RESEARCH INTEREST

GREEN REVOLUTION IN THE 1970s IN KOREA: FROM INTRODUCTION TO DISAPPEARANCE OF HIGH-YIELDING RICE VARIETY (*TONG-IL*)

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Abstract

Tong-il, a high-yielding rice variety developed in Korea in the 1960s, was widely recognized as successful innovation and was credited with bringing self-sufficiency in rice to Korea in the 1970s. The development of *Tong-il* rice was also selected as one of the most important scientific achievements in the 20th century in Korea. Despite the prominence and socio-economic implications of *Tong-il* rice to other less-developed countries, its history has not been known. Hence, the history of *Tong-il* may have lessons for considering the local development and adoption of new agricultural technologies in less-developed countries. This paper deals with a brief history of *Tong-il* rice from development to disappearance.

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I. Introduction

The "Green Revolution" usually refers to the development and adoption of modern or high-yielding crop varieties in the 1960s and 1970s (Evenson and Gollin). The revolution in rice production in Asia was triggered in 1966 with the development of IR8 by the International Rice Research Institute (IRRI). IR8 was one of the famous semi-dwarf rice varieties and was the first high-yielding tropical rice variety developed and released by IRRI. As soon as the potential of IR8 was recognized, IR8 was widely distributed throughout Asian rice-producing countries. According to IRRI, with the adoption of new varieties, average rice yields in South and Southeast Asia in 1995-97 were 95 percent higher than in 1964-66, the three years before the introduction of the first modern varieties (IRRI).

In the Philippines, rice yields in irrigated areas increased from 1.97 ton/ha in 1970 to 2.54 ton/ha in 1980 because of new varieties (Estudillo and Otsuka). The area of new varieties had increased to 50 percent of all rice fields by 1970 and the Philippines became self-sufficient in rice in 1968 and 1969 (Chandler). India also adopted IR8 and planted it on 2.7 million ha by 1968-69 (Chandler). In China, a hybrid rice F_1 was released in 1976 and the yields of the hybrid varieties were 15 percent higher with the same inputs than the yields of conventional rice (Lin). Thailand also released high-yielding varieties, developed by crossing IR8 with tall Thai rice cultivars, in the late 1960s (IRRI).

Research on high-yielding rice varieties in Korea was also based on a small set of experimental materials received from IRRI in 1966 (IRRI). In 1968, Korea succeeded in developing a high-yielding rice variety, later called '*Tong-il*,'and spread to rice growers in 1972. As a result, Korea attained self-sufficiency in rice in 1976.

So far, *Tong-il* was widely recognized as successful innovation and was credited with bringing self-sufficiency in rice to Korea in the 1970s. The development of *Tong-il* rice was also selected as one of the most important scientific achievements in the 20th century in Korea (Chosun Ilbo, December 31, 1999). Despite the prominence and socio-economic implications of *Tong-il* rice to other less-developed countries, its history has not been known. Hence,

the history of *Tong-il* may have lessons for considering the local development and adoption of new agricultural technologies in less-developed countries. This paper deals with a brief history of *Tong-il* rice from development to disappearance.

II. History of *Tong-il* Rice

Before the green revolution, Korea often experienced food shortages in its long history. Until the 1970s, there was a word used to describe a serious food shortage "Bori Gogae", which literally means "a pass of barley", indicating that barley was used as a bridge between periods when rice was available. This term was used to designate a specific time (usually May and June) when the previous year's rice harvest had been eaten but the barley planted in the winter had not ripened yet. This two-to-three month period was the hardest time of the year for most poor people. Thus, it was in the national interest to help all people successfully passed through the period of "Bori Gogae". One of the strategies employed to increase domestic production was to develop high-yielding varieties.

Tong-il was developed, introduced and adopted as a part of a government policy of rice for self-sufficiency that was presented as a solution to food security for Korea. National food security was thought of as a kind of public good and self-sufficiency in rice was considered a self-evident means to that end. It is a common phenomenon in less-developed countries that local agricultural R&D and extension of new varieties or other technologies are considered part of food security policy.

1. The Early History of *Tong-il* Rice (Before 1980)

The first attempt to develop a high-yielding rice variety in Korea was made in 1965. Based on new seeds imported from Egypt in 1964, field tests were carried out in several areas in 1965. Though the field tests failed in most

areas, one test done in the Suwon region was a success. The yields of the test variety were 30 percent higher than the yields of conventional varieties. This variety was known as "miracle rice" and was distributed to rice growers in 1967. However, the result was a failure. Some growers could not even get seed for the next year from their crops. In the fall of 1967, researchers concluded that this variety was not appropriate for the Korean environment (JoongAng Ilbo, September 11, 1997).

Research on new varieties suitable for the Korean environment had been conducted by the Rural Development Administration (RDA). In October of 1968, new possibly high-yielding varieties were found among the lines of IR 667, which was itself a derivative of IR8. IR667 was developed by crossing IR8 (from IRRI) and IR568, which was a cross variety of Yukara (a Japanese variety) and Taichung Native 1 (an Indian variety) (Kim, p.37).[1] From IR667, seven types that were proven to have good crop features were selected: Suwon 213, 213-1, 214, 215, 216, 217 and 218. Tong-il was the name used for Suwon 213, 213-1 and 214 in 1971 (Kim, p. 43) (for a brief history of *Tong-il*, see Table 1).[2]

The yields of the newly-found varieties were 30 percent higher than those of the highest yielding conventional varieties. However, only 12 kg of *Tong-il* rice were harvested at experimental stations in 1969, not enough to carry out the following year's nation-wide field tests. RDA decided to grow *Tong-il* at IRRI during the winter and sent 4 kg of *Tong-il* seeds to IRRI in October of 1969 with some researchers. The 4 kg of *Tong-il* seeds returned as 600 kg in April of 1970. In 1970, 10 kg of *Tong-il* seeds were sent again to IRRI and returned as 4.3 tons in the spring of 1971. Based on the field tests performed from 1969 to 1971, RDA decided to supply *Tong-il* seeds to farmers in 1972, and *Tong-il* rice was planted again at IRRI in the fall of 1971. RDA got 17,000 tons from IRRI in April of 1972. The seeds shipped from IRRI were supplied to growers and planted in June of 1972. The over-

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[1] In the early stage of the development of *Tong-il*, Professor Heu of the Seoul National University contributed considerably, in cooperation with IRRI.

[2] Though dozens of new varieties were developed in order to improve the shortcomings of the original *Tong-il* variety, all varieties derived from IR667 were called *Tong-il* type rice or just *Tong-il* in brief. From now on, '*Tong-il*' is designated to mean all *Tong-il* type rice in this context.

seas planting of *Tong-il* seeds greatly contributed to shortening the time from development to adoption.

TABLE 1. Timeline of the Development, Adoption and Disappearance of *Tong-il*

Year	Main Events
1966	IR8 was distributed by IRRI.
1968	IR667 was developed by RDA.
1969	A new policy raised the price of rice purchased by the government.
1970	A dual price system was introduced under which the government bought at a high price and sold at a lower price. A new law changed the funding for rice purchase.
1971	IR667 began to be adopted and was named *Tong-il*.
1972	The consent of the National Assembly for the procurement rice price and quantities was abolished.
1976	Korea became self-sufficient in rice.
1977	Maximum yield of 5.5 tons/ha was produced
1978	The area for *Tong-il* reached the maximum, which accounted for 75.5 percent of total rice area. Rice blast disease broke out.
1980	A record bad harvest took place because of blast disease and cool weather. President Park was assassinated.
1981	Over 2 million tons of grain were imported. The cultivated area of *Tong-il* fell by 50 percent, compared with the previous year.
1983	The procurement price was frozen at the level of the previous year.
1984	Some costs of the rice procurement program were compensated for from the government general budget.
1987	The consent of the National Assembly on approving the government purchase price was resumed.
1989	*Tong-il* was purchased by the government separately from conventional varieties at a lower price
1992	The government purchase program for *Tong-il* was terminated and *Tong-il* completely disappeared.

Note: Data and descriptions from several sources were summarized and arranged by the author.

The discovery of new high-yielding varieties was reported to Korean President Park by the RDA Administrator on December 31, 1968. The Administrator briefed him about the new variety and asked for financial support for facilities necessary to expedite rice breeding. On the spot, the President promised to allocate 100 million won (about $300,000) and told his aides to reflect the rest of the RDA request in the next year's budget. Because of the interest of the President, three big greenhouses and one growth cabinet facility were constructed in 1969 and 1970, respectively. The President attended the ceremony for the completion of the growth cabinet facility (Kim, pp. 31-36).

The interest of President Park in self-sufficiency in rice was extraordinary. He expressed his desire for self-sufficiency and mentioned *Tong-il* whenever he had the opportunity. President Park's interest was shown in every New Year's press conference held between 1970 and 1974, as demonstrated by the following excerpts. In the 1970 press conference, he stated:

> "RDA has performed research on high-yielding rice varieties and recently succeeded in developing a new high-yielding variety, called IR 667. The yield of the new variety is said to be 50 percent higher than the yield of conventional varieties. I hope that this variety will be adopted by growers as soon as possible. However, it will take several years for the variety to be spread to all rice growers even if we repeat the process that the government purchases all rice of the new variety harvested and releases them to growers every year. By 1976, I think self-sufficiency of rice will be possible if the variety is adopted by all rice growers, combined with development of new water sources, sufficient supply of chemicals and fertilizers, mechanization, and paddy land readjustment. Though some may have a doubt about the success of this new variety because we failed in the past, I believe this time our try will succeed"(Kim, pp. 45-46).[3]

One famous anecdote was a *Tong-il* rice tasting held on February 5, 1971, immediately after a ministerial meeting. The RDA Administrator asked all participants to rate *Tong-il* in terms of color, stickiness, and taste, but not to write their names on the taste sheet. After tasting *Tong-il* rice, President

[3] All translations from Korean to English were prepared by the author.

Park rated it "good" for color, "moderate" for stickiness, and "good" for taste. He also wrote down his name on the taste sheet, for others to see his interest and support for *Tong-il* rice. He was the only person who wrote down his name(Kim, pp. 48-49; JoongAng Ilbo, September 11, 1997). In contrast, the responses of other people were somewhat different from the response of President Park. Unlike the President, the majority of participants checked "moderate" for all three categories (69%, 46%, and 67% for color, stickiness, and taste, respectively)(Kim, p. 49).

On June 1, 1971, a Farming Day event was held in the Chungchong province. It was the first day that *Tong-il* was planted on farms. President Park participated in the event and planted *Tong-il* rice together with farmers. Beginning in 1971, Farming Day was coincidentally moved from June 10 to June 1, to accommodate *Tong-il*'s longer growing period.

In the spring of 1971, *Tong-il* rice was distributed to the Joint Rice Cultivation Districts to conduct field tests at the farm level. The Joint Rice Cultivation Districts were established in 1968, in order to reduce production costs and enhance efficiency by making farmers work together. The paddy fields of the districts were well-irrigated and had good quality, compared to other fields. Each district was composed of 15-20 growers and the total area was 5 ha per district. In 1971, 550 districts were selected as a leading farmers' group. The number of districts increased to 48,034 in 1972 (Kim, p. 188).[4] At least one extension worker was assigned to each district and all members, including leaders of the district, were educated by the RDA extension service about *Tong-il* rice. Priority for extension and financial services, in addition to fertilizers and chemicals, was granted to these districts. After harvest, the quotas for government purchase were given to these priority districts (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 77(5), 1971; Vol. 82(2), 1972).

Average yield of the 1971 crop in the 550 Joint Rice Cultivation Districts was 5.0 tons/ha (milled basis) and the highest yield was 7.13 tons/ha (milled basis). Considering that the average yield of conventional rice was

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[4] The trend of the number of the Joint Rice Cultivation Districts is as follows: 550 in 1971, 22,945 in 1972, 20,778 in 1973, 29,224 in 1974, 32,446 in 1975, 51,396 in 1976, and 48,034 in 1977.

3.37 tons/ha in 1971, the 1971 crop of *Tong-il* rice was a great success. In the spring of 1972, the RDA temporarily employed 1,870 new extension workers with the approval of the President. Given that the total number of RDA extension workers was 2,877 in 1971, this increase was substantial. These new extension workers were employed solely to promote the adoption of *Tong-il* rice. Their primary tasks were to visit and persuade growers, to monitor the growing situation of *Tong-il* rice, and to report any diseases and insects observed in *Tong-il* fields to RDA headquarters. They were switched to permanent employees in 1977.

With great expectations, farmers began to plant *Tong-il* widely in 1972. Unfortunately, in many areas, the 1972 crop was very poor because of unfavorable weather. This included a prolonged rainy season, flooding, low temperatures, and high winds. Farmers complained that the crops were much poorer because it was *Tong-il* and asked the government to compensate for their losses. The government paid 150 million won (US$376,000) in compensation (Kim, pp. 92-102). In November, the Ministry of Agriculture and Fishery (MAF) held a meeting with the directors of the agricultural departments in local governments, to hear their opinions. At this meeting, most of the directors were opposed to expanding the adoption of *Tong-il* rice in the coming year. In December of 1972, the MAF finally announced that nobody could recommend a specific variety to farmers and that anyone who recommended a specific variety would be punished without exception, irrespective of their ranks in the government. In addition, the MAF stressed giving farmers a choice on which rice varieties to grow(Kim, p. 105).

This situation, however, was reversed in late December 1972, after President Park gave a special order. In his order, he emphasized the achievement of self-sufficiency in the shortest possible time through an increase in production and a decrease in consumption. A task force was organized under the President in April, 1973. The Minister of MAF was responsible for reporting the crop progress to the President every month at the ministerial meeting (Kim, p. 109). Despite the special order of the President, the 1973 area of *Tong-il* decreased from 187,471 ha to 121,179 ha (Kim, p. 113). However, producers had good crops of *Tong-il* in the fall with average yields of *Tong-il* at 4.81 tons/ha. This yield was 37 percent (equivalent to 1.31 tons/ha) higher than the yields of conventional rice. In 1973, *Tong-il* spread rapidly among

producers. The adoption rate of *Tong-il* was so fast that the total area producing *Tong-il* expanded from 180,900 ha in 1974 to 929,004 ha in 1978. This area accounted for 15.2 percent, and 75.5 percent, respectively, of the total rice cultivated area.

Several factors contributed to the rapid spread of *Tong-il*. The most influential factor was the systematic and unwavering support of the Korean government. Among the most powerful factors was the role of the government's purchase policy. In the 1970s, the government expanded the government 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 *Tong-il* was developed, the actual quantity purchased from growers by the government was almost always below the planned quotas because the government prices were below market prices (Kim, p. 136). To fill the quota, local government officials had to persuade producers to sell rice to the government.

This situation changed in 1974 when the area of *Tong-il* rice expanded dramatically. From 1974, farmers asked the government to increase the quantity purchased by the government because market prices were below the government prices. After 1972, when *Tong-il* was introduced, the majority of rice quotas were filled with *Tong-il*. The share of government purchases of non-*Tong-il* rice was below 10 percent of non-*Tong-il* in most periods. This trend continued until 1988. After 1988, the government began to decrease the purchase of *Tong-il* rice substantially, while it increased the purchase of non-*Tong-il* rice.

As noted the Korean government induced growers to adopt *Tong-il* by setting the government prices higher than market prices. The policy set the price for lower-quality (*Tong-il*) rice at the same price as higher-quality (*conventional*) rice. Beginning in the early 1970s, the government substantially raised the government price for rice every year. Under the government pur-

chase program, real rice prices (i.e. deflated by the consumer price index (CPI)) rose 5.7 percent annually between 1969 and 1979. Compared to the annual growth rate of real prices of 2.4 percent between 1980 and 1990, and -1.1 percent 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 conventional varieties.

Another important factor that affected the rapid adoption of *Tong-il* was the government's strong recommendation. To enhance the adoption rate, a target level of adoption was assigned to local government officials as well as each extension worker in the provinces. However, some farmers did not favor *Tong-il*. Some producers insisted on continuing to plant conventional varieties because of the low quality of *Tong-il*. To persuade them, local government officials and extension workers confronted farmers who were not willing to switch from conventional varieties to *Tong-il*. While the assignment was, in theory, merely a strong advisement to officials and extension workers, there was a penalty for failing to persuade farmers to adopt *Tong-il*. The adoption of *Tong-il* was tied to the officials' and extension workers' ability to get promoted. It was not uncommon to see farmers and officials have disputes in the field over rice varieties. In some extreme cases, officials and extension workers took away other varieties of seeds, trampled on paddy fields, or physically removed other varieties from the field that had already been planted (Kyungnam Domin Ilbo, December 31, 2003). With strong "persuasion" from the government, *Tong-il* was planted in 75.5 percent of all rice cultivated area by 1978 (MAF).

The Korean government also provided several kinds of support to growers of *Tong-il*, including exclusive extension services, non-farm labor and financial support. Growers who adopted *Tong-il* received intensive service from the RDA extension service from planting to harvest. Any diseases, insects, or unusual growth of *Tong-il* rice that were observed in Tong-il fields, were immediately reported to RDA headquarters. The RDA dispatched specialists to the areas in question to find causes and solutions. During the peak season of planting and harvesting, government officials, soldiers, and students were sent to rice fields to assist farmers. In 1975, about four million officials, soldiers, and students helped producers plant rice (National Assembly Committee on Agriculture and Forestry, *Minutes*, vol. 93(2), 1975). This number was approximately five

million people in 1979 (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 101 (3), 1979).All kinds of agricultural funds were granted first to the *Tong-il* rice growers. A planting advance and a harvest advance were also distributed first to *Tong-il* rice growers.

Other incentives were also introduced to stimulate the adoption of *Tong-il* and to increase its productivity. In 1973, an award was given to the growers who produced the highest yield. In the first year, the award was given to all growers whose yields were over 6 tons/ha (milled rice). To those growers, 100,000 won ($250) was given as a prize (National Assembly Committee on Agriculture and Forestry, *Minutes*, vol. 86 (1), 1973). In addition to the awards for individual growers, there was another award for the joint rice cultivation districts. For the districts whose average yields were the highest in the country, one million won ($2,500) was awarded, and for those with the second highest yield, 500 thousand won ($1,200) was awarded (National Assembly Committee on Agriculture and Forestry, *Minutes*, vol. 86 (1), 1973).

Farmers and districts competed with others in their local area. The grower who won the competition locally proceeded to the competition in the county, then the state, and finally to the national competition. The grower who produced the highest yield in the country was invited to the Blue House of the President and was awarded a medal and a prize by the President. The local government officials in the winning province were promoted and received a reward (Kyungnam Domin Ilbo, December 31, 2003).

These awards succeeded in encouraging farmers to grow *Tong-il* rice. Only growers of *Tong-il* rice could win the award because conventional varieties could not compete with *Tong-il* rice in yield. The number of individual growers who were awarded increased from 4,525 in 1973, to 29,985 in 1974. The number of districts that received awards also increased from 54 in 1973 to 122 in 1974 (National Assembly Committee on Agriculture and Forestry, *Minutes*, vol. 91(1), 1975). Due to the rapid increase in the number of awarded growers, the government had to raise the threshold to 6.3 tons/ha in 1975 and to 7 tons/ha in 1976. The cash prizes were also replaced by agricultural machines or materials (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 95(1), 1976).

In the 1980s, the award system changed. The award that was previously given to all growers whose yields exceeded the threshold set by the

government, was now only granted to the growers who produced the highest yield in the country or in the states. One national winner and eight state winners were given ten million won ($12,000) and a silver medal and five million won ($6,000) and an iron medal, respectively. An award for the states was also introduced. To the state that showed the best performance in producing rice, a presidential prize worth 10 million won was granted. The second- and third-best states were awarded five million won and three million won, respectively. In 1983, the amount of the prize was doubled (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 116(2), 1983). Officials who worked in the province that produced the medalist for the highest yield in the country not only received a special bonus but also were promoted. However, there were some shortcomings of the award system. Since the performance of growers was linked to the promotion of officials, statistical fraud occurred frequently in all provinces (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 101(3), 1979; KyungNam Domin Ilbo, December 31, 2003).

Meanwhile, research to improve *Tong-il* continued. In 1974 two short-day varieties were developed from the original *Tong-il* in order to promote adoption in mountainous areas. In the same year, a quality-improved variety (Iri 317, later called *Yushin*), was developed, although the quality characteristics were still inferior to those of conventional varieties. A dozen new *Tong-il* type varieties were developed by 1976. These varieties were developed with a focus on improvement in quality, tolerance to shattering, and resistance to pests. Some examples of these were Milyang 21 and Suwon 264 (shattering-resistant), *Milyang* 23, *Suwon* 251 and 258 (quality-improved), and *Milyang* 30 (pest-resistant) (Kim, pp. 52-54).

2. The Decline of *Tong-il* Rice

The development and dissemination of *Tong-il*, combined with other government policies, led to self-sufficiency in rice in Korea by 1976. However, the favorable situation for *Tong-il* was dramatically reversed by two significant events that occurred between 1978 and 1980－an outbreak of rice blast disease and the assassination of the President.

In 1978, the outbreak of rice blast disease was observed nationally. Approximately, 156,000 ha, accounting for 17 percent of total paddy fields, were affected by blast disease. The disease influenced *Tong-il* varieties much more than conventional varieties. The affected area of two *Tong-il* varieties, *NoPoong* and *NaeKyung*, accounted for 75 percent of the total damaged area (National Assembly, *Minutes*, Volume 101(2), 1979). Although some *Tong-il* varieties were developed to be resistant to diseases, their tolerance to rice blast disease was not fully effective. Furthermore, *Tong-il* varieties had very weak tolerance of cold weather because they were based on indica varieties, which grow best in hot and humid environments. After an initial outbreak in 1978, blast disease combined with cold weather considerably reduced the 1980 harvest. Production in 1980 fell to 3,529 thousand tons, 36 percent below 1979. While assessing the damage of blast disease, many officials under-reported the affected area, in order to evade responsibility. Angry farmers complained about the under assessment of the damage. More than 150 officials were punished for inaccurate reporting. The Minister of MAF assumed responsibility and resigned (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 101(4), 1979).

Then, in October 1980, President Park was assassinated. With his death, the driving force behind enthusiasm for *Tong-il* was gone, leading to fundamental changes in agricultural policies. With this event as a turning point, adoption of *Tong-il* began its decline. The high price policy was moderated and *Tong-il* was no longer strongly recommended. After 1981, the number of non-*Tong-il* varieties recommended by the government increased considerably. Prior to 1981, no conventional variety was recommended by the government, though many producers planted conventional varieties. However, 17 conventional varieties were included in the recommendation list of 37 total varieties in 1981 (National Assembly Committee on Agriculture and Forestry, *Minutes*, Vol. 107(1), 1981).

The change in real price of rice slowed and then reversed, increasing by only 0.1 percent in 1982 and decreasing by 3.4 percent in 1983. The slow growth in prices continued until the role of approving prices by the National Assembly was restored in 1988. The role of the National Assembly for setting government purchase prices, first introduced in 1951, had been abolished in 1972. After this, the Administration under President Park could raise prices

without interference of the National Assembly. However, the following Administration used its authority to moderate increases in rice prices. The priority for the new administration was to control inflation. Because rice was a significant item in the price index, rice was one of the target commodities whose price was monitored by the government. Complaints of growers increased, causing a revision of the Grain Act in 1988.

In 1988, the National Assembly resumed the role of approving prices and often pressured the government to raise prices by more than the government had intended. However, the growth rate of the real price of rice was not as high as that experienced in the 1970s. In 1989, the government began to purchase *Tong-il* separately from other varieties, and at a lower price. In 1992, the Korean government finally stopped purchasing *Tong-il*.

The area producing *Tong-il* declined remarkably during the 1980s. The 604 thousand ha in *Tong-il* production in 1980 plummeted to 321 thousand ha in 1981. The area continued to decrease from that point onwards. After 1992, *Tong-il* rice was not planted except in experimental stations.

3. Relevant Data for Tong-il

Rice in Korea has usually been planted on paddy fields but a small portion of specialty rice was grown on upland fields as well. The portion of upland fields is not included in the data on cultivated area, production, and yield, because *Tong-il* research had its impacts solely on paddy rice. The share of upland fields in total cropland was around 2 percent in the 1960s, below 2 percent in the 1970s, and below 1 percent in the 1980s. The bias caused by the exclusion of upland fields in the calculation of research benefits is not substantial.

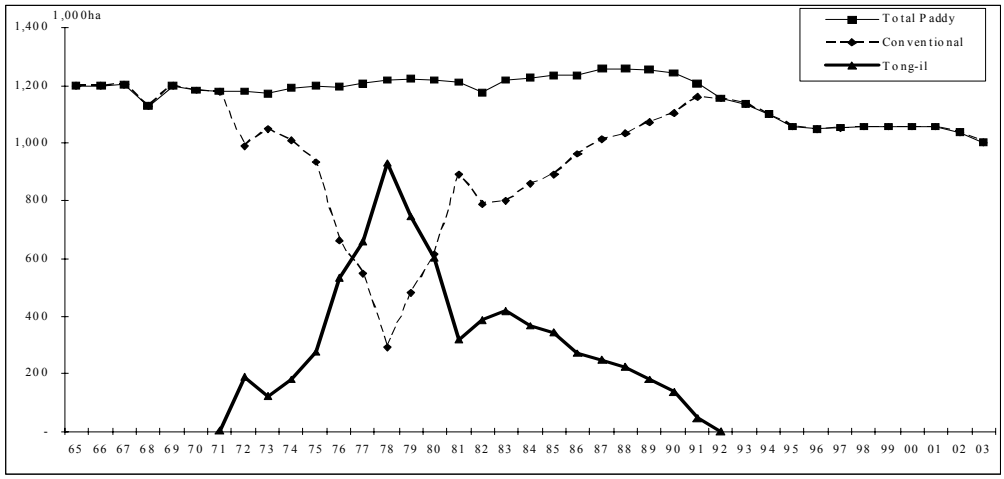
3.1. Planted Area and Adoption Rates by Province

During the *Tong-il* period (1972-1991), total rice paddy area remained about 1.2 million ha (three million acres). The drop in the area of conventional rice offset the rise in *Tong-il* area. When *Tong-il* area reached its peak, the area of conventional rice hit bottom. As the *Tong-il* area decreased, the area of

conventional rice increased (see Table A1 in Appendix).

Table 2 shows the adoption rates by province. Because of the difficulties in obtaining the data, only partial data are presented. North and South Cholla Provinces, North Kyungsang Province, and South Chungchong Province are the main rice-producing regions. In the early stages of *Tong-il* adoption, the regional adoption rates were similar to one another. Adoption rates show an increasing trend over time in all provinces. However, the rate of adoption in South Cholla Province is particularly high and the paddy areas of South Cholla Province are the largest in Korea. Kyung-gi Province has a reputation for high-quality rice, though paddy areas are not so large as South or North Cholla Provinces. Farmers in Kyung-gi Province did not favor the adoption of *Tong-il* rice, so the adoption rates were always lower in Kyung-gi Province than in other provinces.[5]

FIGURE 1. Area of *Tong-il* and Conventional Rice



Source: MAF, *Major Statistics of Korean Agriculture*, each year.

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[5] In general, rice quality is recognized by its varieties at market. However, region-oriented characteristics have been recognized as one of the important factors that determine the quality of rice in Korea. “Kyung-gi rice”, particularly produced in Kyung-gi Province, has been recognized as high-quality rice for hundreds of years. “Kyung-gi rice” has always been sold with premiums. For example, the rice produced in Cholla Province is sold at a lower price than the rice produced in Kyung-gi Province, even though the varieties are the same. This recognition of “Kyung-gi rice” is still widespread among Korean consumers.

TABLE 2. Adoption Rates of *Tong-il* Rice by Province, 1972-1977

Year	Province							
	Kyung-gi	Kang-won	North Chung Chong	South Chung Chong	North Cholla	South Cholla	North Kyung Sang	South Kyung Sang
	---------- *percent of rice area planted to Tong-il* ----------							
1972	9.2	9.9	10.8	10.8	18.3	27.2	16.4	16.2
1973	5.4	6.3	13.1	7.4	7.1	22.7	14.7	1.7
1974	7.9	7.1	23.8	16.2	10.9	20.3	25.0	7.1
1975	14.4	12.0	39.9	25.5	23.3	22.9	33.3	12.5
1976	28.4	31.4	68.9	47.9	39.8	52.8	52.9	32.5
1977	25.6	40.8	74.1	57.4	54.0	75.0	55.2	48.4

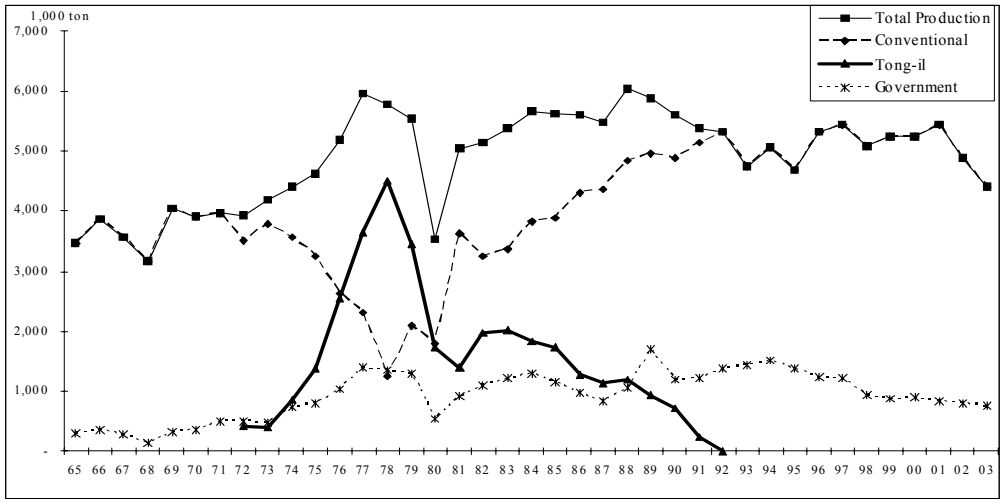
Source: Kim, *Green Revolution in Korea*, 1978, p. 195 (in Korean).

3.2. Production and Government Purchase Quantity

Total production has increased over time. Before *Tong-il* rice was introduced in 1972, the total production of rice in Korea was less than four million tons (see the first and second columns in Table A2 in Appendix). With the introduction of *Tong-il* and innovations that also increased conventional rice yields, production increased so fast that 3.9 million tons in 1970 rose to 5.9 million tons in 1977. Since the late 1970s, total production has generally been between 5.2 million tons and 5.6 million tons with a few exceptions. Production was below 5 million tons in 1980 because of unfavorable weather. In 1988, production broke the 1977 record, with more than 6 million tons being produced.

The quantity purchased by the government grew in the 1970s and has roughly followed production since then. From 1976 forward, more than one million tons were bought by the government each year, while in the 1960s an average of about 0.3 million tons were purchased each year (see third and fourth columns in Table A2).

FIGURE 2. Rice Production and Government Purchase Quantity



Source: MAF, *Major Statistics of Korean Agriculture*, each year.

The share of government quantities reached more than 20 percent in the 1970s. The percentage purchased by the government varied around 20 percent in the 1980s and 1990s (see the first column in Table A3 in Appendix).

The shares of *Tong-il* rice bought by the government in total *Tong-il* production were more than 50 percent in many years (see the third column in Table A3). Between 1977 and 1980, when *Tong-il* production was high, the share dropped to 35 percent of total *Tong-il* production. In the late 1980s, the share rose quickly because the quantity produced decreased substantially but the quantity purchased by the government decreased slowly.

The share of *Tong-il* rice in the quantity purchased by the government was over 90 percent during the 1970s and 1980s (see the last column in Table A3), where the government support through the purchase policy was focused on Tong-il rice.[6]

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6 The high level of *Tong-il* rice in government purchase caused consumers to assume that rice distributed by the government would be of low quality. Most of the government rice released to the market was *Tong-il* rice older than 2 years. Sometimes 5-year-old rice was released. Thus, consumers recognized that "government rice" was low quality of rice.

3.3. Yield

In the early stages of *Tong-il* adoption, the yields of *Tong-il* rice were often 30 percent higher than the yields of conventional rice. During the period of 1972-77, the yield gain of *Tong-il* rice over conventional rice was 31 percent. The yield gain decreased considerably after the outbreak of blast disease. The yield advantage of *Tong-il* rice in the 1980s decreased to approximately 15 percent. This was not only because *Tong-il* yields reached a plateau of about 5.5 tons/ha, but also because some technology developed for *Tong-il* rice was later adapted by growers of conventional rice. In 1977, the *Tong-il* yield was 5.53 tons/ha, the highest yield ever (Table A4 in Appendix). The weighted average yield between *Tong-il* and conventional rice also broke the record, at 4.94 tons/ha. Kim (p. 169) claimed that the 1977 yield was a world record at that time.[7]

FIGURE 3. Yields of Tong-il and Conventional Rice (ton/ha)

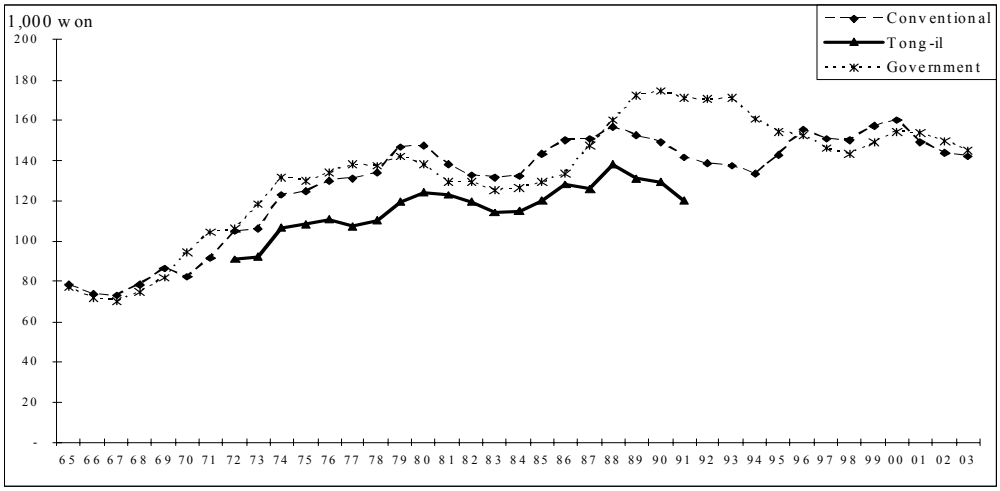
Source: MAF, *Major Statistics of Korean Agriculture*, each year

[7] For comparison, the yield of medium grain rice in California in 1977 was 58.10 cwt/acre (paddy), or 6.50 ton/ha. Multiplying by 0.7, the share of milled rice in paddy rice, we get 4.55 tons/ha on a milled basis.

3.5. Price

Figure 4 provides the trends of farm-gate prices of *Tong-il* and conventional rice, and the government purchase prices (for data, see Table A5 in Appendix). The source of the farm-gate prices is the National Agricultural Cooperative Federation (NACF), which surveyed farm-gate prices. The government purchase prices are the prices set annually by the government. Commercial prices of *Tong-il* rice during the 1972-75 period are missing, because most of the *Tong-il* rice produced during that period was purchased by the government, much of it for seed. All prices were deflated by the CPI (=100 in 2000).

FIGURE 4. Farm-gate Prices and Government Prices



Source: MAF, *Major Statistics of Korean Agriculture*, each year. Price was deflated by CPI (=100 in 2000).

IV. Concluding Remarks

The development and adoption of *Tong-il* was driven by the Korean government. The government supported *Tong-il* through technical and financial assistance. In particular, the interest of President Park in self-sufficiency in rice contributed greatly to the spread of *Tong-il*. With the strong support of

President Park, *Tong-il* brought self-sufficiency in rice to Korea in 1976.

The favorable situation for *Tong-il*, however, was dramatically reversed by two significant events that occurred between 1978 and 1980－an outbreak of rice blast disease and the assassination of the President. With these events as a turning point, adoption of *Tong-il* began its decline and *Tong-il* rice was not planted except in experimental stations after 1992.

This paper sheds on the first light about the history of *Tong-il*, though important in the Korean agriculture but little known. Despite its dramatic process of development and adoption, its detailed history was not known. Thus, it is worth reviewing *Tong-il* history from development to disappearance: how *Tong-il* was developed and adopted, what *Tong-il* contributed to the Korean rice industry, why *Tong-il* disappeared. For the analysis of economic effect of adopting *Tong-il*, further research is needed

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APPENDIX

TABLE A1. Planted Area of Conventional and *Tong-il* Rice, 1965-1991

Year	Total	Conventional	Tong-il
	---------- 1,000 ha ----------		
1965	1,198.9	1,198.9	
1966	1,199.3	1,199.3	
1967	1,204.3	1,204.3	
1968	1,127.0	1,127.0	
1969	1,198.1	1,198.1	
1970	1,183.5	1,183.5	
1971	1,178.0	1,178.0	
1972	1,177.8	990.3	187.5
1973	1,169.7	1,048.5	121.2
1974	1,189.0	1,008.1	180.9
1975	1,207.0	932.9	274.1
1976	1,196.1	662.9	533.2
1977	1,208.3	548.2	660.1
1978	1,219.1	290.1	929.0
1979	1,224.2	479.9	744.3
1980	1,219.8	615.7	604.1
1981	1,212.3	890.9	321.3
1982	1,175.9	789.6	386.4
1983	1,219.6	801.1	418.5
1984	1,224.7	857.8	366.9
1985	1.232.9	890.1	342.8
1986	1,232.7	960.4	272.3
1987	1,259.1	1,012.5	246.7
1988	1,257.2	1,032.4	224.8
1989	1,254.2	1,071.8	182.4
1990	1,241.8	1,103.3	138.5
1991	1,206.6	1,158.0	48.6

Source: MAF, *Major Statistics of Korean Agriculture*, annually.

TABLE A2. Production, Government Purchase for *Tong-il* and All Rice, 1965-1991

Year	Production		Government Purchase	
	Total	*Tong-il*	Total	*Tong-il*
	1,000 tons (milled)			
1965	3,464		302	
1966	3,871		351	
1967	3,572		279	
1968	3,166		132	
1969	4,057		320	
1970	3,907		351	
1971	3,975		492	
1972	3,933	424	507	n.a.
1973	4,190	395	480	n.a.
1974	4,417	856	735	432
1975	4,627	1,380	789	710
1976	5,180	2,553	1,043	961
1977	5,965	3,648	1,403	1,334
1978	5,779	4,516	1,355	1,340
1979	5,546	3,449	1,301	1,280
1980	3,530	1,733	546	544
1981	5,040	1,403	915	802
1982	5,151	1,981	1,091	1,038
1983	5,388	2,023	1,219	1,160
1984	5,671	1,842	1,215	1,150
1985	5,618	1,729	1,153	1,076
1986	5,601	1,286	979	880
1987	5,487	1,128	842	773
1988	6,047	1,206	1,050	943
1989	5,892	931	1,692	834
1990	5,600	720	1,203	628
1991	5,380	240	1,222	189

Source: MAF, *Grain Statistics*, various years.
Note: 'n.a.' represents 'not available.'

TABLE A3. Sharesof Production and Government Purchases, 1965-1991

Year	Shares of			
	Government Quantity in Total Production	*Tong-il* in Total Production	*Tong-il* purchased by Government in Total Tong-il Production	*Tong-il* purchased by Government in Total Government Quantity
	---------- % ----------			
1965	8.7			
1966	9.1			
1967	7.8			
1968	4.2			
1969	7.9			
1970	9.0			
1971	12.4			
1972	12.9	10.8	n.a.	n.a.
1973	11.4	9.4	n.a.	n.a.
1974	16.6	19.4	50.5	58.8
1975	17.1	29.8	51.4	89.9
1976	20.1	49.3	37.6	92.1
1977	23.5	61.2	36.6	95.1
1978	23.5	78.1	29.7	98.8
1979	23.5	62.2	37.1	98.4
1980	15.5	49.1	31.4	99.6
1981	18.2	27.8	57.1	87.6
1982	21.2	38.5	52.4	95.1
1983	22.6	37.6	57.3	95.1
1984	21.4	32.5	62.4	94.7
1985	20.5	30.8	62.2	93.3
1986	17.5	23.0	68.5	89.9
1987	15.3	20.6	68.6	91.9
1988	17.4	19.9	78.2	89.8
1989	28.7	15.8	89.5	49.3
1990	21.5	12.8	87.3	52.2
1991	22.7	4.5	79.0	15.5

Source: MAF, *Grain Statistics*, various years.
Note: 'n.a.' represents 'not available.'

TABLE A4. Yields of Conventional and *Tong-il* Rice, 1965-2003

Year	Weighted averagea[a]	Conventional	Tong-il
	---------- tons/ha (milled rice) ----------		
1965	2.89	2.89	
1966	3.23	3.23	
1967	2.97	2.97	
1968	2.81	2.81	
1969	3.39	3.39	
1970	3.30	3.30	
1971	3.37	3.37	
1972	3.31	3.21	3.86
1973	3.63	3.50	4.81
1974	3.71	3.53	4.73
1975	3.85	3.51	5.03
1976	4.32	3.96	4.79
1977	4.93	4.23	5.53
1978	4.74	4.35	4.86
1979	4.53	4.37	4.63
1980	2.90	2.92	2.87
1981	4.16	4.08	4.37
1982	4.38	4.13	4.89
1983	4.41	4.20	4.83
1984	4.63	4.46	5.02
1985	4.56	4.37	5.04
1986	4.54	4.49	4.72
1987	4.36	4.31	4.57
1988	4.81	4.69	5.36
1989	4.70	4.63	5.11
1990	4.51	4.42	5.20
1991	4.46	4.44	4.94

Source: MAF, *Major Statistics of Korean Agriculture*, annually.
a) Weighted by the share of *Tong-il* rice in quantity.

TABLE A5. Prices of Conventional and *Tong-il* Rice, and Government Prices, 1965-1991

Year	Farm-gate Prices		Government Prices (conventional)
	Conventional	*Tong-il*	
	---------- Won/80kg (real) ----------		
1965	78,293		76,829
1966	73,609		71,870
1967	73,137		70,392
1968	78,393		75,000
1969	86,270		81,746
1970	82,514		94,595
1971	91,357		104,167
1972	104,753	n.a.	106,323
1973	106,292	n.a.	118,510
1974	122,908	n.a.	131,333
1975	124,353	n.a.	130,000
1976	129,873	110,607	134,104
1977	130,753	107,321	138,211
1978	133,628	110,394	137,615
1979	146,461	119,221	141,860
1980	147,268	123,846	137,801
1981	137,876	122,861	129,429
1982	133,014	119,632	129,560
1983	131,604	114,228	125,213
1984	132,035	114,630	126,149
1985	143,100	120,199	129,338
1986	150,343	127,871	133,389
1987	150,536	125,944	147,460
1988	156,685	137,842	159,774
1989	152,310	131,052	172,406[a]
1990	149,107	129,113	174,696[a]
1991	141,640	119,775	170,931[a]

Source: MAF, *Major Statistics of Korean Agriculture*, each year. Price was deflated by CPI (=100 in 2000).

Note: 'n.a.' represents 'not available.'

a) For *Tong-il*, the purchase prices were 169,376 won in 1989, 163,826 won in 1990, and 149,805 won in 1991. In other years, the government prices of *Tong-il* and conventional rice were the same.