CHEMICAL CONTROL OF RICE BLAST IN KOREA

Seung-Chan LEE*

Abstract

Cultivation of high-yielding varieties including *indica-japonica* hybrids and improved production technology have resulted not only in the increase of rice yield potential but also in the changing pattern of rice blast incidence. One of the main constraints to achieving high yields is the damage caused by blast disease. Annual yield losses due to blast in Korea have been estimated at 8.4% for the last 5 years, assuming no chemical control was initiated. Normally, blast chemical control provides annual average increase of 6.3% or 0.27 metric ton per ha in yield.

As acreages of blast incidence increased due to the breakdown of the resistance of new high-yielding varieties, chemical applications have been greatly increased in the last decade, i.e. from 1.5 applications in 1970 to 3.3 in 1981. And the proportional increase of rice yield has also resulted in an average production of 4.3 metric tons per ha per year in the last 5 years.

There is a fair amount of information available on the use of fungicides effective against rice blast, including suitable formulations and methods and timing of application. However, farmers should use fungicides only when other methods, alone or in combination, are ineffective. The use of fungicides should be minimized and decided, based on a blast management approach in combination with other control methods.

Introduction

The demand for higher rice production has been chiefly met through the development and adoption of modern technology, which relies heavily on factors like pesticides, varieties and fertilizers. A major constraint to achieving high yield is the damage caused by rice blast (*Pyricularia oryzae* Cavara), which without chemical control accounted for an average 8.4% loss (or *ca.* 40% yield loss from all rice diseases) during the last decade.

On the other hand, since the introduction of new hybrid cultivars resulting from crosses between *japonica* and *indica* in 1971, varietal resistance to blast has been maintained for 6 years. Then, a severe epidemic of rice blast occurred in 1978 and 1979 due to the abnormal weather conditions all over the country (Fig. 1). Following the outbreak of rice blast disease on new high-yielding cultivars, regular chemical applications are being emphasized and adjusted, and a control program in terms of blast management is being partially implemented.

This paper is to present the general characteristics of chemicals for blast control and control effects for preventing yield losses. In addition, chemical control in harmony with other methods in terms of blast management and future research programs are briefly discussed.

Yield losses of rice due to blast disease and control effects

Yield losses due to blast vary from year to year, and from region to region in the country. It is also difficult to assess the actual damage caused by blast alone. The average annual loss of rice yield due to blast amounted to 2.0% despite farmers' chemical control during the last decade. In other words, of the total damage caused by all rice diseases which amounts to 4.9%, 40% was brought about by blast (Table 1).

During the period 1977–1981, the estimated average annual loss in yield, assuming no chemical control of blast was adopted, reached 8.4%, ranging from 0.9% to 14.1%, whereas the

* Department of Plant Pathology, Institute of Agricultural Sciences, ORD, Suweon 170, Korea.

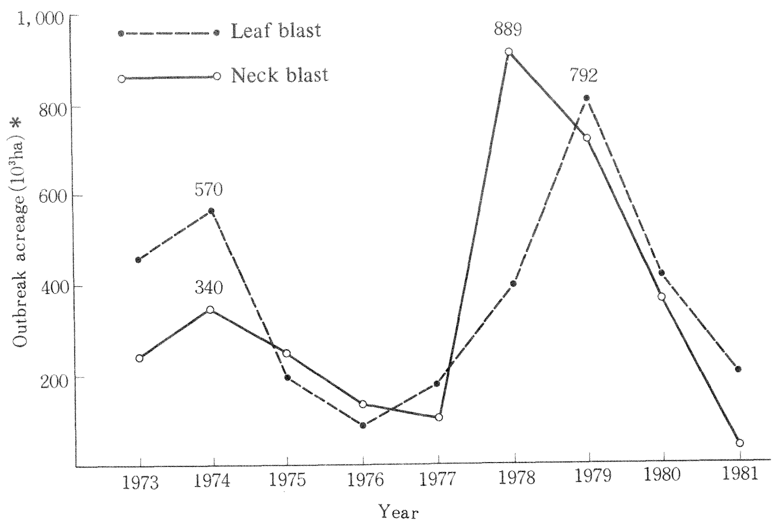

Fig. 1 Annual outbreaks of rice blast during the last 9 years.
* Rep. Pl. Prot. Proj. 1973–1981. ORD.

Table 1 Annual percent losses due to rice pests during the last decade.*

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Mean
Diseases	4.2	10.0	6.0	5.7	3.2	2.5	2.7	6.7	4.8	6.0	1.5	4.9
(Blast)**	(1.8)	(5.5)	(0.6)	(2.6)	(0.7)	(0.4)	(0.2)	(4.2)	(2.1)	(3.9)	(0.03)	(2.0)
Insects	4.0	3.8	1.7	1.6	7.3	1.9	1.5	3.8	1.6	1.9	2.2	2.8
Total	8.2	13.8	8.0	7.3	10.5	4.4	4.2	10.5	6.4	7.9	7.9	7.7

* Rep. Pl. Prot. Proj. 1971–1981. ORD.
** Figures in parentheses indicate % losses due to blast.

average annual loss during the same period with chemical control was 2.1%. For example, the cumulative acreage sprayed with chemicals for the control of leaf blast and neck blast gradually increased to *ca.* 4 million ha or *ca.* 3.3 applications in 1981. As a result, it is considered that an average of 6.3% of total rice production could be saved by the farmers' blast chemical control. Thus, the blast control has increased yield by an annual average of 327,400 metric tons or 0.27 metric tons per ha in the last 5 years (Table 2).

Table 2 Economic analysis of control effects of rice blast disease during the last 5 years.*

Year	Production of milled rice (10^3 metric tons)	% loss		Control effect (B-A) (10^3 metric tons)
		Control (A)**	No control (B)***	
1977	6,005.6	0.2	1.7	90.1
1978	5,797.1	4.2	13.1	515.9
1979	5,564.8	2.1	12.4	573.2
1980	3,550.2	3.9	14.1	362.1
1981	5,063.0	0.03	0.9	44.0
Ave.	5,196.1	2.1	8.4	327.4

* Year Book. Agr. Forest. Statist. 1978–1982. MAF., and Rep. Pl. Prot. Proj. 1981. ORD.
** Average % losses due to rice blast disease.
*** Average % losses due to diseases and insect pests without chemical control administered.

General characteristics of chemicals for blast control

Like in the other countries, organomercury compounds were once widely used on a large scale as the main chemicals for an extended period of time in the early stage of rice blast control because of low cost and availability of other fungicides. In the 1960s, antibiotics (i.e. blasticidin-S and kasugamycin), leptophos (Phosvel) and some organophosphorus compounds became available for blast control and were widely used. However, various side-effects such as environmental pollution and residues in food have arisen with the increasing use of those fungicides. As a result, the use of organomercury fungicides was banned in 1977 and that of leptophos in 1978.

For the control of rice blast, 10 chemical compounds were registered into 17 different formulations including 4 emulsifiable concentrates, 2 liquid forms, 2 wettable powders, 6 dusts and 3 granules. Fungicides recommended to the farmers for the blast control are listed in Table 3.

Systemic fungicides showing efficacy for the control of rice blast are tricyclazole WP, IBP G, isoprothiolane G and probenazole G, etc. The granular applications of fungicides for blast control have steadily become more popular because of their labor-saving advantage and equal or even better efficacy compared to some other chemicals during the last few years. On the other hand, spray formulations accounted for more than 80% of the whole formulations of fungicides until 1978. However, the consumption of spray forms has decreased recently and even that of dust forms is reducing faster every year (Table 4). The advantage of spray forms is that they can usually be mixed with other pesticides at the time of application, unlike dust forms.

Table 3 Fungicides recommended and registered for rice blast control.

Common name	Formulation	Chemical name	Dilution	Quantity applied (ha)
Edifenphos	30% EC	0-ethyl-S, S-diphenyl phosphorodithioate.	1,000 ×	800–1,600 ml
IBP	48% EC	0, 0-diisopropyl-S-benzyl thiophosphate.	1,000 ×	800–1,600 ml
Isoprothiolane	40% EC	di-isopropyl 1, 3-dithiolane-2-ylidenemalonate.	1,000 ×	800–1,600 ml
Blasticidin-S	2% EC	(S)-4 3-amino-5 aminoiminomethyl methylamino -1-oxopentyl amino -1- 4-amino-2-oxo-1 (2H)-pyrimidinyl - 1, 2, 3, 4-tetradeoxy-β-D-erythrohex-2-enopyranuronic acid	1,000 ×	800–1,600 ml
Kasugamycin	2% Lq	D-3-0- 2-amino-4 (-carboxyiminomethyl) amino-2, 3, 4, 6-tetradeoxy- -D-arabino hexopyranosyl -D-chiro-inositol	1,000 ×	800–1,600 ml
Thiophanate	40% Lq	1, 2-bis (3-ethoxycarbonyl-2-thioureide)	1,000 ×	800–1,600 ml
Fthalide	50% WP	4, 5, 6, 7-tetrachlorophthalide.	1,000 ×	800–1,600 ml
Tricyclazole	75% WP	5-methyl-1, 2, 4-triazolo 3, 4-b -	2,000 ×	400– 800 ml
Edifenphos	1.5% D	0-ethyl-S, S-diphenyl phosphorodithioate.	–	30–40 kg
IBP	2% D	0,-0-diisopropyl-S-benzyl thiophosphate.	–	30–40 kg
Kasubaron®	2.1% D	Kasugamycin 0.1% + 0 – ethyl 0,0-di (2, 4-dichlorophenyl)phosphate	–	30–40 kg
Kasugamycin	0.2% D	D-3-0- 2-amino-4- (1-carboxyiminomethyl) amino-2, 3, 4, 6-tetradeoxy-α-D-arabinohe-xopyranosyl -D-chiro-inositol	–	30–40 kg
Fthalide	2.5% D	4, 5, 6, 7-tetrachlorophthalide.	–	30–40 kg
Tricyclazole	1% D	5-methyl-1, 2, 4-triazolo 3, 4-b - benzothiazole.	–	30–40 kg
IBP	17% G	0, 0-diisopropyl-S-benzyl thiophosphate.	–	30–40 kg
Isoprothiolane	12% G	di-isopropyl 1, 3-dithiolane-2-ylidenemalonate.	–	30–40 kg
Probenazole	6% G	3-allyloxy-1, 2-benzisothiazole 1, 1-dioxide.	–	30–70 kg

Table 4 Annual consumption of various fungicides for rice blast control during the last 11 years.*

Unit: a.i. metric tons

Year	Spray form**	Dust	Granule	Total	Per ha (kg)
1971	143.8 (93.1)	10.6 (6.9)	0 (0)	154.4	0.13
1972	220.1 (94.8)	12.0 (5.2)	0 (0)	232.1	0.20
1973	207.3 (90.0)	23.0 (10.0)	0 (0)	230.3	0.20
1974	171.2 (98.1)	0.5 (0.2)	2.9 (1.7)	174.6	0.15
1975	232.4 (80.9)	28.2 (9.8)	26.8 (9.3)	287.4	0.24
1976	62.3 (33.0)	39.2 (20.7)	87.5 (46.3)	189.0	0.16
1977	143.1 (83.2)	27.8 (16.2)	1.1 (0.6)	172.0	0.14
1978	289.2 (81.9)	63.1 (17.9)	0.9 (0.2)	353.2	0.29
1979	821.3 (42.1)	347.3 (17.8)	784.4 (40.1)	1,953.0	1.60
1980	1,057.3 (41.4)	130.3 (5.1)	1,367.4 (53.5)	2,555.0	2.10
1981	1,269.3 (47.1)	80.0 (2.9)	1,378.4 (50.0)	2,754.7	2.13

Figures in parentheses indicate the percent consumption of each fungicide.
* Agrochem. Year Book. 1972–1982. Chem. Ind. Assoc.
** Spray form: EC, Lq, SP, WP, etc.

Fungicide consumption and control equipment

The annual consumption of fungicides, as active ingredient chemicals, for blast control, greatly increased from 154 metric tons or 0.13 kg/ha in 1971 to 2,755 metric tons or 2.1 kg/ha in 1981. Recently, the consumption of granules has considerably increased, because of the shortage of labor, wage increase and ease of handling, while applications of dust formulations have decreased due to the difficulty of mixing chemicals (Table 4).

During the last 12 years the number of fungicide applications per annum for the control of rice blast increased greatly from 1.5 applications in 1970 to 3.3 in 1981, along with the increase of the control acreage of paddy fields throughout the country (Table 5). In the meantime, periodical average yield of milled rice increased greatly from 3.1 metric tons per ha in 1966–1970 to 3.6 metric tons in 1971–1975, and to 4.3 metric tons in 1976–1980.

Table 5 Annual comparison of fungicide applications for rice blast control during the last 12 years.*

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Cultivation acreage (10^3 ha)	1,184	1,178	1,178	1,170	1,189	1,198	1,196	1,208	1,219	1,224	1,220	1,212
Control acreage (10^3 ha)	1,760	2,233	2,142	1,678	2,646	1,660	1,424	1,466	2,183	3,403	3,740	3,999
No. of applications	1.5	1.9	1.8	1.4	2.2	1.4	1.2	1.2	1.8	2.9	3.1	3.3

* Agrochem. Year Book. 1971–1982. Agri. Chem. Ind. Assoc.

As for the equipment for ground control, only manual sprayers/dusters were available in 1961. The introduction of power sprayers in 1970 enabled to spray all paddy fields nationwide once in 8 days. When power dusters were supplied in 1975, only 3.7 days were required to meet the needs of the total rice acreage. In addition, the use of high power sprayers which became available to the farmers enabled to control paddy fields nationwide in 1.4 days in 1980, and 1.2 days in 1981. As the high power sprayers became more popular, the use of manual equipment registered a rapid decrease (Table 6).

Table 6 Spray capability of ground spraying equipment and use.*

Quantity unit: 10^3

Item	Year				
	1960	1970	1975	1980	1981
Manual sprayer	21.0	422.8	687.7	838.4	799.6
Manual duster	9.6	26.7	148.6	16.7	20.9
Power sprayer	–	–	33.0	108.6	142.6
Power duster	–	–	104.7	222.0	219.2
High power sprayer	–	–	–	0.262	2.9
Total	30.6	449.5	974.0	1,185.7	1,185.2
Cultivation acreage (10^3 ha)	–	1,184	1,198	1,220	1,212
Required days** for spraying	–	8	3.7	1.4	1.2

* Agr. Mach. Year Book. 1960–1981. Kor. Soc. Agr. Mach.
** Days required to spray all paddy fields in the nation once.

Aerial application of pesticides is performed only by helicopters in Korea, because of shortage of landing areas and danger to paddy fields. The first application by helicopter was conducted in 1969 for blast control and other rice pests. Helicopter application expenses were subsidized by the government, but the chemicals were provided by the farmers. In 1981, about 105,000 ha (8.7% cultivated acreage) of paddy fields were sprayed by helicopters with a combination of fungicides and insecticides (Table 7). Fungicides for aerial application for blast control are kasugamycin 2% Lq, blasticidin-S 2% EC, IBP 48% EC, edifenphos 30% EC, etc. Chemicals with high toxicity to mammals and fish, or that may cause phytotoxicity, are prohibited for use by aerial application.

Table 7 Annual acreage of helicopter application for control of diseases and insect pests of rice.*

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Treated acreage (10^3 ha)	5	8	29	50	70	78	79	142	105	107	82	85	105
No. of helicopters	2**	2***	3	6	9	7	7	6	12	12	12	12	15

* Agrochem. Year Book. 1970–1982. Chem. Ind. Assoc., and Handbook, 1981. Asia Aircraft Co.
** Rented from Japan in 1969.
*** Rented from Australia in 1970.

Applications of fungicides

There are two diseases which show peaks: leaf blast and panicle blast. Leaf blast usually occurs from June to July after rice transplanting. Panicle blast appears from the milky stage to yellow ripening stage of rice usually from mid-August to early September.

The primary infection of blast in the seedling beds and fields originates from infected seeds and straws. As a result, it induces leaf blast on seedlings in the nurseries and/or on young plants in the fields, resulting in neck blast outbreaks.

The government strongly recommends to the farmers that chemical control of blast be practiced as follows:

1 Seed treatment for blast control

The causal organisms of blast, Bakanae disease and brown spot are well known as being seed-borne. In order to reduce the amount of primary inoculum and incidence of these diseases, seed treatment is practiced through nationwide campaigns.

Registered seed disinfectants for rice-seed diseases are Benlate T (benomyl + thiram), Busan (TCMTB), and Homai (thiophanate-methyl + thiram). Methods for the application of these chemicals are summarized in Table 8. To eliminate the primary inoculum, seeds are soaked in

Table 8 Fungicides recommended for seed treatment of rice.*

Name of fungicide	Formulation	Chemical name	Dilution	Dipping time (hr)
Benlate T®	40% WP	(1) methyl-1-(butylcarbamoyl)-2-benzimidazole carbamate (benlate) (2) tetramethylthiuram disulfide (TMTD)	1,000 ×	24
Homai®	8% WP	(1) 2-bis (3-methoxycarbonyl-2-thio-ureido benzene (topsin) (2) tetramethylthiuram disulfide (TMTD)	400 ×	24
Busan®	30% EC	2-(thiocyanomethylthio)-benzothiazole	1,000 ×	24

* Seed disinfectants registered for control of blast, brown spot and Bakanae disease.

a solution of the recommended fungicides. Seed disinfectants such as Busan are subsidized at least up to 50% by the government for encouraging farmers' use. However, the efficacy of seed disinfectants presently recommended to the farmers is not satisfactory for the control of Bakanae disease (*Fusarium moniliforme*). On the other hand, the incidence of Bakanae disease is gradually increasing as a key disease originating from seed infection since organomercury compounds were banned and cultural practices were changed, particularly in the seedling boxes for machine transplanting. Thus, it is necessary that new disinfectants against this disease be developed to replace the present fungicides used.

2 Seedbed treatment with fungicides for preventing seedling blast

The use of blast-free seedlings for transplanting is very important. The seedling nurseries are usually protected by seed treatment and systemic fungicide applications.

It would be impossible to eradicate overwintering blast fungus in the fields, even though all the sown seeds were disinfected. Hence, it is recommended to the farmers that seedbeds be treated with granular fungicides such as Fuji-one G and Oryzemate G (Table 9) to prevent seedling blast incidence at the same time as sowing just before applying a polyethylene film cover. In case of seedbed treatment, the fungicides are subsidized up to 40% by the government. Furthermore,

Table 9 Effect of systemic fungicides for seedling blast control.*

Fungicide	Formulation	Amount (kg/10a)	No. lesions/ 30 plants	Control index (%)	Phyto-toxicity**
Oryzemate®	6% G	2	42.7	89	–
Fuji-one®	12% G	3	73.0	82	–
Kitazin P®	17% G	3	97.3	76	+
CG 114	2% G	2	2.3	99	–
S 1901	8% G	2	0.3	99.9	++
Control		–	396.7	0	–

* Res. Rep. 1981. Inst. Agr. Sci.
** –: none +: mild ++: severe

if seedling blast occurs before transplanting, seedling beds are treated with 2 or 3 chemical applications at 5–7 day intervals.

3 Fungicide spraying/dusting for blast control

Since the development of various fungicides, many farmers grow more susceptible but high-yielding and/or good quality varieties with higher levels of nitrogen fertilizer than they attempted before, in anticipation of a good harvest of rice. Number of chemical applications for blast control depends upon the degree of varietal resistance. It is therefore recommended to farmers that at least one application be made on moderately resistant cultivars for the control of leaf blast and neck blast, respectively, whereas two applications each should be made on susceptible cultivars for the control of both leaf and neck blast (Table 10).

In general, when leaf blast first appears after transplanting in the fields, the first application of fungicides should be conducted and an additional spray may be required, if the disease continues to spread.

For the control of node, neck and ear blast, two spraying/dusting applications of fungicides are usually recommended from the beginning of heading stage at 5–7 day intervals, but in case of a protracted rainy season, a 3rd application may be necessary. If granular fungicides are used, the proper time of application is at 10–20 days before heading stage. Furthermore, in case of continuous rain which is conducive to panicle blast outbreaks an additional spray will be needed.

Table 10 1982 program for fixed chemical control of major rice pests based on resistance degree of leading varieties.

Time	Pest	Grouping of varieties						
		I	II	III	IV	V	IV	VII
Seedling bed	Disease + insect*	○	○	○	○	○	○	○
Late June – early July	Leaf blast	×	×	×	×	×	○	○
	BLB	○	○	○	○	○	○	○
	SRB	×	×	○	○	○	○	○
Early July – late July	Leaf blast	○	○	○	○	○	○	○
	BLB	○	○	○	×	○	○	○
Late July – early August	Neck blast	○	○	○	○	○	○	○
	BLB	×	×	×	×	×	×	○
	Sheath blight	○	○	○	○	○	○	○
	BPH	×	○	○	○	○	○	○
Early August – mid-August	Neck blast	×	×	×	○	○	○	○
	SRB	×	×	×	×	×	×	○
	BPH	×	○	○	○	○	○	○
No. of applications		6 (2)**	8 (2)	9 (2)	9 (3)	10 (3)	11 (4)	12 (4)
Variety		Baeguchal-byeo Hangangchal-byeo	Baegyang-byeo Taebaeg-byeo Seogwang-byeo	Chupung-byeo Pungsan-byeo Chungchung-byeo	Milyang 42 Samseong-byeo Sujeong-byeo	Milyang 30 Sampung-byeo Palgwang-byeo	Yushin Geumgang-byeo Akibare Jinjubyeo	Milyang 23 Akihikari Nagdong-byeo Reimei

* BLB: Bacterial leaf blight. SRB: Striped rice borer. BPH: Brown planthopper.
** Number of chemical applications for blast control for each group of varieties.

Fungicide resistance of blast fungus

Prolonged and continuous use of one type of fungicides, which might be effective in controlling rice blast, has resulted in the development of resistance to commercial fungicides. For example, strains of blast fungus resistant to blasticidin-S and kasugamycin were widely observed in 1981. Furthermore, some other fungicides, which were being used for many years, have been suspected to induce resistance. Chemical applications, however, must continue to play an important role in the control of rice blast in terms of pest management. Thus, the need for judicious use of effective fungicides should enable to extend the commercial life of various chemical compounds. It is also necessary to develop continuously new alternative chemicals for the future.

Chemical control with resistant varieties

Under environmental and physiological conditions favorable to extremely severe outbreaks of blast, it is difficult to protect rice plants from blast damage by fungicide application alone. The government therefore recommends to the farmers to use resistant varieties and adopt various cultural practices, along with the use of fungicides.

It is well known that the cultivation of resistant varieties is the most effective and practical measure for the control of rice blast in combination with other pest management components. Resistant varieties are particularly recommended for cultivation in areas where blast occurred every year. Depending on the level of resistance of the varieties, they can be used either as the principal method of blast control or can be integrated with chemical control to develop appropriate pest management systems. In 1982, the 40 leading varieties recommended by the government were either susceptible, moderately resistant, or resistant to blast (Table 10). In other words, at least two-thirds of the varieties could be severely attacked by blast when the weather conditions and types of plants favor infection. For example, blast-resistant varieties generally do not need fungicidal protection from blast, but they will need fungicidal/insecticidal protection for the control of other pests to which they are not resistant, as shown in Table 10. Consequently, appropriate integration of all possible methods and techniques such as use of resistant varieties, cultural practices and biological agents in harmony with the use of fungicides is a sound approach to the successful control of rice blast.

Conclusion

If fungicides are indispensable in a system of blast management, efforts must be made to use them efficiently depending on forecasting information and in harmony with other blast control measures. The improvement of blast forecasting methods can be of importance for rice protection, if effective and economical chemical control is to be achieved. Even if all the cultural practices were adopted, chemical control would not be satisfactory, particularly under weather conditions favorable to blast incidence. Farmers, therefore, require reliable chemical control measures, as well as highly resistant cultivars. To reach these objectives, it is necessary to develop continuously alternative chemicals, and improve chemical use. Studies along these lines have been made and results will be obtained in the foreseeable future.

Because of the trend to modernization and industrialization, shortage of labor and wage increase are becoming serious problems year after year. Hence, applications of chemicals in the form of granules will become increasingly important to the farmers in the future.

References

1) Agrochem. Year Book (1970–1982): Agr. Chem. Ind. Assoc. Korea.

2) Handbook (1981): Asia Aircraft Co. Korea.
3) LEE, S.C. (1981): Present status of plant protection in Korea. 1–35 pp. *In*: Pest management of rice in East Asia. Symp. ASPAC/FFTC/ORD. Korea.
4) PARK, C.S. (1981): Studies on the tolerance of rice blast fungus, *Pyricularia oryzae* to fungicides. Cooper. Project '81-1. 20 pp.
5) Rep. Pl. Proj. (1971–1981): ORD. Korea.
6) Res. Rep. (1981): IAS. Korea.
7) Year Book. Agr. Forest. Statist. (1961–1982): MAF. Korea.

Discussion

Ishikura, H. (Japan): You described yearly fluctuations in the incidence of rice blast in the 1970s with two peaks, one in 1974 and an other, the highest, in 1978–1979 and you attributed this phenomenon to the change in varieties. In Japan we know that rice blast incidence is very much affected by the weather conditions. For instance cool summers may affect the incidence of blast depending on the stage of growth of the plant and at heading stage neck rot will be observed while at the growing stage leaf blast will occur. How do you consider the role of the weather conditions in blast incidence (in Korea, I believe that you had cool summers in the late 1970s) and which factors do you take into account in forecasting blast incidence?

Answer: Of course, the weather conditions are one of the most important factors which affect blast incidence in addition to soil conditions and kinds of varieties cultivated. Since the introduction of new hybrid cultivars (namely crosses between *japonica* and *indica* varieties) in 1971, varietal resistance to blast could be maintained up to 1976. However, the resistance of the hybrids was broken down by new physiological races of the pathogen and extensive areas were cultivated with the new varieties in 1978 and in 1979. As a result, a serious epidemic of rice blast occurred in these years although the weather conditions were favorable.

Uesugi, Y. (Japan): Is there any relation between the change in rice variety, races of the blast fungus and the annual fluctuations in blast incidence?

Answer: It seems that the change of variety (cultivation of Tongil variety) was the most important factor in the incidence of the disease along with changes in the weather conditions.

Grossmann, F. (Federal Republic of Germany): Your experience that the resistance of new varieties is overcome by the appearance of new races of the pathogen after some years is a very common one. To prevent this phenomenon from occurring, it might be desirable to develop varieties with a more horizontal or durable form of resistance. Are there any breeding programs of this type in your country with regard to rice blast disease?

Answer: Yes, there are such programs.