, National Federation of Fisheries Cooperatives, and National Livestock Cooperative Federation

Source: 50-Year History of Agricultural Policy in Korea

2.4.2 Reform of Farmland System

Farmland reform was implemented during the 8-year period from 1950 to 1957 in accordance with the Farmland Reform Act, which was enacted in June 1949. It contributed to both the abolition of the landlord-tenant relationship and the establishment of self-employed farmers. At the time of liberation from Japanese colonialism, agricultural industry was comprised of small tenant-farmers that leased plots from large landowners. Nearly two-thirds of households owned no land, and 85% of total farm households farmed small or large plots of land leased from large landowners. The majority of these plots were less than 1 hectare in area, and low productivity and high rent prevented these farmers from harvesting enough to even feed their own families.

Table 1-8 | Changes in the Area of Owner Farming after the National Liberation

(Unit: 1,000ha)

Year	Total Farmland	Owner Farming (%)
1945 (December)	2,226	779(35.0)
1947 (December)	2,193	868(39.6)
1948 (December)	2,132	1,305(61.2)
1949 (June)	2,071	1,398(67.5)
1950 (April)	1,971	1,739(88.2)

Source: 50-Year History of Agricultural Policy in Korea(1992)

Thus, one of the most pressing issues of the newly established government was land reform, which could provide stability to the nation's largest demographic group and enhance agricultural productivity. The revised constitution of Korea included the clause "distribution of land to real farmers," an ultimatum that stated the government's decision to start land reform. The Land Reform Act was promulgated in June of 1949, and land reform began in the spring of 1950. Lands exceeding three hectares per household or plots uncultivated by the owner were subjected for redistribution and the government compulsorily purchased these plots and distributed them at affordable cost to small farms and agricultural laborers.

Total of 585,000 ha of land were redistributed through the land reform, amounting to 40% of total distributed farmland. At the end of the land reform in 1950, 88.2% of the total South Korea's farmland, which included the 713,000 hectares of land sold by landowners before and after the start of the land reform, was transferred to the real farmers <Table 1-8>. The land reform created an independent owner farming system, which provided the minimum safety net for the rural economy. The ownership of the farmers inspired them to enhance productivity. The children of farmers were capable of receiving a public education, which created a pool of educated workforce that formed the backbone of the Korean economic development. The eradication of the landowning class also removed a barrier preventing the proper development of capitalism in Korea.

Since the late 1960s, the use of farmland for purposes other than farming increased rapidly due to urbanization and industrialization <Table 1-9>, and in the 1970s, the world experienced an oil crisis and food shortage. Alarmed by these challenges, the government enacted Farmland Preservation and Utilization Act in 1972 and strictly restricted diversion of farmland for non-agricultural purposes. The core content of this law was to selectively protect farmland by designating them as "Absolute farmland" and "Relative farmland". Absolute farmland was designated for mostly rice paddies and other farmland that needed to be strictly protected and Relative farmland for other types of farmland. The government also required anyone who intends to use farmland for other purposes to obtain government permission and pay a fee to Farmland Management Fund to bear the “Farmland creation cost” in making alternative land available for farming. During this period, the government’s will to preserve farmland was stronger than ever before.

Table 1-9 | Changes in Farmland Area

(Unit: ha)

Year	Increased area(A)	Reduced area(B)	Difference(A-B)
1967	55,240.6	33,781.3	21,459.3
1968	41,090.3	33,131.0	7,959.3
1969	25,294.1	29,114.9	△ 3,820.8
1970	40,517.4	59,691.6	△19,174.2
1971	55,709.0	90,169.2	△34,460.2
1972	42,612.3	64,352.8	△21,740.7
1973	47,940.6	46,725.6	1,215.0
1974	8,572.1	11,393.0	△ 2,820.9

Source: 50-Year History of Agricultural Policy in Korea(1992)

2.4.3 Building the Infrastructures for Agricultural Production

“Poor harvest occurred very often even under a slight drought caused by the shortage of farm water. Crop yield was entirely dependent upon the circumstance of an appropriate precipitation in that year. Big and blue rivers flowed nearby were beyond the utilization for agriculture!” -The 50-Year History of Agriculture in Korea–

The utilization of water in farmlands has been an essential element in food production. In Korea, many and diverse projects for development of agricultural infrastructure were carried out to change lands and water resource utilization. Before 1960s the projects called the irrigation project focused mainly on improvement of irrigation system for the rain-fed or incompletely-irrigated paddy fields. In 1960s, projects for land reclamation, reclamation of coastal areas, farmland consolidation, and management of the facilities for farmland improvement as well as the irrigation facilities were implemented under the related laws and regulations such as the Law of Land Improvement, and the Law of Reclamation, etc.

In 1970s the projects focused on the preparation of foundation of the improvement on the stable agricultural infrastructure. Diverse projects to obtain food self-sufficiency were carried out; a large-scale comprehensive agricultural development project by the introduction of foreign fund and implementation of sustainable agricultural water development, implementation of agricultural infrastructure such as farmland enlargement though reclamation and farmland consolidation and drainage improvement. Outcome of the implementation of the agricultural infrastructure development is shown in Table 1-10. In brief, 76% of paddy field was irrigated and 60% of farmland was consolidated during the period from the liberation from Japanese rule to 1997. In addition, the farmland enlarged to 230 thousand hectares by reclamation of 189 thousand hectares and by reclamation of coast area of 41 thousand hectares. The drainage projects also improved 71 thousand hectares of farmland. Of these outcomes the irrigation improvement by the water development project was the most outstanding and sustainable result.

Table 1-10 | Farmland Development after the National Independence (1946~1997)

(Unit: ha)

Project	Total	1946~1949	1950~1959	1960~1969	1970~1979	1980~1989	1990~1997
Total	2,073,526	15,756	164,241	594,048	525,683	309,215	464,583
Water development	896,709	15,520	158,308	337,171	214,648	82,627	88,435
Irrigation improvement	71,145				16,256	25,783	29,106
Farmland consolidation	695,797			95,935	196,972	160,759	242,131
Agricultural comprehensive development	179,599				68,707	30,362	80,530
Farmland development	189,395		2,514	152,833	27,550	4,646	1,852
Coastal reclamation	40,881	236	3,419	8,109	1,550	5,038	22,529

Source: 50-Year History of Agricultural Policy in Korea(1992)

2.4.4 Policies for Agricultural Inputs

a. Chemical Fertilizers

The supply of fertilizers to farmhouses was seriously limited at the time just after the liberation of the nation from Japanese colonial rule, because most factories for fertilizer production were located in the northern part of Korea after the separation of the country into the north and the south. Even small factories of the southern Korea were almost destroyed during the Korean War and a few of the remained fertilizer factories did not run well. From these reasons there were lots of difficulties in agricultural production and supply of chemical fertilizers relied entirely on import from abroad and the government had to pay a lot of foreign currencies for the chemical fertilizers.

The construction of fertilizer factory was initiated by “Chungju Fertilizer Co.” under the aid plan of Food and Agriculture Organization, United Nations at 1961 and followed continuously by several large-scale fertilizer factories such as “Yeongnam Chemical Co.”, “Jinhae Chemical Co.”, “Hankuk Fertilizer Co.” etc. The yearly capacity of fertilizers reached 1,132 thousand tons in the late 1967 and at last, the production of fertilizers became over the demand of farm households in 1975. The fertilizer industry achieved self-sufficiency from 1977 and became an export industry <Table 1-11>.

Table 1-11 | Progress in Construction of Chemical Fertilizer Factories in Korea

Year	Company	Kind of fertilizer	Production capacity (M/T/yr)	Financial resource
1961	Chungju Fetilizer Co.	Urea	85,000	AID loan
1962	Honam Fertilizer Co.	Urea	85,000	The Government
1967	Yeongnam Chemical Co.	Urea, Composite	264,700	Domestic capital, AID loan
1967	Jinhae Chemical	Urea, Composite	264,700	Gulf Co., AID loan
1967	Hankuk Fertilizer Co.	Urea	330,000	Mitsui Co., Samsung Co.
1966	Kyunggi Chemical Co.	Fused phosphate	50,000	Domestic and foreign capital
1967	Pungnong Fertilizer Co.	Fused phosphate	54,000	Foreign capital
1963	Chosun Fertilizer Co.	Composite (mulberry)	-	Joint with NACF
1968	Chosun Fertilizer Co.	Composite (forest, grassland)	-	-

Source: 50-Year History of Agricultural Policy in Korea(1992)

Note: NACF: National Agricultural Cooperative Federation *b. Agrochemicals*

The Increasing food production, which was among the most urgent tasks in Korea during 1960s~1970s, was successfully achieved thanks partly to the control of diseases and insect pests with the use of agrochemicals. Agrochemicals became the essential inputs together with chemical fertilizers for increase of agricultural productivity in the intensive agriculture <Table 1-12>.

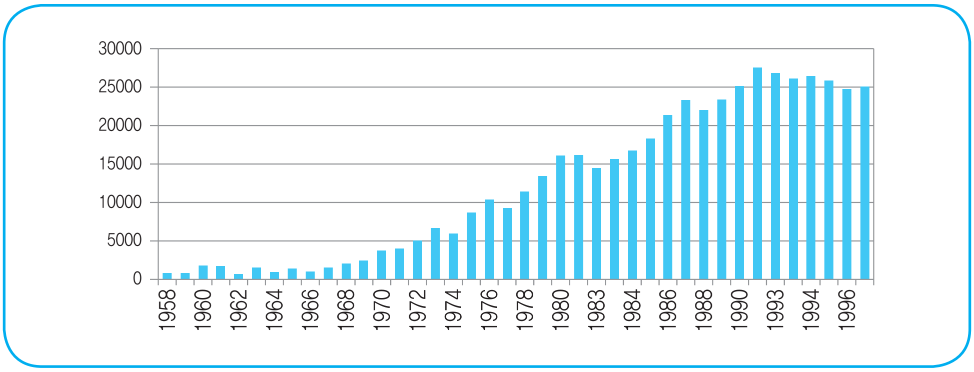
The policy for agrochemicals has been shifted from the period of import of end products (1945~1959) to the period of import of raw materials (1960~1970), resulting in the period of supply of domestically manufactured raw materials since 1970. Since "Pabam" and "DDT" were imported for the first time in 1949, several kinds of agrochemicals such as "BHC (1952)," "EPN (1954)", "2,4-D" and etc. were imported in the form of finished products. Heavy fertilization was necessary to increase the food grain production and caused the outbreak of crop diseases and insect pests. In 1960s, lots of companies producing agrochemicals were founded and the consumption of agrochemicals increased every year [Figure 1-4]. In the mid of 1970s, the industries of agrochemicals substituted the imported raw materials with domestic products up to around 70% for manufacturing the products and they started to export the domestic products to the world market.

Table 1-12 | Effect of Agrochemicals on the Control of Plant Disease and Insect Pests

Year	National Rice production (1,000t)	Effect of use of agrochemicals on rice production			
		Control of diseases and pests (%)	Yield increase (1,000t)	Value added by yield increase (100 million won)	Yield reduction in control plot (%)
1976	5,215	16.5	900	2,610	20.9
1977	6,006	18.2	1,141	3,708	22.4
1978	5,797	22.1	1,432	5,368	32.6
1979	5,565	17.6	1,047	4,787	24.0
1980	3,550	14.7	567	3,241	22.6

Source: 50-Year History of Agricultural Policy in Korea(1992)

Figure 1-5 | Amount of agrochemicals supplied to farmhouse (1958~1997)



Source: 50-Year History of Agricultural Policy in Korea (1992)

2.4.5 Food grain policy

The Korean War lasted for three years and exacerbated the food supply problem. Thus, the focus of national agricultural policy during this period was the creation of national storage of food grain and addressing the food shortage. The government created a grain purchasing system and turned to the United States for food aid. Between 1956 and 1964, a large amount of food aid flew into Korea under the United States Public Law 480 and the Mutual Security Act, accounting for 5% to 23% of total national grain production <Table 1-13>. The aid from the U.S.A. helped to solve the severe food shortage in Korea. However, this foreign aid also had the negative effect of depressing grain prices and reducing farm household income, and is sometimes considered to have damaged the long-term grain production of Korea. Wheat crops, which had little price competitiveness, disappeared gradually, and Korea had to rely on the permanent imports even after the American aid ended.

In the 1970s, the government expanded the public purchase program that had been in place since the 1950s. The government purchase policy was composed of two parts: a "quota" that set the quantity to be purchased by the government, and the purchase price paid by the government for this quantity. The total quota was set by the government each year, based on the historical production and the area reports of local governments. The total quota was distributed to each province, then local governments assigned the given quota to counties, and county offices allocated the quota to individual producers, based on the historical production of each individual farmer. Before HYV "Tongil" variety was developed, the actual quantity purchased from growers by the government was almost always below the planned quotas because the government prices were below the market prices.

Table 1-13 | Food Aid from the United States Based on the Public Law 480

Name of aid	Period	Sum	%
GARIOA	1945-1948	182,659	6.1
ECA-SEC	1949-1953	59,210	2.0
CRIK	1950-1956	202,201	6.7
UNKRA	1951-1959	11,145	0.4
FOA-ICA	1953-1961	332,126	11.1
PL480-1	1955-1971	777,580	26.0
PL480-2,3	1955-1973	433,782	14.5
AID	1962-1967	13,024	0.4
PL480-1, CLCC*	1968-1981	896,108	29.9
AID CLCC	1971-1973	86,988	2.9
Total	1945-1981	2,994,923	100.0

CLCC: Convertible Local Currency Credit

Table 1-14 | Changes in Amount and Price of Rice Purchased by the Government

(Unit: %)

Year	Ratio of rice purchase as compared to total production	Increase in purchase price as compared to market price	Increase in purchase price as compared to price of previous year
1970	8.9	6.8	35.9
1971	12.3	4.6	25
1972	12.8	0.4	13
1973	11.4	3.1	15.1
1974	16.5	-4.0	38.5
1975	16.9	-0.9	23.7
1976	20.0	16.9	19.0
1977	23.4	32.9	13.2
1978	23.4	14.8	14.2
1979	23.4	12.8	22.0
1980	15.4	-1.3	25.0

To fill the quota, local government officials had to persuade producers to sell rice to the government. This pattern changed in 1974 when the area of HYV rice variety expanded dramatically. From 1974, farmers asked the government to increase the quantity purchased by the government because market prices were below the government prices. As noted the Korean government induced growers to adopt Tongil-type varieties by setting the government prices higher than market prices. The policy set the price for lower quality rice at the same price as higher quality rice. In the early 1970s, the government substantially raised the government price for rice every year. Under the government purchase program, real rice prices rose 5.7% annually between 1969 and 1979. Compared to the annual growth rate of real prices of 2.4 % between 1980 and 1990, and 1.1 % between 1991 and 2000, the rate in the 1970s was high. This induced a faster adoption of the lower quality rice since farmers could sell more rice at the same price as japonica varieties.

Chapter 2

Development of Semi-dwarf High Yield Rice Variety

Development of Semi-dwarf High Yield Rice Variety

The full impact of Green Revolution was realized after the development of semi-dwarf high-yielding varieties. It should be noted that new rice varieties were the product of a long and sustained research effort. Developing a new rice variety is a product of times to the socio-economic and consumers requirement, and derived from a procedure of an artificial evolution that changes the genetic make-up of the rice plants through gene recombination for the further improving the existed varieties.

In Korea, the comprehensive work of rice breeding initiated with a systematic collection of native rice varieties and their pure-line selections when “Gweonupmobeomjang”, the first national research organization, was founded in Korean peninsula in 1906. However, it was not properly operated to adopt for Korean environment during the Japanese rule (1910~1945) mainly due to Japanese policy that favored Japanese people. After the liberation from Japan, the Korean government enforced its policy prioritizing agricultural development for national food security. Under such circumstances, the productivity of rice varieties progressed to 4.06~4.57 t/ha for the leading varieties during 1960s and its national average also hiked to 3.3 MT/ha on the farmers’ field, but it was not sufficient to meet self-sufficiency in rice as a staple food crop.

Modern scientific technology have made tremendous progress in the technology of rice production which induced the Green Revolution, self-reliance of the staple food since 1962 when the ORD(Office of Rural Development), the government agency for national agricultural research and extension service, was reshuffled to perform agricultural research and technology transfer system. During 1970s, Tongil-type rice varieties that fueled the Green Revolution in Korea were developed with a goal to achieve the self-sufficiency of rice, a staple food crop. “Tongil”, the initial semi-dwarf high yielding rice variety, was released in 1971, and subsequent Tongil-type varieties were released 25 by 1977 and 40 by 1986, which powered the Green Revolution in Korea. The productivity of Tongil rice variety hiked to 5.13 t/ha, 28% greater than that of the best japonica rice variety at that time. The productivity of subsequent Tongil-type varieties steadily increased to 5.76 t/ha for Milyang 23 in 1976 and 6.05 t/ha for Yongmubyeo in 1985. The national average of milled rice yield in the farmer's field dramatically increased to 4.93 t/ha ranging 4.37~5.53 t/ha in 1977, as compared with japonica varieties yielding 3.3t/ha of milled rice.

Tongil-type rice varieties spread rapidly across the country, in which the acreage reached to 54.6% of total rice areas in 1977 and 76.2% in 1978, resulting in the self-sufficiency of a staple food grain in a short period of 7-years, which was brought by shuttle breeding with close corporation with IRRI.

This chapter viewed the progress of varietal development before Tongil, technical background and procedure of developing Tongil rice variety which was the first semi-dwarf high yielding rice variety, and subsequent developing Tongil-type rice varieties which powered the Green Revolution in Korea.

1. Rice Ecology in Korean Peninsula

Korea is located on a peninsula that is bounded to the continent in the north and surrounded by the Pacific Ocean on the other three sides in the Far East Asia. The peninsula lies along 33°06'~43°01'N latitude and 124°11'~131°53'E longitude. The climate of the peninsula belongs to the temperate monsoon that is characterized by freezing and snowy cold winters and warm and humid summers with a rainy season from June to August. The rest of the year is more or less dry with mild spring and autumn. Annual average temperature ranges from 5 to 12°C with some regional differences from south to north, and plains to mountains. Annual precipitation is 1,000~1,300mm on the average with about 70 percent of total rainfall in summer season of June through August. The day length ranges from 12 to 14 hours with the longest in the late June and the shortest in the late December.

Rice season occurs from April to October; only a single crop of rice is grown in a year. During the rice season, the weather is usually dry at seedling and maturing stages of rice growth and often some cold injuries occur at early and late stages of rice growth, particularly in the mountainous and coastal regions. In the past, there were rain-fed paddy fields; naturally the crop yield was very uncertain. The cultivated rice in the Korean peninsula was generally classified into three groups such as the food grains, animal feeds and weedy rice. There were two different varietal groups for food grains: japonica rice and Tongil-type, which were also subdivided into glutinous and non-glutinous by the characteristics of endosperm and as low-land and upland rice by their difference in cultivation ecology. Even though the cultivated rice varieties in the world have diverged, the rice varieties of the Korean peninsula are quite simple and differ from those of south Asia and Africa. The African rice species, Oryza glabberima, was never cultivated in the Korean peninsula; only the Asian species, Oryza sativa has been cultivated. There are mainly three ecotypes of rice varieties, indica, temperate japonica and tropical japonica within the Asian rice, Oryza sativa. Among them, the major ecotype cultivated in the Peninsula is temperate japonica with additional ecotype of Tongil type, which was derived from the hybridization between japonica and indica in Korea.

The present technology of rice cultivation had its beginning in the early 20th century when the "Gweoneop mobeomjang" (the Agricultural Demonstration Station), the first public research organization, was founded by the Korean Empire in 1906. During the first half of the 20th century, the total areas of rice cultivation in Korean peninsula ranged from 1.402 to 1.656 million ha of which around 70 percent area was in the southern half (presently South Korea) and around 30 percent in the northern northern half (presently North Korea) of the peninsula. The total rice cultivation area of South Korea ranged between 1.10 and 1.26 million ha, during the 2nd half of the 20th century, and is currently reduced to around 1.0 million ha.

Average rice cultivation acreage per rice farmer has changed from less than 1.0 ha in 1990 to 1.06 ha in 2006. Rice is mostly grown in lowland paddy by mechanical implements; about 7 percent by direct seeding and 1~2 percent as upland rice. It is estimated that 78 percent of rice area is irrigated with water supplies from reservoirs, multi-purpose dams, rivers and wells equipped with pumping facilities. Rest of the area is rain-fed, especially in the areas that are at the bottom of the valleys and hilly terrace with little control by the growers.

The rice growing areas in the South Korea are sectioned in three major regions; the northern, the central and the southern based on the climatic conditions, and into six sub-regions with respect to ecosystems and distribution of rice varieties. These sub-regions are (1) the south-western sea coast with very late maturing varieties, (2) the southern plains with late maturing varieties, (3) the central plains including mid-western and south-eastern sea coast with intermediate maturing varieties, (4) the northern plains and the mid-mountainous areas with early maturing varieties, (5) the alpine and high elevation areas with very early maturing varieties, and (6) double cropping areas where short duration rice varieties are grown with cash crops.

2. Outlines of Historical Rice Varieties in Korea

Rice culture in the Korean peninsula is assumed to have settled down as a staple food crop throughout the Korean history. Archaeological findings reveal that rice culture in Korea began in the Neolithic era of Korean history in around 4,000 BP. It appears that rice did not originate but transmitted from China to the Korean Peninsula.

The comprehensive work of rice variety improvement started with a systematic collection of native rice varieties and their pure-line selections followed by exotic introductions and their adaptability tests during the early period of the 20th century. These were replaced by domestic-hybrid varieties bred through hybridization within the traditional temperate japonica varieties since the late 1930s. During 1970s, all different new eco-type rice, so-called Tongil-type that was derived from the hybridization between indica and japonica rice were developed and cultivated to power the Green Revolution in Korea. These Tongil-type varieties were completely replaced by the improved modern japonica varieties with improved plant architecture, high yield potential and premium grain quality in the early 1990s.

2.1 Chronological Changes of Rice Cultivar

2.1.1 Period of Native Rice Varieties

According to the historical record of "Nongsajigseol (1929)", many rice varieties were already grown in Korea since 15th century. Prior to 20th century, a large number of native rice varieties were cultivated by the farmers throughout the Korean peninsula. However, it is not clear how they were formed or developed; they were probably the outcome of unconscious selections by growers. Most of cultivated rice varieties belonged to native and/or land race ones until the early 20th century. The Agricultural Demonstration Station (Gweonupmobeomjang) collected 3,331 accessions of native varieties which were growing in the farmers' fields all over the country in 1910~1912 and identified 1,451 distinct genotypes (excluding duplicates due to similar names and characteristics) among them. These included 876 non-glutinous and 383 glutinous lowland paddies, and 117 non-glutinous and 75 glutinous upland rice collections. It also revealed that 124 varieties out of them occupied 20 percent of total rice acreage at that time. An additional collection of 448 varieties was listed in 1923 and 581 varieties including 388 non-glutinous and 193 glutinous in 1931. These native collections were characterized for awn (presence or absence), maturity duration, number of tillers, height, number of grains per panicle, grain size and shape, period for ripening, tolerance to drought, susceptibility to lodging and blast disease and germinability under moisture stress and soil conditions (Choi, 1978, and Lee, 1965).

2.1.2 Period of Introduced Varieties

Thereafter, the introduced varieties from Japan replaced native rice varieties during the period of Japanese rule. During Japanese occupation from 1910 to 1945, Japanese cultivars were introduced into the Korean peninsula as the farmers were compelled to produce food grains mainly for the consumption of Japanese people. Those introduced cultivar from Japan revealed 16~21 percent higher yield potential than the native varieties, and replaced the native varieties and expanded in cultivation areas to around 85 percent by 1937. About 47 varieties were introduced for general cultivation by 1939. Major rice varieties introduced were Ilchul, Joshinryeok, Gokryangdo, Goomi, Eunbangju, Ryukwoo 132, Norin 6, etc.

2.1.3 Cultivation of Domestic Bred Traditional Japonica Varieties

The first hybridization program to develop rice varieties in the Korean peninsula began in 1915 and the first home-bred rice varieties, Namseon 13 and Poongok, were released to the farmers in 1932. Since then, a total of 36 home-bred rice varieties including Iljin, Palgwaeng, Paldal, Palkeum, Jinheung, Nongbaek, Gwanok, etc. were developed <Table 2-1>; these covered 80 percent of the total rice cultivation area during 1960s. During this period, most of the genetic resources utilized for rice breeding were purely the traditional temperate japonica rice including the native and foreign introductions. Major selection method employed was the pedigree method and partly mutation technique. Major breeding targets were high yield potential, tolerance to heavy doses of nitrogen application and lodging, and resistance to major diseases and insect pests including rice blast and stripe virus.

Table 2-1 | Domestic-Bred Rice Varieties before Tongil-type Rice Varieties

Time-period	No. varieties	Variety names
1933~1944	13	Pungok, Seogwang, Yeonggwang, Iljin, Eungu 5, Eungu 6, Namseon 13, Palgweng, Jogwang, Seonsu, Paldal, Namseon 102, Jungeusuwon 2
1946~1949	5	Gancheok 9, Gosi, Beadal, Saenara, Manseung
1950~1960	7	Suweon 118, Iri 239, suseong, Palgi, Noggwang, Nampung, Iri 265
1962~1970	11	Jinheung, Jaegeon, Shinpung, Hogwang, Suweon 82, Pungwang, Gwanok, Palgeum, Nongbaeg, Mangyeong, Milseong

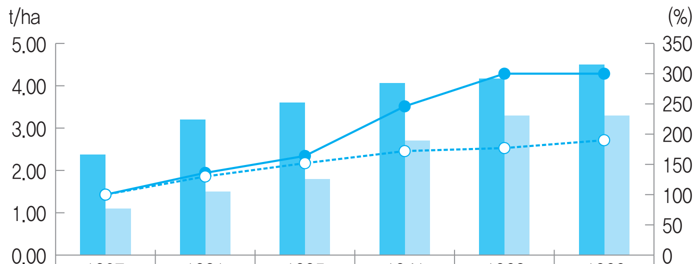
Source: Paddy and Rice (KRWG, 2010)

During the mid-1960’s, the innovative breeding program of rice initiated with wide hybridization between indica (tropical rice) and japonica (temperate rice) under the international cooperative research works with International Rice Research Institute (IRRI), which emphasized the exchange of rice germplasm including breeding materials, the improving capability of research scientists, and shuttle breeding system including generation advances of breeding lines and seed multiplication of new varieties at IRRI during winter season in Korea.

2.2 Progress in Yield Potential of Rice Cultivar prior to 1970

No clear information on rice productivity prior to the 20th century is available in the historical records. However, according to available historical data and farmers' diaries, it is assumed to be less than one ton per ha. It was not until the early 20th century that the official recording of data on rice productivity was attempted. Yield potential of native rice varieties revealed to be around 2.37 t/ha of Jodongji, a leading native rice variety in 1910s, and increased by 3.10~3.60 t/ha, 30~60% higher with the leading introduced varieties, Joshinryeok and Eunbangju in the period of 1920s~1930s. The national average yield from the farmers' field was 0.9~1.1 t/ha with native varieties during the 1920s, and 1.5~1.8 t/ha with the introduced varieties and about 2.0 million MT and 3.0 million MT for the total rice production. However, it was far behind in the national demands mainly due to the fac that 40~50% of production was shipped out to Japan [Figure 2-1].

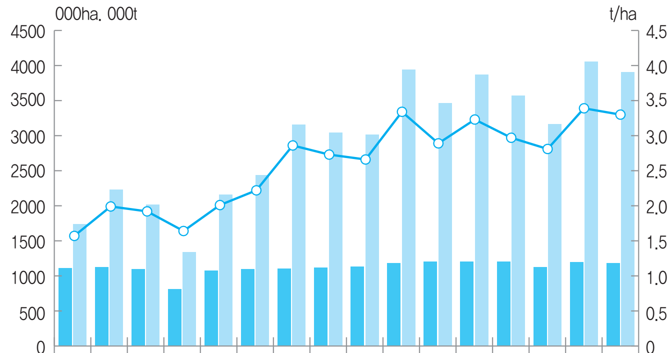
Figure 2-1 | Changes of Yield Potential Rice Varieties Prior to 1970 in Korea



	1907 Jodongji	1921 Damageum	1935 Eunbangju	1941 Palgweng	1962 Jinheung	1966 Gwanok
	Native variety	Introduction		Domestic-bred		
Rice yield protential(t/ha)	2.37	3.20	3.60	4.06	4.17	4.50
Rice yield in farmers field(t/ha)	1.10	1.50	1.80	2.70	3.30	3.30
Rice yield potential(%)	100	130	152	172	177	190
Rice yield in farmers field(%)	100	136	164	246	300	300

After liberalization from Japan in 1945, the yield potential of domestic-bred rice varieties were significantly progressed to 4.06~4.57 MT/ha for the leading varieties such as Palkweng, Jinheung and Palgeum during 1960s, and it was greatly increased to 3.3 t/ha in the national average of the farmers' field. As a result, the improving both varieties and cultural practices pushed the total production of rice up from 2.23 million MT in 1948 to 3.94 million MT in 1964 [Figure 2-2]. However, the national productions of rice declined and/or stagnated during the late 1960's with unstable productivity of rice varieties, mainly due to the susceptibility to major pests and diseases and easy lodging at harvest time with tall height and low nitrogen responses of rice varieties. Therefore, it was still behind in meeting requirements for self-sufficiency in rice production as a staple food crop in Korea.

Figure 2-2 | National Rice Production in Korea (1946~1970)



	'46	'48	'50	'52	'54	'56	'58	'60	'62	'64	'66	'68	'70	'72	'74	'76
Area(000ha)	1,107	1,121	1,098	812	1,074	1,093	1,104	1,117	1,134	1,181	1,199	1,199	1,204	1,127	1,198	1,784
Total production(000t)	1,735	2,230	2,013	1,335	2,158	2,436	3,158	3,044	3,011	3,941	3,464	3,871	3,572	3,166	4,057	3,907
Rice yield in farmers field(t/ha)	1.57	1.99	1.92	1.64	2.01	2.22	2.86	2.73	2.66	3.34	2.89	3.23	2.97	2.81	3.39	3.30

Source: Modern history of Korea agriculture vol.2 (RDA, 2008)
Recalculated: translate "seok" to ton(1 seok = 144kg)

3. Development of Tongil-type Rice Variety

During the period of 1950's~1960's, breeding program of food crops in the world were quite diverse and most actively practiced to solve food problems with inclining world population after World War II. The advances in the science and technology drove the Green Revolution with the substantial public investments and policy support during the 20th century. Irrigation and fertilizer contributed to raise rice yields, but their full impact was only realized after the development of semi-dwarf high-yielding rice variety.

Developing a new crop variety is a product of time consuming efforts. It should be noted that the high-yielding varieties were the product of a long and sustained research effort. A crop breeding is a technology rather than a science because it produces not knowledge but materials that are used for benefit of people (farmers). Therefore, it integrates knowledge drawn from many scientific disciplines. The application of crop breeding technology requires a precise planning and careful implementation since it cannot be expected that a regular succession of improved varieties can be obtained on the basis of chance or fortuity. A decision sequence of management in a developing new crop variety must be followed:

① Define objectives: The objectives for varietal improvement should consider the needs of growers, handlers, processors and consumers. This requires understanding of agro-socio-economic and physical factors of the environment, biological factors including pathogenetic organisms and pests, and quality factors of the consumers. Objectives may have to be changed during the course of the program if any.

② Determine the combination of morphological, physiological, pest resistance and quality characteristics needed to attain the defined objective.

③ Assess the availability of appropriate genetic variation which may be derived from available plant materials which are collected: cultivated varieties, primitive forms and closely related species.

④ Determine the selection criteria to be used in the implementing selection and the strength of selection to be practiced.

⑤ Decide on the priority characteristics to be exposed to selection.

⑥ Select breeding program on the basis of genetic aspects of targeting characteristics. Breeding program for development of semi-dwarf high yielding rice varieties that powered the Green Revolution in Korea, are described as follows.

3.1 Rice Semi-dwarf Gene Source and its Assessment

3.1.1 Rice Semi-dwarf Gene Source

The rice semi-dwarf gene (sd1) that is well known as the “Green Revolution gene” has contributed to the significant increase in rice production shown in the 1960s and 1970s, especially in Asia [BOX 2-1]. Genetic basis of the short-stature of Tongil-type rice that powered the Green Revolution in Korea was derived from the sd1 gene of indica rice, IR8 and Taichung Native-1 (TN1). IR8 was the first indica semi-dwarf rice cultivar that was developed by IRRI. The sd1 gene was derived from Dee-Geo-Woo-Gen (DGWG).

Dee-Geo-Woo-Gen (DGWG) was crossed with Peta, a traditional tall indica variety in Indonesia in 1962 by the International Rice Research Institute (IRRI) in the Philippines. One of the breeding lines from the cross was selected in 1965 and released in 1966. IR8 revealed the outstanding in its yield potential with lodging resistance, and better suited to local conditions and consumer needs in tropical Asia. The semi-dwarf rice variety could produce more yield when grown with certain fertilizers and irrigation, about 5 t/ha with no fertilizer and almost 10 tons per hectare under optimal conditions. It was 10 times the yield of traditional rice. IR8 was a success throughout Asia, and earned a nickname “Miracle Rice.” T(N)1 (Taichung Native 1) was created as a semi-dwarf rice cultivar in 1956 through a crossing of Chai Yuon Chong/DGWG in Taiwan.

Korean rice scientists were sent to IRRI under a collaborative program in 1964. They had an opportunity to observe those semi-dwarf breeding lines including IR8 and T(N)1 that were grown in the rice field at IRRI. Those breeding lines revealed to be an ideal plant type with strong resistance to lodging even in the circumstances of strong typhoon after heading stage of rice growth. Based on these experiences, Korean rice breeders did not take long to determine to develop rice varieties suitable for Korean environment. Considering the unsuitability of indica rice which was evolved to adapt in tropical regions, rice breeders have often experienced a lot of difficulties in transferring desirable traits from indica into japonica varieties which was evolved to adapt in cool temperate regions. This opportunity initiated to develop an elaborative breeding program of indica/japonica hybridization in Korea. Several IRRI breeding lines including IR8, IR262 and T(N)1 that had semi-dwarf gene derived from DGWG were identified to use as the genetic resources of semi-dwarf gene. These indica semi-dwarf genotypes were crossed with several prominent Korean japonica cultivar including Jinheung, Padal and Palgweng, and some Japanese varieties, Yukara and Fujisaka 5 with early maturity, cold tolerance and disease resistance both at IRRI and in Korea. Most outstanding ones out of many crosses that Korean rice breeders made at IRRI since 1965 were IR667, IR781, IR1317 and IR1325, from which a bunch of high yielding, Tongil type, and new semi-dwarf HYV varieties were selected and released. They fueled the Green Revolution in Korea.

Box 2-1 | Rice Semi-Dwarf Gene(SD1=Semi-Dwarf 1)

Most of high yielding rice varieties, so-called Tongil-type rice that powered the Green Revolution in Korea are also sd1 gene from IR8 and Taichung Native-1 (TN1) which is derived from De-Geo-Woo-Gen (DGWG). IR8 (Pata/DGWG) were developed by IRRI in 1965 and released as the 1st indica semi-dwarf high yielding rice variety. T(N)1 (Chai Yuon Chong/DGWG) was developed by Taiwan. Rice semi-dwarf gene (sd1) was the basis of short-stature high yielding rice varieties that powered the Green Revolution technology in Asia. The (sd1) gene was originally derived from a Chinese variety, 'DGWG' that was selected from natural mutation in China. A large number of dwarf genes have been recognized in rice. However, most of them are not useful in practical, mainly due to deleterious effects of too much stunting plant height together with other agronomic traits and grain yield related characteristics including panicle and grain size and yield potential. The sd-1 gene from 'DGWG', provides rice cultivars with short, thick culms, raises the harvest index, improves lodging resistance and response well to high nitrogen fertilizer, resulting high yields without affecting panicle and grain quality.

3.1.2 Creation of New Semi-dwarf Genotype from Indica/Japonica Hybridization

The first step of implementation in rice breeding program was to figure out how these indica semi-dwarf genotypes adapted to Korean environment. A large number of those semi-dwarf genotypes including IR8 and IR262 created by IRRI were introduced to examine the potential suitability for Korean environment since 1966. From the works it was discovered that most of IRRI bred genotypes were not well adaptable to Korean environment. Late heading and unfavorable grain quality were not suitable to Korean environment and circumstances although they appeared a good plant type with short-statured and erect plant type.

In 1967, around 490 selections of 39 crosses including R667 (IR8//Yukara/TN1), IR781 (IR8*2/IR667) which were crossed and selected by Korean rice breeders at IRRI, were introduced to identify suitable genotypes to Korean conditions. Some of segregates that were derived from IR667 (IR8//Yukara/TN1) cross, outstood in yield performance and revealed resistance to lodging with good plant architecture of short-statured and erect leaves. But they had some weakness; low cold tolerance and grain quality compared to japonica varieties, which rice breeding program focused on making improvements thereafter.

To overcome the shortcomings of high yield selections from IR667 progenies, 3~4 Korean rice scientists were sent to IRRI during winter season to create new crosses and selecting their progenies between indica semi-dwarf and prominent Korean cultivar: 21 crosses (IR1303~IR1325) in 1968/1969 winter and 31 crosses (IR1583~IR1613) in 1969/1970 winter. This resulted in remarkable increase in remote crossing between indica and japonica genotypes, more than 50% of total hybridization in Korean rice breeding program in 1969. The shuttle breeding program, alternative selection of breeding lines in Korea and IRRI, initiated and actively implemented, which allowed the strong power to drive the Green Revolution in a short time of 7-year period in Korea?

This outcome was able to occur with strong and close international collaborative program between Korea and IRRI.

3.2 Establishment of Rice Breeding Programme

3.2.1 Establishing Strategy and Planning

IRRI rice breeders and scientists also visited to Korea in September 1967. They observed and evaluated those genotypes of new plant type that were grown in the field of the Crop Experiment Station, ORD in Suweon. From their field evaluation, they found and agreed on the availability of semi-dwarf high yielding rice varieties suitable for Korean environmental conditions in the near future at that time. They also discussed on the initiating cooperative works between Korea and IRRI on rice research to develop the high yielding rice varieties for Korea with mutual benefit, from which the IRRI-Korea collaborative project on rice research formally agreed in 1968. Under the international collaborative project, both sides agreed to exchange genetic resources including breeding materials, to train Korean scientists at IRRI to build capacity among young Korean scientists, exchange of senior scientists, and utilize and develop research facilities.

The concrete strategy and planning were devised on the rice breeding program to develop semi-dwarf high yields rice varieties to reduce food shortage and achieve self-sufficiency of rice, a staple food grain in 1968. It was based primarily on the confident results of selecting several semi-dwarf high yielding rice genotypes from IR667 progenies which was derived from the hybridization between indica and japonica under the Korea-IRRI collaborative works since 1965. The planning was evaluated in the special meeting which the high ranking officials of the Government participated in; Administrator of ORD, Secretary of Policy, Secretary of Economics, Secretary of Agricultural and Forestry and related scientists of ORD. It was finally reported to the President by the Director General of ORD in December of 1968. The report contained the varietal improvement and its effects, the status of rice varieties, the technical strategy including conventional procedures of rice varietal development and innovative technology pursued, and the process of development of IR667 and the background of developing new breeding selections in the 1960s.

After the report, the President decided full national support for the appropriate implementation of the program, and allocated a special fund of 100 million Korean won to construct new greenhouses for the three rice research organizations (Suwon, Iri and Milyang) and phytotron at Suwon. The fund was not sufficient for construction, but it was to play a role as a seed fund for securing the rest of the required funds. The details of strategy and planning for semi-dwarf high yielding rice varieties for Korean conditions are summaries as follows:

○ Objectives: Challenge to eradicate the national food shortage through the development of high yielding rice varieties with short-statured and pest resistance

○ Targets

① Rice yield potential 6.0 t/ha (in milled)

② Rice plant height: 70~8cm

③ Improved plant architecture: Lodging resistance, short-statured erect leaves

④ Resistance to major rice pest and diseases (rice blast, stripe virus etc.)

⑤ High nitrogen responsiveness

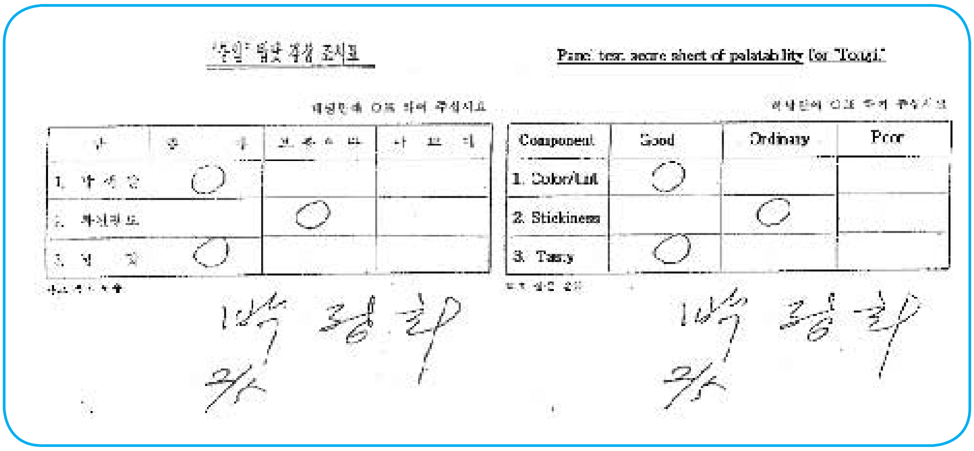
- Strategy: International cooperation with IRRI
  - ① Exchanges of rice germplasm including breeding materials of semi-dwarf
  - ② Research and developing rice production technology, particularly improving soil fertility in low productive soil
  - ③ Advances capability: training research and extension workers at IRRI modernization of research facility and technology
  - ④ Exchanges of scientists in mutual
- Utilization of IRRI facilities for shuttle breeding and generation advances of breeding materials

3.2.2 Approval Programme and Nomination of "Tongil"

In December 1971, the plans to expanding area seed increasing of new high yielding rice variety and future strategy to improve further its shortages were reported to the President. The President also participated in the panel test for eating quality evaluation of cooked rice. His evaluation score on eating quality of newly developed high yielding rice variety; "Tongil" is shown in [Figure 2-3].

The 1st Tongil-type rice variety, "Tongil" which was crossed in 1966 and selected in 1969 was designated as a cultivar in 1971 and released to the farmers in 1972. It was developed from IR667 which was crossed in 3-way (IR8//Yukara/TN1) by Korean scientist at IRRI. Its pedigree is IR667-98-1-2-2 which was selected from F7 generation in the period of 4-year under the shuttle breeding system, advancing two generations a year, summer in Korea and winter in IRRI. It was outstanding in grain yield of 5.13t/ha in milled rice, 30% higher than the best commercial japonica cultivar at that time. Its characteristics were short-stature and resistance to lodging with thick culms, better photosynthetic ability with erect and thick-short leaves, high responsiveness to nitrogen fertilizer, and resistances to rice blast and stripe virus diseases. It was quite successful in the developing short-statured high yielding rice variety at the first step although it appeared low in cold tolerance and grain quality compared to japonica cultivar. These shortages actually accelerated to improve further in the subsequent developing Tongil-type varieties which powered the Green Revolution in Korea.

Figure 2-3 | Panel Test Score of the President for Palatability of “Tongil” (1971)



3.3 Development of “Tongil” Rice Variety

3.3.1 Production of IR667 Hybridization between Indica and Japonica

Korean scientists, who were dispatched to IRRI in 1964, made remote crosses between indica and japonica at IRRI to create semi-dwarf high yielding rice variety fitting under Korean circumstances.

To make a single cross, Yukara was planted at IRRI field in September, 1965, and crossed with TN-1 in November, 1965, and given IRRI cross number of IR568. Yukara is a japonica cultivar with cold tolerance and disease resistance from Hokkaido, Japan, and TN-1 is an indica with semi-dwarf gene (sd1) from Taiwan. The F1 plant of the single cross, IR568 (Yukara/TN-1) appeared like a wild-like plant type of rice with black hull, long awned kernel and high sterility. To overcome the hybrid sterility of the single cross between japonica and indica, IR8 was crossed with a little amount of pollen from F1 of IR568 in March, 1966 at IRRI. This was given to IRRI cross number, IR667 that was produced in three-way cross (IR8//Yukara/TN-1), from which “Tongil” rice cultivar was selected later on in Korea.

3.3.2 Overcoming of Hybrid Sterility

Genetic sterility is generally critical when the distantly related crossing is applied in rice breeding program. Hybrid sterility that commonly occurs in the crossing between indica and japonica hinders selecting a normal fertile progeny because of genetic sterility from abnormal synthesis of chromosomal pairs in the subsequent generations [Box 2-2]. However, rice breeders have often overcome sterility through the bridge crosses with third genotypes, so-called top-cross and/or 3-way cross. Some of F1 plants of IR667 cross in 3-way of (IR8//Yukara/TN-1) almost restored grain fertility, and completely recovered in the F2 generation.

Box 2-2 | Hybrid Sterility between Indica and Japonica

The partial sterility of F1 plants between distantly related rice cultivars has been well known since the early days. Hybrid sterility between japonica and indica rice was first reported in 1930 by Kato S. Based on it, he identifies japonica and Inca genotype in the rice classification.

Hybrid sterility may lead to failure of development of male and female gamete. This is either chromosomal disturbance in meiotic in meiotic pairing, or genetic effects of gametophytic (H.I. Oka, 1988). The former occurs when different chromosomal variations cause sterility with increasing abnormal segregation of chromosome during reproductive cell formation of hybrid. It is mainly due to the evolution process from the geological isolation. It was once suspected that indica and japonica types differ in cryptic structure of chromosomes. However, no positive evidence for this has been produced so far. Various chromosomal anomalies are found with a low frequency in hybrids as well as in parental homozygotes, and have shown no significant relationship with F1 sterility.

The latter is that the F1 sterility is controlled by gametophytic genes. Evidence for this principle is the change in segregation ratio for glutinous pollen grains associated with pollen sterility. Therefore, the hybrid sterility observed in indica/japonica hybrids is all genetic, with the reservation that small chromosomal rearrangement cannot always be distinguished from genetic differences. In the indica/japonica hybrids, segregation ratios usually deviate from the Mendelian ratio owing to an increase of genes derived from the indica parent (Oka, 1955). When an indica/japonica hybrid was grown successively without selection, one of the complementary genes (associated with producing chromogen for apiculus coloration) which derived from indica parent continued to increase with generations mainly due to the higher fertility of the plants with the genes, while the genes from japonica parents decreased. The increasing alleles were all derived from an indica parent and the decreasing alleles from a japonica parent. Distortion of sterility in the later generations may cause to gametic selection but zygotic selections due to sporophytic sterility genes and competitive ability in which indica are generally more aggressive than japonica (Oka, 1960).

The F3 progenies from these F2 plants enabled to select the semi-dwarf genotypes with normal fertility that was completely restored in the hybrid sterility, resulting in the success of remote cross breeding between indica and japonica rice.

F1 plant was used as female and the third genotype as pollen sources when breeders make a 3-way cross in breeding program. In this case, we need progeny test to make sure to identify self or crossed plant. Alternative method that the single F1 plant were used to a pollen sources as done in the IR667 cross is much easier to identify out-bred or inbred plant and reduces breeding time as well.

3.3.3 Progress Developing “Tongil” Rice Variety

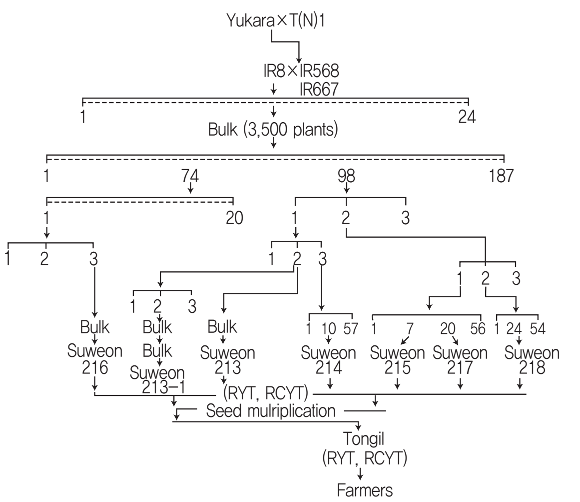
There were different levels of fertility in the F1 generation of IR667 which was crossed in 3-way (IR8//Yukara/TN-1). The seeds from fertile plants with short-statured traits were harvested to advance F2 family during the winter season of 1966/1967 at IRRI field. All of plants from these F2 family showed the short-statured in plant height with semi-dwarfism which is controlled by single major recessive gene. Around 200 plants were selected from the F2 family, and harvested to grow F3 generation at IRRI. The F3 seeds of 22 genotypes out of 200 selections were also introduced in Korea to select the genotypes which were suitable for Korean circumstances during the summer of 1967.

The F4 seeds of 22 lines which were selected from F3 generations of IR667 in Korea were sent IRRI to advance F4 generation. All of the 222 lines including 200 lines which were selected at IRRI in 1967 were planted to advance F4 generation during winter season of 1967/’68. Around 200 selections of F5 generation were also grown in Korea during the summer of 1968, from which 10 prominent genotypes with semi-dwarfism were harvested each line in bulk to test yield performance in Korea, in 1969. Until the final selection was done in F7 during the summer of 1969 in Korea, all of the selection was progressed through the shuttle breeding system between IRRI and Korea.

Ten prominent genotypes which were harvested in bulk evaluated yield performances as well genetic homogeneity in preliminary yield trial plot with two replications in Korean environment during the summer of 1969. The six most promising genotypes with high yield potential, short-stature and erect leaves were selected to test their performance in the replicated yield trials in Korea, in 1970. They were IR667-98-1-2, IR667-1-3-10, IR667-98-2-1-7, IR667-74-1-3, IR667-2-1-20 and IR667-98-2-2-24, named respectively Suwon 213, Suwon 214, Suwon 215, Suwon 216, Suwon 217, and Suwon 218. The other outstanding line, IR667-98-1-2-2 was also isolated from a bulk population of IR667-98-1-2(Suwon 213), and designated as Suwon 213-1. Three most promised genotypes, Suwon 213, Suwon 214 and Suwon 213-1 were sent to increase seeds at IRRI. One out of the seven genotypes, Suwon 213-1 that revealed relatively better cold tolerance than the other, was selected in final and named to “Tongil” as a new commercial cultivar in 1971. It yielded of 5.13t/ha, 30% greater as compared to the best japonica commercial cultivar. The details of the selection procedure of “Tongil” rice cultivar are listed down below and its genealogy is shown in [figure 2-4].

Figure 2-4 | Genealogy of “Tongil” Rice Variety

Year	Generation
1965	Single cross
1966	3–way cross
1966	F1
‘66–’67 (Winter)	F2
1967 (Summer)	F3
‘67–’68 (Winter)	F4
1968 (Summer)	F5
‘68–’69 (Winter)	F6
1969 (Summer)	F7
‘69–’70 (Winter)	F8
1970 (Summer)	F9
‘70–’71 (Winter)	F10
1971 (Summer)	F11
1972 (Summer)	F12



■ Breeding Procedure of “Tongil” Rice Variety

- ○ November, 1965.: Single cross (Yukara/T(N)1) at IRRI
- ○ Winter, 1965/’66: Three way cross(IR8//Yukara/T(N)1) at IRRI
- ○ Winter, 1966/’67: Growing F2 family at IRRI, Harvest F3 seeds of the selected plant
- ○ Summer, 1967: Growing F3 generation and selection both at IRRI(200) and Korea(22)
- ○ Winter, 1967/’68: Advancing F4 generation at IRRI (222 lines)
- ○ Summer, 1968.: Growing F5 generation in Korea (200 lines), select 10 prominent lines with semi-dwarf, and harvested them each in bulk to test yield performance
- ○ Winter, 1968/’69: Generation advances for F6 generation, and test of grain quality at IRRI(200 lines)
- ○ Summer, 1969: Preliminary yield trials of 10 prominent genotypes in Korea, and identified 7 selections with short-statured high yield and harvest 7 outstanding lines

- Winter, 1969/'70: Generation advances and seed increase at IRRI for 7 selections
- Summer, 1970: Replicated yield trials(RYT) and local adaptability test(LAT) of 7 selections in Korea, and selected the best 3 lines
- Winter, 1970/'71: Seed increase the best 3 lines at IRRI
- February, 1971: Nominated "Tongil" as a new commercial cultivar RYT, LAT, pilot farm trials in large scale
- 1972: Release to the farmers field

3.4 Major Characteristics of "Tongil" Rice Variety

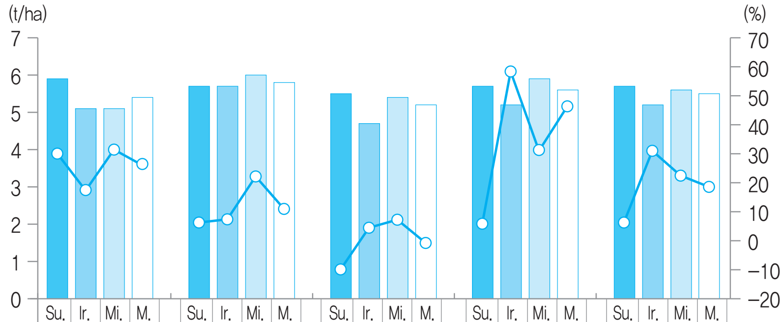
"Tongil" rice variety has greatly improved in plant architecture with semi-dwarfism which was dramatically changed from those of japonica. Its plant type was quite innovative; Korean rice breeders were eager to create it for a long time. In eco-physical aspects, "Tongil" cultivar is relatively less sensitive to photoperiod and requires higher temperature on the growth and development of rice plant compared with japonica rice. It was remarkably improved in the lodging resistance at harvest time, high nitrogen responsiveness, photosynthetic ability, and harvest index with heavy panicle and high yield potential. It also revealed resistance to some major diseases including rice blast and stripe virus diseases which could lead to yield losses in Korea at the time.

"Tongil", however had some critical weakness; cold susceptibility, easy grain shattering at harvest time, and low grain quality with intermediate-long grain shape low palatability which were not favorable compared with traditional japonica varieties produced in Korea. The details of major characteristics were described below.

3.4.1 Rice Yield Potential of "Tongil"

"Tongil" rice variety yielded 5.4 ton/ha (in brown rice) in average during the replicated yield trials at three locations in 1970, 26% higher than that of Jinheung, the best japonica check cultivar which showed the increasing rate of 30% in Suwon, of 17% in Iri and of 31% in Milyang, respectively [Figure 2-5]. Its yield performances at three locations during 4-year period of 1970~1973 was 5.51 ton/ha (5.19~5.73) in brown rice (equivalent to 5.13t/ha in milling recovery of 93%) in average, out-yielding around 18% greater than 4.65ton/ha of japonica check varieties in the ordinary culture, and 5.67 ton/ha (5.38~5.97), 27% greater than 4.48 ton/ha with heavy fertilizer. The degree of yield increase was greater in southern regions of the country, 31% and 22% at Iri and Milyang, respectively, than northern regions such as 6% in Suwon. Also, it was 30~41% greater in the year that had relatively warm temperature than cool temperature. On the other hand, the yield performance was largely dropped in the year of cool temperature, in the late planting and in the direct seeding culture as compared to japonica cultivars in the replicated and regional adaptability yield trials. “Tongil” rice variety more adapt to warmer conditions. This may imply that “Tongil” rice variety requires higher temperature than japonica rice does, and need to improve cold tolerance which would secure sufficient growth periods under the environmental circumstance of the limited growth season in Korea.

Figure 2-5 | Rice Yield Performance of “Tongil” Rice Variety in the Replicated and Regional Adaptability Yield Trials

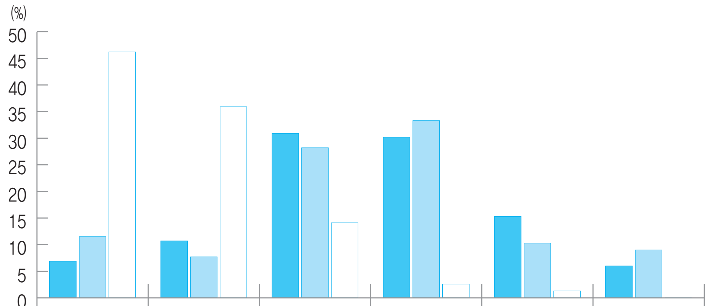


	1970				1971				1972				1973				Avergae			
	Su.	Ir.	Mi.	M.	Su.	Ir.	Mi.	M.	Su.	Ir.	Mi.	M.	Su.	Ir.	Mi.	M.	Su.	Ir.	Mi.	M.
Rice yield(t/ha)	5.9	5.1	5.1	5.4	5.7	5.7	6	5.8	5.5	4.7	5.4	5.2	5.7	5.2	5.9	5.6	5.7	5.1	5.6	5.5
Increasing rate(%)	30	17	31	26	6	7	22	11	−10	4	7	−1	6	58	31	46	6	31	22	18

Note: su.: suwon; MI.: Milvang; M.: Mean

The high yielding potential of “Tongil” rice variety was proved by the regional adaptability test at 58 locations and by pilot farm trial in large farm scale at 75 sites. The large scale farm trials yielded in average of 5.09 ton/ha at 78 pilot farms and 5.01ton/ha at 550 collective group farms, respectively [Figure 2-6]. In particular, 51.5% and 52.6% of the pilot farms and collective farms showed over 5.0ton/ha in average with “Tongil” rice variety, compared to less than 4.5 ton/ha in 92% of farmers and less than 4.0ton/ha in 46.2% of farmers with the japonica check cultivar.

Figure 2-6 | Rice Yield Performance of "Tongil" Rice Variety in the Pilot Farms Trials with the Large Scale Farm Trials



	Under 4.00	4.00~ 4.49	4.50~ 4.49	5.00~ 5.49	5.50~ 5.99	Over 6.00 t/ha
Group culture(Tongil)	6.9	10.7	30.9	30.2	15.3	6
Pilot farm(Tongil)	11.5	7.7	28.2	33.3	10.3	9
Pilot farm(Check var.)	46.2	35.9	14.1	2.6	1.3	0

3.4.2 Morphological Characters

"Tongil" rice variety was remarkably improved in plant architecture with semi-dwarf gene(sd1) which has the characteristics of shot-stature, thick stem, erect and stiff leaves, and reasonable tillering angle opened [Figure 2-7]. Its plant architecture was quite different from japonica which had tall height, thin stem, long droopy leaves, and more or less compact tillering angle. Its plant type certainly was innovative; what Korean rice breeders had been striving to create to develop high yielding rice cultivar for a long time. Its development was a milestone to drive the innovation in rice breeding program as well as other crops'. The morphological traits of "Tongil" rice variety are summarized as follows:

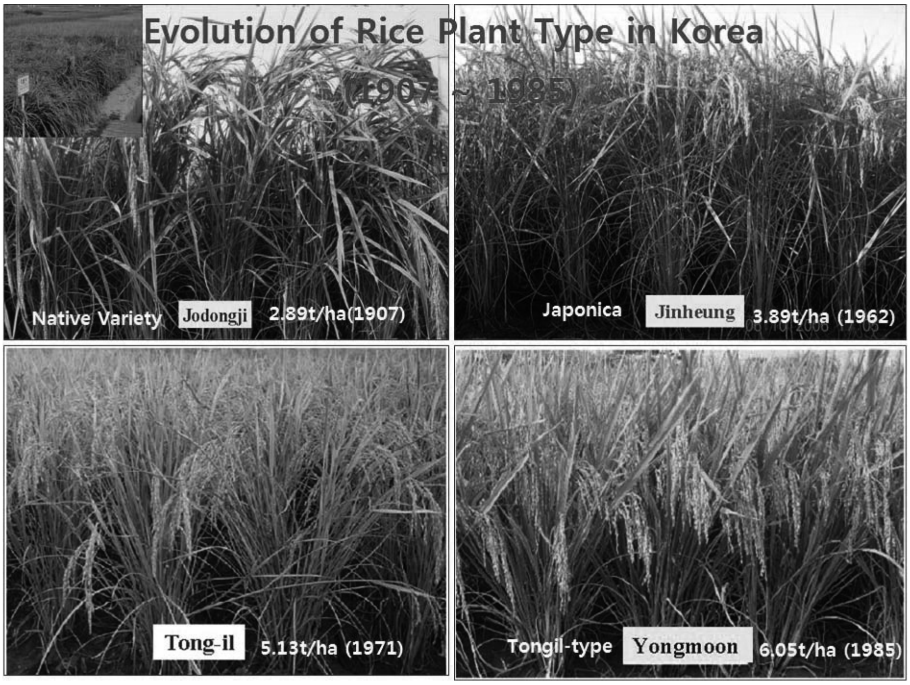
① Short-stature with semi-dwarf gene (sd1)(80 → 60cm in culm length)

② Thick stem with short internodes and over-rapping leaf sheath

③ Erect and stiff leaves with dark green and intermediate size and shape

④ Thick leaf sheath and dark green, which protect to lodge well plant stem with over-rapping leaf sheath

Figure 2-7 | Evolutionary Changes Rice Plant Architecture in Korea



3.4.3 Growth Duration (Characteristics of Heading and Maturity)

"Tongil" rice cultivar is relatively less sensitive to photoperiod, and requires relatively higher temperature on the growth and development of rice plant compared with japonica rice. It is medium-late variety similar to Jinheung. Its growth duration was about 125 days from transplanting to maturity with relatively longer period of the basic vegetative growth, but with shorter maturing period from heading to maturity. Its grain maturity is relatively faster than japonica varieties in normal temperature conditions, which was earlier by around one week in Suweon, middle part and about two-week in Iri and Milyang areas, southern parts of Korean peninsula. However, it is delayed in heading at the circumstances of late planting and in the lower temperature conditions in northern and mountainous areas owing to the declining temperatures during the maturing stage of rice plants.

3.4.4 Characteristics Related to Grain Yield and Quality

"Tongil" rice variety was relatively panicle-weight type with more tillers and many seeds per panicle as compared with japonica cultivars. Its rice grain was medium sized with intermediate long and easy shattering at harvest time. The grain appearance of milled rice was poor translucency with some white valley which caused low grain quality compared to traditional japonica cultivar. Its medium amylose contents of 23% and intermediate gelatinization temperature also reduced cooking time and eating quality, due to low stickiness even though it had high protein contents (8.7%) and better quality of essential amino acids including lysine. These low grain quality including tasty and grain appearance was one of the weaknesses that had to be improved [BOX 2-3].

Box 2-3 | Rice Grain Quality

Rice quality is generally country and regional specific. Rice is mostly consumed in form of boiled rice in Korea. In terms of grain quality, japonica-like rice is highly preferable to Korean consumers. Rice quality basically consists of the characteristics for marketing, cooking, taste and nutrient components. Marketing quality mainly depends upon grain type and appearances, most likely traditional japonica, which Korean consumer generally refers to short-round or medium size, and has clean chalkiness and translucency. Gelatinization temperature (GT) that is determined by ADV (alkali digestion value) is the major determinant factor of cooking behavior. Although GT is partly associated with amylose contents of the starch of rice grain, it has been known that the physical cooking properties of rice are more closely related to GT than to amylose contents. Rice with low GT requires less water and time to cook. Most of japonica rice is low in GT, while Tongil-type rice is low or intermediate. Low or intermediate GT is desirable to Korean consumer. Amylose content is also a major factor on the characteristics of cooked milled rice. Korean consumers prefer low amylose and proper sticky rice. Eating quality is much more delicate and complex because it varies from regions and individuals' consumption patterns. Panel test is usually employed by the well-trained talent experts. The components related to the eating and cooking quality tests are: gloss, tenderness, stickiness, flavor and chewiness.

In general, rice breeding targets for grain quality consist of small-round with 4.6~5.8mm in length and 2.0 in length/width ratio of brown rice grain with clear chalkiness and translucency for grain type and appearance, below 70°Cof GT with high ADV and below 20% of amylose contents proper stickiness cooking and eating quality.

3.4.5 Pest and Diseases Resistance

Many diseases and insect pests influenced rice production negatively in Korea. The varietal resistance to major diseases thus was a significant breeding goal in rice breeding program. However, it was not so successful with traditional japonica rice, and the yield loss was massive by the 1960s because there was no desirable resistance source within japonica germplasm. “Tongil” rice variety revealed high resistance to stripe virus and bacterial leaf blight diseases and moderate resistance to rice leaf blast, but not for other diseases including neck blast, dwarf virus, and leaf sheath diseases even though there were not so serious damages in the farmers field. It was also highly resistant to small brown plant-hopper, but not to other major insects including brown plant-hopper, white-backed plant-hopper and green leaf-hopper.

3.4.6 Tolerance to Environment and Physiological Stress

Major physiological stresses of rice that could cause rice yield loss in Korea were plant lodging, stresses to low temperature and salinity, akkiochi-disease, etc. The yield losses were particularly common with lodging at harvest time and cold damages in the low temperature regions such as mountainous and northern parts of the peninsular. “Tongil” rice cultivar was remarkably improved to lodging resistance and to akkiochi-disease mainly due to short-statured plant height with high nitrogen responsiveness. On the other hand, the stresses disasters on cold and salinity were not much improved. Particularly, cold susceptibility was the most serious weakness in Tongil rice variety, which was derived from indica/japonica hybridization. If temperature is not high enough for Tongil rice cultivar during the early seedling and the late maturing stages of rice plant, it would lead to poor germination, retarded growth of seedling, yellow leaves, suppressed tillering at early stage of growth. And low temperature at late stage of plant growth would cause cold disasters including early leaf senescence, reduced root activity and poor grain ripening, resulting in poor grain quality and yield losses. Hence, the changing system of rice cultural practices including early planting and technology against the cold damages were required.

4. Subsequent Development of Tongil-type Rice Cultivar

4.1 Weakness of “Tongil” Rice Variety and its Challenge

“Tongil” which was the first semi-dwarf high yielding rice variety that initiated modern rice breeding in Korea. It was an innovative plant type with short-stature and erect leaves, which was a different plant architecture from the traditional japonica cultivar. It had a number of advantages including resistance to lodge, high responsiveness to nitrogen fertilizer, better photosynthetic ability, greater harvest index, resistance to diseases, and outstanding yield potentials.

On the other hand, it also had some shortages for stabilization in Korean circumstances. Temperatures at the early seedling and the late maturing stages of rice growth are not high enough for rice growing, especially in the mountainous, the eastern sea coastals, and late planting in the regions of the rice-based double cropping. Therefore, cold susceptibility was the most critical weakness. "Tongil" has relatively longer period of basic vegetative growth due to low sensitivity during photoperiod, and requires relatively higher temperature for the growth and development of rice plant. It was also low rice quality with intermediate-long grain shape and low palatability. Most of Korean consumer is a habit with rice quality of traditional temperate japonica cultivar that was short-round small and/or medium size of grain, low amylose below 20% with sticky in boiled rice, low gelatinization temperature below 70°C. Rice quality of "Tongil" was not so acceptable to Korean consumers with intermediate amylose contents of 23% and medium white belly in grain appearance which were critical to the consumers. Easy grain shattering was another weakness which significantly affected on the yield losses at harvest time. It was critical when harvesting manually with sickle, but not with machine harvester.

These shortages strongly induced to put forces on the driving the change of selection criteria in priority with better rice quality and cold tolerance of semi-dwarf high yield potential genotypes to expand the production areas through the country. The challenge was attempted as follows:

① The first attempt was to select the earlier maturing rice cultivar with semi-dwarf high-yield potential that allowed to expand the stable production areas even in the northern parts, the mid-mountainous and the rice-based double cropping, in which requires the relatively short-growth duration of rice cultivar.

② It also required strongly to improve cold tolerance of semi-dwarf high yielding rice cultivar, particularly for the regions or circumstances with cold damages during rice crop season.

③ It was generally among top priorities to improve grain quality of semi-dwarf high yielding rice cultivar, particularly grain shape, grain appearance and tastes. Reducing amylose contents below 20% of rice starch was a key factor character for improving cooking and eating quality of rice. Grain type and appearance was a key factor for marketing quality of rice which is significant for rice farmers' income.

④ Grain-shattering of Tongil variety was also a significant defect to challenge improving for the semi-dwarf high yielding rice cultivar. Grain shattering of semi-dwarf high-yielding cultivar affected significantly to reduce yield loss in the hand harvest farming at the time.

⑤ The improving varietal resistance to disease and insect pests was strongly enforced for the continuing security of stable production with Tongil-type rice varieties. Even though "Tongil" was highly resistant to some pests, the increasing acreage of Tongil-type varieties caused to the increased variation of pathogenecity of rice blast fungi.

Most of Tongil-type varieties with improved rice quality were injured by epidemic new races of rice blast in 1978. "Tongil" was highly susceptible to some of major rice insects.

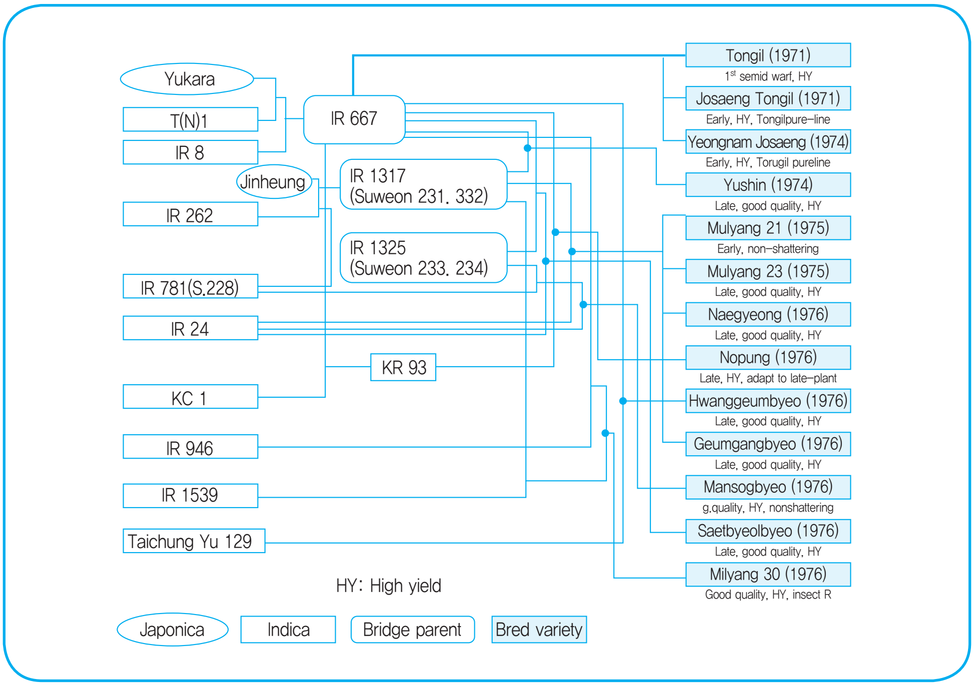
4.2 Development of Subsequent Tongil-type Rice Variety

4.2.1 Geneology of Major Tongil-type Rice Varieties

During the 1970s, the national breeding program for rice had been focused on the challenge to improve the semi-dwarf high-yielding rice cultivar not only through the correction of the weakness of Tongil, but through the fresh blooding to re-bloom new semi-dwarf high yield potential.

A variety of crosses such as IR262, IR 667, IR 781, IR 1310, IR 1317, and IR 1325 had been made distantly related hybridizations between japonica and indica, and utilized as intermediate bridge parents. In particular, the many selections from the progeny of IR1317 (Jinheung/IR262) and IR1325 (Jinheung/IR262//IR781) were widely utilized for improving cold tolerance and late leaf senescence as well as for improving grain quality. IR24, an only low amylose content genotype which IRRI developed, was also centered to employ for the improving better grain quality, especially for reducing amylose contents of Tongil-type varieties. Four promising lines, Suweon 229, Suweon 230, Suweon 231, and Suweon 232 were selected from the progenies of IR1317, and used to cross as intermediate parents. Several indica semi-dwarf genotypes including the progenies of IR946 and IR1539 were also used as parents for improving a resistance of disease and insect pests.

Figure 2-8 | Genealogy of Green Revolution Drived Tongil-type Cultivar



These selections produced many crosses showing good combining ability such as SR814, YR675, HR1619, HR1897, SR2040 and YR1010, from which a plenty of Tongil-type rice cultivar were produced, 25-cultivar was released by 1977 and drove the Green Revolution in Korea. The cultivation areas of Tongil-type rice variety reached to 54.6% in 1977 and to 76.2% in 1978. The average yield potential of Tongil-type rice varieties increased to 5.53ton/ha in milled rice in 1977, and the national average of total rice to 4.94 ton/ha which was record over the world. Total rice production was recorded of 6 million ton which was historical records of rice production and concreted self-sufficiency. The genealogy of these major varieties is shown in [Figure 2-8].

4.2.2 Early maturing Semi-dwarf rice cultivar

"Tongil" rice cultivar that was medium-late, was not well performed in the rice zones, in which the early maturing rice cultivar were generally grown because of the restricted growing period and the cold damages during the rice growing season.

The first challenge to solve the weakness of the cultivar was to develop the varieties of short-growth duration with cold tolerance. Four early Tongil-type rice varieties were developed. Two of them, Josaengtongil and Yeongnamjosaeng that were released in 1974 were selected by the pure-line selection procedure in the advanced population from the progenies of IR667, the cross of Tongil rice variety. These two varieties were earlier heading of two- and one-week, respectively than Tongil variety. These early Tongil-type varieties allowed growing stable production the semi-dwarf high-yielding rice varieties at the farmers' fields of the rice growing zones including mountainous and northern regions and rice-based double copping rice areas <Table 2-2>.

Table 2-2 | Characteristics of Early Maturing Tongil-Type Rice Varieties

Variety	Cross	Year crossed	Year selected	Yield (t/ha)	Adaptation
Tongil	IR8//Yukara/(N)1: IR667	1965	1971	4.88	Middle/south plains
Josaengtongil	Pure-line selection from progeny of IR667	-	1974	4.97	Mid- /north plains, Mid-mountainous
Yeongnam-josaeng	Pure-line selection from progeny of IR667	-	1974	5.10	Mid-mountainous, double cropping areas
Tongichal	IR1317-315/IR833-28//IR667-98*2	1970	1974	5.64	Middle/south plains
Honam-josaeng	IR667-98-1-3-4/IR781-186-3-1-3-1-3-1	1970	1976	5.03	North plains, mid-/south mountainous

4.2.3 Improving Rice Quality of Tongil-type Rice Cultivar

Another most significant challenge of Tongil-type rice variety was the attempt to the improving rice quality. Korean people have inhabited to the rice quality of temperate japonica rice that is the short-round in grain shape, sticky with low amylose below 20%, and clear and translucent in chalkiness which affected on the palatability and marketing quality. As the results, improving rice quality was greatly progressed on the palatability and the grain appearance through the development of a bunch of Tongil-type varieties with low amylose contents below 20%, non-chalky grains, and gradual improving in grain shape.

"Yushin", the first high quality cultivar, was selected in 1974 and released in 1975, which significantly improved in the tastes and grain appearances. Another 10 varieties were released during two years of 1975 and 1976. The yield potential of them was also remarkably increased, ranging from 5.52 to 6.32ton/ha of Naegyeong in milled rice <Table 2-3>.

The growing areas of them sharply increased and reached to 25.8% in 1976, 45.2% in 1978. They were the main powers which drove the Green Revolution in Korea. The most distinguished parental resources was IR24 and the selections from the progeny of IR1317 (Jinheung/IR262) and IR1325 (Jinheung/IR262//IR781).

4.2.4 Improvement of grain shattering

Another challenge was to improve the grain shattering. Easy grain-shattering of semi-dwarf high-yielding cultivar significantly increased yield loss in the hand harvest farming at the time. Two semi-dwarf varieties, Milyang 21 and Manseokbyeo (Suweon 264) revealed the some tolerance to grain shattering as well as high rice quality. Milyang 30 that was released in 1977 also had intermediate grain shattering as well as good rice quality and resistant to rice blast and brown plant-hopper.

Table 2-3 | High Quality Tongil-type Rice Varieties and their Yield Potential

Variety	Cross combination	Year crossed	Year released	Yield potential (t/ha)	Adaptation
Yushin	IR667-98-2-3-2-3/ IR1317-392-1	1969	1975	4.25	Mid-/south-plains
Milyang 22	IR1317-316-3-2/IR24	1971	1975	6.02	Mid-/south-plains
Milyang 21	IR1317-316-3-2/IR24	1971	1976	5.52	Med-/north plains, south double cropping areas
Milyang 23	IR1317-316-5-1/IR24	1971	1976	6.26	Mid-/south-plains
Geumgang Byeo	IR1317-316-5-1/IR24	1971	1976	5.91	Mid-/south-plains
Manseokbyeo	IR1325B1-27-2/ Suwon228//IR24	1972	1976	5.66	Mid-/south-plains
Saetbyeolbyeo	IR1325B1-27-1/ Tongil//IR24	1972	1976	5.94	Mid-/south-plains, mid-mountainous
Naegyeong	Suwon231/IR24	1971	1976	6.32	Mid-/south-plains
Milyang 30	YR938F1/Milyang21	1973	1976	5.67	Mid-/south-plains
Nopung	KR93/Tongil	1971	1976	5.57	Mid-/south-plains
Hwanggeum Byeo	TaichungYu129/Tongil	1969	1977	5.52	Mid-/south-plains

YR938F1: Tongil/IR946-33//IR1317-392/IR1539-29;
Suwon 231: IR1317-316-3-2; Suwon 232: IR1317-316-5-1

4.2.5 Disease Insect Resistance of Tongil-type Rice Varieties

"Tongil" rice variety was highly resistant to stripe virus and rice leaf blast (KJ races which is epidemic to japonica but not to indica rice), but not to major rice insects including brown plant hopper (BHP). Rice blast caused by fungi of Pyricularia oryzae, was the most serious disease in Korea. Korea enjoyed no serious disease injuries in rice production with Tongil-type varieties during 5~6 years until 1978 when most of Tongil-type rice varieties were injured seriously in every corner of the country by new epidemic strains of rice blast (T-2+t, N-2+t, C-8+t). Genetic vulnerability was noticed with increased rice acreage of Tongil-type rice, which has uniform genetic formation of semi-dwarf gene (sd1) from DGWG. Attack by new strains of pathogens of fungal and bacterial diseases was always a possibility.

The national rice breeding program devoted to incorporating the multiple resistances to both major disease and insect pest into semi-dwarf high yielding rice varieties. As the breeder's efforts, some of Tongil-type rice varieties were very much improved on the resistances with some of multiple resistances to major rice diseases and insect pests since the late 1970s through 1980s <Table 2-4, 2-5>. Major genetic resources to improve the resistances in Tongil-type rice varieties were indica germplasm from IRRI: IR946, IR1539, IR1545 (DE192), IR747 (TKM 6), IR2061 (O. nivara), IR4445 (Mudgo, O. nivara), IR4442 (O. nivara, PK203), IR5533 (Carreon, Tetep), etc. Double and/or multiple crosses were intensively employed to incorporate and accumulate the resistance genes, and intensive screening system was developed and implemented by close cooperation between breeders and pathologists.

Table 2-4 | Progress of Major Rice Disease of Tongil-type Rice Varieties

Variety ecotype	Variety	Rice blast		Bacterial leaf blight			Virus		Sheath blight
		Leaf	neck	K1	K2	K3	Stripe	Dwarf	
Japonica	Jinheung	MS	MS	S	S	S	S	S	S
Tongil type	Tongil	M	MS	R	MR	S	R	S	S
	Milyang 23	M	MS	S	S	S	R	MR	S
	Milyang 30	MR	M	R	MR	S	R	MR	S
	Taebaegbyeo	R	R	MR	MR	MR	R	MR	MS
	Samgangbyeo	MR	R	R	MR	MR	R	MR	MS
	Namyeongbyeo	MR	R	R	R	R	R	MR	MS

Table 2-5 | Progress of Major Rice Insect of Tongil-type Rice Varieties

Variety ecotype	Variety	Small brown hopper	Brown plant hopper(BPH)			White backed BPH	Green leaf hopper
			biotype I	biotype II	biotype III		
Japonica	Jinheung	S	S	S	S	S	S
Tongil Type	Tongil	R	S	S	S	S	S
	Milyang 30	R	R	S	R	S	MS
	Hangngchal	R	R	S	R	M	R
	Samgangbyeo	M	R	S	R	S	MS
	Gayabyeo	R	R	R	R	M	R
	Jangseongbyeo	M	R	R	R	M	R

4.2.6 Progress Improving Rice Cold Tolerance

The improving cold tolerance would offer great possibility of the increasing rice yield through the stable production output in the regions where cold damages occurred at any stage of rice growth during the rice crop season. Therefore, cold injuries of rice plants would be the region-specific because different countries and/or different regions have different types of cold injuries of rice plant.

The prevalent growth period that needs mean air-temperature of at least 13°C appears only around 150 days during the rice crop season in Korea. Minimum air-temperature is not high enough at the early and the late stage of rice growing with. Thus, rice plants of Tongil-type variety often suffers from cool air-temperature, especially in the northern, the mountainous, and the eastern sea coastal regions even in the year of normal weather.

The prevailing cold injuries of Tongil-type varieties were generally identified with the poor and delayed germination, the retarded seedling and leaf yellowing at low water temperatures in the early stage of rice growing; the retarded seedling growth and slow tillering at the vegetative stage; inhibition of panicle initiation and development, the spikelet degeneration, disturbed pollen formation at the reproductive stages; delayed heading, poor exertion of panicle, inhibition of anther dehiscence and pollination, and the occurrence of spikelet sterility at heading stage; and poor grain filling and development, and rapid leaf senescence at maturity stage.

Therefore, the specific goals for cold tolerance in the rice breeding program were practically considered with the different phenomena at different stages. The effective selection of cold tolerance are essential the reliable screening methods and facility for both cool-air and cool water temperature through the whole stages of rice growth.

The cold-water screening system has efficiently been employed, especially for the screening of combined type cold tolerance through the whole stage of rice growing <Table

2-6>. The screening system consists of 12m long in a row, and gradient change of flowing water temperature in 10m from 17°C at inlet of cool water to 24°C at outlet. Cold water is irrigated into the paddy field facility during the whole period of rice cultivation. Treatment of cold water started from 20 days after transplanting to maturity, which allows to determine the responses of various agronomic traits associated to cold injuries as well as the spikelet sterility.

The improving cold tolerance of Tongil-type rice variety was gradually progressed, but its level was not reached to that of japonica variety <Table 2-7>.

Table 2-6 | Methods and Facilities for Rice Cold Tolerance Screening Employed in Korea

Types of cold damages	Screening methods	Facility screening
Germinability	13~15℃ for 7-day	Germinator
Seedling-chilling injury	5℃ for 2~3 days at 2~3 leaf stage	Growth chamber
Seedling -growth & leaf discolor	12/10℃ (D/N)cool-air for 10-day at 2~3 leaf	Phytotron
Seedling -growth & leaf discolor	13℃ cool-water for 10-day at 3 leaf stage	Cool-water-flowing screening nursery in Chuncheon
Delayed heading	18/10℃ (D/N) for 10-day at 10~20 days after transplanting	Phytotron
Spikelet Sterility	18/18℃ (A/W) for 10-day at meiosis stage	Phytotron/ greenhouse
Combined type	17℃ cool water flowing for whole stage from 20-day after transplanting	Cool-water-irrigated screening nursery in Chuncheon
Grain filling	20/15℃ (D/N) for 20~30 days at maturing stage	Phytotron

D/N: day/night, A/W: air/water

Table 2-7 | Physiological Stresses of Tongil-Type Rice Varieties

Variety ecotype	Variety	Low-temp. germin-ability	Cold tolerance			Lodging resist-ance	Salinity	Grain shattering
			seedling	delayed heading	spikelet sterility			
Japonica	Jinheung	R	R	R	M	MS	M	R
	Nakdongbyeo	R	R	MR	MS	MS	M	R
Tongil type	Tongil	M	S	S	S	R	S	E
	Milyang 23	M	S	MS	S	R	S	E
	Pungsanbyeo	MR	MS	M	M	R	S	ME
	Samgangbyeo	M	S	MR	M	MR	S	ME

5. Rice Seeds Multiplication and Supply System in Korea

New superior varieties of rice can make contribution to agriculture only when there is sufficient supply of seeds to farmers, genotypically pure, in a viable condition, free of noxious weeds, in adequate quantities and at a reasonable price. To produce the high quality seeds, a grower must have a source of superior seed of a well-adapted variety. When an experimental line is approved as a new variety in commercial growing by the National Seed Certifying Committee, it is increased for release to growers. It must be tested thoroughly for the regional adaptability at the 144 pilot sites selected from the every corner the country before the variety is approved. In Korea, the comprehensive program for the renewal and supply of new rice seed started in 1908. It was operated by self-exchange system of rice growers themselves as the 5-year and/or 3-year innovation cycle until 1978, in which it was changed to renewal system of 4-year cycle under the government-leading project through the government agency, the National Seed Production and Distribution Office (NSPDO) under the Ministry of Agriculture, Forestry and Fishery.

5.1 Multiplication System of Rice Seed

The seed rice in a certification program is usually classified by 4-class stepwise: breeder seeds, foundation seeds, registered seeds, and certified seeds. Korea had two main stream passages for the national certified seed rice program: production and supply [Figure 2-9]. The production of breeder's and foundation seeds is an integral part of the cooperative rice-breeding projects of the three Crop Experiment Stations, Rural Development Administration. The registered and certified seeds are produced and certified by the seed agents under the Ministry of Agriculture, Forestry and Fishery because they are outrange of breeding program.

○ Breeder's seeds: The rice seeds of cultivated varieties are produced in very small amount by plant breeders, being directly controlled by the authorities of originating rice breeding agency, RDA. It is the source for the seed production of the certified classes.

○ Foundation seeds: It must be the progeny of breeder's seed handled to keep specific genetic purity and identity. It is produced by the Provincial Office of Rural Development (PORD), and must be acceptable by the certifying agency.

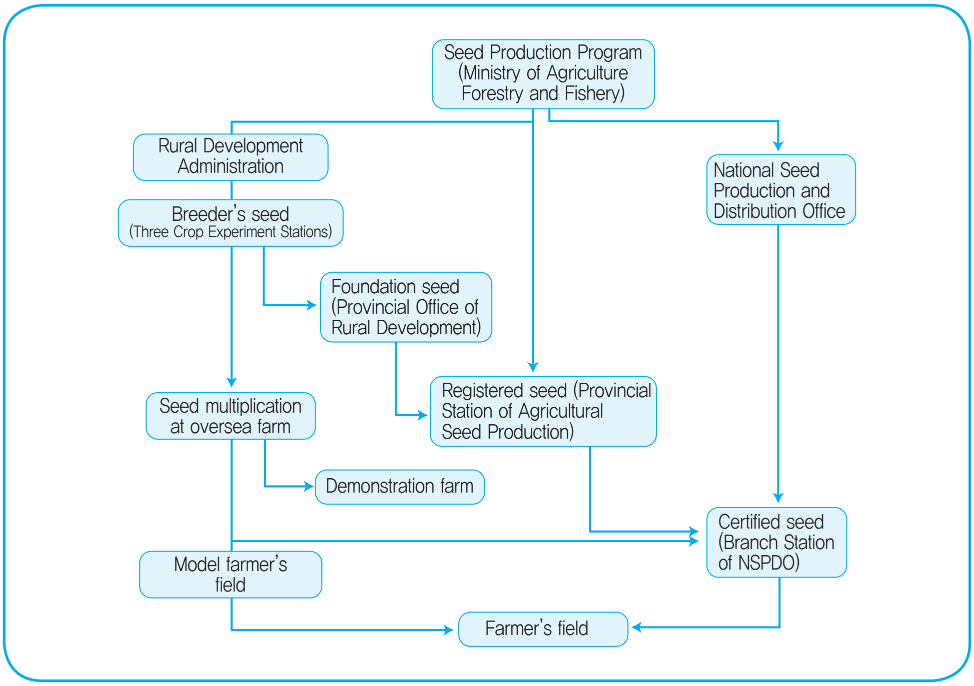
○ Registered seeds: It must be the progeny of breeder's and foundation seed, and is produced by the Provincial Station for Agricultural Seed Production (PSASD). It is offered to produce the certified class of rice seeds.

○ Certified seeds: It must be the progeny of breeder's, foundation and/or registered seeds, and produced by the Station of Certified Seed Production under NSPDO.

The registered and certified seeds belonged to a certified program must keep genetic purity and identity, and have also acceptable to the certifying agency.

Rice seeds of a new variety used to reach to the farmers 4-year after approving a new variety. Therefore, Korea also allowed operating a special system of seed rice, in addition to the main system to produce and supply the certified seed, through the rapidly increasing seed rice in the overseas production sites during winter season in charge or the experiment farm at IRRI, the Philippines. The rice seeds of the outstanding new rice variety were sent to the Philippines to multiply in mass during winter season of Korea. These seeds which were multiplied in the Philippines are returned back to Korea, to allow cultivation in the normal season in Korea. These seed used to grow in the selected pilot farm or group farm, which the seeds harvested from the pilot or group used to supply to the general farmers. This system was able to reduce 1~2 years to the farmers with a new variety, resultants shortening the time period of Green Revolution in Korea.

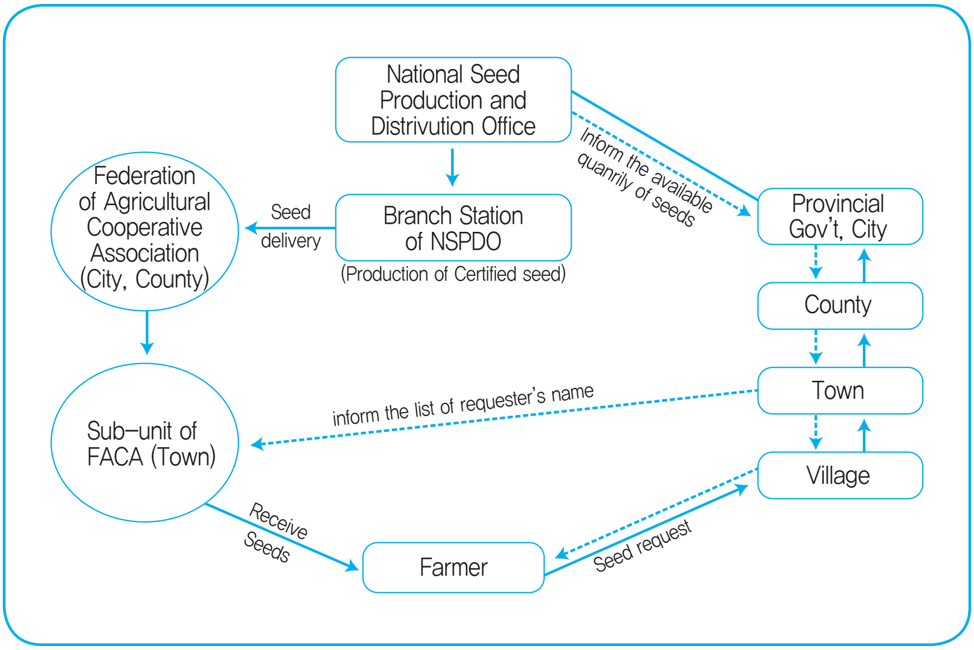
Figure 2-9 | Multiplication System of New Rice Variety and its Issemination in Korea



5.2 Distribution System of Certified Rice Seed

The request and supply system of the certified seed were operated to practice under the passageway indicating on [Figure 2-10]. The rice growers request or order the proper certain quantity of the certified seed of their favorable variety to the NSPDO through the relevant local government organizations during the period from previous December to the end of January. After collecting the grower's requests over the country, The NSPDO informs to the growers the possible availability of seeds and varieties requested. According to the notices of the NSPDO, the growers receive the seeds after making a payment through the Federation of Agricultural Cooperative association.

Figure 2-10 | Supplying System of Certified Rice Seed in Korea



Chapter 3

Improvement of Cultivation Techniques for Tongil-type Rice Varieties

Improvement of Cultivation Techniques for Tongil-type Rice Varieties

The technology of rice cultural practices in Korea has greatly advanced by the cultivation of Tongil-type rice varieties since the early 1970s because of some ecological responses different from japonica varieties.

Major characteristics of Tongil-type rice varieties were short stature in plant architecture with erect leaves, high yield potential, tolerant to heavy nitrogen and lodging, and resistance to major diseases and insect pests, particularly more or less neutral responses to photoperiod and longer period of basic vegetative stage of rice growth. However, there were also some shortcomings such as the susceptibility to low temperature, easy shattering of grains, and unacceptability of grain quality and palatability to Korean consumers.

In order to secure the sufficient number of panicles per unit area, it fostered healthy seeding; proper transplanting density; facilitated tillering by applying both basal fertilizer and topdressing at tillering stage; secured the sufficient number of effective tillering to avoid non-productive tiller at the early stage by mid-summer drainage in paddy fields. The technique – topdressing at panicle initiation and flowering in a timely manner - was developed to increase the percentage of filled grains for the effective number of grains per panicle. Also, manure, silicate, rejuvenation of soil, and deep tillage were applied to enhance the fertility and physical structure of paddy soil. Rice was planted based on the region-specific weather condition at a proper period to reduce the risks by natural disasters such as outbreak of diseases and insects, lodging, and cold injury , since those may occur frequently under the high fertilization and dense planting conditions.

By successfully disseminating this high yield techniques for 15 years from 1973 to 1987, the national average yield on rice for Tongil type rice surpassed that of Japonica by 17%, 4.71 ton per ha and 4.03 ton by milled rice per ha, respectively. The productivity of high-yielding farms (8.94 ton by milled rice) increased by 2.22 times compared to that of Japonica (4.03 ton), and by 1.9 times higher than that of Tongil type rice.

1. Developmental Progress of Rice Cultivation Techniques

Korean rice crop has around 5000 year history, and cultivation techniques have been constantly changing along with the concurrent situations and conditions. The most prominent technique that had been used until the 14^{th} century, Koryo Dynasty, was the direct-sowing cultivation technique, and then farmers exploited the transplanting cultivation with the direct-sowing cultivation through the early Joseon Dynasty in the 15^{th} century. The transplanting techniques expanded and disseminated all over the country by 16^{th} century.

Foundation of modern rice cultivation was established when the researches on the transplanting techniques through seedling method, transplanting method, paddy field management and standard cultivation techniques for disaster safety were conducted in earnest by a national agricultural research organization (the Gweon-eop-mo-beom-jang) in 1906, establishing the hand transplanting technique. The Gweon-eop-mo-beom-jang became Agriculture Research Institute (1957) and Rural Development Administration (1962) after the liberation in 1945.

The Rural Development Administration (RDA) organized a scientific system for modernized rice cultivation techniques, which impacted greatly on the rice cultivation techniques through this development and dissemination of high yield variety, Tongil. The development of modern cultivation technique can be mainly divided into two distinctive stages: pre-1960s and post-1970s in <Table 3-1>. Before 1960s, although the agency strived to develop the cultivation techniques such as lodging reduction, blight control, diseases reduction, cultivation technologies for low level production paddy with soil management, mainly focusing on Japonica rice, there were some limits that hindered increasing productivity.

Table 3-1 | Changes of Rice Cultivation Techniques

Items	1960s	1970s	1980s
Plow	Animal tillage	Power tiller	Power tiller, Tractor
Seedling nursery	Flooded nursery	PE protected semi-irrigated nursery	Tray raising
Transplanting	Manual	Manual	Machine
Fertilization	Manual	Manual	Manual
Water management	Manual	Manual	Manual
Weed control	Manual, Herbicides	Herbicides, Sprayer	Herbicides, High-press sprayer
Post-harvest	Manual	Binder, Sun-dry	Combine, Heat-dryer
Rice eco-type	Japonica	Tongil type	Tongil type, Improved japonica
Targets	High-yielding Reducing disasters	High-yielding Fertilization Reducing disasters	High-quality, High-yielding, Reducing disasters, Labor-saving & mechanization

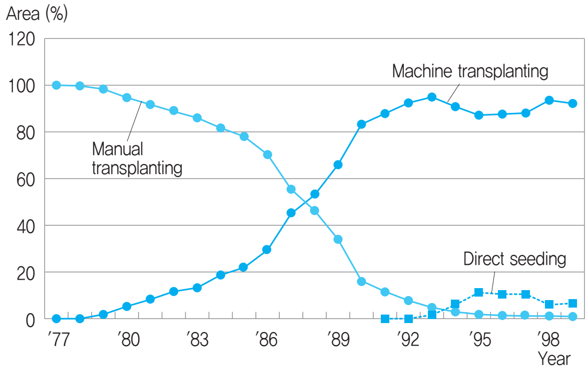
Source: History of Korean Agriculture Technology (1983)

Unlike Japonica varieties, it was a very important issue to secure a safe cultivating growth period, semi-dwarf, and high-yielding potential for Tongil-type rice as it turned to 1970s. Therefore, the early planting cultivation techniques settled down with the development of protected seedling cultivation techniques, which enabled reducing the low-temperature loss in the early growth cycle, by substantially moving up the transplanting stage.

In addition, the RDA enhanced the efficiency of fertilizer application by developing the optimum fertilizer amount and application methods for safe high yield, established the variable cultivating techniques to reduce low temperature injury. And the agency established the improving techniques on low productive paddy soil using inorganic matters such as lime, silicate, and organic matter application for correcting soil acidity.

Also, the change in demography from national industrialization and aging work force brought about adoption of the mechanical farming techniques in national wide in 1980s. It led to reducing labor hour and effort greatly by constituting 83.8% of the total paddy area in 1990s [Figure 3-1]. After 1990s, proper amount of applied fertilizer was greatly reduced for improving grain quality and safe production of semi-dwarf high yield japonica which replaced Tongil type. In addition, direct sowing cultivation techniques were developed to cut down the cost of production by labor-saving.

Figure 3-1 | Changes of Cultivation Techniques in Rice



Source: Annual Report on Agro-forestry Statistics (1977~1999)

2. Eco-physiological Characteristics of Tongil-type Rice Varieties

2.1 Advantage and Weakness of "Tongil" Variety

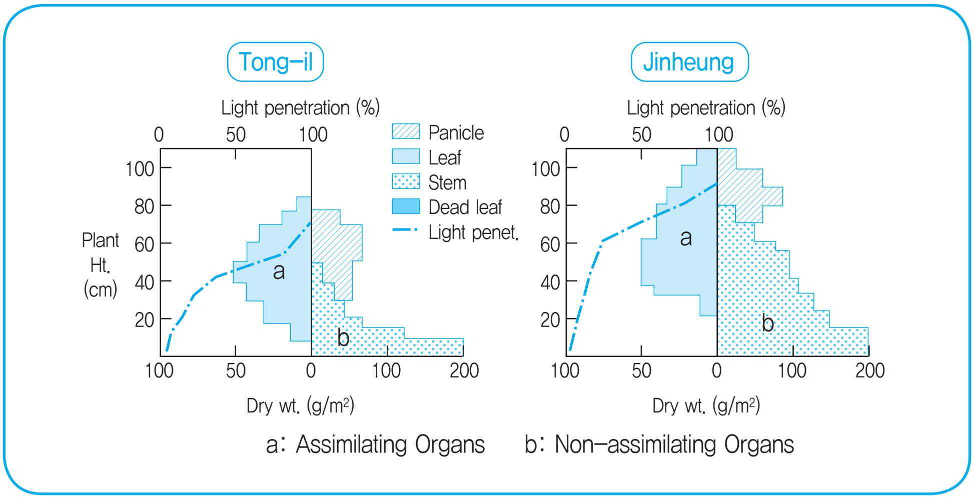
"Tongil" was an innovative high yielding variety in a way that it increases the yield by 30% (5.01 ton/ha) compared to that of Japonica. Tongil showed not only many advantages but also some shortcomings that should be overcome for successful cultivation. The advantages were efficient photo-utilization, lodging resistance, high nitrogen responses, disease and pest resistance with short culm, panicle weight, and erect plant type <Table 3-2>. Tongil-type varieties were genetically short height, panicle weight, erect plant type, in contrast to Japonica varieties with tall plant height and droopy leaves. Short and erect Tongil-type varieties had lodging resistance and efficient photosynthetic capacity.

Tongil-type rice varieties showed the relatively longer basic vegetative growth with more or less neutral response to photoperiod as compared with traditional temperate Japonica, and needed relatively higher temperature during the growth stage of grain ripening under the Korean climate conditions.

In addition, Tongil-type varieties demonstrated the thickness of 1st and 2nd internodes from neck node double the japonica varieties. Accordingly, number of vascular bundle in the 1st internodes from top were 32.7~46.6 for Tongil which was compared to 23.4~26.6 for Japonica. A number of vascular bundles is closely associated with the number of rachis branchs and spikelets, which is an important factor to rice yield. Therefore, Tongil-type rice had morpho-anatomical traits, advantageous for yield improvement.

The plant structures of Tongil and Jinheung (Japonica) are compared in [Figure 3-2]. At the heading stage, the plant height of Tongil is less than that of Jinheung. The ratio of assimilation/non-assimilation organ or the leaf blade/culm + leaf sheath of Tongil is greater than that of Jinheung. And the panicle weight of Tongil is greater than that of Jinheung. Only the top leaf blades of Jinheung can receive sufficient light, while more than 50% of green leaves of Tongil can receive sufficient sun light due to its erect leaves. Although Jinheung is an improved Japonica rice variety, Tongil has an ideal plant type for higher yield under highly fertilized conditions.

Figure 3-2 | Plant Architecture of "Tongil" (Tongil-type) and "Jinheung" (Japonica type)



In the late 1964, proper nitrogen application for Japonica was less than 100kg per ha. However, that for Tongil increased to 200~250kg, showing no lodging, more spikelets resulting high yield potential. This indicates that Tongil has an outstanding character in great responses to nitrogen fertilizer.

Tongil-type rice also carried several disadvantages mainly due to its cold sensitivity derived from Indica germplasm in physiological aspects as well. These flaws in Tongil type rice caused discoloration in seedling nursery, retardation of rooting and growth at the early stage of paddy field, and increased infertility, and poor ripening by excess number of spikelets.

Tongil type varieties demonstrated markedly-dropped physiological activities at low temperature due to higher optimum temperature, 2~3°C higher than Japonica. However, at the optimum temperature range, Tongil rice plants showed the great physiological activities, which made it possible to attain high yield. Therefore development of technologies for Tongil-type rice mainly focused on maximizing the genetic capacity and utilized the advantageous traits of them.

2.2 Improving Directions of Cultivation Techniques for Tongil-type Varieties

Tongil-type varieties have easily chilling injury due to long vegetative growth period at low temperature at established flooded nursery. Therefore it is quite important to secure enough growth period for grain filling at high temperature stage by moving up the seeding and transplanting periods. With this, protected seedling method and early planting techniques should precede for early seeding <Table 3-2>.

Early leaf senescence at late grain filling stage in Tongil rice caused poor quality due to low percentage of ripened grains. It was required to develop water management and nitrogen fertilizer split application method to increase grain filling percent and maintain the root vitality until late grain filling.

Table 3-2 | Major Characteristics of Tongil-type Rice and Improving Directions of Cultivation Techniques

	Japonica (1960s)	Tongil-type (1970s)	Directions
Morphological traits	Long&panicle no. type, Droopy, Less sink organs, Less vascular bundles	Short&panicle wt. type, Erect, More sink organs, More vascular bundles	Enhancement of grain filling and yield
Ecological traits	Short basic vegetative growth	Long basic vegetative growth, Insensitive photoperiodism	Early seeding, Protected seedling nursery
Cultural traits			
- Fertilizer	Low uptake	High uptake	Heavy fertilization
- High-density	Low adaptability	High adaptability	Dense planting
- Canopy	Optimum LAI 4, 30,000 spikelets per ㎡	Optimum LAI 5~6, 45,000 spikelets per ㎡	Improved grain filling and soil fertility
Physiological traits			
- Low-temp.	Tolerant	Susceptible	High-yielding
- High-temp.	Low activity	High activity	
- Photosynthesis	Low	High	
Discoloration traits			
- Seedling stage	None	Occur under 15℃	Protected seedling nursery

	Japonica (1960s)	Tongil-type (1970s)	Directions
- Ripening stage	None	Occur under 20℃	Optimum water management
Resistance to pests	Intolerant to most pests	- Tolerant to blast, Stripe blight, Small brown planthopper - Intolerant to Wasting disease, Nilaparvata lugens, Sogatella furcifera	Regular control, Simultaneous control

Source: Reviewed from various research papers (Je-Kyu Kim, 2011)

Moreover, as Tongil was subjected to heavy fertilizer application and high density planting conditions in which many insect and disease could be easily prevalent and resulting damages., Therefore, an effective system preventing diseases/insects and following damages should be established.

Low productive paddy soil comprised 67.4% of the total paddy area, with high acidity and low mineral contents in Korean. Improvement of paddy soil and enhancement of soil fertility must come first for high yield, through heavy fertilizer application and high-density planting. <Table 3-2> shows agronomical characteristics of Tongil- type rice and improving directions.

3. Method of Raising Seedlings

3.1 Raising Seedling Method before "Tongil" Variety

Nursery form of raising rice seedling in Korea was mostly flooded nursery in the farmers until 1960s. In the flooded nursery, farmers make seedbeds, 120cm width with 30~40 cm furrows each, 4 to 5 days before the sowing and harden the seedbeds, as hard as a block of tofu, for 2 to 3 days. Nursery bed was made on the seedbed and seeding was made on the surface of seedbed in submerged condition. Nursery period varied depending on regions, with 50 days on average.

Upland nursery techniques exploited in early planting and low temperature injury regions, developed oilpaper covering semi-irrigated nursery in 1956. However, there was a difficulty for dissemination of semi-irrigated nursery due to shortage of covering material for polyethylene film or oilpaper tunnel.

1960s (Japonica)		1970s (Tongil-type)		Effects
Flooded nursery - Seeding: May 1~10 - Transplanting: June 1~10	→	PE protected seedling nursery - Seeding: April 10~20 - Transplanting: May 20~30	→	Early seeding / transplanting - Healthy seedlings - Longer growth duration - Ripening under high temp.

3.2 Polyethylene Film (PE) Covering Semi-irrigated Nursery Techniques

Tongil-type rice is insensitive to photoperiod relative to Japonica rice, hence requiring enough growth duration. Furthermore, relatively higher temperature is required to grain filling of Tongil rice. Therefore, it is important to plant early enough for Tongil rice varieties to flower before safe flowering period, so that they could be subjected to 23~24°C during gain filling stage. By means of PE protected seedling nursery technology, early seeding and transplanting became possible.

The PE protected semi-irrigated nursery techniques with mass polyethylene film production were developed and disseminated after releasing the Tongil variety in 1971 and seedling nursery period was 40 days. Seedbed of PE protected semi-irrigated nursery was improved to tunnel form which spaced 30~40cm from the paddy land. As a result, healthy seedling cultivation was possible by sowing at low temperature stage around on April 10th, which was 20 days earlier than in flooded nursery.

The PE protected semi-irrigated nursery led to modernization of rice cultivation techniques in Korea. It was the core technique to achieve Green Revolution through successful Tongil-type rice cultivation. The characteristics and diagram of PE film covering seed bed are on [Figure 3-3, Box 3-1 and Figure 3-4].

Figure 3-3 | Diagram of PE Protected Semi-Irrigated Nursery

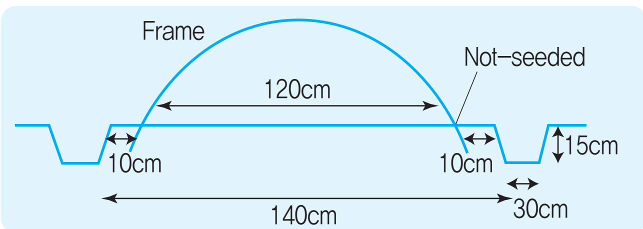
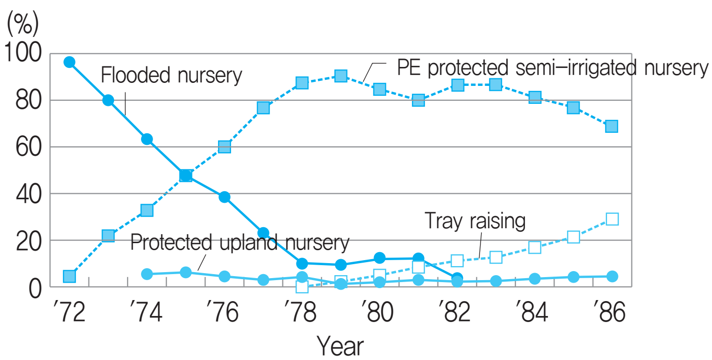


Figure 3-4 | Establishment of Polyethylene Film Protected Semi-Irrigated Nursery

① Leveling ② Seeding ③ Growing the seedlings ④ Transplanting

As dissemination of Tongil-type varieties increased, the percentage for PE protected semi-irrigated nursery increased accordingly: 4% in 1972, 59% in 1976, and 90% in 1979. Eventually, flooded nursery vanished in the farm scene from 1983 [Figure 3-5].

Figure 3-5 | Changes of Seedling Nursery Methods (Area-Based)



Source: Annual Report on Agro-forestry Statistics (1972~1986)

Box 3-1 | Polyethylene Film (PE) Protected Semi-irrigated Nursery Techniques

The PE protected semi-irrigated nursery is a seeding technique developed to extend the vegetation period for a rice crop in the cold climate regions, where the summer is relatively short, and to prevent low-temperature damage after the heading time. When farmers beds out the young rice seedlings using this method, it improves the growth in the root, resulting in the better matured seedling rate, as well as the balanced growth of the rice plants. The sowing season could move up approximately 20 to 30 days earlier than that of the flooded nursery because insulation is available right after the sowing.

In the PE protected semi-irrigated nursery, farmers make seedbeds, 120cm width with 30~40 cm furrows each, 4 to 5 days before the sowing and harden the seedbeds, as hard as a block of tofu, for 2 to 3 days.

After covering up rice seeds with the soil moderately, followed by the sowing, the moistness in the seedbeds would be maintained by supplying the water only through a passage of the completely covered up PE tunnel, which is made by bowing and sticking 180cm long bamboos or 3mm thick steel wires at 60~90cm intervals [Figure 3-3].

Sealing with the PE would stimulate budding by insulating the rice seeds until those completely sprout after the sowing. However, the bottom of the PE tunnel should be rolled up to ventilate the air at the temperature above 35˚C in the nursery since it impedes the growth of the young rice plants, and removing the PE completely if the outside temperature goes up beyond 15˚C.

4. Changes of Seeding and Transplanting Time

4.1 Early Seeding and Healthy Seedling Raising Method

Period of seeding and transplanting at different regions are very important for rice cultivation due to low night temperature at late stage of ripening in autumn in a limited cropping duration in Korea. Generally, seeding in flooded nursery requires average temperature above 10°C, the seeding period was limited to early to the middle of May due to weather condition in middle and southern plain area in 1950~1960, in which warming techniques in seedbed for healthy seedling were not so advanced to overcome this issue.

However, disseminating Tongil-type varieties and broad availability of PE protected semi-irrigated nursery techniques and warming material made early seedling culture feasible, resulting in substantial moving up of the earlier seeding period. It is important to plant and transplant Tongil-type varieties in low temperature period, along with adjusting transplanting to heading and ripening in high temperature period to secure enough vegetative growth duration.

Proper time of applying the PE protected semi-irrigated nursery for Tongil variety was 10th to 15th of April. Compared to pre-dissemination of Tongil, seeding period moved up approximately 20 days earlier <Table 3-3>. Such early seeding is a critical technique developed for safe ripening for Tongil, which needs more accumulated temperature compared with that of Japonica.

Table 3-3 | Changes of Seeding Period (Mid-Plain Area)

Year	Seeding period	Nursery type
1960s~ Early 1970s	May 1~10	Flooded nursery (Manual transplanting)
Mid 1970s~Early 1980s	April 10~15	PE protected nursery (Manual transplanting)
Mid 1980s~	April 10~May 5	PE protected nursery (Machine transplanting)

Source: History of Korean Agriculture (1983)

Meanwhile, Tongil-type variety needed breaking dormancy for uniform germination, which has genetically partial dormancy in Indica rice. In 1974, "Yushin" variety began to be cultivated in the 15ha of farm field in the Philippines in December, produced 105 tons of rice in April 1975 [Figure 3-6], and those were transported to Kimpo International Airport through three Korean Airline carrier airplanes [Figure 3-6]. The seeds were classified and delivered to Provincial Office of Rural Development (PORD) in each province immediately after arriving to the airport to meet appropriate seeding period (April 10th to 15th).

In succession, each PORD processed most seeds as early as possible with nitric acid treatment to break dormancy for 24 hours to unify germination and sun drying, and sent the dried seeds to agricultural extension offices in each city or county promptly to finish seeding in a timely manner [Box 3-2].

Figure 3-6 | Transportation of Multiplied Seeds of "Tongil" Variety by Korean Air Line in Manila International Airport, Philippines

4.2 Early Transplanting and Safe Heading Stage

Although early transplanting increased rice production, there were some limits. The techniques of PE protected semi-irrigated nursery not only advanced date of seeding time but also seedling period comparing to flooded bed, it resulted in moving up transplanting to the main paddy. Low limit temperature of possible rooting for PE protected semi-irrigated nursery seedling in which seedling duration lasts 40 days is 14.5°C. Thus, earlier date of transplanting stage, where the rice's rooting is possible, was set as three consecutive days with the temperature above 14°C.

Optimum transplanting time of Japonica rice used to be on June 10 in 1960s for the early flooded nursery bed. However, as Tongil was disseminated, the optimum transplanting time moved up to May 20 with PE protected semi-irrigated nursery.

The safe late heading date of Tongil variety in Suwon, central plain area, was on August 15th where grain filling completed and ceased safely at the lowest temperature dropped below 10°C and the average temperature at 15°C, and calculated backward to estimate average accumulative temperature falling between 880°C, transplanting should finish no later than May 30 <Table 3-4> [Box 3-3].

Box 3-2 | Breaking Rice Seed Dormancy

Seed dormancy in rice differs depending on genotypes. Indica rice demonstrates stronger seed dormancy than Japonica rice. Since Tongil type rice genotypes originated from Indica rice, they have generally strong seed dormancy. The following are methods to break rice seed dormancy.

① Hulling that removes palea and lemma from rice seeds is an efficient way of breaking seed dormany, because it helps providing oxygen to rice embryo and remove germination-inhibiting substances from rice husks.

② Nitrate treatment is a proper method to break seed dormancy of mass rice seeds in a short term. Dry seeds are soaked in 0.1N-HNO3 solution (1.2kg seeds in 1L 0.1N-HNO3) for 16~24 hours.→Solution is poured off from the seeds that are sun-dried.

③ High-temperature treatment is an easy way of breaking seed dormancy but requires longer time than other methods. Dry seeds are stored at 50˚C for 5~7 days.

Table 3-4 | Safe Flowering Dates Based on Mean Temperature During Grain Filling Stage

Region	Site	Safe flowering period		Flowering limits	
		Tongil type	Japonica	Tongil type	Japonica
Cumulative temperature (Optimum daily mean temp. for ripening)		920℃ (23℃)	880℃ (22℃)	840℃ (21℃)	800℃ (20℃)
Alpine	Jinbu (alt. 560m)	-	Aug. 5	-	Aug. 10
Mid-mountain	Jecheon (alt. 290m)	-	Aug. 12	-	Aug. 23
Middle	Cheolweon (alt.192m)	-	Aug. 10	-	Aug. 15
	Suwon (Mid.)				
Plain	Iksan (South)	Aug. 10	Aug. 15	Aug. 20	Aug. 25
		Aug. 15	Aug. 20	Aug. 23	Aug. 30

* Cumulative temperature: Sum of daily mean temperature for 40 days from flowering

** Source: Analysis on Rice Cold Damage and Comprehensive Technological Solutions (1981)

The temperature and radiation during 40 days after heading affect greatly on grain filling and the yield. According to the cultivation season shift experimentations the temperature and yield amount during filling period, proper safe grain filling temperature for 40 days after heading appeared to be 21.5°C (21~22°C) for Japonica and 23°C for Tongil type varieties. Early transplanting for heading at 23~24°C is a critical technique because Tongil type varieties need to head 5~10 days earlier than Japonica.

Box 3-3 | Setting the Safe-Flowering Period of Rice

① Decide "Late-limiting date for ripening (LLDR)" when minimum temperature is 10Ð and average temperature is 15°C.

② Find the date when cumulative mean temperature reaches 880°C for Japonica and 920°C for Tongil type rice by reverse-calculating from LLDR. Calculated date is "Late limiting date for safe-flowering (LLDSF)."

③ Decide the date when cumulative mean temperature reaches 800°C for Japonica and 840°C for Tongil type rice by reverse-calculating from LLDR. This calculated date is "Late limiting date for flowering (LLDF)."

④ Decide "Early limiting date for panicle initiation (ELDPI)" when minimum temperature of 19°C or higher continues for 3 days or more.

⑤ "Early limiting date for safe flowering (ELDSF)" is 20 days after ELDPI.
→Therefore, safe-flowering period of rice is from ELDSF to LLDF.

4.3 High Density Cultivation

Since rice yield is determined by panicle number and spikelet number per panicle and grain weight, primarily number of planting are important. Until 1960s, optimum planting density of tall Japonica variety was 210,000 (21 hills/㎡) per ha. Optimum planting density for Tongil was estimated to be about 221,200 plants (22.1 hills/㎡), which was higher than Japonica by 3~4 seedlings per hill in mid 1970s <Table 3-5>.

Table 3-5 | Optimum Planning Density for Tongil-type Varieties

Region	Cropping System	Hills/㎡	Seedlings/hill	Planting density&Hill spacing	
				Density(hills/㎡)	Hill spacing(㎝)
Middle	Single	24.2~25.8	3	22.1	30 x 15
South	Single	21.2~24.2	3	23.6	30 x 14
South	Double	24.2~25.8	4	24.5 25.5, 27.3	30 x 13.5 14.5 x 27, 13.5 x 27

Source: Guidelines of Technology Extension, RDA (1975)

Unlike Japonica which was tall (73cm) with drooped leaves and not adaptable to dense planting, Tongil whose height is relatively short (60cm) grew straight with a strong stem, making better dense planting adaptability by improving spikelet number per ㎡ in dense planting.

Japonica (1960s)	→	Tongil-type (1970s)	→	Effects
- Density: 20.9 hills/m^2 - Seedlings: 5 plants/hill		- Density: 22.1 hills/m^2 - Seedlings: 3~4 plants/hill		More panicles due to dense planting

Most of farms exploited broadcast-transplanting by hand even until 1920s in Korea. However, the trend had moved toward checkrowing rice planting after 1950s. The checkrowing transplanting method in hand-transplanting is composed of square planting where intra-row and inter-row are equal; rectangular planting where intra-row is narrower than inter-row; row planting where intra-rows half times narrower than inter-row.

There is a strong co-relationship between transplanting depth and tillering. For hand-transplanting, seedling is planted in 2~3cm depth so that it barely does not fall on the ground to promote tillering in lower internodes.

5. Fertilizing and Irrigation Systems

5.1 Heavy and Balance Application of Nitrogen Fertilizer

The purpose for inorganic nutrients, fertilizer, should be focused on balanced increment in yield components. In the test with Tongil and Jinheung (Japonica), both number of panicles and number of spikelets increased with increasing nitrogen application rate, but the increases were more significant in Tongil. Tongil requires balanced nitrogen dressing for both number of spikelets and grain filling ratio.

As it appears in the table for variance in standard fertilizer application methods in Korea, rice yield for Japonica varieties(Jinheung, Jaegeon, Sinpung) remained 3.0 ton per ha by using N–P-K = 52.4-37.0-27.0kg per ha with manure 1,000kg in 1964 <Table 3-6>.

Table 3-6 | Changes of Fertilizer Application Rate in Paddy (Plain Area)

(Unit: kg/ha)

Year	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Remarks
1932~1963	26~40	21~55	33~42	Ammonium sulfate, Super-phosphate, Potassuim sulfate,
1964~1970	52~80	37~50	27~60	Urea, Triple superphosphate, Potassium chloride
1971~1978	100~120	50~60	60~80	Urea, Fused phosphate, Potassium chloride
1979	150	90	110	Tongil cultivars
1984	110	70	80	Japonica cultivars

Source: History of Korean Agriculture (1983)

Standard fertilizer application for Tongil-type varieties increased substantially, N-P-K = 150-90-110㎏/ha, with more panicles and spikelets. Especially, nitrogen spilt application methods changed from basal-tillering-panicle initiation = 40-30-30% to basal-tillering-panicle initiation-flowering = 50-20-20-10%, enabling great increase in the yield for Tongil-type varieties by improving percentage of ripened grains and 1,000 grain weight from active chlorophyll production and photosynthesis <Table 3-7>.

Table 3-7 | Standard Fertilizer Application Method in Paddy (Plain Area)

Rice eco-type	Fertilizer	Rate (kg/ha)	Split application ratio (%)			
			Basal	Top-dressing		
				Tillering	Panicle initiation	Flowering
Tongil type	N	150	50	20	20	10
	P	90	100	-	-	-
	K	110	70	-	30	-
Japonica type	N	110	50	20	20	10
	P	70	100	-	-	-
	K	80	70	-	30	-

Source: Guidelines of Technology Extension, RDA (1979)

For the effect of phosphate fertilizer is more obvious in the beginning of growth and development, the entire amount is being used as basal in general. Seventy percent of potassium fertilizer is used as basal, and the rest 30% is used as additional fertilizer in panicle formation stage, enhancing grain filling. Meanwhile, proper amount of applied fertilizer for improved Japonica was less than that of Tongil-type varieties, 36.4, 28.6, and 37.5%, respectively.

Japonica (1960s)		Tongil-type (1970s)		Effects
- N: 80kg/ha - Basal-Tillering-Panicle initiation = 40-30-30%	→	- N: 150kg/ha - Basal-Tillering-Panicle initiation-flowering = 50-20-20-10%	→	Improved grain filling and grain weight

5.2 Rational Water Management

The water management should be optimized for each growth stage. While planting seedling, the water should remain 2~3cm depth low, which prevents shallow planting and lodging. In rooting stage water temperature is more important than air temperature. As the temperature drops the rooting gets worse. Therefore, standing water should remain 5~7cm depth in both day and night during rooting period <Table 3-8>.

The management with shallow water (2~3 cm depth) can stimulate increasing water temperature and tiller occurrence during the daytime in tillering period. In unproductive tillering stage, 40 days before heading, midsummer drainage is required to suppress excess tillering because productive tillers are determined during the period. Mid-summer drainage would dry out the soil of rice paddy so that cleavages can be seen.

Table 3-8 | Water Management at Different Rice Growth Stages

Stage	Water management	Water depth (cm)	Effects
Transplanting	Shallow	2~3	Mitigation of seedling lodging
Rooting	Deep	5~7	Reduced shock and transpiration
Tillering	Shallow	2~3	Enhanced tillering
Unproductive tillering	Intermediate drainage	0	Inhibited tillering&excess N uptake, enhanced loading resistance
Panicle initiation	Intermittent irrigation (Deep at flowering)	3~4	Promoted root activity, elimination of hazardous elements from soil
Grain filling	Intermittent irrigation (3d-watering, 2d-drainage)	3	Maintenance of root activity&leaf greenness, enhanced grain filling
Ripening	Permanent drainage (30~35d after flowering)	0 (Permanent)	Promoted grain filling and easy farm work

Source: Guidelines of Technology Extension, RDA (1977)

Intermittent irrigation technique from panicle formation stage to grain filling stage was developed to improve poor ripening ratio found among Tongil-type varieties. Intermittent irrigation is designed to maintain root activity through accommodating oxygen supply to the roots by draining water for two days after irrigation with 3~4 cm and to procrastinate leave's aging, and it is a crucial point for water management at late growth stage. Permanent drainage period begins 30~35 days after heading to make quality improvement and farm working.

Japonica(1960s)		Tongil-type(1970s)		Effects
- Water saving management	→	- Drainage during unproductive tillering stage - Intermittent irrigation from panicle initiation	→	Enhanced root activity and delayed leaf senescence

6. Plant Protection and Weed Management

6.1 Protection from Diseases and Insects

Rice blast and stem-borer gave severe damages to rice production in 1950s. As entering to 1960s the damage from blast, stripe blast, and small brown planthopper became serious. From 1970s, disseminating Tongil-type varieties that have strong resistance against blast brought a huge change in the ecosystem. Whereas there was no report for the damage from blast, sheath blast and bacterial leaf blight emerged as main diseases due to heavy fertilization and dense cultivation, with the loss from brown planthopper and white-baked planthopper. Researchers discovered a new mutant type of variant (T-2+t) for the first time in 1976, and the variant spread out nationwide, occurring neck blast from 12.7% of the entire farming land <Table 3-9>.

Diseases and insect control were conducted in accordance with a regular pest control schedule, from late June to early September, in concurrence with the pest occurrence season, for 5 times in total <Table 3-10>. An extermination period, the number and target pests were flexibly adjusted with each region's specific conditions, yet the government set a pest control period according to an ideal extermination period for blast and brown plant hopper to improve the effect and to minimize the effort through a block pest control. As a result from these efforts, both occurred area and yield decreasing rate decreased. Such result confirms a correlation between prevailing growth of Tongil-type rice and frequent occurrence in diseases and insects in 1970s.

Table 3-9 | Shift of Major Pests in Rice Plant

Disease&Insect		1950s	1960s	1970s	1980s	1990s
Disease	Blast	◎	◎	◎	○	○
	Sheath blight	△	○	◎	◎	◎
	Bacterial leaf blight	△	△	◎	○	△
	Stripe blight	○	◎	△	○	△
Insect	Chilo suppressalis	◎	○	△	△	○
	Leaf folder	△	○	○	◎	◎
	Small brown planthopper	△	◎	△	○	○
	Brown planthopper	△	○	◎	◎	◎
	White-backed planthoppe	△	○	◎	◎	◎

* Occurrence: ◎ (severe), ○ (moderate), △ (minimal)

** Source: Agricultural Experiment Report (1982)

Table 3-10 | Standard Control Methods of Pests in Rice Cultivation

Items	Times	Time	Target pests
Seed-bed	1st	Late stage of nursery	Blast, small brown planthopper, rice leaf beetle
Field	1st	Late June~early July	Blast + Chilo suppressalis
	2nd	Early July~mid-July	Blast +bacterial leaf blight/sheath blight
	3rd	Late July~early Aug.	Neck blast(1st)+brown planthopper+sheath blight/bacterial leaf bilght
	4th	Early Aug.~Mid-Aug.	Neck blast(2nd)+ Chilo suppressalis +leaf folder, brown planthopper
	5th	Late Aug.~Early Sep.	(Late-maturing variety) Neck blast +brown planthopper

Source: Guidelines of Technology Extension, RDA (1975~1977)

Japonica (1960s)		Tongil-type (1970s)		Effects
- Control: 2~3 times - Upon disease occurrence	→	- Control: 6~7 times - Timely and simultaneous control	→	Less infected area and less yield loss

6.2 Weed Management

Before 1960s, where herbicides were not widely used, weeding was done using hoe or weeder manually 4 to 5 times. In early 1970s, the government recommended the herbicides such as Pamucone, PCP, TOK, Machete, MO, Saturn-S effective to annual weeds. The experiments on one-shot application herbicides and the systemic control system were developed and disseminated to prevent from annual and perennial weeds as safe herbicides began to get registered in 1980s.

For a paddy with relatively low amount of weeds, single control, early control (10 days after transplanting), early mid control (10 to 15 days after transplanting), or mid late control (20 to 40 days after transplanting) was adequate. And they were controlled twice in case paddy had frequent occurrence in weeds or annual and perennial weeds were mixed together.

Manual weed control (1960s)		Chemical weed control (1970s)		Effects
- Control: 4~5 times by hands - Labor: 146 hr/ha	→	- Control: one-shot or systemic control - Labor: 9hr/ha	→	Labor saving for weed control (93.8%)

Whereas manual weeding consumed 146 hours per ha in 1960s, using herbicides reduced the time to only 9 hours, saving 93.8% of overall weeding efforts.

7. Improving Soil Fertility of Paddy Field

Korean paddy soil consisted of 32.6% of normal paddies, and 67.4% of the low-productive paddy such as immature paddy, sandy paddy, humid paddy (Appendix, <Table 1>). Physical and chemical properties for paddy soil showed acidity and low contents of mineral, silicic acid, potassium, calcium, and salt <Table 3-11>.

Table 3-11 | Chemical Composition of Korean Paddy Soil and Targets for Improvement

	pH (1:5)	OM (%)	CEC (me / 100g)	Cation (me/100g)			Silicate (ppm)	Available phosphate (ppm)
				Ca	Mg	K		
Korea	5.7	2.3	9.2	3.8	1.4	0.27	88	107
Target	6.5	3.0	20.0	6.0	2.0	0.5	130	100

Source: Soil Improvement Technique (1992)

The comprehensive improvement method for such low-productive paddy was developed by standardizing improvement methods for each type of low-productive sandy paddy, immature paddy, clay paddy, and salty paddy <Table 3-12>.

Table 3-12 | Comprehensive Amendment Technologies Depending on Paddy Soil Types

Factor	Loamy	Sandy	Immature	Clay	Salty
Whole layer application	●		●	●	
Deep plowing	●		●		
Soil dressing		●		●	●
Organic matter	●	●	●	●	●
Drainage				●	
Exchanging water					●
Silicate	●	●		●	
Addition of phosphate and potassium		●	●	●	
Calcium sulfate					●
Micro-elements		●		●	●

Source: Soil Improvement Technique (1992)

7.1 Application of Silicate and Organic Manure

Although silicic acid is not an essential element for plants, rice absorbs vast amount of silicic acid as a required element, and thus needs a sufficient amount of silicic acid for high yield. The available silicate content for paddy soil was 78 ppm on average in 1976. The paddy area, with the silicate content under 130 ppm where using silicate fertilizer would show effectiveness, was implemented into 94% of Korean paddy. In 1970, before the release of "Tongil", the application amount for silicate in Korea was 13,000 ton. But as the area for Tongil expanded, the rate dramatically increased to 80,000 tons in 1974 and 300,000 tons in 1977. The application rates were 3.21 tons and 1.43 tons per ha where available silicate content were 41~50 ppm and 71~130 ppm, respectively. Silicic acid was applied every four year <Table 3-13>.

Table 3-13 | Silicate Application According to Available Silicate Contents in Paddy Soil

Available silicate content (ppm)	<30	31~40	41~50	51~60	61~70	71~130
Silicate application (ton/ha)	4.04	3.61	3.21	2.85	2.47	1.43

Source: Guidelines of Technology Extension, RDA (1973)

Organic material containing rice straw strengthens the rice by improving soil's physical and chemical properties, as well as increasing decay contents. However, only 26% of the Korean paddy met the target level, 3% of organic contents. Organic matter application rate aimed at 10 tons per ha, and organic matter home-made manures mainly consisted of barnyard manure and wild grass. Researches were conducted to replace wild grass with barley and rice straw.

7.2 Soil Rejuvenation and Deep Tillage

Soil rejuvenation was performed on sandy paddy under 10% of clay content until 1977. Deep tillage was targeted to normal and immature paddy, along with autumn plowing for immature paddy field.

The optimal amount of soil dressing for rejuvenation were 100 to 200 tons per ha of mountain red soil on sandy paddy, 75 to 100 tons of sandy soil on clay paddy. Soil with clay content higher than 30% was selected as a soil dressing source until 1977.

Before "Tongil" variety (1960s)	→	After "Tongil-type rice" (1970s)	→	Effects
Organic matter, Shallow plowing		More OM application, Deep plowing, Soil dressing, Silicate		Improved soil fertility

Deep plowing is required for yield increase. Tillage depth was approximately 8cm for animal plowing. Power tiller made it possible to deepen the plowing to 15~18 cm.

8. Post-harvest Management and Farming Mechanization

8.1 Post-harvest Techniques (Harvest, Threshing, Drying, Storage and Milling)

Until 1960s, farmers used scythes to harvest the rice, but starting in 1977 as a binder appeared in the scene, the process began to mechanize slowly. Compared scythe with a binder, the mechanized process showed 13 times better working efficiency than the manual process.

The threshing process until 1960 was drying the rice after cutting from the paddy, carrying to the farm, and then threshing using foot thresher. Starting in 1970s, power thresher replaced the foot thresher, changing all process to power thresher. Combine was available from 1975, harvesting and threshing combined together as the number of combine increased substantially to 1,211 in 1980. Especially, placing chaff back to the paddy improved the fertility on the soil, becoming one of factors contributing to the increased yield.

The drying process of rice used to carry out and utilize power thresh practice by paddy shelf-drying method, small-binding stand-drying method, and spread-drying method, but the drying practice was done after threshing because combine manual practice made un-dried rice threshing.

1960s	→	1970s	→	Effects
- Harvest: Manual - Threshing: Crude thresher - Dry: Sun-dry - Milling: Rubbing type - Storage temp.: 16℃		- Harvest : Manual, Binder, Combine - Threshing: Automatic thrasher - Dryer: Heat-dryer - Milling: Grinding type - Storage temp.: 15℃		Improved rice quality and minimized grain loss

For the milling method, whereas the milling recovery rate reached to 69.4% due to cracked rice since Tongil is a long grain variety, using the traditional fractional milling machine, modified abrasive rice polisher was 71.1%, 1.7% higher milled rice recovery based on rough rice compared to the friction, reducing the milling loss substantially.

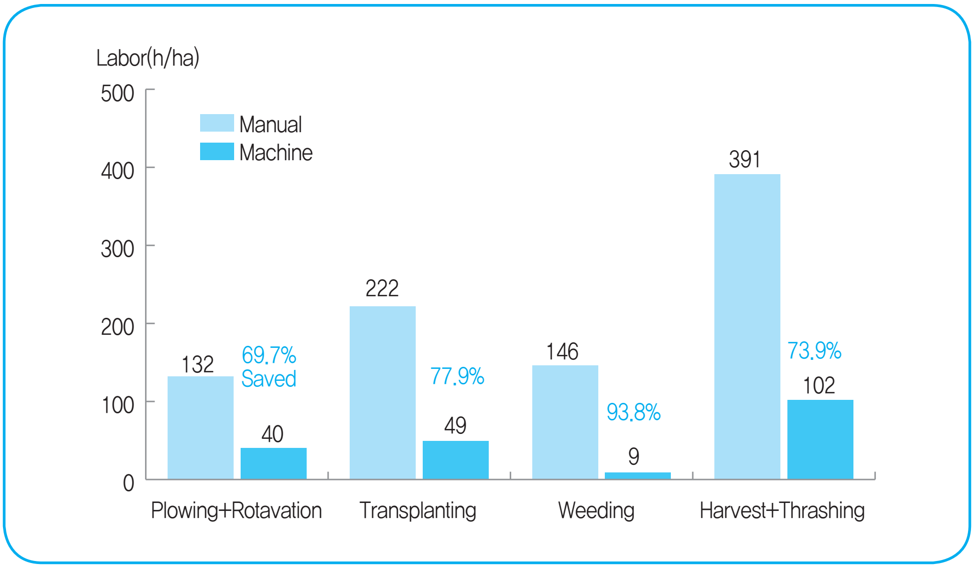
8.2 Farming Mechanization

The rice crop until 1960s relied heavily on human and animal workforce. It made up approximately 65.5% of the entire work force, 1,357 hours per ha, contributed to harvest and threshing (28.8%), transplanting (16.3%), weeding (10.7%), plowing and harrowing (9.7%). By 1970s, a portion of the practice replaced with machines, and all the practice eventually replaced to mechanized practices except fertilization and water management in 1980s.

1960s	→	1970s	→	Effects
- Power source : Human&animal - Labor hour: 1,357h/ha	→	- Tools: Engine&herbicides etc. - Labor hour('77): 491h/ha	→	Labor-saving (63.8%)

The working time was reduced from 1,357 hours in 1960s to 491 hours in 1978, 63.8% overall reduction. Saved time was 73.9% for harvest and threshing, 77.9% for transplanting, 93.8% for weeding, and 69.7% for land preparation [Figure 3-7].

Figure 3-7 | Labor-Saving through Mechanization of Major Farm Works



Source: History of Korean Agriculture Technology (1983)

9. High-yielding Cultivation Techniques on Tongil-type Varieties

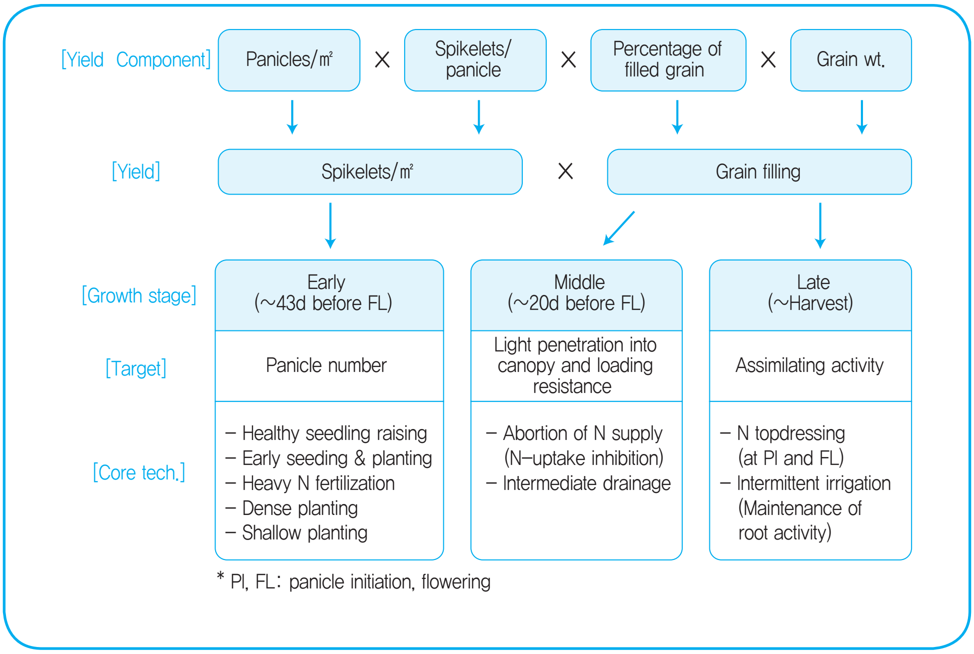
9.1 Techniques for Yield Increase of Rice

Harvest index should be increased along with maximized net dry mass production per area to increase the amount. Pulling up the harvest index requires increasing the sink size, following the increased amount of photosynthesis products through those sinks.

The four factors composing the yield components, number of panicles per area x number of spikelet per panicle x percentage of ripened grains x 1000-grain weight of brown rice, can be calculated as number of ears per area multiplies by percentage of ripened grains. However, since these two factors have a mutually inverse correlation, maximizing spikelet numbers per ㎡, meanwhile minimizing reduction in percentage of ripened grains, is crucial.

The rice's life cycle can be divided into 3 stages, the early, mid, and late. The goals are to enhance the number of panicles per unit area in the early stage, to adjust form for light-interception in the mid stage, and to enhance assimilative capacity in the late stage [Figure 3-8].

Figure 3-8 | A Model for Rice Yield Improvement



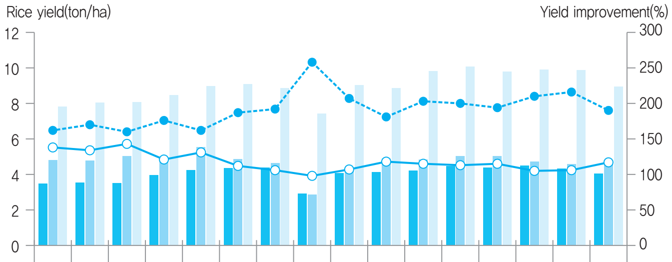
Source: Matsushima(1980), Jong-Hun Lee (2001)

9.2 Example of High-yielding Cultivation Techniques of Rice

In Korea, selecting the high yielding farmhouses began in earnest after 1973, when Tongil began to be supplied. It contributed to increasing the production and to self-sufficiency in staple grains. [Figure 3-9] shows the comparison between yield of high-yielding farmhouse for Tongil-type varieties with the average yield for Tongil-type and Japonica type nationwide for 15 years from 1973 to 1987. For the 15 years, the average yield for Tongil-type varieties was 4.71 ton per ha, which was greater than that of Japonica by 17%, and high-yielding farmhouse for Tongil-type varieties exceeded that for Japonica by 2.22 times, and that for Tongil-type varieties by 1.9 times.

High-yielding comprehensive growing techniques included healthy seedling culture replaced with the PE-protected semi-irrigated nursery as a PE-protected upland rice nursery, application of deep plowing and soil dressing, and the provision of massive amount of manure and silicic acid that improved physical and chemical properties and increase the soil force [Figure 3-10].

Figure 3-9 | Comparison of Average Rice Yield through Whole Korean Farmhouses and High-Yielding Farmhouses



	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Mean
Avg. yield–Japorica (A)	3.49	3.53	3.51	3.96	4.23	4.35	4.37	2.92	4.08	4.13	4.20	4.46	4.37	4.49	4.31	4.03
Avg. yield–Tong–il (B)	4.81	4.73	5.03	4.79	5.53	4.86	4.63	2.87	4.37	4.89	4.83	5.02	5.04	4.72	4.57	4.71
High–yielding–Tong–il (C)	7.81	8.03	8.07	8.45	8.98	9.09	8.87	7.41	9.03	8.86	9.81	10.06	9.79	9.91	9.87	8.94
% Yield improvement (B/A)	138	134	143	121	131	112	106	98	107	118	115	113	115	105	106	117
% Yield improvement (C/Mean)	162	170	160	176	162	187	192	258	207	181	203	200	194	210	216	190

Source: Annual Report on Agro-Statistics ('73~'87)

Figure 3-10 | An Example of Comprehensive High-Yielding Techniques for Tongil-type Rice (1975)

Milled rice yield	100% 6.19 ton/ha	117% 7.23 ton	130% 8.07 ton
Factor	Conventional technique	Leading farmhouses	High–yielding farmhouses
• Seed–bed	Protected semi–irrigated nursery	Protected semi–irrigated nursery	Protected upland nursery
• Improvement of soil fertility			
– Plowing (cm)	12	18	24
– Manure (ton/ha)	10	30	30
– Silicate (ton/ha)	0	3.0	4.5
• Fertilizer (N–P–K,kg/ha)	150–75–115	240–120–180	240–120–180
• Plant density (hills/㎡)	22.1	27.3	32.7
• Water management	Maintenance of standing water	Intermediate drainage + intermittent imgation	Intermediate drainage + intermittent imgation

Source: Innovation of Advanced Agricultural Technologies (1987)

9.3 Significance of Cultivating Techniques Development in Tongil-type Varieties

Korean rice farming has many disadvantages, such as seeding and transplanting in the low temperature period, with a heavy on July and August, insufficient sunlight exposure, low temperature in the latter phase of ripening, and low soil fertility. In spite of these negative factors, Korean rice crop could achieve both self-sufficiency and the Green Revolution through high yield by supplying Tongil-type varieties. Such achievements prove the significance of the cultivating technique development;

First, development of the PE protected semi-irrigated nursery techniques that make healthy seedling cultivating feasible in the low temperature period is critical.

Second, securing sufficient vegetative growth duration for Tongil-type varieties, and early sowing and early transplanting for grain filling at high temperature is important.

Third, establishment of the safe high-yielding cultivation technique is crucial.

Fourth, practicing the regular and simultaneous pest control effectively is important.

Fifth, enhancement the soil fertility force for low-productive paddy soil is a key to successful cultivation.

Sixth, establishment of intimate and cooperative research system between central research organization and regional extension organization is vital.

The development and dissemination of Tongil-type varieties and the production techniques enabled the Green Revolution in Korea through self-sufficiency of staple grains. Also, the experts evaluate that the high-yielding production technique that contributed to the basis for the growth in various related industry such as polyethylene film industry, fertilizer and pesticide industry, and farming machine industry, etc. were also crucial.

Chapter 4

Dissemination of Tongil-type Varieties and New Techniques to Farmers

Dissemination of Tongil-type Varieties and New Techniques to Farmers

The extension activities focused on making farmers to understand the characteristics of new varieties apart from the previous Japonica ones, encouraging them to select the new varieties on their free will and actually apply new agricultural techniques.

These endeavors included various training programs on new agricultural technologies for farm households during off-season, prompt dissemination of new technology through various mass media such as broadcasting and newspapers and so on, also with necessary advices on various useful information of agricultural management, controls of major rice diseases and insects, and etc.

Field extension service workers visited individual farmers, with their focuses on the vulnerable places and on-the-ground solutions of any possible problems by supporting rice production expert technology support body,' to provide them with the on-the-spot technical technology, monitoring and giving advices to major rice diseases and insect controls.

Also they reminded farmers of the time limit in agricultural works and assigned area for cultivating Tongil-type rice by giving hands for transplanting, rice harvesting, necessary administrative work, and providing them with needed publicities and reminders. Further to inspire farmers to expand their rice production, the government saved no administrative supports and endeavors to give full support to establish expanded awarding system to high yielding farmers, rice saving movement and etc.

This chapter reviews to show how this strong and full-scale supports had been provided to the systematic dissemination of the Tongil-type rice and necessary new technology.

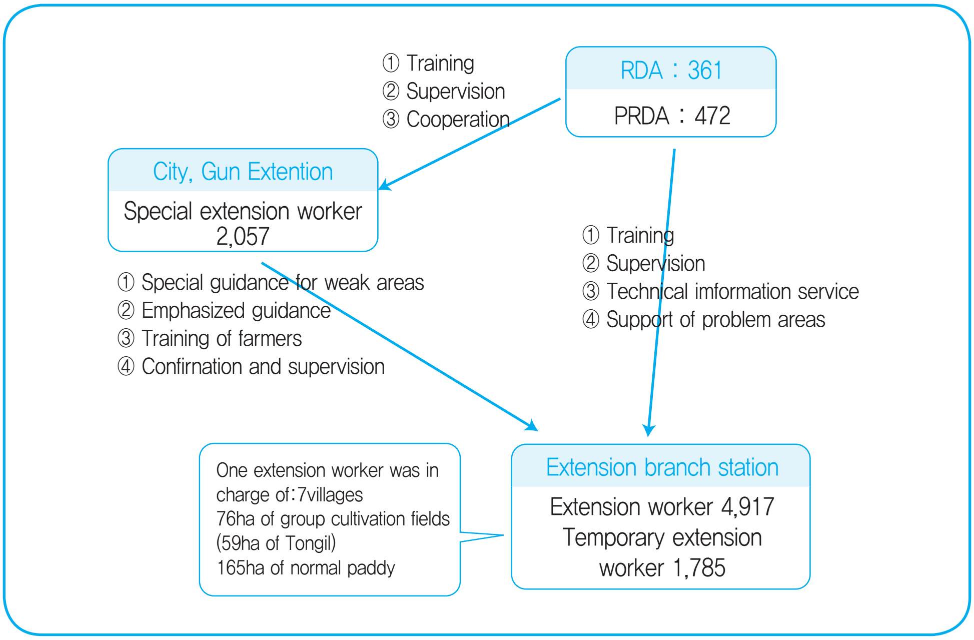
1. The Dissemination System of New Technology

1.1 System of Technology Dissemination

In Korea, the system of extension services is networked top-to-bottom, from RDA headquarters to PRDA in eight provinces, and to the City and County Agricultural Extension Service Centers that were the basic unit of agricultural extension services.

[Figure 4-1] shows how the Korean government focused on the new agricultural technology dissemination for the preparation of its promotion. All the lines of extension services from RDA (ORD) headquarters to branch offices of County Extension Service poured out tremendous efforts to educate and train their staff members with well-equipped technology from experts against in preparation of on-the-ground farmer training and possible problem solving. The City and County Agricultural Extension Service Centers made great endeavors to provide the farmers with necessary technical intensified extension services, particularly on the vulnerable places and training programs. One branch office worker in townships (Myun = a basic unit of government administration) was in charge of average 7 villages. This system contributed greatly to providing new technology through the extension service.

Figure 4-1 | Technology Dissemination System in Rural Extension Service (1974)



Source: Kim, I.H. (1978)

1.2 Procedure of Technology Dissemination

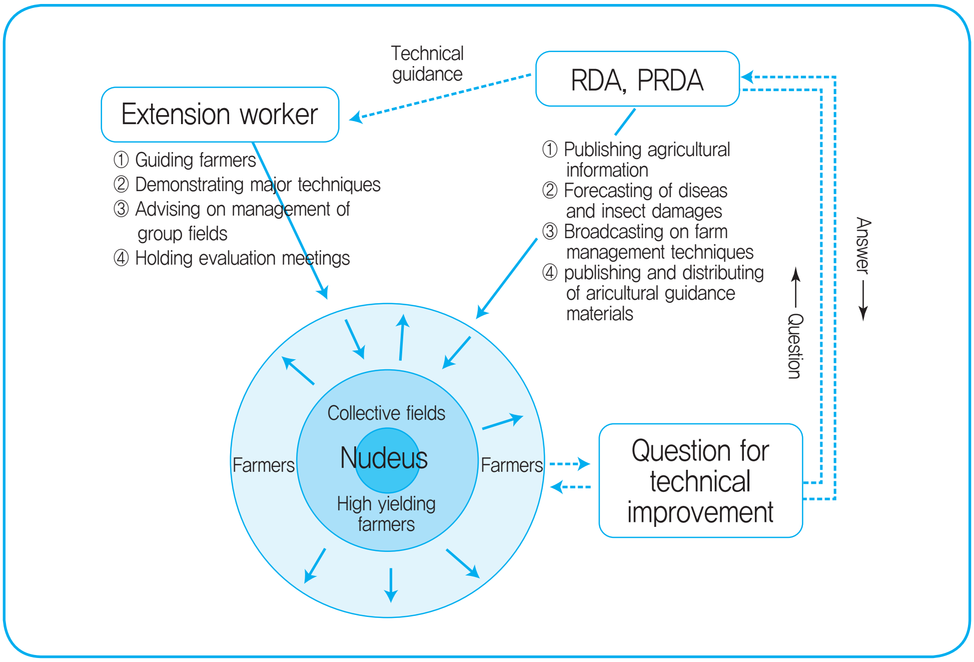
RDA and PRDA provided the extension field workers the technological directions necessary for rice growing, and the extension field workers were stationed on the spot to diffuse the new technology to adjacent villages the effective management of intensive rice growing through the group cultivation members, the member meetings of group cultivation fields, major new technology demonstration meetings for desirable farmers, and evaluation meetings. In addition, RDA and PRDA provided various information of technology for the field management and cultural practices, and the control of disease and insect pest for monitoring and actual control works along with dissemination of published materials based on recently broadcasted contents.

RDA published various information materials for education and training both the teaching staff and farmers such as "Text Book for Winter Farm Management," "Technical Guidance for Production of 30 Million Seoks (equivalent to 4.32 million ton) Rice," "Nursery Bed Techniques for Rice" and "Management of Upland Nursery for Tongil." During every winter seasons from December to March, all the teaching staffs of senior extension officers were educated by the senior rice research scientists. Also, the educated teaching staffs transmitted to educate and train all of the extension field workers and all of the leading farmers who participate in the group cultivation program until March.

Briefing rooms for food crop production were operated at RDA headquarter, Extension Centers nationwide, and Agricultural Cooperatives to inform the farmers about farming education and to guide farmers effectively throughout all farming processes.

In particular, necessary arrangements are shown in [Figure 4-2] for farmers to contact RDA or PRDA through postal cards for prompt solutions when faced with possible problems during their agricultural activities.

Figure 4-2 | New Technology Dissemination by Step



2. Expanded Dissemination of Tongil-type Varieties and Extension Service

2.1 Expanded Growing Area

2.1.1 Demonstrational Farming and Multiplication of Rice Seeds

"Tongil", the first semi-dwarf high yielding rice variety was nominated as a new cultivar in February of 1971. 'Tongil' means self-sufficient production of staple food grain and unification of South and North Korea which was divided in the Korean War in 1950.

For early dissemination and securing its seeds, a total of 82.5M/T of rice seeds was prepared in 1971. Seeds were produced in the demonstration plots of PRDAs in 1970 and the seeds were multiplied at IRRI during the winter season of 1970/'71. Furthermore, the seeding rate in the seed-bed to raise seedling was also reduced to 30kg/ha instead of 40-50kg/ha in ordinary seeding, which was available for 2,750 ha of paddy fields.

To improve the efficiency of technical guidance, co-operative group-farming cultivation system was adopted with 550 group demonstration units of 5ha each in nationwide, a total area of 2,750ha, arranging in the way of co-operative seedling nursery and equipments and copping jointly and easily with any possible concerns in the fields. These group-culture fields were allocated mainly on principal roadsides, and a big size of labels "Group Demonstration Plot for a New Rice Variety, IR667" was set up for farmers. Farmers as well as extension service workers were not so familiar with growing the new semi-dwarf rice varieties which had completely different characteristics from the traditional japonica varieties. For the successful cultivation and production of the variety in the first year, the similar cultural practices and technologies were essential for reducing production costs and carrying out tasks together at the same time. However, there were certainly some difficulties to manage a single variety in a large acreage of a group cultivation field because the individual farmer used to prefer growing their own particular variety, since they are better adapted to varietal vulnerability to disease and insect pests. In addition, the advances of growth and development of rice plant and all working procedures carried out in the demonstration plot were recorded, and evaluated at different stage rice growth: at seedling, heading, and ripening stages by related scientists, extension workers and farmers.

Also the lecturing tour of the 3-day program offered education on the characteristics of the new variety and relevant cautions for cultivation to the extension service workers and the members of group farming, nationwide for successful cultivation and production of the new variety. Experienced research workers frequently visited 550 units to give on-the-spot training and record growing conditions to be utilized for the overall evaluation later on.

Figure 4-3 | On-Farm Training for the Growers of Tongil-Type Varieties at a Demonstration Plot

Irregular and poor seeds germination/sprouting and retardation of early seedling growth in the watering seed nursery bed were observed in some of these units mainly due to low temperatures. However, these problems were properly overcome with conscious management in cultural practices, or rather transplanting was completed 10 days earlier than that of the ordinary years nationwide. Seedling grown under the polyethylene (PE) film tunnels grew vigorously and was remarkably strong and healthy with thick stems, broad and thick leaf blades, and dark green color. It was quite successful to raise rice seedling of "Tongil" rice variety using the polyethylene film tunnel even with relatively unfavorable cool temperatures at early season of rice cropping (see the details in Chapter 3 about PE film tunnel nursery of rice seed bed).

There were also some unexpected disasters such as leaf discolorations in some regions around mid August in some regions, damages from bacterial leaf blight and rice leaf rollers on account of strong typhoons during ripening stage. Such phenomena occurred quite frequently in the early stage of new variety

The extension service workers in charge of the demonstration plots visited the plots daily to observe and record the crop growth in providing on-the-spot services and in the cultivation evaluation meeting; in turn showing their records and growing conditions to adjacent farmers and related agency members.

The demonstrational group cultivations of the new variety that 8,451 farm households participated revealed the yielding of 5.01 t/ha in average milled rice, an amazing out-yield as compared to that of 3.3 t/ha for the traditional japonica varieties. Among the 550 units of group demonstration fields, the greatest yield was 7.14 t/ha in milled rice in average of 5 ha scale and many of units with 6~7 t/ha, which was a great success. It installed hope to increase the rice production nationwide afterward.

It was highly significant to figure out appropriate soil conditions and cultural practices for the semi-dwarf high yielding variety. The favorable conditions for the variety included adequate supply of irrigation water and optimum percolating rate of irrigation water. According to a farmers group leader, he had simply followed the guidance of extension workers because "Tongil" was a totally new variety unfamiliar to him. The first experiences acquired from the "Tongil" variety demonstration plots are shown in the [BOX 4-1].

Box 4-1 | Precautions in Growing the Tongil-Type Variety Demonstration Plot Acquired from the First Experiences

① Selecting suitable cultivation site: avoid regions with potentially poor water permeability, cold water welling fields, rain-fed fields and strong windy fields

② Raising seedling: seeding at optimum sowing time, and grow rice seedling under the Polyethylene film tunnels to protect cool temperature

③ Transplanting: avoiding late transplanting in July (Traditionally transplanting was done until mid July)

④ Fertilization: applying silicate fertilizers and proper amount of nitrogen to protect leaf discoloration

⑤ Diseases and insect control: watching and protect rice stem borer , grass leaf roller, bacterial leaf blight, leaf sheath blight

⑥ Water management: mid-summer drainage and intermittent irrigation alternate desirable

⑦ Harvesting: binding in a small quantity and thrashing on the spot

2.1.2 First Year Expanded Dissemination of "Tongil" Rice Variety

With the great success of 'Tongil' in 1971, the government released the variety to the farmers' field, and strongly drove the policy in 1972 with a slogan 'A Year of Increased Production of Rice and Saving', and showed a strong support for the increased food grain production to expand the growing areas of 187,471ha at 22,945 group farming nation-wide in spite of all the farmers' complaints. However, there were large arguments surrounding some weakness of "Tongil" rice variety, and against expanding the acreage of the new variety by over 20% of all paddy in annual due to the following reasons: yield losses with grain shattering, unfavorable usage of rice straw with short-statured, requiring 20-30% more nitrogen fertilizer with high nitrogen response, less marketability with poor rice quality. Even though such arguments, the historical recording high-yield potential was the only way to solve prolonged food shortage of staple food grain. Particularly, the stickiness of boiled rice quality of the variety was worse than that of traditional japonica variety, but certainly much better than that of imported rice. It was immediately improved with subsequent Tongil-type rice varieties later on. Rest of the controversies was more or less minor ones compared with the debates on high yielding potential, which was solved by further improving variety later on.

In 1972, the government provided 12 thousand M/T of rice seeds to grow in 300 thousand ha, a quarter of the total paddy area in Korea. It was paid at price of 9,920 ₩ (Korean Won) per M/T for all the seeds which were produced in the demonstration plots, and provided the intensive agricultural training programs to farmers during winter season. In order to intensify agricultural technology extension services, the government temporarily hired extra 1,871 extension workers using the special budget of food grain management and stationed them in the rural area for rice production in 1972. At that time the "Tongil" rice variety was not so favorable as Japonica in rice quality, shattered easily, and required 20-30% more nitrogen fertilizers; all these phenomena made farmers' hesitating to grow the new variety and strongly complain about the dissemination.

During the rice crop season in 1972, the weather conditions progressed significantly unfavorable: cool temperature in some parts occurred cold-weather damages, drought and abnormal cold weather (August - September), hail damages in grain filling period (mid to late September). Thus, "Tongil" rice variety revealed a serious weakness to cold-weather when cultivated on unsuitable fields (about 5,226ha) as cold water influencing fields and cold alpine areas. In defiance of all the climatic disasters, the outstanding characteristics of this variety was proved by its increased production of more than 6 t/ha in 250 group units and 5~6M/T in 2,729 group units, that was 3.86 t/ha in average nationwide, a 17% increase as compared that of Japonica 3.29 t/ha.

Figure 4-4 | Transferring New Techniques Was Carried Out for the Tongil-Type Variety at an Individual Farm

On one hand, in 1973 the government paid compensation of 155 million ₩ (2,863ha) for damaged farm households and upwardly adjusted their quality degree in the government purchase at 3,896 ₩ per bag (40kg in paddy). In the meantime, the government stood at the crossroad whether or not to continue in 1973 up against this considerable opposition on the expansion of the Tongil variety.

Some farmers also tended to avoid growing the Tongil, and agricultural extension service workers who strongly urged farmers to cultivate the Tongil by fixing yellow flags. It was not long before the Minister of Agriculture and Fishery on March 28th gathered all agriculture related people at Chungnam PRDA to open a big food grain production promotion meeting to demonstrate his continued support for cultivating the Tongil variety.

President Park strongly urged to promote food grain production. However, the result was that the cultivated area stayed at 121,179ha, only slight decrease over that of the previous year.

Extension services workers devoted desperate efforts to create a successful result on areas already planted with Tongil variety by the RDA led to the amazing national average 4.81 t/ha, shedding some light on the turning point of future expansion of the Tongil in

1973. Furthermore the government began to encourage farmers by providing awards to high yielding farmers, leading to 150 day rice growing operation, and stopping fertilizer exports; all out endeavors including government's production promotion policy and enthusiastic on-the-spot extension services of rural guidance officers played a great role in bearing fruit as a affluent year 1973.

2.1.3 At Last the Tongil Variety Expansion Came to Stay

The government began to gain confidence through the affluent year of 1973, tried to expand the cultivating area in 1974, confirmed its resolution to achieve rice 30 million seoks (equivalent to 4.32 million M/T) of rice target [BOX 4-2], made and distributed systematic training materials on rice growing for farmers up to March, and powerfully put this 30 million seoks (equivalent to 4.32 million M/T) of rice production target into practice from the beginning of the year.

The government went further to provide 4,100 M/T of PE film at no interest for warm seedling nursery beds on 24th March and stopped altogether fertilizer imports from abroad. In this connection the extension service centers (agencies) positively participated in making various necessary training materials and distributed them to farmers for achieving 30 million seoks (equivalent to 4.32 million M/T) of rice, organized intensive rice cultivation zones show in [Figure 4-1].

Furthermore the government set up a situation (report) rooms in related agencies for the food grain production promotion,' running year round from March to November for related administrative support, extension services, putting current agricultural issue into practice, identifying overall performance, and preparing for any unexpected situations

Rice transplantation, grass cutting for manure, and disease and insect controls were on the way under time limit just like a reminder of actual wars, connecting these whole national active food grain production expansion drives to the Saemaul Movement.

<Table 4-1> shows the 7-step strategy to achieve the targeted production of 30 million seoks(equivalent to 4.32 million M/T) of rice. Another work of the 72 demonstration zones was set up for the thoroughbred Tongil variety, one of whose characteristics is early maturity, and so is 'Youngnam Josang.'

Thorough countermeasures (extension services) to cold damages during the seedling nursery bed time and low temperature of May-July in early transplanted stage were prepared for water control, tillering stage fertilization, combined with farmers' enthusiastic efforts; all these factors taken together contributed to arriving at 30.86 million seoks (equivalent to 4.44million M/T) of rice to attain our long-cherished desire by surpassing the targeted production of rice, paving the way for the rice self-sufficiency.

Box 4-2 | Agricultural Extension Service Workers' Resolutions

Here, we, agricultural extension service workers of 7,742 nationwide stand together !

We declare a resolution to become building blocks, deeply realizing the significant national assessment of responsibility the president Park's special awards for the promotion of epoch-making agricultural technology development with scientific farming and the food grain production enhancement leading to farm household incomes

1. We as leaders of farmers declare our resolution with precious pride as agricultural experts to polish our agricultural knowledge and provide wholehearted quality services to farmers
2. We declare that we are fully aware of a vital importance of the food grain self-sufficiency in the national power and spare no efforts in bringing into a success the Green Revolution for staple grain self-sufficiency
3. We declare to elevate a 'Saemaul Movement' up to the farm household income expansion conducive to a affluent rural society based on the diligence, self-help, and cooperation. (Sources: Kim, I.H., 1978)

Table 4-1 | 7 Stage Strategy for the Breakthrough 30 million Seoks (Equivalent to 4.32 Million M/T) of Rice Production in 1974

Step	Strategy	Action period
First step	Farming preparation	Mar. 1~Apr. 20
Second step	Nursing beds	Apr. 10~May 20
Third step	Transplanting	May 20~Jun. 30
Fourth step	Blight and insect control	Jun. 1~Sep. 20
Fifth step	Grass cutting	Jul. 20~Sep. 30
Sixth step	Rice harvesting	Oct. 1~Oct. 20
Seventh step	Barley seed sowing	Oct. 10~Nov. 10

Source: The development process of rural extension service in Korea (1979)

2.1.4 Consolidation of Continuing Rice Self-Sufficiency by the Expanded Tongil type Varieties

In 1975, all the related agencies and farmers together put up all-out endeavors to expand the acreage of Tongil-type rice varieties including Yushin, a improved Tongil-type rice variety for attaining 32 million seoks of rice production, resultants increasing by 274 thousand ha accounting for 22.9% of the total rice areas.

Box 4-3 | Guidelines of Emergency Measure Office for Breakthrough 30 million Seoks (Equivalent to 4.32 Million M/T) of Rice Production

1. Duration activity: 1974. 3. 1~11. 10
2. Agencies Concerned: MAF, RDA, NACF, metropolitan cities and provinces, cities and counties, townships.
3. Responsibilities: Achieving 30 million seoks of rice production, driving mission and strategy for drought and other food grain policy
4. Organization: Comprehensive command(Head of agency), Chief(major related organization staff), Assistant staff (related agency staff), Working staff(related staff members)
5. Operation: Dispatch team with alternative members for week days, special team for weekends, and other special team necessary for nights and/or worse weather etc.
6. Management: Regular conference/meeting - more the 3 times a month; creating, analyzing and solving measurements cope with related and possible problems occurred.

Sources: Korea agricultural history 40years, 1989

A downy mildew occurred on seedling nursery of the Yushin variety in part, and unexpected heading came upon Josaegongil which was early maturing Tongil-type rice variety. In particular, unusual heat wave struck the country that exerted severe damages such as brown plant-hopper (BPH), centering around Honam Area, in south western Korea. In defiance of these disasters as unusual weather and BPH, the average production reached to 5.05 t/ha, whopping 1.52 t more or 43% over that of the Japonica. Thus the total rice production reached to 32.42 million seoks that surpassed the long-cherished target 30 million seoks of rice; this amount was more than enough to meet the demand of 31.5 million seoks of rice, showing the favorable sign of overcoming the chronic food grain shortages.

In 1976, rice production for self-sufficiency was achieved; thus the government began to accumulate food grains storage for the preparation of national security. Now, it was highly motivated that the government made a plan to store at least 10 million seoks of rice and to achieve another new goal of 34 million seoks of rice, accounting for four month consumption of the people. On the aggressive policy of government, the acreage of Tongil-type rice was planned to expand by 600 thousand ha including 300 thousand ha of Tongil and Josaengtongil and 300 thousand ha Yushin which was newly released in 1975. As a result the Tongil-type varieties stood at 533 thousand ha accounting for 44.6%, thus the Tongil-type varieties production reached 4.79 t/ha and the Japonica 3.96 t/ha with average farm household production of 4.33 t/ha, surpassing the splendid rice production achievement in unit area 4 t/ha, and elevating the total amount to affluent 36.21 million seoks of rice.

2.1.5 Attaining the Green Revolution Through the Expanded Dissemination of the Tongil Varieties

In 1977, the government made a plan to produce over 40 million seoks of rice and put it into practice. In turn, continuous variety improvement efforts were accelerated to produce Milyang 21, Milyang 23, Suwon 258, each with different characteristics, allowing the ways for selecting suitable varieties, and accounting for 54.6% out of total rice areas nationwide.

Figure 4-5 | The Newspaper Reporting the Achievement of Rice Self-sufficiency in Korea (1977.12.6)


The Chosun Ilbo <1920年3月5日創刊> 西紀 1977年 12月 6日 火曜日

쌀實收穫 4,170萬섬

農水産部 平年보다 1,087萬섬 증산

段步當 531kg 自給率 113%

Considering the continued drought at the early stage of rice season from June to July, transplanting was delayed selectively, and some planted fields experienced difficulties with drought even after of transplanting. Farmers and related government workers put in all efforts to irrigate drying fields by water pumps, and to control insects and diseases for minimizing damages, leading to the affluent year not by the weather but by the manpower.

Even with such struggles with the worse weather conditions, the average rice yield in farmers' fields reached to 4.94 t/ha, recording the world highest, and 41.7 million seoks of rice which was a historical record safely achieving long desired self-sufficiency. This achievement is referred to as the Green Revolution.

2.1.6 Substituted by High Yielding Quality Japonica Variety

The acreage of Tongil-type varieties sharply inclined from 22.9 % in 1975, to 54.6% in 1977 and 76.2% in 1978, a sharp expansion in a short period. As the Tongil-type varieties expanded their planted area since 1971 with safety (resistance) against blast disease for about 6 years. However, the situation began to turn to the worse with serious damages of blast diseases on the Tongil-type varieties following the spring drought and summer floods in 1978, giving chances to new races blast disease pathogen germs to be rampant and making the blast disease resistance disappear.

To make the matters worse, white panicle blanking by typhoon in 1979, particularly unexpected worldwide summer low temperature brought on cold damages resulting in 34% reduction in harvest in 1980, resulted in the acreage of Tongil-type varieties decrease sharply to 26.5 in 1981. As this opportunity gave the government to recheck the rice production policy centering around the Tongil-type varieties, farmers raised their voices to demand much more safer varieties.

In turn the rice production policy centered around the Tongil-type varieties went on the chopping blocks for rechecking, the government had to turn around sharply to the safe high yielding quality of Japonica varieties.

As the national income level rose considerably and people began to find some comforts in life, consumers' satisfaction criteria also began to shift from the quantity to quality, that is, their preference was inclined to taste with less regard to price. In turn, farmers also highly tended to grow tasty rice.

Following this trend the high yielding quality Japonica varieties were developed and disseminated continuously with necessary cultivation technology development as to reach that of the Tongil-type varieties in terms of quantity, ending in the natural substitution of the Japonica with the Tongil-type varieties, and the Tongil-type varieties at last disappeared from the rice farming history in 1992.

Table 4-2 | Tongil Variety Cultivation by Year

Year	Planted area (ha)	Percentage of Tongil-type variety (%)	Production (ton/ha)		
			Tongil-type	Japonica	Average
1971	2,750	0.02	5.01	3.37	3.37
1972	187,471	16.0	3.86	3.29	3.34
1973	121,179	10.3	4.81	3.49	3.58
1974	180,916	15.2	4.73	3.53	3.71
1975	274,102	22.9	5.03	3.51	3.86
1976	533,192	44.6	4.79	3.96	4.33
1977	600,101	54.6	5.53	4.23	4.94
1978	929,004	76.2	4.86	4.35	4.74
1979	744,271	60.8	4.63	4.37	4.53
1980	604,153	49.5	2.87	2.92	2.89
1981	321,346	26.5	4.37	4.08	4.16

Sources: Korea agricultural history 40 years(1989)

2.2 Agricultural Training Programs for the Expansion of Tongil-type Varieties

2.2.1 Agricultural Off-season Winter Training Programs for Farmers

The winter agricultural program started for rural society poverty banishment in 1961. At first, the program was meant for farmers to do away with chronic evil practices of gambling and drinking during the winter off-season and making them work for straw bag weaving, straw rope making and so on during the day time, and Korean language education for illiteracy eradication during the nights.

In the initial stage, the programs were nothing but light discussions, turning into agricultural technology training later: these discussions were adopted as regular agricultural technology training from 1969 by the agricultural extension service agency.

Table 4-3 | Development of Winter Saemaul Agricultural Training

Classification	1960s	→	1970s (Green Revolution)
○ Training process	Winter farmer training (literacy education)	→	Winter Saemaul Agriculture Training
○ Period	Dec.~April (1~5days)	→	Jan.~Mar. (1day: 5hrs)
○ Target trainees	1 person per farm household	→	All rice farming householders (members of Demonstration zone)
○ Locations	Village (reception room)	→	Saemaul, school zone unit, township unit
○ Methods	Discussions (lectures)	→	Application of audio-visual educational materials
○ Instructors	Administration worker, extension worker	→	Rice expert, the high yielding champions
○ Training materials	Leaflets, Pamphlets	→	Educational materials, slides, movies
○ Contents	Rice cultivation techniques	→	Rice cultivation techniques emphasis on problems of the previous year

With the advent of Tongil-type varieties dissemination, the programs were provided to farmers in 1972 called ‘winter farmer training,’ in 1973 called ‘winter Saemaul agricultural training’ for the basic spirit of diligence, self-help, and cooperation as well as the cultivating technology of Tongil-type varieties, and in 1975 the program was renamed to ‘winter Saemaul agricultural technology training.’

Theses continuous training programs for farmers every year on new variety and new technology formed a foundation for the self-sufficient rice (The Green Revolution) in 1977.

The 5 day, 5 hours each, program services were at first provided by the agricultural extension service workers to visit rural villages from December to March (4 months), then as the busy farming season was moved forward with the advent of the Tongil- type varieties dissemination, the programs were accordingly provided by a single day (5 hours) at the village, school district or township.

At first extension workers gave lectures without prepared materials, later rice growing experts, high yielding champions, leading and farmers joined as instructors to give realistic presentations based on their accumulated experiences, fully reminding trainees of merits or demerits of the Tongil-type varieties and matters to be attended to, regarding rice farming.

These materials were leaflets and pamphlets at first, then they evolved into easy and interesting graphs, drawings, caricatures, and slides; later these training materials on rice farming were prepared by extension service centers every year.

Instructors for farmer training were selected among middle-grade extension officers to be trained in RDA for 3 days and then these instructors passed what they learned to field workers, turning into the next stage was gathering persons in charge of the Tongil variety cultivating zones, irrigation zones, and blight and insect control zones to be trained for 3 days by province under the supervision of Provincial RDA.

The farmers were compelled to participate at least 1 person per household in the programs, naturally there arose some problems as compulsory mobilization in part and reluctant participation. However , these programs served as a foundation to fill themselves with refreshed mind and willingness to practice the Saemaul Movement.

2.2.2 Agricultural On-the-Spot Training

a. Agricultural Training through Visiting Extension Services

As extension service workers were well aware that farmers would surely complain about any failure on even a single rice plot when cultivating the Tongil-type varieties, they devoted themselves in taking care of the farming, from the seedling nursery to harvesting as well as the agricultural training programs.

One on-the-spot extension service worker was in charge of villages including 59 ha of the Tongil-type variety zone and 76 ha of intensive(collective) cultivation zone as well as 165 ordinary plots as of 1974.: He gave counsel to farmers and answered phone advices in the mornings, visited his districts to give personal counsels extension services along with on-the-spot training in the afternoons, solving related problems, and also using village amplifying broadcast systems to announce or educate farmers.

Figure 4-6 | Extension Worker's Activities in the Rice Field for an Individual Farm and Group of Farmers

They wore arm-bands for the farmers to easily identify them even from distance apart and gave farmers agricultural farming trainings and extension services, wearing yellow caps with the 'extension service marks,' and using green bicycles or green motorcycles. They couldn't afford to enjoy any vacations legally given to them and it was not unusual for to the work overtime even on Sundays. This devotional work of on-the-spot extension workers combined is believed to contribute greatly to the food grain self-sufficiency.

b. Agricultural Training through Monitoring Blights and Insects, and their Control

The vital mission given to them was to monitor and control insects and blights for the rice growing duration. All extension workers designated 1st, 11th, 21st of every month as a 「blight and insect control day」, then actually monitored a 'blight and insect control demonstration plot' set up out of the farm household plots, and utilized information acquired for identifying the occurrence trends.

Extension service worker in charge of districts visited at least once in 5 days to monitor possible occurrences, and fixed red flags (containing instructions of controls) when considered needed so as for farmers to easily identify and follow instructions, encouraged farmers through village amplifying broadcasting systems to rush insect and blight controls, and made reports to related agencies.

Insect and blight control warning small size flags had taken roots from 1965 and from 1969 large size flags added for 5ha and over fields, then in 1974 only big flags were used by reason of alleviating extension workers' work burdens, and in 1989 the flag using was liberalized.

City and county extension service centers arranged annual 3~4 time meetings for the controls 7 days previous to suitable time for control, discussed the control date, recommended suitable chemicals, provided necessary instructions, subsidized farmers' chemical purchase, and distributed all the results discussed through printed matters.

Further for the Saemaul demonstration villages, manuscripts for amplifier broadcasting were made and distributed which led to create the blight and insect control booms.

Five-day interval fair days were also fully utilized for publicity in rural areas by setting up temporary consultation centers where various blight and insect specimens were displayed alive, and where expert extension workers gave consultation about the control while distributing leaflets for agricultural technology.

Despite all these efforts, supervising agencies frequently visited on site to check up possible problems regarding controls and reprimanded related workers, finally ending in coming into conflict with hard working people.

c. Agricultural Extension Training using "Rice Farming Expert Technology Service Group"

The group was composed of rice farming research experts and extension service experts to visit vulnerable and problematic places, to give technical training and to solve possible problems for various stages of preparation, obtaining the Tongil variety seeds and expanded dissemination, and suitable time farming.

The groups by province, county, and township were in charge of providing technical training programs. In particular these groups turned into the 'blight and insect control technology service groups' for intensive control period, they visited their respective districts to solve problems promptly. Mean-while RDA and regional extension organizations jointly monitored the occurrence of rice leafhoppers and performed suitable time controls.

When any unusual symptoms or uncertain insects or blights were found on any plots under their charge, extension workers described them in detail and sent this report along with specimen in life to RDA and then RDA promptly gave reply or sent experts to the site to solve problems.

d. Agricultural Training through Questioning on Agricultural Farming

If farmers had anything doubtful or curious about the Tongil variety expansion or new technology dissemination, they could send questions through postal cards on agricultural management from 1973 to RDA or PRDA, and their rice farming experts directly gave replies on it. Many questions for the first year were on acquiring rice seeds and rice farming technology, total questions reaching 2,157 cases and increasing annually. These questions and answers were compiled and utilized for consultation and training materials. Agricultural extension service agencies also solved numerous questions or problems and made efforts to disseminate new technology through telephone consultations or visiting services.

e. Agricultural Training through Agriculture Related Events

The government gathered responsible people from related agencies from the beginning of the year to make staple food self-sufficiency a success through successful Tongil-type variety farming, sending a strong message of food grain production promotion. RDA made a guideline for the rice production technology, distributed and hosted annual study meetings for heads of agricultural extension agencies as a Green Revolution leader, and pledged to fulfill the long desired project. Through these agriculture related gatherings such as study meetings, evaluation meetings, and early year meetings and so on, the RDA provided agricultural training programs and delivered tightened ready-established plans for the Tongil-type varieties farming area expansion, responsible production quota, and tasks to be fulfilled. In case of disasters from unusual weather, symptoms, and new insects and blights in particular, then research and extension workers were sent to gather emergent meetings and they made records of what were discussed to be delivered to on-the spot workers, in turn, all related workers were mobilized to work overtime.

2.2.3 Agricultural Training through Broadcasting Mass Media

a. Agricultural Training through Radios

Radio agricultural training program began in 1958. As agricultural technology and agricultural information were broadcasted by radio, farmers greatly welcome and audience rating also grew gradually. To comply with this response in 1962, the RDA prepared a 'Radio Agricultural School Program' to broadcast on farm households at every dawn, laying the foundation for the agricultural technology to take roots.

In 1963, three radio programs, 'My Hometown Samchunli' on the TBC , Day Breaking Morning' on the MBC and 'Plaza of Dawn' on the DBC for farm household programs were started and followed on the KBS. The programs further expanded in 1970, and from 1972 over thousand time of these programs were broadcasted for the agricultural training. To support this trend, RDA prepared recorded tapes for new agricultural technology broadcasting and sent them to broadcasting stations, thus active agricultural technology programs of new variety introduction, new technology and so on were provided through radio broadcasting.

Table 4-4 | No of Cases Broadcasted on the Radios

Stations / Year	KBS	MBC	TBC	CBS	DBS	total
1970	307	62	75	53	11	508
1971	388	89	136	97	15	725
1972	539	157	274	189	17	1,176
1973	692	149	285	191	24	1,341
1974	506	135	279	182	21	1,123
1975	457	180	272	172	22	1,103
1976	737	147	299	202	25	1,410
1977	558	178	225	201	24	1,186
Total	4,184	1,097	1,845	1,287	159	8,572

Source: Kim, I.H. (1978)

b. Agricultural Farming Training through TV

TV broadcasting started from 1968. In early stage, the TV sets were extremely rare in rural area so that the broadcasting for farmer were insignificant; however in 1972, the Saemaul Movement was in a full swing and the Saemaul programs were newly broadcasted on TVs and the broadcasting for farm households became regular programs, which paved the way for expanding farming technology training. In addition to this, new programs featuring rice farming success story in consequence of the Tongil variety planting area expansion were broadcasted.

Active agricultural farming broadcastings for the expansion of the Tongil variety expansion featured rice farming experts every day and introduced main characteristics of the Tongil varieties, guidelines for rice farming, and insect and blight controls and so on. In addition they also provided prompt and valuable information along with countermeasures about unexpected disasters as droughts and typhoons in various forms of spot news, TV subtitles, telephone broadcasting. Agricultural experts actively appeared on TV live to give information on the minimization of agricultural crop and agricultural facility damages. As shown above, RDA devoted significant efforts to provide agricultural information on new varieties, new agricultural technology, and agricultural farming technology through broadcastings and to find excellent examples.

c. Agricultural Farming Training through the Saemaul Amplifier System

The Saemaul amplifier systems dates back to subscription based cabled radio speakers in 1968 for farm households, and the system turned into the Saemaul amplifier system from 1972.

In this background, on-the spot extension service workers used this system to give information on insect and blight occurrences and other work guidelines when they were visiting on-the- spot.

In the intensive insect and blight control period, extension service workers visited the Saemaul and used this amplifier broadcasting systems at dawn.

Extension workers always visited at dawn for farmers to listen to broadcasting before going to work. Some villagers, however, filed complaints about disturbing their sweet sleep at dawn.

From 1975 on amplifier broadcasting manuscripts were prepared and the villagers were encouraged to make broadcasts themselves. While in major agricultural work period, vehicles with wireless amplifiers made street broadcasts, for backlands and wave blind spots 2,800 LP records (in 1970) were prepared and distributed to farmers on rice growing technology, however in time, the radio broadcasting gradually took the place of it.

2.2.4 Saemaul Movement

a. Collective Farming Demonstration Zones

As in early stage of agricultural technology dissemination, the demonstration plot was simply for displaying technological effects under individual farming, but in 1968 collective and cooperative farming 500 zones were first set up to produce more rice.

For collective farming demonstration zones, farmers entered into written agreements for unifying rice variety and farming method on the similar soil quality in order to produce rice in a collective way, conducive to production cost and labor saving, and more production.

Table 4-5 | Collective Zones Installed and their Performances

Year	Area (ha)	No. of zones	No. of farm households	Rice production (ton/ha)		
				Zones	National average	Percentage rise
1971	300,650	23,095	818,952	4.16	3.37	23%
1972	187,471	22,945	625,174	3.86	3.86	16
1973	317,736	20,778	917,495	4.08	3.58	14
1974	393,115	29,224	1,197,367	4.54	3.71	22
1975	428,441	32,446	1,280,831	4.67	3.86	21
1976	527,690	51,326	1,423,800	4.92	4.33	14
1977	481,294	48,034	1,303,262	5.36	4.94	19
1978	545,560	50,554	-	5.12	4.74	8

Sources: Korea's agricultural extension service development stages (1979)

With short-handed extension service workers who demonstrated new technologies comprehensively, they worked hard for on-the-spot extension services, evaluation meetings by stage, and hard research gatherings for leading farmers and ordinary farmer to see crop conditions.

They explained in detail how they worked for careful farming, making these reports as on-the-spot training materials, not only bringing on the increased production <Table 4-5> but also nourishing strong teamwork among farmers, and contributing greatly to the expansion of Tongil variety.

It was only 5 ha in the initial stage of the collective farming, gradually grew to be around 10～15ha, and in some part adjacent several zones combined made over 5,000 ha.

b. Demonstration Plot Management for Rice Variety Performance Comparison

Rice variety performance comparison demonstration plots were set up next to the roadside or village access road plantation of farm households for all farmers themselves to select quality varieties, arranging frequent on-the-spot evaluation meetings for training purposes.

The rice produced on the demonstration plots could be exchanged for seeds of their own free will to encourage them to expand their cultivating area.

c. The Saemaul Movement

The collective farming zones based on the Saemaul Movement spirit of diligence, self-help, and cooperation. Through unified new variety selection, farming technology, collective work, and sharing agricultural materials, farmers were able to bring upward standardization of production on their plantations; furthermore, they were able to overcome wisely disasters such as droughts, floods, cold waves, and typhoons using cooperative spirits. In addition farming season joint cooking places and farming season day care centers for rural women to work in comfort were set up so as to solve labor force shortage, thus indirectly supporting precise work possible (Appendix).

Table 4-6 | Day-Care Centers

(Unit: No. of places)

Year	1971	1972	1973	1974	1975	1976	1977
Place	2,250	7,679	4,455	5,558	5,570	5,557	5,519

2.2.5 Giving Support to Making Agricultural Training Materials

RDA published 'Agricultural technology' in 1967 containing new agricultural technology, core technology in chronological order, and exemplary success stories; in particular, the president Park wrote 'Agricultural technology' himself, the book was published biweekly in leaflet form of 800 thousand copies, and was used as one of training materials. In 1972 it became monthly was distributed by 10 copies for each Saemaul village, and in 1973 containing pages of 8 expanded to 20 in 1973 to be utilized for mass media broadcast training materials and agricultural school teaching materials.

They also prepared color slides and super 8㎜ films to disseminate them to on-the-ground workers to be used for small group or general public training materials, on the other hand movie vehicles also visited the Saemaul for the enhancement of training effects to show films titled for example 'Green Revolution is Possible,' 'High Yielding Rice Farming Technology,' etc. Adding to these activities they made lots of printed materials in various forms containing rice farming technology, diary of rice farming, agriculture related leaflets, posters, and flyers to be distributed and used as on-the-spot agricultural training materials.

From 1969 to 1970, the 'Korean Agricultural Terminology' explaining 3,040 hard terms in plain Korean words was published, facilitating easier communication with farmers to deliver new technologies quickly.

2.3 Providing New Farming Technology for Actual Practice

2.3.1 Announcing Agricultural Information

RDA and PRDA announced weekly agricultural farming information all the year round including the weather forecast for the coming week, guidelines for next week's major agricultural work, and new agricultural farming technology and weekly information, to be printed and distributed to the related agencies and extension service agencies, being used as various forms of training and the general public publicity.

In particular these materials also played a great role to minimize damages from typhoons, flooding, cold waves as well as rice farming technology.

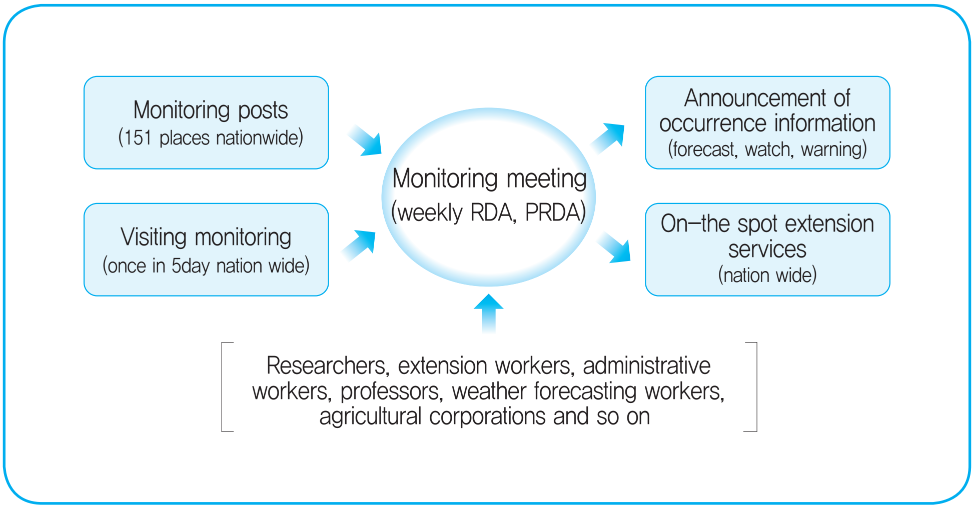
2.3.2 Announcing Information on Blight and Insect Occurrences

To minimize damages from disease and insect by forecasting precise occurrence, RDA announced information on disease and insect occurrences during the rice growing period from March to September.

Records by disease and insect monitoring posts (151) under the supervision of agricultural extension service agencies, farm household monitoring posts in 1977 (1,644), on-the-spot workers' work diaries on insect and disease controls, pilot rice cultivation surveys, disease and insect occurrence surveys, and weather forecasting etc. were comprehensively analyzed;

then disease and insect occurrence monitoring weekly(Friday) meetings, composed of 20 members selected from related agencies and universities, were held based on of these data and information.

Figure 4-7 | Announcement of Disease and Insect Occurrence Information



Based on the result, the announcement was classified into forecast, watch, and warning indicated by printed paper color, these classified papers were sent to on-the-spot extension service agencies and related agencies to be used for making plans, and also to farmers by various mass media for them to control insects and diseases at a suitable time. Each PRDA also announced more specified insect and disease control technology reflecting regional characteristics.

① Forecasting (light green paper) signified that the usual diseases and insects occurred and that controls were required.

② Watch(yellow paper), occurrences were increasing or decreasing and control is necessary.

③ Warning(red paper), occurrences were sharply rampant and required urgent control, if not there would be serious damages.

2.3.3 Providing Agricultural Farming Technology through Newspapers and Periodicals

As newspapers and periodicals are writing media, extension agencies provided necessary articles to central and local newspapers which contained new agricultural technology much required by farmers, agricultural information, monthly agricultural work schedule, and exemplary agricultural farming activities. Also for periodicals mainly targeting rural are readers such as 'Saningmin,' 'Saemaul,' and other periodicals, extension agencies contributed their articles for farmers to read and put them into practice.

2.4 Post-Harvest Techniques (Harvest, Threshing, Drying, Storage, and Milling)

Having overcome 'spring poverty period,' a symbol of starvation, Korea achieved rice production self-sufficiency through incredible efforts animated by the Tongil variety Green Revolution with many ups and downs.

2.4.1 Ordeal But No Abandonment

In 1972, 187,000 ha of Tongil was planted and met with unendurable suffer from bad weather.

Mountainous areas such as Hoengsung, Youngdong, Okchun and Yougwol suffered nursery bed cold damages during June~July, droughts in Gyunggi and Gangwon droughts, 3 big riverside floods during July~August, strong wind damages in costal area, hail damage in September around Hongsung; all these taken together brought upon retarded ear-coming and infertility.

In many parts of the country rice nursery beds was covered by PE film or heat was supplied to growing rice seedlings to protect the cold damages by burning used tires or barns all night through. All these devotional extension workers' efforts bore fruit.

Despite all these endeavors, they suffered cold damages on unsuitable cool alpine region 5,226 ha where cold water flew in.

From late September many mass media headlined the stories of Tongil variety's demerits and unsuitability, then the parliamentary inspection team called these issues into account in October, and some farmers who suffered damage demanded compensation.

RDA, however, started to analyze causes of disasters and prepared technical restorations, one of executive members refuted the newspaper articles bit by bit 'Why Do You Blame Variety Only?' 'What's Your Idea Behind Ignoring 92 % Success and Playing Up 8% Failure?' His logical counterattack became priming powder for turning the table and all mass media began to bend over backwards to cover Tongil varieties' characteristics and guidelines for rice farming technology.

2.4.2 The Most Difficult Period for "Tongil" Dissemination was Year 1973

Early in 1973 lots of people went along with anti-Tongil expansion atmosphere. In defiance of this gloomy atmosphere, the then head of RDA showed a amazing passion about the Tongil and persuaded all related people to cultivate at least one more year; for all his fervor and extension workers' desperate endeavors, plated area decreased.

That is, the planted area of 1973 remained at 121,179 ha reduced by about 6000 ha over that of 1972. Although agricultural extension service agencies tried their best to expand planting area, the task was beyond their ability.

2.4.3 Persuading Farmer for "Tongil" Expansion

RDA believed that the only way for Korea to achieve Green Revolution is the expanded cultivation of Tongil varieties. Thus RDA put a great stress on suitable land selection and suitable farming technology and encouraged farmers through fervent publicity to expand their planting area, however, farmers were reluctant to cultivate the Tongil by reason of previous year's disasters, in most case extension workers' tenacious persuasion was the game when it comes to prevailing with farmers.

Extension service workers visited rice seed soaking farmers one by one and fervently encouraged them to select Tongil and fixed yellow flags on the Tongil nursery beds, checking up every nursery beds.

In Shinan county of Cheonnam Province extension workers brought their zeal to the expansion of Tongil planting area under the slogan of 'visiting farm household 10 times'. Many farmers felt bound to plant Tongil variety on only a part of their fields to save extension workers' face. Extension workers' desperate efforts to expand Tongil planting are indescribable. At the time, encouraging Tongil farming was extension service agencies' exclusive task.

Their desperate efforts bore fruit in 1973; affluent rice farming, contributed significantly to the expanded dissemination of Tongil and new farming technology.

2.4.4 Stunning Things Happened to On-the-Spot Extension Service Workers

Two early maturing Tongil-type varieties, Josaengtongil and Yeongnamjosaeng which were developed by pure-line selection from "Tongil" variety, were recommended to grow in the cool alpine regions in 1974. However, the rice seedling leaves of these varieties in the demonstration nursery bed occurred to discoloration into dark brown and yellowish due to low temperature, resulting in wither and death.

In 1975, another unexpected phenomena also happened on the newly released Tongil-type: occurrence of downy mildew on the nursery bed of Yushin variety which was newly improved Tongil-type and the non-seasonal heading in the Josaegtongil plot evoked serious criticism with high yielding Tonil-type rice varieties.

The lingering high temperature in summer in southern regions of the Coutry gave rise to rampant leafhoppers and last from September 20th, and farmers began to spray chemicals resulting in confusions of farmers' scrambling to purchase powder chemical (Bassa).

In 1976, white leaf wilting disease (bacterial blight), for the first time in Korea, occurred on the demonstration plots of Milyang 23 in Hwasoon county in Cheonnam province, and on all demonstration plots nationwide occurred before long to our horror, Yushin began to rot around roots on account of continuing rain in August, drying abruptly and collapsing acute wilting occurred on 7,843 ha nationwide.

Overall from 1973~1977 animated by favorable weather condition, crop conditions were good. However in 1978 spring droughts, floods, serious new blast damages, in 1979 white wilting ear by typhoons, an in 1980 followed nationwide cold damages making consecutive 3 year disasters; all these incidents combined made farmers build up accumulated complaints. As a result all extension service workers were treated as criminals for farmers, extension workers sometimes persuaded farmers and sometimes apologized to them.

2.4.5 Sacrifice of Noble Extension Service Workers

Behind the success story of the Tongil type varieties there were tremendous hidden heartbreaking and touching anecdotes. Everyday work of extension workers to encourage farmers to expand the Tongil variety planting area was a difficult task; some extension workers even made a promise to farmers that 'If you fail your farming following the directions of extension worker then I'll repay you selling my fields.' When farmers were stubborn to the end without following their persuasion, then extension workers themselves purchased that plot and planted Tongil type varieties to meet the target.

For this hard work day and night, some of them even died with their boots on at their prime age in accidents and many of them became disabled from serious injuries. This kind of stories were too numerous to list, but roughly from 1971 to 1977 when the Green Revolution was realized those died at work reached 13, seriously injured 74, slightly injured 43; total 129 sacrifices.

As shown above when we recollect the Green Revolution, these valuable sacrifices must not be forgotten.

2.4.6 Less Careful about the Regional Characteristics by Variety

Consecutive affluent several years brought about carelessness, people were solely bent on rice production boosting, thus the dominant opinions boiled down to the fact of caring less about the safety of the variety.

In a year or two, planting area expansion of certain variety proved their carelessness. In 1976 planting area of Yushin and Milyang 23 were 25.8%, 0.6% respectively and reversed next year to 8.3%, 22.6% and in 1978 staggering 14.2% Nopung disappeared without a trace next year. Thus late in 1970s out of the Tongil varieties usually a single variety accounted for 25 % of the total or top three varieties accounted for over 60%.

Therefore when it comes to selecting varieties it was recommendable that the 2~3 varieties out of recommended varieties, the selection should have been arranged to avoid concentration of maturing period adjusting by region so that the blight and insect disasters and weather damages should have been minimized.

2.4.7 Many Cities and Counties Planted More than 90 % of Tongil-type Varieties

In many places of hard work for expansion and technological extension services, their desperate efforts were not without valuable rewards.

Several examples are Tongil-type variety village making, Tongil-type variety township making, Tongil-type variety county making, rice and barley 1,000kg achieving zone making, and rice 700 kg boosting club, showing their enthusiastic activities. Guangsan, Damyang, Goksung (97%), and Jangsung and several counties expanded Tongil-type variety area to more than 90%.

Apart from agriculture in commerce and industry sector there was a sharp demand in source materials on which the government held a tight rein, the government made arrangement for polyethylene film to be allotted to hotbed nursery first. This arrangement in early 1970s contributed significantly to availability of the PE film for protective nursery making in turn, paving the way for the Green Revolution by expanding Tongil-type varieties.

2.4.8 Special Prizes for Agricultural Extension Service Workers

Extension service workers poured out all their energies to attain “Tongil” expansion and self-sufficiency in food grain production. With these active efforts they actually led the affluent year In 1973, at last.

In 1973, the president gave a direction to give special prizes to agricultural extension service workers to reward them for achieving the Green Revolution. The National Assembly also agreed unanimously, they received 200 % of their usual salaries for the first time in Korea.

2.4.9 Paramount Decorations Given by Farmers

The rice high yielding awards beginning in 1973, lasted to 1976. Awarded farmers volunteered to offer construction costs of sub-branch offices in townships as a token of their rewarding minds for the extension workers' desperate efforts day and night. Thus up until 1975, 87 sub-branch offices were built nationwide, and they also offered to purchase bicycles, make suits, and gave full material and emotional support.

Looking back, the reward given to farmers and extension workers might seem absurd; however at that time, for farming villages and agriculture existing were extension service workers, more valuable than anything else from farmers' was their pure thankful minds based on this.

2.4.10 Facing the Pleasant Agony Following the Rice Production Self-Sufficiency

From 1975 Korea's long cherished rice production self-sufficiency has been achieved, and looking back we set two times of 'no rice day' in a week and put it into, 70 % rice polishing, preparing multi-grain rice, and prohibiting grains for brewing materials; all these agonies were put behind them at that time.

Furthermore, from 1977, rice has become over abound, the table has been turned this time and Korea face struggling to store abundant rice; began to turn around to export, promotion to more consumption, then the government happily began to encourage people to use rice for making Makoly (kind of alcohol beverage), rice noodle, rice bread.

2.4.11 Conferment and Special Prize Money to Government Workers Who Made Great Contributions to New Rice Variety Development

In the process of the dissemination of Tongil type varieties; there was a big social perception improvement on devoted agricultural extension service workers, encouragements poured on them from the Assembly members at the parliamentary inspection and awards followed every year.

On December 20th, 1977 president Park gave his hand written 'Green Revolution Achievement' and gave confers and special reward money to government research and extension service workers who made outstanding contributions to new variety development and dissemination. In 1977, the Agriculture and Fishery Minister gave commemorable tablets to governors of metropolitan cities and provinces in commemoration of surpassing 40,000 thousand seoks (equivalent to 5.76 million M/T) of rice production, additionally those provinces which surpassed average rice production 5 ton/ha as Chungnam, Chungbuk, and Cheonnam received commemorating tablets of 'surpassing,' and gave small size commemorating tower-shaped tablets to executive members of the Agricultural and Fishery Ministry with congratulations.

With this opportunity, fundraising was done for RDA research workers, county extension service center head was promoted to senior scientist (level 4 from level 5), and newly appointed technology officers.

The hard study meeting named 'National Food Grain Production Promotion Meeting' was held on March 1964 at RDA auditorium, president Park played a strong stress on the pan-national drive on rice production boosting for achieving food grain production self-sufficiency at the meeting, RDA hung out the sign 'Green Revolution Cradle' at the entrance of the auditorium to commemorate president's words and distinguished accomplishments on March 1978, and additionally built a tower of 'Green Revolution Achievement Tower' in front of the auditorium to commemorate the Green Revolution gained through the fruit and sweetness from the desperate efforts.

3. Administrative Support for Rice Production Self-sufficiency

3.1 Going Ahead Strong with Time-Limit Farming

For rice farming on major factor labors of production promotion, RDA set up a time limit in advance, exercised strong dispensation of justice to both merits and demerits and crimes.

They set the time limit by kind of work for people from all walks of life to volunteer to offer helping hands, arranging transplanting or rice cutting gathering, assigning Tongil variety planting responsible area, delivering guideline directions, and pressing forward this time limit farming through printed matter or media publicity.

The time limit farming was an 'operation' similar to military operation. Just a few examples are transplanting operation (drive), grass cutting operation, and blight and insect controls.

In addition, other operations included rice farming 150 day operation in 1973, rice production over 4 million M/T surpassing operation; in the process of these operations the pressed forward with their staple food grain self-sufficiency like that of military operation.

All these endeavors combined, they were able to achieve the Green Revolution relatively in a short period. These pressing policies are believed to have played a leading role for food grain production boosting.

3.1.1 Setting up Time-Limit for Major Agricultural Work

The weather in May to June and September to October have a great influence on farming. In particular with the advent of the Tongil varieties that was a tremendous challenge to overcome, this time-limit dated back to ‘transplanting 2 week moving up drive’ in 1973 when putting a big focus on the food grain production boosting policies.

For Tongil type variety farming protective nursery bed (hotbeds) making was a core farming technology; with quantity production of polyethylene film possible to be used for indispensable hotbed making, then it was only possible for them to move up transplanting period up to two weeks so as to ensure safe high yielding.

Preparing rice nursery beds, transplanting, harvesting, insect and disease control and all farming works were scheduled according to regional characteristics and by farmer to complete as shown in <Table 4-7>.

Some people criticized that the time limit farming policy, too uniform and one-sided, was to disregard regional state of things going against local farmers’ autonomy. However, in that time food grain production promotion was urgent that was necessary evil, naturally it’s hard for anyone to put a low valuation on it uniformly.

Table 4-7 | Time-Limit of the Major Rice Farming Works in 1974

Farming works		Mid-and north region	South region
Nursery bed preparing	Hot beds	April 15	April 20
	Ordinary beds	April 25	April 30
Transplanting	Tongil type variety	- (May 25)	June 20 (May 25)
	Japonica variety	June 25 (May 25)	June 30 (June 15)
Rice harvesting		Oct. 10	Oct. 20
Barley harvesting		June 25	June 20

Note: () indicates the case of Mono cropping.

Source: Food grain production boosting plan, Ministry of Agriculture and Fishery (1974)

3.1.2 Giving Helping Hand to Rural Villages

Arranging helping hand nationwide for rural villages by the government was the first time when Tongil-type variety dissemination drive was in full swing from 1973. At that time when there was only low level of agricultural mechanization, timely transplantation 2 week moving up was huge task without intensive helping hand, around 2 million people nationwide took part in the transplantation as a helping hand.

In 1970, barley in cutting and rice transplanting pan-national drive of total 6 million people gave a helping hand; government workers, public agency members, military forces, military reserve forces, students, and various social bodies also participated.

Helping hand receiving farm households (HHS) were limited to that of patriot and veteran farm HHS, protective HHS, the old and infirm HHS and women only HHS, and HHS without labor force on account of military service etc; however in 1980s with a rapid advent of agricultural work mechanization no. of participants dropped sharply with 7.7 million in 1985 as the peak, and from 1997 on government initiation turned into the agricultural agency ‘Agricultural Corporation’ on a volunteer basis.

3.1.3 Setting up Food Grain Production Boosting Situation Room

In early 1970s, expanded food grain production became government’s core task, shipshape strong administrative system nationwide was required more than anything else, metropolitan cities and provinces, cities and counties, and townships as well as Ministry of Agriculture and Fishery , RDA and NACF installed situation rooms of food grain production promotion to report or give directions through cable communication network on the progress of pressing farming tasks, weather conditions, problems and countermeasures of on-the-spot situations.

Box 4-4 | Food Production Expansion Office Setting Up in the President Office

1. Installation: Installed in April 1974 in the President’s Office (Blue house) based on the president’s directions on achieving food production self-sufficiency on December 22nd, 1972
2. Purpose: Making long and short term plans for the food production expansion and the rice consumption reduction along with the adjustment in work coordination among related government agencies as well as the identification and evaluation of the government policy dissemination among the general public
3. Committee members: Committee President - Economy Department Secretary of the President Office
   - Committee members - Minister of Agriculture, Vice-minister of Home Affairs, MAF, MHA, Administrator of RDA, Chairman of NACF, and CEO of Rural Community Corporation.
   - Temporary committee members - Vice-ministers of EPB, MOF, CM
   - Organizer - Secretary for agriculture and fishery in Blue House (Chungwdae)
4. Report: Monthly report as a part of the economic trend attended by the president

Note: MHA; Ministry of Home Affairs, EPB; Economic Planning Board, MOF; Ministry of Finance, CM; Construction Ministry

In farming season the situation room give directions to related government workers to work overtime for a long time, in vital period made on-site checking groups and sent them to affiliate agencies to check their activities and at times even rural villages and farming sites for providing technical directions or urging them.

These brisk activities with mobility and tension all related agencies pushed forward with their work according to original plans; they checked the timely acquiring farming materials, timely controlling insects and diseases, rapid and suitable countermeasures against natural calamities through administrative and financial supports. The uniform leading without villagers' autonomy evoke lots of criticisms and side effects too.

In 1973, the situation room was set up for the rice farming 150 day operation as a part of successful food grain production promotion, in 1974 for rice 30,000 thousand seoks (equivalent to 4.32 million M/T) of rice surpassing, and from 1977 on for food grain production enhancement policy.

Particularly from March 1973 on in Blue House (president's office) 'Blue House Food Grain Production Promotion Planning Office' was set up with the First economy secretary as a chairperson for food grain production boosting and consumption reduction, this office adjusted works among different work agencies; this also shows how strongly the president and the government put a stress on food grain production boosting policy.

3.1.4 Production Quota by Region

Necessary measures were taken in 1970s that the quota and the time limit were imposed on related extension agencies to promote the food production expansion.

The quotas were assigned by metropolitan city and province, by city and county, and also sometimes by government worker and by farm-household allotting pre-scheduled amount of rice production, also allocating scheduled Tongil-type variety cultivation.

Directions were given on the deadline of rice transplanting and barley harvesting. Responsible government workers must have made flat-out efforts to carry out their assigned responsibilities within time limits.

In the process of this hard drive, however, considerable local public workers, heads and subordinates, were fired or faced other disciplinary measures by reason of their difficulty in securing sufficient growing area for Tongil-type varieties, neglect in pre-checking tubular wells or water pumps, and insufficient blight and insect control, as a result, these sacrifices came as insult to injury to agricultural extension workers.

Furthermore, lots of government workers fall victims to exhausts and traffic accidents leading to dead and other job-related serious illnesses on account of their tight deadline and hard extension service work day and night.

Unforgettable are these valuable efforts and sacrifices made behind the successful Green Revolution.

Also giving president's handwritten letters to uncountable ministers, governors, mayors, county governors was one of typical ways of.

Although these compelled production allocation can be considered absurd and undemocratic from the view points of nowadays. Yet, these seemingly irrational measures were accepted smoothly by the general public under the long-cherished national goal of achieving self-sufficient staple grain production.

3.2 Awarding for High Yielding Competitions

3.2.1 Rice High Yielding Farm-Households

These awards had come into effect beginning 1973. the exceptional one hundred thousand dollar worth (government purchasing price at that time per 8M/T 1,100 dollars) awards went to all the farm-households who produced more than 6M/T per 1ha with 0.2 ha of arable land, upgrading adjustments to the level that the 6M/T for a single harvest and 5.5M/T for double harvests a year in 1974.

This awarding system, however, was forced to discontinue from 1977 on account of budget burden arising from growing number of farm-households animated by the technological development.

Those desiring high yielding awards should have submitted necessary documents to related government agencies, receiving three time survey of eye-measuring, grain number measurement, actual measurement (unit sampled area cutting).

Although they met the requirement for awarding in terms of production amount, those with test plot of less than 0.2ha, solitary plots (enclaves), not recommended varieties, salient weeds, more than 10% of diseased plants, not planting beans on the cultivable plot ridges, or excessive weeds were singled out.

Beginning in 1976 and continued 4 years to 1979 this awarding system produced many high yielding farm-households almost in any farm village also bringing on spill-over effects revolving around these farmers on conspicuous cultivating technical development.

Table 4-8 | Awards on High Yielding of Rice

Year	Score for awards			Amount of awards (thousand dollars)		
	High yielding farm households	Intensive rice farming zones	Total	For high yielding farm households	For Intensive rice farming zones	Total
1973	3,765	54	3,819	379	32	411
1974	29,418	122	29,540	2,946	52	2,998
1975	53,603	2,243	55,846	4,452	688	5,140
1976	53,808	5,490	59,298	5,472	1,652	7,124

Sources: Kim, I.H. (1978)

3.2.2 Awarding for Champion High Yielding Farmers and Intensive Production Zones

Although the awarding system had come into effect prior to 1970 for the champion farm-households, the system was upgraded to the level of national bronze decoration added to ten thousand dollar awards from 1973 for the national champions. Beginning in 1975, it was further upgraded to a silver decoration.

Continued upgrades came in 1980 to USD 20,000 and sharp uplifting to hundred thousand dollars from 1982. In 1984 champion exemplary farmer Kim Yuon-Do, Sunsan County in Gyeong-Buk province harvested 10,06 ton/ha of Samgang (name of high yielding variety) achieving brilliant world record. This amazing achievement provided him with the honorable opportunity to give his success story presentation at the 25th anniversary of the international rice crop research institute in June 1985 in Philippines. Also this award has gone to the excellent intensive rice growing zones too from 1969. On the other hand, nationwide publicity on the necessity of winter season farmer agricultural technology training encouraged by the consecutive rice high yielding success stories.

Table 4-9 | Records of High Yielding Rice Champions

Year	Names	Region	Varieties	Yield (t/ha)
1973	Cho, Hwan-Gu	Chungnam Seocheon	Tongil	7.808
1974	Song, Young-Sik	Chungbuk Youngdong	Tongil	8.028
1975	Seo, Kang-Won	Kyeonggi Anseong	Tongil	8.067
1976	Yang, Hae-Seop	Chunbuk Kimje	Yushin	8.452
1977	Lee, Kwan-Seok	Kyeonggi Yicheon	Milyang23	8.980
1978	Lee, Il-Saeng	Kyeongbuk Yeongil	Raekyeong	9.090
1984	Kim, Yeon-Do	Kyeongbuk Sunsan	Samgang	10.060

Sources: Korea's Agricultural History 40 Years (1989),

3.2.3 Awarding Agencies of Merits

It was meaningful to give awards to agencies and individual government workers by region, those deserving their credits in performing outstanding work in the grain production expansion, to encourage all related workers.

The president (or prime minister in person) gave the presidential awards along with nationally-honored phoenix flags to the champion provinces from 1973.

At that time 'the phoenix flags' were much envious to the governors, naturally which led them to all out efforts and finally even resulting in excessive competitions at times. As a result, affluent awards were given to related government workers and other related agency personnel.

Chapter 5

Achievements and Impacts of the Green Revolution

Achievements and Impacts of the Green Revolution

1. Achievements of Green Revolution

1.1 Self-Sufficiency in Rice

Korea produced only about 20 million seoks (2.7~3.4 million tons) of rice during the 10 years after 1960. However, more than 30 million seoks (about 4.3 million tons) was produced yearly since 1974 when the new Tongil-type rice varieties were planted in more than 15% of the total paddy land and, just three years later, when the new varieties had been expanded to 660 thousand hectares. The national average of milled rice yield in the farmer's field dramatically increased to 4.93 MT/ha in 1977 as compared with japonica varieties yielding 3.37~4.69 MT/ha of milled rice. Total rice production reached 4.67 million MT in 1976 which was the first self-sufficiency of rice in Korea, and 6.01 million MT in 1977 which was the first time to exceed 5 million MT of rice production in the history, resulting in a significant achievement for the Green Revolution in Korea.

Table 5-1 | Average Yield and Total Production of Tongil-Type Rice Varieties

Year	Cultivation area		Yield (MT/ha)				Total production		Self-Sufficiency of rice (%)
	Total (1,000ha)	Tongil-type varieties (%)	National average	Tongil- type varieties (T)	Japonica varieties (J)	Comparison (T/J, %)	Amount (1,000M/T)	Ratio of Tongil- type varieties (%)	
1970	1,203	-	3.30	-	3,30	-	3,939	-	93.1
1974	1,204	15.2	3.71	4.73	3.53	134	4,445	19.4	90.8
1975	1,218	22.9	3.86	5.03	3.51	143	4,669	29.8	94.6
1976	1,215	44.6	4.33	4.79	3.96	121	5,215	49.3	100.5
1977	1,230	54.6	4.94	5.53	4.23	130.7	6,006	61.2	108.6
1978	1,230	76.2	4.74	4.86	4.35	111.7	5,797	78.1	103.8

1.2 Increase in Farm Household's Income

The Green Revolution was able to achieve not only rice self-sufficiency in Korea but increased farm household's income. Before 1973, the farm household income was lower than that of the urban worker's household but after achieving production of 30 million seoks (equivalent to 4.32 million M/T) of rice in 1974, the farmer's income surpassed the urban laborer's income due to the high contribution of the rapidly expanded area of the new rice varieties. In line with the increase of rice production by means of expanded cultivation of newly developed varieties, the volume of governmental purchases of rice has continuously expanded to a level capable of a steady growth of farmers' earnings along with stimulation of farmers' incentive for increased production.

Table 5-2 | Comparison between the Income of Farm Household and Urban Worker's Income

(Unit: won)

Year	Farm Household Encome (A)	Urban Worker's Income (B)	A/B (%)
1970	255,804	381,240	67.1
1971	356,382	451,920	78.9
1972	429,394	517,440	83.0
1973	480,711	550,200	87.4
1974	674,451	644,500	104.7
1975	872,933	859,320	101.6
1976	1,156,254	1,151,760	100.4

Source: Kim, I.H (1978)

2. Impacts of Green Revolution

2.1 Innovation of Farm Technologies and Changes in Farming Features

The expansion of the seed bed technologies brought a number of alternative benefits such as more production due to early transplanting and harvest, the possibility of planting barley in paddy fields after the rice harvest, reducing labor competition during the busy seasons, the careful treatment of rice plants and an expansion of the barley planted area. The earliness of the new rice varieties also enabled the vegetable cultivation in areas near the cities, which contributed greatly to farm management improvement. The group farming in rice cultivation was the momentum for the cooperative production of foundation of joint utilization of farm machinery as well as joint purchase of farm materials and joint marketing of farm products. It played a core role in rural community development by making cooperation possible in every detail of farming.

Figure 5-1 | Changes in Yield Potential of Korean Improved Rice Cultivars, Japonica (●) and Tongil-Type (○), during 1958~1989

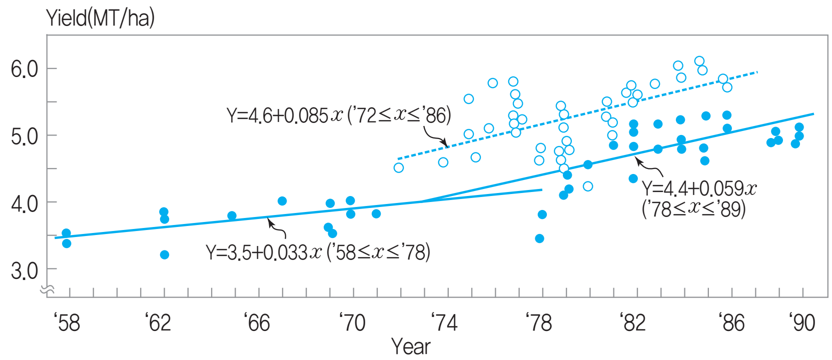


Table 5-3 | Alteration of Farming Period due to Early Transplanting and Harvest of Tongil-type Varieties

Farming procedure	Before Green Revolution	After Green Revolution	Saved days
Rice seeding	May 1	April 10	21
Rice transplanting	June 19	May 20	20
Rice harvesting	Oct. 21	Oct. 8	13
Barley seeding	Oct. 28	Oct. 18	10

2.2 Contribution to National Economic Growth

Rice self-sufficiency has played a great role not only in stabilizing food supplies in Korea but also saving foreign exchange in and contributing to economic growth and strengthening national power enabling confident and active implementation of national policies and creating hope for the future.

Table 5-4 | Economical Effect of Expansion of Rice Production After Spread of the Tongil-type Rice Varieties to Farmers

(Unit: million Korean won, constant value by 1989)

Year	Cultivation area (%)		Value added by yield increase[1)]	Social benefit by expansion of rice production	
	Japonica varieties	Tongil-type varieties		Increased social income[2)]	foreign currency savings[3)]
1973	89.4	10.6	161,368	38,267	42,859
1974	84.8	15.2	261,928	94,981	106,378
1975	77.1	22.9	645,837	85,932	96,244
1976	54.5	45.5	764,543	374,337	419,257
1977	45.4	54.6	1,389,170	724,309	811,226
1978	23.8	76.2	1,130,447	744,302	833,618
1979	39.2	60.8	922,438	483,903	541,971
1980	50.5	49.5	-934,242	-467,681	-523,803
1981	73.5	26.5	458,529	264,406	296,135
1982	67.1	32.9	606,920	292,900	328,048
1983	65.7	34.3	628,266	309,969	347,165
1984	70.0	30.0	853,155	465,668	521,548
1985	72.2	27.8	714,984	382,223	428,090
1986	77.9	22.1	689,389	447,317	500,995
1987	80.4	19.6	414,596	267,821	299,960
1988	82.1	17.9	921,079	607,459	680,355
1989	85.5	14.5	740,362	530,236	593,865

Source: Suh, D. K.(1992)

Note: 1) Value added by yield increase = amount of production expansion × unit price
2) Social benefit: producer's surplus value + consumer's surplus value
3) Foreign currency savings: foreign currency needed to import the shortage when there occurred no expansion in rice production

2.3 Increase in Farm Househlod's Saving

The increase of farm household income due to the expanded cultivation of the new rice varieties played the role not only of increasing farm assets, but also of raising the living quality in rural regions. The increase of farm household income allowed the farmers to lessen the debts and to make funds for re-investment to agriculture.

2.4 Changes in Food Grain Policy

Increasing rice production resulted in a change in the rice consumption pattern in Korea. Previously a rice saving policies prevailed: use of 70% polished rice for cooking, cooking rice mixed with other grains, and prohibition of using rice for brewing, etc. These policies are now obsolete and a rice consumption promotion program has been undertaken.

Chapter 6

Implications

Implications

1. Factors Contributing to Accelerating the Green Revolution in Korea

1.1 Development of High-Yielding Rice Varieties

Through breeding a new variety by using a strategy involving a 3-way cross of Indica and Japonica types, which had long been ignored as being of little practical value, a miraculously high-yielding variety, "Tongil" has been developed. Since then, several new "Tongil-type varieties" possessing better characteristics, have been continuously developed. The rapid disseminations of the newly developed varieties and improved cultural practices to the farmers were the core factors to the Korean Green Revolution.

1.2 Efficient Breeding System

The success of varietal improvement relies heavily on the efficiency of the breeding systems for testing and selection of breeding materials. In 1970s the research institutes covering all the country were set up under RDA in Korea and functioned well to development of the new rice varieties.

1.3 International Cooperation

In close collaboration with the university and IRRI, RDA was able to make use of their talent, facilities and technical information in the process of breeding new varieties. Formation of such a cooperative system has laid a strong foundation on which agricultural technology can be continuously developed. In order to distribute the newly hybridized varieties to farmers as soon as possible, segregation materials were shipped to the Philippines for multiplication during the winter season. The seeds multiplied were immediately flown back to Korea early the next year. By doing so, extensive dissemination of the new variety became shortened by one year, but rice self-sufficiency was able to be realized earlier than expected.

Table 6-1 | Major International Cooperation with IRRI

Year	Technical exchange		Seed multiplication		
	Training&internship	Invitation of experts	Selection of winter crossing material	Segregation material	New varieties
1962~1968	16	12	1,329	57	242 (1974~1977)
1969~1976	70	51	28,215		

1.4 An exclusive Extension Service

1.4.1 Winter Farm Training

Technical farm training was widely conducted so that farmers would be able to obtain the technologies for high yield by through understandings of the special traits of the new Tongil-type varieties. Since 1971, when the pilot planting was begun, a series of intensive technical farm training sessions were conducted during the winter season for three months from December to March of the following year not only for those farmers who planted the newly developed varieties but also for those who had not yet attempted to grow them.

1.4.2 Farm Training by Mass Media

Farm technical training by means of radio and TV services has been very active and most effective thanks to the cooperation of the radio and TV stations providing time for farm programs.

1.4.3 Accountable Field Guidance

Field guidance agents persuading farmers to grow the new varieties risked severe criticism when the farmers experienced even a slight crop failure with the new varieties. Therefore, in order to reduce chances of crop failure, they were fully occupied with unceasing field guidance from seedbed preparation through harvest, and even assisted with marketing, as if the farms were their own. It was not unusual for all the research and guidance agents serving across the nation to be unable to enjoy their rightful summer vacation or even Sunday off due to their extraordinarily overwhelming workload. The Green Revolution is to a great degree ascribable to their noble sacrifice.

1.4.4 Distribution of Agricultural Information

On each Saturday, a special radio program was issued on the following week's weather forecast, including an outline of the week's farm work and other farm information so that farmers could prepare for the farm works. Information on plant diseases and insect pests was also broadcasted every Friday from March to September.

1.5 Importance of Leader's Role and Administrative Support

1.5.1 National Leadership

The former President, Park emphasized the achievement of food self-sufficiency through varietal improvement for three years from 1970 to 1972. Also, he expected endless efforts from research and extension workers for the development of new varieties and dissemination of new technologies to farmers. He said: "At first, increase in food production! We import a great deal of food at present time, but we must reduce food import by increasing food production. At least we should achieve self-sufficiency in rice (in the New Year's press conference, 1974)." He showed great concern and gave strong support to achieve the self-sufficiency in rice through the development of new rice varieties and immediate dissemination of them to farmers.

1.5.2 Governmental Strong Recommendation and Administrative Support

a. Governmental Purchasing Policy

The most influential factor was the systematic and unwavering support of the government. Among the governmental measures the most powerful factor was the government's rice purchase policy. The government induced growers to adopt Tongil-type varieties by setting the government' purchasing prices higher than market prices. Beginning in the early 1970s, the government substantially raised the government price for rice every year. Under the government purchase program, real prices rose 5.7% annually between 1969 and 1979. In line with increases of rice production the volume of government purchases of rice has continuously expanded to a capable level of accommodating as much as farmers wish to sell.

b. Governmental Strong Recommendation

It was known that the rapid adoption of Tongil variety was enhanced by the government's strong recommendation. To enhance the adoption of new rice varieties a target level of adoption was assigned to local government officials as well as each extension worker in the provinces. Sometimes the adoption of Tongil variety was tied to the officials' and extension workers' ability to get promoted.

c. Supply of Agricultural Inputs

The administrative support of timely supply of the inputs required for rice production. Increases in rice production could not have been obtained except for the timely and sufficient supply of fertilizers, agricultural chemicals, vinyl film, and other materials for seedbeds.

d. Awarding Prize to High Yielding Farms

The award prize system was introduced in 1973 as an incentive to stimulate the adoption and to increase the productivity of Tongil-type variety. The award was given to all growers whose yields were over 6 tons/ha as milled rice. In addition, another award was given to the joint rice cultivation districts whose average yields were the highest in the country. This incentive system has succeeded in encouraging farmers to grow Tongil and later, Tongil-type varieties.

2. Lessons of Green Revolution

2.1 Systematic and Unwavering Support of the Government was the Most Influential Factor

Among the factors contributing to the Green Revolution in Korea, the most influential factor was the systematic and unwavering support of the government. In particular, the interest of President Park in self-sufficiency in rice is known as influenced greatly to the achievement of Green Revolution in Korea.

2.2 Financing on Construction of Agricultural Infrastructures

From the end of the 1960s to the early 1970s, the industrial development of a few areas on which the government concentrated available financial resources began to lead the industries in other sectors. The agricultural sector was awakened and funded substantially for construction of agricultural infra-structure like as agricultural water resources, irrigation systems, land reclamation, and consolidation of farmland to build the basis for improvement of agricultural productivity. The governmental policies to supply appropriately of agricultural inputs such as chemical fertilizers and agrochemicals for crop protection from disease and insect pests contributed greatly to the achievement of self-sufficiency in rice.

2.3 Foundation of Rural Development Administration

The Rural Development Administration (RDA) was founded in 1962 for implementation of agricultural policies on development and dissemination of new agricultural technologies. The fact that RDA had both functions of managing agricultural research works and extension services under one umbrella could make it possible to disseminate the newly developed technologies very quickly and efficiently from the research institutes to farmers and to accept the feedback from the extension services to the related institute, and to brought the Green Revolution earlier than expected.

3. Adaptability of the Korea's Experience in Green Revolution to Developing Countries

The agricultural policies and experiences in achieving the Green Revolution in Korea are surely helpful to the developing countries still suffering from the food shortages in Africa and Asia. Our agricultural system will be rather well applicable to those countries that have small-scaled agricultural systems. The Experiences and knowledge obtained from the innovation of agricultural technology in Korea will be a good model for the developing countries in the world.

3.1 Principles of Strategic Approach

Financial resource is also an important factor for the innovation of agriculture as same in other industrial sectors. There can be two models for the developing countries to achieve the agricultural innovation and solve the food shortage problem through expansion of food production. The country that has some capability to invest in agricultural sectors is able to build the basis for innovation of agricultural productivity within a short period. Meanwhile, the country that has no financial resources except agricultural sectors would maximize the financial resources by the mobilization of domestic resource and aids from abroad, and concentrate the resources on some targeted areas within agricultural sectors at first. The targeted areas would be developed and have the competitiveness gradually by implementation of technology enhancement and financial supports. With the successful performance in the targeted areas, advanced technologies and available funds can be shared with the food security areas.

In either case of the two models, governmental investment on agricultural sector with national leader's firm conviction, building the basis of infrastructures for agricultural production, organization with an efficient operation system for development of new technologies and spread of them rapidly to farm, and the close cooperation system with the related institutions of home and abroad are needed for the successful achievement of Green Revolution through the expansion of food production. But most of all, farmer's consciousness and national consensus would be prerequisite for achievement of the Green Revolution.

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Appendix: Saemaul Undong in Korea

○ What is Saemaul Undong Movement?

Basically, Saemaul Undong Movement is a movement seeking community development and modernization. Of all things, it is a movement to escape from poverty. This ideal is not limited to individual lifestyles and living conditions, but encompasses the whole community. It means not working for only myself, but for my village and for my country; not depending upon somebody else for help nor dreaming of a lucky fortune, but doing things with our own hands in the right ways. It cannot be done alone. We must stand together and help each other to move forward. Our village is a community where we work and live, and that is why we should develop it together, hand-in-hand. It is also a fight against old and deep pessimistic views such as ‘poverty is our fate’ or ‘it is impossible.’ It is a movement of getting over our pessimism, a movement of mental reformation.

○ Goals of Saemaul Undong

- Develop a modern, comfortable and convenient social community.
- Establish companies that workers can be proud of and where sustained growth is achieved in a cooperative and trusting working environment.
- Develop and maintain sound and healthy society whose members are able to enjoy pleasant and intimate relationships.
- Build a continuously improving nation that we can be proud of.

○ Saemaul Undong’s Guiding Spirit

- Diligence: The realization of efforts to make the most of what is available. This entails the development of the society
- Self-help: The will to independently define one’s fate based on personal efforts, setting the basis of self- control and independence
- Cooperation: The realization of self expansion that guarantees higher efficiency and development

○ Five Steps of Saemaul Undong Movement

Step 1: Basic Arrangements

Three arrangements for the start: People, Seed Money, Basic Principles

Forming a Core Group 1: Leaders

Forming a Core Group 2: Cooperative working

Forming a Core Group 3: Applying existing organization

Forming a Core Group 4: Sectional organizations

Raising Seed Money 1: Through sample cooperative project

Raising Seed Money 2: By cooperative work

Step 2: Operation of Projects

Principles and standards for selecting project

Planning a project

Persuading villagers 1 - Set a model to villagers

Persuading villagers 2 - 'You can do it.' Present results

Collecting consensus 1- Small group meetings

Collecting consensus 2- General meeting of villagers

Let everybody play a part

Prepare and manage public property

Preparing center

Encouraging each other

We are one living creature. Let blood circulate

Getting assistance from outside

Step 3: Main Stage of Project

Project 1 for living environment improvement: Eliminate inconveniences of the houses

Project 2 for living environment improvement: Eliminate inconveniences of the village

Project 3 for living environment improvement: Create an environment needed for income increase Project 1 for income increase: Remove the obstacles

Project 2 for income increase: Launce cooperative projects

Project 3 for income increase: Commercialize things around you

Project 4 for income increase: Introduce something new

Project 5 for income increase: Modify distributive construction

Project 6 for income increase: Operating factory

Consolidating community 1: Revise good morals and manners and extirpate evil practices

Consolidating community 2: Providing culture center and facilities

Consolidating community 3: Residents' credit union movement

Step 4: Final Stage of Project

Share results and celebrate success

Share long - term prospects

Stabilization of joint funds

Active sectional organizations

Regularizing meetings for technology research

Establishing village hall

Publishing local newspaper

Establishing partnership with other regions and government offices

Setting up sisterhood relationship with foreign countries

Step 5: Feedback at National Level

Creation of a favorable environment by the Korean government

Provision of supplies and funds by the Korean government

Comprehensive government support system

Intensive information and technology education - Saemaul Training Center

Development by Stage

Stage	Priority Projects	Characteristics	GNP per capita
Foundation &Groundwork (1970~73)	Improve Living Environments: expand roads inside villages, construct laundry facilities, improve roofs Increase Income: expand agricultural roads, improve farmland and seeds, divide labor Attitude Reform: diligence, frugality, cooperative atmosphere	Launching and igniting the campaign Government-initiated activities Top priority on improving living environment	257 in 1970 375 in 1973
Proliferation (1974~76)	Increasing Income: straighten rice field ridges, consolidate creeks, encourage combined farming, operate common working places, identify non-agricultural income sources Attitude Reform: Saemaul education and public relation activities Improve Living Conditions: housing, water supply	Expanding program scope and functions Increasing income and changing attitudes Earning national understanding and consensus	402 in 1974 765 in 1976
Energetic Implementation (1977~79)	Rural Areas: modern housing, special purpose plant Urban Areas: paving alleys, cleaning Corporations and Factories: higher productivity, material conservation, sound labor management	Larger units of implementation by developing Linkages among villages in the same region Economies of scale Appearance of distinct unit characteristics	966 in 1977 1,394 in 1976
Overhaul (1980~89)	Promote Cooperative Social Atmosphere: kindness, order, selflessness, cooperation Economic Development: combined farming, distribution improvement, credit union activities Improve Living Environment: clean roads, develop parks, build better access roads	Reborn as a private sector-organization Dividing the role between government and Private sectors Escape from inactivity and contraction	1,507 in 1980 4,934 in 1989
Autonomous Growth (1990~98)	Sound Atmosphere: develop traditional cultures, emphasize hard work and sound lifestyles, recover moral ethics Economic Stability: economic recovery, urban-rural direct trade, diligence, frugality Improve Living Environment: cultivating better community environment, emphasizing autonomous living	Reinforcing the basis of autonomy and self-reliance Meeting the need for liberalization and localization Efforts to overcome economic crisis	5,503 in 1990 10,548 in 1996
Second Phase Saemaul Undong (1998~2006)	Mental Reform: build morals and a sense of citizenship Improve Living Environment: revive the rural economy, protect living environment Social Security: help poor neighbors	Promote morals and achieve spiritual reform Build a warm community International Cooperation Business	15,830 in 2005

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