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Rice Breeding for the Resistance to the Disease and Insect Pests

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水稻 病害虫에 대한 抵抗性品種의 育種

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ABSTRACT

Yield losses due to diseases and insect pests were mentioned and emphasized the efficiency of resistant cultivars in curving the yield losses and increasing chemical efficiency. Present status of resistance breeding for blast, bacterial leaf blight viruses, brown planthopper and white backed planthopper were introduced and the resistance sources for those are discussed. Breeding strategies for above items were presented. Specially for the blast resistance, discussions were made in some detail. With brief future prospects of resistance breeding in Korea, a suggestion was made for pathologists to make clear about whether the blast spores will be brought from mainland China as we see with Bph and Wbph or not.

IMPORTANCE OF THE RESISTANCE BREEDING

The average annual rice losses during 1971~1980 caused by diseases and insect pests in Korea was reported to reach 5.3% and 3.2%, respectively. As high as 13.8% yield loss was recorded(with 10.0% due to diseases and 3.8% due to insect pests)in 1972. The losses caused by diseases are generally greater ranging from 2.5% to 10.0% in comparison with the losses caused by insect pests which ranges from 1.5% to 7.3% during same period in Korea (Lee 1981). Lee also cited data from Agrochemical Yearbook 1980 indicating that an average 17% to 22.1% of total potential yield losses were prevented by the appopriate chemical control during 1975~1979. During same period, the yield losses due to diseases and insect pests, in the plots where the chemical control was not adiministered ranged from 20.9% to 32.6% with average of 24.2%. This yield losses which amounts to 1,496,500 M/T coul prevented if it were planted to resistant culti

Ideally, the resistant varieties should preve yield losses completely and permanently. Ho such high levels of resistances are not reali far with rice crop. Resistant cultivars, even with low and moderate levels of resistance, a number of advantages to an integrated c system. The reduction of disease sources and ber of insect pests achieved through resi make control by chemical and cultural m easier. And, the level of natural biological c required to hold the level of diseases and below crop-damaging levels need not be so gre Another advantage of growing a resistant cultiv is that the reduced rate of pathogen or pest i crease may greatly prolong the time required by t pathogen or pests to reach the economic thresh for crop damage. This is especially true in t case of brown planthopper and whiteback pla hopper which are not overwintering in Korea.

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Resistant cultivars are highly compatible with biological control since they usually do not materially affect the natural enemies of the pests. Had we cultivars resistant to both hoppers, brown and whiteback, the average 8.2 times of chemical spray in 1980 could be cut down to a level of reallistc, and provide opportunities to the natural enemies to operate for the equilibrium.

PRESENT STATUS OF RESISTANCE BREEDING

1. Breeding for blast resistance

Breeding for the resistance against blast disease was one of solid objectives of rice breeding since 1915 when the artificial rice hybridization was started to improve rice varieties in Korea. Many resistant sources were introduced from Japan, China and Philippines and utilized incorporating into Japonica varieties through back-crosses or polycrosses to Japonica parents. The significant blast resistance ʼith high yielding potential under heavy nitrogen lication was demonstrated by the release of gil type cultivars. Farmers experienced that ıalanced heavy fertilizer application can lead h yield only with highly blast resistant culti- The breakdown of Tongil type cultivars due ous blst infestation in 1978 forced breeders to he stabilization of blast resistance of that ielding Tongil type cultivars.

rts for searching broad resistance were acted with a hope that the broad resistance may t longer and damage in a lesser degree when ›last races come out. As shown in the Table ne cultivars show resistance both in Korea

: 1. Annual losses due to rice pests during last decade

	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	Mean
)is a es	4.2	10.0	6.3	5.7	3.2	2.5	2.7	6.7	4.8	6.0	5.3
ns cts	4.0	3.8	1.7	1.6	7.3	1.9	1.5	3.8	1.6	1.9	3.2
'o al	8.2	13.8	8.0	7.3	10.5	4.4	4.2	10.5	6.4	7.9	8.5

Report on plant protection project. 1980. ORD (Cited from Lee)

and Philippines. We found quite many entries in the International Blast Nursery showing this kind response. But the rise and decrease of race population of blast fungus is in a functional relationship with the acreage of specific cultivars being planted currently. This relationship was very well depicted by Chung (1979) and Lee (1982). The change of susceptibility-resistance response is variable depending on the location and cultivars as shown in Table 2. Under the situations such as variable depending on the cultivars, locations and years, the better breeding strategies for stable resistance are required urgently.

Table 2. Blast response of some cultivars in the KOREA-IRRI coordinated blast nursery in 1980

Location	Blast reaction			
Suweon	S	S	R	R
IRRI	S	R	S	R
	Tongil	Jinheung	S 284	S 287
	Yushin	Matsumae	S 294	S 288
	M23	Ishikari	Iri 338	S 291
	Nopung	Tsuyuake	Iri 348	S 292
	Raekyung	Kanto 51	M30	S 235
	Tongil chal		M42	Satominori
	Norin 6			Tetep
	M15			Raminad St 3
	Aich A.			IR 5533
	Pi 4			

2. Breeding for the resistance to bacterial leaf blight(Blb)

According to the results of survey made by IAS for the distribution of pathotype of causal bacterium, all of the five pathotypes which are identified in Japan (Horino 1981) and Philippines (Mew and Vera Cruz 1979) exist in Korea too (Choi 1982), though the pathotype IV and V are very rare. The local distribution of those pathoypes are shown in table 3 (IAS 1980). As we see in the table, the pathotype I is spread all over the country, the pathotype II is found in the most of the area of the counrty, and the pathotype III is still being localized to a limitted area. If a cultivar has resistance to the bacteria belong to all of the patho-

Table 3. Provincial distribution of *Xanthomonas oryzae* groups in Korea during 1980(IAS)

	Bacterial group				
	I	II	III	IV	V
Seoul	1	0	0	0	0
Gyenoggi	17	0	1	0	0
Gangweon	13	5	0	0	0
Chungbug	7	1	0	0	0
Chungnan	8	4	4	0	0
Jeonbug	12	6	0	0	0
Jeonnam	10	6	3	0	0
Gyeongbug	23	0	0	0	0
Gyeongnnam	9	2	1	0	0
Total	100	24	9	0	0
%	75.2	18.0	6.8	0	0

type I, II and III, hopefully we can prevent the bacterial leaf blight with only varietal resistance with more than 95% safety.

Most of the recently released cultivars have resistance to the pathotype I and II as shown in the Table 4. The resistance source of pathotype III is not well established yet, and only a few tropical cultivars are known to have resistance to pathotype III in Korea (Choi 1982). The efforts are being made to transfer the resistance to the breeding lines.

Table 4. Varietal response to the bacterial leaf blight (IAS 1981)

	Pathogroup			
	I	II	III	IV
Taebaeg	M	MR	M	R
Nampung	R	R	S	S
Hangangchal	R	R	M	M
Seogwang	R	R	S	S
Pungsan	R	R	S	S
Baegang	R	R	M(S)	M
Chugchung	R	S	S	S
Milyang 30	R	M(S)	S	S
Milyang 42	R	R	R	R
Milyang 23	S	S	S	S

3. Breeding for virus resistance

Stripe, dwarf and black streaked dwarf which are transmitted by samll brown planthopper (*Laodelphax striatellus*), rice green leafhopper (*Nephotettix cincticeps*) and zigzag leafhopper (*Recillia dosalis*), and small brown planthopper respectively are the main rice virus diseases in Korea. Most of the Japonica rice cultivars, except a few such as Milyang 15, are susceptible to stripe disease. Until Tongil type cultivars were released, the stripe disease was found everywhere in south Korea. The distinct resistance of Tongil cultivars to the stripe disease fully demonstrated that how a resistant cultivar can prevent effectively the virus diseases (Table 5).

Table 5. Virus response of some Tongil type and Japonica type cultivars

Cuitivar	Virus reading		
	Stripe	Black streak	Dwarf
Taebaeg	0	3	3
Seogwang	0	1	3
Gaya	0	3	3
Samnam	5	3	3
Gwanag	5	3	5
Eunha	5	3	3

The dwarf virus which is noticeably increased since about 1967 is still growing the area without distinct resistant cultivars to countermeasure the spread of the disease. Though the Tongil type cultivars do not show distinct resistance in the laboratory,some of them show significant reduction oi virus infection in the field and cut down the viru: spread.

Black streaked virus was noticed in 1973 in Kore: and still the incidence is localized to a few areas but the spread to other areas are expected due no distinct resistant cultivars.

4. Breeding for brown planthopper resis

The breeding for the resistance to brown hopper which is practically initiated in 1971 is progressed successfuly. As shown in Table (cultivars released recently are resistant to a one biotype of Bph and some of them show tance to all of three biotype Bph. Up to 198 differentiation of biotypes was noticed in Since 1980 informations from IRRI called att about the differentiations of biotypes Ⅱ and Ⅲ in mainland China where the insects originating the migration into Korea every year. Several IRRI lines which has resistances to all of three biotypes were crossed into Korean breeding lines and some of their breeding lines were screend in IRRI against the insects of three biotypes. No breakdown of resistance of particular biotype was experienced yet in Korea. Patient survey of insect migration may give us the clue to solve the monogenic resistance breeding.

5. Breeding for white back planthopper resistance

Rice damages caused by white-back planthopper (Wbph) are comparable to those caused by Bph in Korea. Nevertheless, the breeding work against Wbph was not actively progressed. This is due to lack of resistance sources readily available and short in hand to work for insects rearing in breeding field. As the resistant IRRI breeding lines became more easily available the efficiency became noticiably increased and some of advanced lines show resistance to the Wbph in addition to the resistances against all of the Bph biotypes (Table 6).

RESISTANCE SOURCES BEING UTILIZED

1. Blast resistance source

Quite many IRBN entries were mentioned by Ou

Table 6. Breeding lines showing resistances to brown planthopper and whiteback planthopper

Line	Bph biotype I	Bph biotype Ⅱ	Bph biotype Ⅲ	Wbph
ι	R	R	R	MS
	R	S	R	MS
	R	S	R	MS
	R	S	R	MS
71-31	R	R	R	M
1-70-1	R	R	R	MR
3-45-4	R	R	R	MR
4-30-4	R	R	R	R
6-43-2	R	R	M	S
5-56-1	R	R	R	MR

Table 7. Varieties most resistant to blast, IRBN 1964~1973. (from Ou)

Variety	Total tests	Resistant(%)
Tetep	302	98.0
Nang chet cuc	292	95.9
Tadukan	309	94.5
Trang cut L. Ⅱ	263	94.3
Pah Leuad Ⅲ	258	94.2
C46-15	307	93.8
Mekeo White	276	92.8
H-5	314	92.7
R-67	291	92.4
Ram Tulasi(sel)	297	91.9

Table 8. Blast response at IRRI blast nursery(1980)

Cultivar	Blast reaction Jan 20	Blast reaction July 20
IR8	5	6
IR20	7	5
IR24	8	7
IR26	8	7
IR36	5	6
IR42	5	4
IR50	6	6
IR52	6	6
IR54	5	5

Table 9. Blast response at IRRI blast nursery (1980~1981)

Cultvar/line	Blast reaction seeded in May	July	Sept.	Nov.	Jan.	Mar.
IR10154-20	1	1	1	1	1	1
IR10176-24	1	1	1	1	1	1
IR1905-81	1	1	1	1	1	1
IR1905-PP11	1	1	1	1	1	1
IR3259-5	1	1	1	1	1	1
IR3273-289	1	1	1	1	1	1
IR4547-2	1	2	1	1	1	1
IR5533-PP854	1	1	1	1	1	1
IR9660-00948	1	2	1	1	1	1
IR9667-PP846	1	2	1	1	1	1
IR24	7	7	8	7	8	8

(1979) as the broad resistance source (Table 7). But, most of those are not accepted as amiable one for Korean breeders due to their strange ecological adaptability. Even well trimmed IRRI bred lines are not very suitable source for blast resistance (Table 8). A number of lines showing resistance consistently at IRRI (Table 9) were introduced and being utilized as the resistance source for blast and other diseases. The application of source varieties for field-resistance or slow blasting is not actively conducted yet simply because no available proper screening techniques.

The clear pattern of alternation of blast race groups along the change of varietal groups demonstrate us that we can group both the resistance source materials as well as blast races according the resistance-susceptible responses.

2. Blb resistance source

As we see in the Table 4, many cultivars have resistances to the bacteria belong to pathogroup I and II, and a few cultivars are possessing resistance to even up to pathogroup III and IV (Table 10). Many IRRI bred lines which have broad resistance to Blb and early enough so as they can mature in time are available also.

Table 10. Resistance sources for bacterial leaf blight (from IAS 1981)

Cultivar	Pathogroup			
	I	II	III	IV
Milyang 42	R	R	R	R
Hankangchal	R	R	M	M
Baegyang	R	R	M	M
Chupung	R	R	R	R
Baegunchal	R	R	M	R
IR1545	R	R	R	R

Survey of pathogenic bacteria made in IAS (Choi 1982) show the variability of pathogenic reactions of bacteria within a pathogroup. As shown by Yoshimura et al. (1982), if the differential varieties could be identified properly so as we can single out the resistance gene/genes, the ambiguous variable response would become clear.

3. Virus resistance source

Most of the parental materials introduced from

Table 11. Virus resistance sources

Designation	Virus reanding (YCES)		
	Stripe	Blackstreaked	Dwarf
Iri 350	0	1	3
Iri 356	0	0	3
Suweon 309	0	1	3
Seogwang	0	1	3
Suweon 311	0	1	3
Gwanag	5	3	5

IRRI showed resistance to stripe virus and some of those showed recognizable tolerances to dwarf virus and black streaked virus. All of Tongil type cultivars are resistant to stripe virus and some of those showed discernible tolerance to black streaked virus and dwarf virus (Table 11). A few Japonica cultivars released recently are holding resistance to stripe virus derived from Chukoku 31. No Japonica cultivars showing resistance to dwarf and black streaked virus was found. Efforts are being made at Youngnam Crop Exp. Stn. to identify the preferable source parents through IRTP.

4. Bph and Wbph resistance sources

Many of IRRI bred lines are possessing multiple resistances to the different biotypes of Bph and Wbph in addition to the desirable plant types (Table 12). But, most of those are too late for Korean weather and their rice qualities are not acceptable. Neverthless, the resistance of these materials are inherited monogenicaly or oligogenicaly and relatively

Table 12. Responses to the brown planthopper, white back planthopper and green leafhopper of some IRRI released cultivars

Cultivar	Bhp biotype			Wbph	Glh
	I	II	III		
IR 28	R	S	R	M	M
IR 32	R	R	R	R	MS
IR 36	R	R	R	M	MS
IR 46	M	MS	R	MS	MS
IR 50	R	R	R	MS	M
IR 52	R	R	R	MS	M
IR 54	R	R	R	S	R
IR 8	S	S	S	S	S

simple to transfer to another lines provided the proper screening techniques are available.

BREEDING STRATEGIES

1. Blast resistance

Several plausible strategies were suggested to countermeasure the blast disease. Some of them are already in trial application and others are still remained in the demension of pure theory. Some of them are proved to be effective by other crops but not practiced with rice. It would be worthwhile to be discussed briefly here about their significance and applicabilities in the rice blast resistance breeding.

a) Introduction and integration of new R genes.

Introduction of different resistance genes and cumulating them on to one cultivar was progressed with the hopes to breed a line which has many resistance genes to many blast races. Thus, as we see in the Table 13, the "Tongil" cultivar was bred to introduce the resistance genes from "IR 8" which has the resistance genes derived from "Peta", "TN-1" and "Yukara". "Nopung" and "Raekyung" had the same resistance genes as the "Tongil" possessed and they broke down at the same time. "Taebaek" has cumulated resistance genes from "IR 24" which has resistance genes from "Century patna", "SLO 17" and "Sigadis", and from "IR 747" which has the resistance gene of "TKM-6". How long this "Taebaek" would stand against new races is questionable now. In this way, there is no guarantee yet to escape from so called "Boom and bust cycle of resistant cultivar production (Robinson 1976).

Table 13. Introduction of new R genes

Tongil	=IR 8
Nopung	=Tongil
Raeggyeong	=Tongil
Taebaeg	=IR24+IR747
312	=Carreon+Tetep
ameong	=IR24+VZ192
ri357	=Tetep+Tadukan+Gp15+IR747
Chungchung	=Tetep+IR24
155	=Sigadis+IR747+KDM105

b) Pyramiding of R genes

Ou(1980) emphasized the selection of stable resistance pyramiding many resistance genes through multiple crossing utilized several donors and testing at many locations during many years. But, he did not discussed about the efficiency of the pyramiding many resistance genes on to an agronomically elite line.

c) Rotation of resistance genes.

Crill et al. (1981) suggested rotation of monogenic resistance cultivars under the strictly controlled cultivar management. Theoretically, they assume that there are inexhaustible resistance sources and these resistance break down by only monogenically. Then, as soon as the original cultivar becomes susceptible due to the appearance of pathogenic new race a, release the cultivar A which is bred against the race. As soon as the cultivar A becomes susceptible due to the evolution of race b, release the cultivar B which is resistant to race b. In this way, sometime after, the old races may come out again and then old cultivars which were bred against those races may show resistance again as indicated by Chung (1979), here, the difficulties are the prediction of new races to come up and breeding against for them in time.

d) Deployment of R genes.

Browning et al. (1969) suggested to make 2-3 zones of resistance cultivars with deployment of special resistance genes so as to block the seasonal spread of rust infections from the south Texas to the north of Minnesota. But this was not practiced due to the difficulty achieving many resistance genes and pressure to the local breeders.

e) The use of multilineal or composite varieties.

Borlaug (1958) has demonstrated methods employed in developing multilineal varieties. Kiyosawa and Shiyomi (1972) showed the effectiveness of multilines by mathematical analyses. Ezuka(1979) citing Shindo's unpublished data demonstrated the effectiveness of mixed cultivation in reducing the s-type lesion of leaf blast and panicle infection index (Table 14). Considering the time factor required to breed nearisogenic lines and the time factor allowing to the fungus to variate we do not have enough supporting data yet. Also the possibility to

Table 14. Effect of mixed cultivation of varieties with different true resistances to blast (cited from Ezuka)

Variety	True resist ance gene	S-type lesion no./hill	Panicle infection index	Yield Kg/3,3m²
Mono culture				
Fukei 69	pi-k	12.25	8.68	1.58
Tohoku108	pi-a, pi-i	25.75	23.78	1.58
Toyonishiki	pi-a	7.25	4.08	1.95
Average		15.08	12.18	1.70
Mixed culture		2.25	1.68	1.98
Mono culture				
Bikei91	pi-k	0	0.03	1.83
Miyoshi	pi-a,pi-i	3.25	6.18	1.75
Norin41	pi-a	15.50	23.10	1.75
Average		6.25	9.97	1.80
Mixed culture		1.75	3.45	1.83

produce a so-called super race in the expanded multiline culture are not fully excluded.

f) Horizontal resistance.

Robinson (1976) postulated the horizontal resistance as universal and permanent one in the genetically flexible crop populations. He explained the stability of horizontal resistance citing the Person model (Fig 1) which arriving at the stability through the selection for reproductivity in parasite and the selection for reproductivity in host. He attributed the cultivar susceptibility to the errosion of horizontal resistance and insisted that the errosion of the resistance could be restored by breeding. But, no clear mentioning was made about the possibility that a cultivar which has horizontal resistance would never become susceptible by vertical specific race fungus. Until the breeding devices are

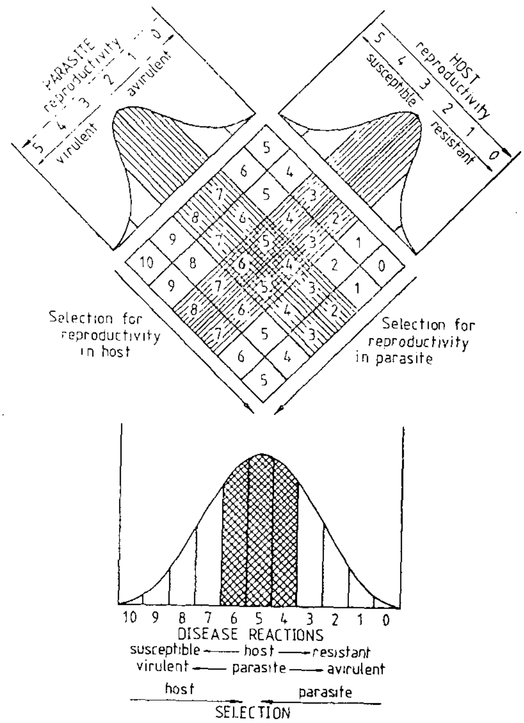

Fig. 1. Paths of depression associated with typical mass immigration (TYP) and minor immigrations (MF_2) of Bph and Wbph and minor immigration of Wbph (MF_1)

Table 15. Reaction of some japanese field resistant varieties to P. *oryzae* In IRRI (1979)

Variety	Reaction to the isolates								Resistance in Japan	
	T23	T28	T36	T37	T55	T56	T61	T63	True	Field
Ou 247	S	R	R	R	R	S	R	S	l	rr
Tokai 26	R	R	R	R	R	S	S	R	l	rr
Murasaki ine	S	S	S	S	S	S	S	S	l	rr
Suzuhara M	S	S	S	R	S	S	S	S	l	rr
Rikuto N 24	S	S	R	R	R	R	Rm	R	l	rr
Ishioka 3	S	S	S	S	S	R	S	S	l	rr
Sensho	Rm	R	R	S	S	Rm	S	R	l	rr
Fukuton	R	R	R	Rm	R	R	R	R	l	rr
Rikuto N M 26	Rm	Rm	R	S	R	Rm	R	R	l	rr

developed so as the horizontal resistances could be manipulated geneticaly, the horizontal resistance breeding would be staggering.

g) Field resistance

Field resistance is the resistance which can be detected under natural conditions in the field. Theoretically the field resistance could be grouped into race specific and race-nonspecific because the criteria which grouping true resistance and afield resistance is different from the criteri grouping race specific and race-nonspecific. Nevertheless, the field resistance is generally considered as race-nonspecific one and governed by polygenic systems (Kiyosawa 1980). Field resistance generally is spoken as the one which we can cumulate and can avoid the breakdown, but difficult to utilize in breeding (Yunoki et al. 1970).

Ou examined the reactions of several Japanese cultivars known as possessing both resistances of true and field, to the isolates at IRRI (Ou 1979) (Table 15). From the results and the facts that we observed in the IRRI blast nursery which showing reversed resistance -susceptibility reactions of Japanese cultivars we are skeptic to utilize those field resistances in our breeding program. How the racenonspecific field resistance inherits and can effectively be transfered into breeding lines are not well understood.

h) Combination of true resistance and field resistance.

Kiyosawa and Shiyomi (1976) demonstrated by the mathematical simulation that the combination of true resistance and field resistance could retard a cultivar to become susceptible and reduce the disease severity after a cultivar becomes susceptible. To combine both resistances in a line effectively, backcrosses using true resistance parent as non-recurrent parent and field resistance parent as the recurrent parent, are suggested (Kiyosawa 1980). Whatever the combination program is, to screen those resistances effectively, we need proper inoculums which cope with those resistances. The identification of those inoculums specially for field resistances and the screening techniques for those resistances are not well understood.

i) Slow blasting cultivars.

Villareal (1980) have identified several cultivars which showing slow blasting and infered the relevant characteristics of those cultivars to suppress the disease progress. Considering the differences in virulence of pathogenic races, how widely and effectively this kind resistances can be applicable is questionable.

2. Bacterial leaf-blight resistance

As we have seen in the Table 3 and 4, the major pahtogenic bacteria belong to pathogroup I and II (more than 90%), and most of current cultivars have the resistances to both bacteria. Nevertheless, we often observe severe infection and drastic yield reduction. Perhaps this is due to inadequite identification of isolates to use for breeding. Horino(1981) reported relatively high heritability of the resistances of IRRI bred lines such as IR26 and IR28 ranging from 0.909 to 0.714. As Yoshimura (1982) has shown, different cultivar can have different resistance gene either dominant or recessive to a same bacterial isolate.

To breed rice effectively against bacterial blight in Korea, the identification of appropriate isolates to screen breeding materials with it, is paramount requirement. The resistance-susceptibility response is so much influenced by the dosage of bacteria that the race specificity is sometimes not conspicuous. Also the variability of the bacterial isolates bring more difficulties in the identification of applicable isolates. Many resistance genes showing resistance to the bacteria belong to pathogroup I are reported (Yoshimura et al. 1982). But, only a few resistant genes showing resistance to pathogroup II and III are reported, though many cultivars showing resistances to those pathogroups are reported already.

3. Virus resistances

Present systems which is adapted for breeding against stripe virus are quite successful. The breeding systems for dwarf virus and for black streaked virus which is currently operated in Youngnam Crop Experiment Station are also seems appropriate provided enough resistant parental materials. A number of resistant parental cultivars are reported already (Ling 1975), and the ways to transfer those resistances into breeding lines are well understood. As soon as we can have a resistant

Table 16. Source materials resistant to planthoppers

Designation	Reaction To				
	Bph			Glh	Wbph
	I	II	III		
IR 13427-40-2	1	1	1	3	3
IR 13429-287-3	1	1	3	3	5
IR 15314-43-2	1	1	1	3	5
IR 19735-5-2	1	1	5	3	5

cultivar which is resistant to those viruses we may be able to block the spread of those viruses towards north.

4. Hopper resistances

Some of IRRI bred lines show satisfactory resistant responses to the brown planthopper, white-back planthopper and green leafhopper besides showing desirable agronomical characteristics such as productive plant type and early maturity (Table 16). Though the brown planthoppers and white-back planthoppers do not over-winter in Korea, because they are immigrating from mainland China every year, we have to be prepared with resistant cultivars to all those biotypes of hoppers which might have in China. The present systems to breed against these hoppers are relatively successful and effective. Introduction of still better parents from IRRI may increase efficiency in the integration of hopper resistancies

FUTURE PROSPECTS

In Korea, for the rice breeding systems are relatively well established and the resistance sources are relatively well supplyed through IRTP and the selection facilities and techniques are being further improved. But, in some fields, there are problems which requiring immediate solutions or further improvements in accessing pathogens or introducing better resistance sources.

Breeding for the blast resistance, both the pathologists and breeders are requested to pay deep considerations on the assessment of pathogenic races and on the resistances of hosts to be utilized. Kishimoto(1973) traced and demonstrated the paths of Bph and Wbph migration from mainland China to Korea and Japan along the air current during from June to August. Teng et al. (1979) made clear the routes and season for the migration of Bph in mainland China. Stakman and Harrar stated in their book (1957) that fungus spores after once having attained altitudes up to 10,000 feet, may be carried indefinite distances by mass air movements unless brought to earth by down currents or by rains. They mentioned an example which the rust spores were spread from Mexico to Canada during 1923 to 1935. Then, what will be the possibilities that the blast spores can be brought from mainland China and from Japan to Korea by air mass (Fig. 2) We expect this will be cleared by pathologists and also expect that the strategies to overcome blast epidemics may need modifications along this line.

Breeding for the Blb resistance,the collection and grouping of bacteria and identification of proper isolates to work with are argued first of all. The resistance sources will be assessed along the necessary isolates.

Breeding for the virus resistance, the efforts to search better resistance sources will be continued to overcome the dwarf virus and black-streaked virus.

Breeding for the hopper resistances, breeding efficiency will be improved through the introduction of better resistance sources and improved management of screening techniques.

So called innovative techniques such as pollen culture and CMS-hybrid will be improved. Severa breeding lines derived from pollen culture are al

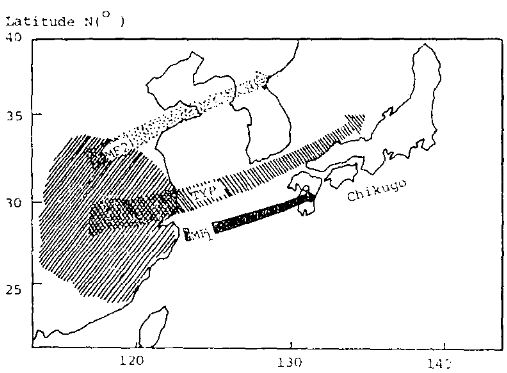

Fig. 2. The Person model.

ready in advanced trials. Several current cultivars are good maintainer and others are good restorer of Chinese CMS. The improved CMS-hybrid may add a new strategy to the blast resistance breeding.

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