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IMPLICATION OF THE INTERNATIONAL RICE BLAST NURSERY DATA TO THE GENETICS OF RESISTANCE

an approach to a complicated host-parasite relationship

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IMPLICATION OF THE INTERNATIONAL RICE BLAST NURSERY DATA TO THE GENETICS OF RESISTANCE[1]

-------An approach to a complicated host-parasite relationship-------

ABSTRACT

The lack of a system for describing the types of host resistance and fungal races is a major problem in research on rice blast because of the wide variability of *Pyricularia oryzae*. A first step toward developing functional differential varieties is knowledge of the prevailing types of host resistance. This paper examines the International Rice Blast Nursery (IRBN) for some primary data for better understanding of the prevailing types of host resistance.

Of 397 entries tested in the IRBN in 1976-77, 261 were classified into 10 major types of resistance. The resistance patterns of groups of varieties represented by Tetep, Carreon, *O. nivara*, Sigadis, and Dawn clearly discriminated each other based on reactions at many sites; however, it was difficult to distinguish the type of resistance by Tetep from that by Zenith. Some large groups of varieties classified on the basis of their reactions in the Philippines also showed more or less similar reactions in other countries, strongly suggesting that such varieties may have a similar genotype.

The present differentials in the IRBN appear irrelevant to the prevailing host resistance patterns. More functional differentials should be developed in the IRBN to diversify the types of resistance sources. Functional differentials will permit identification of the type of resistance of new IRBN entries.

Segregations of sister lines within a cross in the IRBN are indicative of possible genic relations among the major types of host resistance. A tentative set of differentials to maintain distinct races is proposed to facilitate the genetic analysis of blast resistance.

[1] By H. Ikehashi, former plant breeder, Plant Breeding Department, International Rice Research Institute, Los Baños, Laguna, Philippines. Submitted to the IRRI Research Paper Series Committee August 1978.

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IMPLICATION OF THE INTERNATIONAL RICE BLAST NURSERY DATA TO THE GENETICS OF RESISTANCE

------ An approach to a complicated host parasite relationship ------

Rice blast is probably not a major threat in most of the irrigated rice fields of the tropics. Although some IRRI varieties, such as IR26 and IR36, have only moderate blast resistance, they are widely accepted by Asian farmers.

Special difficulties arise in breeding rices for blast resistance because of the wide variability of the causal organism (Ou and Ayad 1968, Ou et al 1970). Significant progress in breeding for resistance will require establishment of methods to describe races, and a critical study of the various types of the host plant resistance.

This paper reviews the general nature of differential varieties, and applies some principles from the review to analysis of data from the International Rice Blast Nursery (IRBN). I present suggestions for improvement of the differential varieties and the IRBN as a base for future work on the genetics of blast resistance.

A REVIEW OF THE PROBLEM

A set of differential varieties is essential to an understanding of the diversity of the blast disease organism. Before examining the specific nature of the differentials for blast, it is necessary to examine their general nature.

Nature of differentials

If two varieties react differently to one fungal race, the two varieties are differentials. Two differential varieties can theoretically discriminate four types of races. Potentially, 4 differential varieties can distinguish 16 races, and so on. Based on eight varieties of the international differentials (Atkins et al 1967), all possible blast races ($2^8 = 256$) are named by a number system (Ling and Ou 1969). The greater the number of varieties used as differentials, the greater the number of races that can be differentiated (Ou et al 1979). If a disease organism varies widely in its infectibility, and if a large number of varieties must be handled, the number of races and differential varieties can easily exceed a manageable limit. If this is the situation currently faced with blast, how can this exhaustive interaction between the number of races and the differentials be overcome?

Some previously proposed national and international differential varieties have never been used intensively against blast disease, except in Japan, and where the differentials were improved as a functioning standard (Yamada et al 1976). Although the present international differentials have been used in Taiwan (Wu et al 1976) and India (Veeraraghavan 1975), those and Philippine differentials (Bandong and Ou 1966) are not very effective (Table 1).

Because the causal organisms vary unpredictably, any effort to arbitrarily select a set of differential varieties to identify races of a causal organism will likely be unsuccessful. Instead, *a functional set of differentials should primarily be founded on the genotypic divergence of the host plant.* In fact, in a certain area, or in a certain range of breeding activities, there is a relatively limited number of resistant genes that would enable us to construct a system for differentiating causal organisms. When distinct resistant genes are identified in the host plant, the causal organism would show a diversity corresponding to that in the host resistance.

Although there has been some work on genetics of blast resistance in the tropics (Padmanabhan et al 1973, Tepora and Jennings 1966), it has been rather isolated and has never systematically searched for genes in many varieties. A reason could be that the work was done before an extensive survey of prevailing types of host resistance was made.

The base for further work should be the identification of prevailing resistance genotypes that function in a certain way in a given area. To determine the prevailing resistance genotypes, a theorem that has never been consciously applied in blast resistance work in the tropics should be used.

The theorem

A group of varieties with identical genotype react to various races uniformly. But their uniform reaction does not imply that the varieties have an identical genotype. The varieties would have a common genotype only when they react uniformly when exposed to diverse races (Fig. 1).

To apply the theorem a hypothetical isogenotype group can be composed based on uniform reaction from primary data. Following that the group should be tested at diverse sites and in different years to determine whether they react uniformly. If the group of varieties reacts uniformly, there is a good possibility that they have an identical genotype. If not, the group should be reclassified. A systematic examination such as this would lead ultimately to the recognition of some groups of varieties with an identical genotype.

In actual trials, however, there is no guarantee that rice varieties are exposed to sufficiently

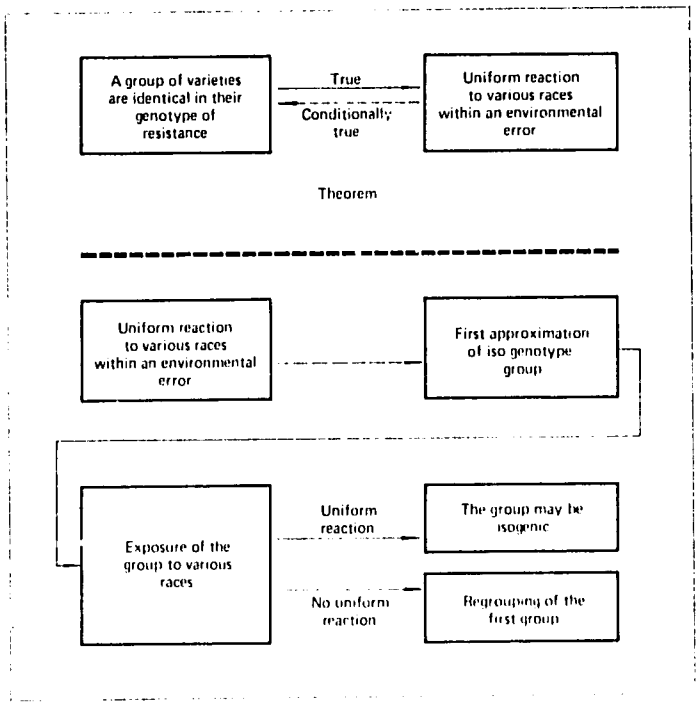

Fig. 1. Application of theorem.

different races to reveal differential reaction. In many cases, different genotypes show similar reactions because of the lack of differential races. Therefore, it is important to establish an artificial inoculation system with truly different races.

The number or the magnitude of each of such isogenetic groups would provide information on the diversity of the resistant sources and their stability at various sites. This should be the start of scientific breeding work. The next step would be to analyze resistant genes through hybridization of the different groups.

Use of the International Rice Blast Nursery data

The IRBN should permit a test of the theorem. The IRBN should be checked to determine whether it can satisfy the requirement for determining major genotypes of blast resistance.

Some limitations in the IRBN data are noted:

- Except for a small number of differentials, the IRBN entries have been chosen for their resistance at many sites. The primary objective is identifying resistant sources. Thus, there has been no attention to the development of diversity in IRBN, and this might have led to the elimination of entries with resistance at a limited number of sites.

- Most of the IRBN breeding lines come from IRRI after confirmation of their resistance at Los Baños. Because their source of resistance has been relatively limited, the diversity of the resistant types might have likewise been limited.

- Not all test sites have given a wide distribution of scores from resistance to susceptibility. At some sites, most IRBN entries are often rated resistant.

- Only a limited number of varieties from the international or other differentials have been included in IRBN because of difficulties in increasing their seed.

- Resistant breeding lines have not been systematically tested along with their parents.

- The IRBN entries for each year are tested with a limited number of races at about 20 sites, despite the great geographic divergence available. This is a serious drawback if one attempts to compose reasonable differentials based on the IRBN.

- The IRBN data reflect the judgment of many individual scientists who take the readings. There may not be full agreement in use of the rating system among participating scientists.

Despite these limitations, careful analysis of the IRBN data will be useful for further work. The following methodology is therefore adopted in data analysis.

ANALYSIS OF THE IRBN DATA

The IRBN data were sorted and classified for reaction types among the entries.

1. Only tests with reliable levels of infection were used (Table 1). The criteria were that disease scores showed a full range of reactions from resistance to susceptibility, with a substantial number of entries in each rank and no ambiguity in the recording system.

2. Classification of resistance types was made primarily on data from the Philippines, with data from other countries as supporting evidence.

In determining reaction types the following procedure was followed:

- Entries showing distinct resistant or susceptible reaction in the four tests in the Philippines were taken.

- o Intermediate reactions were used as a secondary criterion for entries showing two or three distinct reactions of susceptibility or resistance.

- o Entries showing distinct reaction to Philippine races were used because the contrasting results of tests in Leyte and Los Baños indicate distinct Philippine races.

Table 1. Reaction of existing sets of differentials in the International Blast Rice Nursery.

Line or variety	Reaction[a] to blast										
	Basic criteria				Secondary criteria						
	Philippines				Bumbong Lima						
	IRRI		Leyte		Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
	'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
U.S. differentials											
Zenith	3	1	3	1	3	3	1	1	4	3	1
Lacrosse	9	9	9	-	9	-	3	-	1	-	-
Caloro	1	-	6	-	6	-	7	-	9	-	-
Purple) No entries											
Straw)											
CI5309	8	5	5	1	9	9	3	2	7	2	8
Dular	5	3	6	1	4	4	5	1	4	4	2
NP-125	4	1	5	1	2	-	1	1	1	-	-
Raminad Str. 3	4	1	2	1	3	2	3	1	9	3	2
Wagwag	4	-	3	-	1	-	1	1	4	-	-
Rexoro											
Philippine differentials											
Kataktara DA-2	4	4	4	3	5	3	3	1	8	2	1
CI5309	8	5	5	1	9	9	3	2	7	2	8
Chokoto	8	8	7	4	9	5	8	2	7	3	4
Co 25	5	7	7	4	8	8	5	6	5	8	2
PI231129 (Wagwag)	4	-	3	-	1	-	1	1	4	-	-
Pai-kan-tao	1	-	4	-	-	-	2	-	6	-	-
Peta	7	8	7	8	9	9	9	9	7	7	4
Raminad Str. 3	4	1	2	1	3	2	3	1	9	3	2
Taichung T.C.W.C.	9	9	8	8	9	9	9	9	3	9	-
CI8985 (Lacrosse)	9	9	9	-	9	-	3	-	1	-	-
CI8970 (Straw)	No entry										
Khao-teh haeng 17	9	9	8	8	8	9	9	9	3	8	3
International differentials											
Raminad Str. 3	4	1	2	1	3	2	3	1	9	3	2
Zenith	3	1	3	1	3	3	1	1	4	3	1
NP-125	4	1	5	1	2	-	1	1	1	-	-
Usen	5	4	7	6	8	5	8	5	1	5	3
Dular	5	3	6	1	4	4	5	1	4	4	2
Kanto 51	9	4	7	1	8	6	9	2	6	-	4
Shia-tia-tsao (S)	9	-	5	-	9	-	9	9	9	-	-
Caloro	1	-	6	-	6	-	7	-	9	-	-

[a]1976 Standard Evaluation System for Rice Scale of 1-9: 1 = none to small brown specks of pinhead size, 9 = 100% of leaf area infected.

Classification of types of resistance

From 397 entries tested both at Los Baños and Leyte in 1976 and 1977, 261 entries were classified into 10 major types (Table 2). Subtypes were composed for each major group based on reactions outside the Philippines.

The more or less uniform reactions in the other tests, of those types classified in the Philippines suggested that each group may have a similar genotype. The fact that sister lines from the same cross often fell in the same group also indicated that the grouping reflected some similarity in genetic background.

Some minor groups had two or more scores of ambiguous resistance in the Philippines, and showed some significant differences within the

group at other sites. For such groups, further tests are needed.

Obviously, groups I-IV represent many of IRRI's resistant lines.

Group I. Among the 397 entries, 81 showed resistance at 4 tests in the Philippines. They are classified into several subgroups according to the reactions in other countries.

A group of 49 entries represented by Tetep is characterized by overall resistant rea tions in the testing sites, except in Colombia, where many lines showed moderate resistance. Some lines (CIAT-ICA 9, two lines of IR9669, and Ta-poo-cho-z) were infected severely outside the Philippines.

Within group I, there is a subgroup similar to the Tetep subgroup, but distinguished from this subgroup by the intermediate reaction in Nepal. Three lines of IR3273 are between these two. This subgroup, tentatively represented by Zenith, is probably not easily separated from Tetep by many races, although Tetep and Zenith reacted differently to other races (Bandong 1965).

The third subgroup can be separated from the Tetep subgroup by the reaction in Nepal. Carreon, Dissi Hatif, Ram Tulasi, and probably Raminad Str. 3 (Table 2) seem to have a similar genotype.

The fourth subgroup represented by M302 from Sri Lanka shows resistance in the Philippines, but moderate resistance at other sites. A possible donor of resistance to IR946 (IR4-93-2/H4) is H4 or H105 (through IR4-93-2) from Sri Lanka, where this type of resistance could have been used.

The last four entries performed similarly in the Philippines, but clearly differed from the fourth subgroup in other countries.

Group II. Twenty-eight entries are classified in group II, which has distinct resistance at Los Baños but was susceptible in Leyte in 1976. Although this group seems almost continuously related to group III, which showed intermediate reaction in Leyte in 1977, the primary grouping according to reactions in the Philippines is accompanied by similar reactions in other countries. Reactions in Colombia in 1977 indicate some heterogeneity in this group.

The major subgroup in group II can be represented by IR1721-11-5-3-2-3-1, which was derived from IR24*3/*O. nivara*. Because IR24 had no resistance to blast at Los Baños during the tests, the resistant genotype could have been introduced from *O. nivara*. There is a possibility that this genotype can be governed by a single major gene from *O. nivara*, because it is unlikely that two or three genes were simultaneously introduced in the course of two backcrossings.

The other subgroup revealed clear blast susceptibility in Nepal similar to that of the Carreon subgroup.

Group III. Sixty-seven entries are classified in group III, which resisted the races at Los Baños but was susceptible in Leyte in 1976, and showed either intermediate reaction (as in subgroup A) or susceptibility (as in subgroup B) in Leyte in 1977.

Subgroup A is distinguished from the previous group's *O. nivara* types only in respect to intermediate reaction in Leyte in 1977, whereas the *O. nivara* type showed generally high level of resistance there. Hence, this subgroup is designated as sub-*O. nivara* type.

Subgroup B, possibly represented by IR34, is different from subgroup A in terms of clear susceptibility in Leyte in 1977, and is more clearly distinguished from subgroup B by susceptibility in Indonesia.

There are still some heterogeneous reactions in the entire group, which is clearly evident in Colombia and partially evident in Thailand and Nepal with lines IR2823 and IR2053.

Group IV. Group IV seems to be characterized by distinct resistance only at Los Baños in 1976 and by lack of significant resistance at other sites. Because it is likely that the resistance of IR1529-680-3 came from Sigadis, group IV is called the Sigadis group. Here the primary classification, according to the reactions in the Philippines, seems to be indicative of almost uniform reactions at other sites except in Colombia where possibly some different genes would be functioning. There are also some ambiguous patterns, some of which seem similar to those of group III. A closer look at the relationship between subgroup B and C is necessary.

Group V. Group V is represented by Dawn, which revealed susceptibility at Los Baños in 1976 but was resistant or moderately resistant at Leyte. The fact that this group does not include many IRRI breeding lines is probably due to the continued rejection of susceptible lines at Los Baños.

The first subgroup that can be designated by Dawn showed similar response to the races in other countries, indicating a similar background for this group. Besides, there seem to be at least two different types with two entries each in this group. Kanto 51 and Dawn have been proven to have the *Pi-k* gene in common (Kiyosawa 1974).

Group VI. Group VI is generally similar to group V, but may be distinguished by a distinct resistance shown at Los Baños in 1977. There are no good entries to represent this group, but due to the parentage of IR3271 (IR8*3/PK203//IR8/Dawn) and to the proximity to group IV, this can be named as the sub-Dawn group. It includes many IRRI lines, probably because those lines may occasionally show resistance at Los Baños. The four

Table 2. Classification of types of resistance to blast in IRBN[a].

Line or variety	Reaction[b] to blast										
	Basic criteria				Secondary criteria						
	Philippines				Bumbong Lima						
	IRRI		Leyte		Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
	'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
REACTION TYPE: RRRR (I)											
A Tetep	1	1	4	1	2	1	2	1	1	2	2
CIAT-ICA 1	1	1	3	1	2	2	1	1	4	2	4
CIAT-ICA 3	1	1	3	3	2	1	3	1	1	1	3
CIAT-ICA 5	1	1	1	3	1	1	1	1	1	2	2
CIAT-ICA 9	1	1	1	3	3	1	1	1	3	7	7
CIAT-ICA 10	1	1	3	1	4	2	1	1	3	3	4
CIAT-ICA 11	1	1	3	1	4	4	1	1	3	2	2
CIAT-ICA 12	1	1	1	2	4	3	1	1	3	1	3
CIAT-ICA 2	1	1	1	3	2	1	1	1	1	3	3
44/1433-100-802	1	1	1	1	4	3	1	1	3	3	3
1150/Obs 74	1	1	3	1	4	1	1	1	2	2	1
152/54	1	1	2	1	4	2	1	1	3	2	5
IR1905-P11-29-4-61	3	1	1	1	1	1	1	1	1	4	4
IR1905-PP19-73-2	1	1	3	1	2	1	1	1	1	4	4
IR1905-PP21-73-4	1	1	3	1	2	1	1	1	5	3	3
IR3259-PP8-172-6	1	1	1	1	1	1	1	1	1	4	2
IR3259-PP8-172-7	1	1	3	1	1	1	1	1	1	3	3
IR3259-PP11-182-4	1	1	2	1	1	1	1	1	1	3	3
IR3259-PP11-186-4	1	1	1	1	1	1	1	1	1	3	2
IR3259-PP11-186-4	1	1	1	1	1	1	1	1	1	3	2
IR3259-PP18-821-2	1	1	1	1	1	1	1	1	1	1	3
IR3273-289-2-1473	3	1	3	1	4	2	1	1	4	5	4
IR3273-342-1-6	1	1	4	1	4	2	1	1	4	3	4
IR3273-339-2-5	1	1	1	1	3	2	1	1	3	3	4
IR4547-14-3-1	.	1	1	1	1	2	1	1	1	3	6
IR5533-56-1-12	1	1	1	1	2	2	1	1	1	3	6
IR5533-55-1-11	1	1	1	2	1	1	1	1	1	3	5
IR5533-15-1-1	1	1	1	2	1	2	1	1	1	3	4
IR5533-14-1-1	1	3	1	3	1	2	1	1	1	4	4
IR5533-13-1-1	1	1	1	3	1	2	1	1	1	4	5
IR5533-PP850-1	1	1	1	1	1	2	1	1	1	3	5
IR5533-PP855-1	1	1	1	1	1	1	1	1	1	2	6
IR5533-PP856-1	1	1	1	1	1	2	1	1	1	3	6
IR9559-PP889-1	1	1	1	3	1	2	1	1	1	3	3
IR9559-4-1-1	1	1	1	1	1	2	1	3	1	1	4
IR9669-PP846-1	1	1	3	1	3	2	1	1	1	9	5
IR9669-PP836-1	1	1	1	1	1	2	1	1	1	9	4
IR9669-PP830-1	1	1	1	1	1	2	1	1	1	2	4
IR1905-81-3-1	1	1	1	2	2	1	1	1	1	3	3
IR2546-23-2-2-2	1	1	1	3	2	2	5	1	3	3	6
Ciwi/Alupi	3	1	3	2	1	2	1	1	3	4	1
Guatakka	1	1	3	1	-	1	3	1	-	1	1
Dissi Hatif (73127)	2	1	1	1	1	1	1	1	3	3	1
Ciwine	1	1	3	1	1	2	1	1	2	4	1
Campone	1	1	3	1	2	1	1	1	2	5	1
IR1416-1-42-2-3-3	1	2	1	3	1	2	1	3	1	2	3
IR1416-128-5-8	1	1	1	1	1	2	1	1	1	3	2
Secano Do Brazil	1	1	3	1	-	2	1	1	2	3	2
Ta-poo-cho-z	1	1	3	1	1	3	2	1	2	2	8

Table 2 (continued)

	Line or variety	Reaction[b] to blast										
		Basic criteria						Secondary criteria				
		Philippines				Bumbong Lima Malaysia						
		IRRI		Leyte				Indonesia	Thailand	Nepal	Indonesia	Colombia
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
REACTION TYPE: RRRR (I)												
B	Zenith	3	1	3	1	3	3	1	1	4	3	1
	B-72	1	1	1	3	2	2	1	1	5	2	2
	IR4547-6-2-3	1	1	1	1	1	2	1	1	4	3	4
	IR4547-6-2-4	1	1	1	1	1	2	1	1	4	3	4
	IR4547-6-2-5	1	1	1	1	1	2	1	1	5	3	3
	IR4547-6-2-6	1	1	1	1	2	2	1	1	4	3	5
	IR4547-6-3-2	1	1	1	1	1	2	1	1	4	3	6
	Tres Marias	1	1	1	1	2	2	1	1	4	3	1
	Washabo	1	1	3	1	2	2	1	1	4	2	1
	Ceysvoni	2	1	3	1	2	2	1	1	5	4	1
C	Carreon	1	1	1	2	1	2	2	1	6	4	2
	Colombia I	1	1	1	2	1	2	2	3	7	3	2
	HR6674-4-8-1-2	3	1	3	1	-	2	2	1	7	1	4
	CT2011-1	1	1	1	3	3	2	2	1	9	2	1
	Colombia II	3	1	3	1	3	2	4	3	8	3	2
	Dissi Hatif	3	1	1	1	1	2	2	1	8	3	2
	El Gopher	3	1	3	1	2	2	2	1	6	3	5
	818-3 BR9	3	1	1	1	3	2	2	1	9	2	7
	JKW S20	3	1	1	1	2	2	2	1	7	4	2
	Ramgarh	1	3	3	1	4	3	2	1	7	-	5
	Ram Tulasi	1	1	3	1	3	2	1	1	8	3	2
	Ram Tulasi (Sel.)	1	1	1	1	3	2	1	1	7	3	3
D	M-302	1	1	3	1	4	2	4	5	1	6	5
	TOS2300/7-3-4-10-B1	3	3	2	1	4	2	4	4	2	5	4
	IR946-33-2-2-2-2	1	1	1	3	4	5	5	5	5	7	4
	IR946-52-2-1-3-3	1	1	1	1	6	6	6	5	2	7	5
	H-5	1	1	2	1	4	2	5	3	5	3	5
	Leter 08	1	1	3	1	4	2	4	2	4	4	3
E	Miscellaneous											
	Chulweon 1	1	1	1	1	8	9	1	1	5	1	1
	Chulweon 3	1	1	1	1	6	9	1	1	3	2	1
	74-1407	3	1	3	1	1	2	9	2	3	6	1
	Chugoku 31	3	1	2	1	3	2	2	1	7	9	3
REACTION TYPE: RRSR (II)												
	O. nivara											
A	IR1721-11-5-3-2-3-1	1	1	7	1	5	4	1	1	2	3	5
	(Reference IR24)	(8)	(9)	(9)	(3)	-	-	(8)	(9)	-	-	-
	CIAT-ICA 8	1	1	7	3	4	2	1	1	5	3	8
	CIAT-ICA 13	1	1	7	1	4	2	1	1	3	3	3
	B-2	1	1	6	3	4	2	4	2	1	3	1
	IR4547-1-2	1	1	5	1	1	2	1	1	2	5	8
	IR4547-20-7	1	1	6	1	4	4	1	1	5	5	4
	IR4547-6-1-1	1	1	6	3	3	4	1	1	4	3	3
	IR4547-6-1-3	1	1	5	1	4	4	1	1	4	2	4
	IR4547-16-3-2	1	1	5	1	4	2	1	1	1	4	7

Table 2 (continued)

Line of variety		Reaction[b] to blast										
		Basic criteria				Secondary criteria						
		Philippines				Bumbong Lima Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
		IRRI		Leyte								
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
REACTION TYPE: RRSR (II)												
A	IR9660-50-3-1-1	1	1	5	1	3	2	1	1	1	2	4
	IR9559-PP871-1	1	1	5	1	4	2	3	1	1	3	4
	IR9559-PP870-1	1	1	4	1	2	2	1	1	1	2	3
	IR9559-00889-5-3	1	1	7	4	1	2	1	1	1	3	3
	IR2035-255-2-3-2	1	1	6	3	4	2	1	1	2	3	4
	IR2035-290-2-1-1	1	1	7	1	3	3	1	1	5	2	5
	IR2035-435-3-2-2-2	1	1	7	3	4	2	1	1	3	3	4
	IR2546-31-2-1-2	1	1	7	1	3	2	4	1	1	3	6
	IR2588-2-3-3	1	1	8	1	5	2	1	1	[illegible]	2	5
	IR2588-5-1-2	1	1	8	1	5	2	1	1	4	2	5
	IR2588-29-3-3	1	1	8	4	4	2	1	1	1	3	4
	IR2588-49-3-3-3	1	1	7	1	4	3	1	1	1	2	2
	IR2588-271-4	1	1	7	1	4	2	1	1	5	3	3
	IR2819-70-3-1	1	1	7	1	4	4	4	1	3	5	1
	74-5461	[illegible]	1	7	1	2	2	3	1	2	3	4
	74-5461 (B1. R. BG34-8)	1	1	6	1	3	1	3	1	5	3	4
B	B-24	1	1	7	1	6	4	3	2	7	3	2
	74-5499	1	1	5	1	2	4	2	1	9	3	4
	74-5507	1	1	6	1	4	4	1	1	9	3	4
REACTION TYPE: RRSM-RRSS (III)												
Sub-O. nivara type												
A	IR2328-198-1-3	1	1	8	5	4	5	4	3	1	4	8
	IR2793-18-5	1	1	8	4	4	2	1	1	1	4	4
	IR2793-38-3	1	1	7	4	5	4	3	1	1	4	3
	IR2793-83-2	1	1	7	4	5	3	1	1	1	4	3
	IR2793-123-1	1	1	8	5	4	2	3	1	1	4	4
	IR2798-138-6-2	1	1	7	5	4	-	4	2	2	-	-
	IR2823-399-5-6	1	1	8	5	4	4	1	1	3	9	3
	IR3397-33-3-5	1	1	9	5	4	2	1	1	1	3	1
	IR3483-180-2	1	1	7	4	4	4	2	1	6	2	3
	IR4227-9-1-6	1	1	7	4	4	3	1	1	4	3	2
	IR4227-18-3-2	1	1	8	5	4	2	1	1	1	2	3
	IR4427-23-2-3	1	1	8	4	3	4	1	1	3	9	7
	IR4227-24-3-1	1	1	8	6	4	4	3	2	1	4	3
	IR4227-109-1-3	1	1	8	5	4	4	1	1	1	5	2
	IR4227-120-3-2	1	1	8	5	4	4	1	1	1	3	2
	IR4227-140-2-1	1	1	8	4	4	4	4	2	1	4	1
	IR4227-170-2-1	1	1	8	4	4	3	1	1	1	3	2
	IR4227-199-3-2	1	1	8	4	4	4	1	1	1	3	3
	IR4227-240-3-2	1	1	9	5	4	1	1	1	1	3	3
	IR4427-315-2-3	1	1	7	4	4	2	3	3	1	5	6
	IR4409-28-3	1	1	7	4	4	2	3	2	3	6	4
	IR4409-65-3	1	1	7	4	4	2	3	2	4	5	3
	IR4409-141-2	1	1	8	5	4	2	3	2	2	4	4
	IR4409-145-1	1	1	7	4	4	2	3	2	4	3	6
	IR4409-171-1	1	1	8	6	4	3	4	2	4	4	6

Table 2 (continued)

	Line or variety	Reaction[b] to blast										
		Basic criteria						Secondary criteria				
		Philippines				Bumbong Lima						
		IRRI		Leyte		Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
	IR4409-177-1	1	1	8	4	4	3	4	2	1	3	8
	IR4443-271-3	1	1	8	4	4	3	5	2	3	4	6
	IR4570-83-3	1	1	7	4	4	2	1	1	1	4	5
	IR4625-4-3	1	1	7	4	3	5	1	1	5	5	8
	IR4712-32-2	1	1	8	5	4	4	4	1	1	6	2
	IR4712-45-2	1	1	9	7	4	4	4	3	5	5	3
	IR4722-36-1	1	1	7	4	3	3	1	1	1	4	3
	IR4722-163-3	3	1	8	6	6	6	4	9	1	6	4
	IR4722-251-4	1	1	7	5	4	4	3	1	1	6	2
	IR4722-298-1	1	1	8	5	4	4	1	1	4	3	4
	IR4723-76-2	3	1	9	4	4	4	1	2	2	5	3
	IR4723-217-3	1	1	8	6	4	4	3	1	1	3	1
	IR5311-163-3	1	1	8	6	4	4	3	2	1	6	4
	IR5311-295-3	1	1	8	5	4	2	1	1	1	4	3
	IR5853-51	1	1	7	6	3	3	1	2	1	7	2
	111/1116	1	1	7	5	4	5	3	6	2	2	3
	IR2053-521-1-1-2	1	3	7	4	5	4	1	1	6	3	7
	IR2053-522-5-4	1	4	8	4	5	2	1	1	5	3	2
	IR2055-462-3-2	3	4	8	4	5	3	1	1	1	2	2
	IR2058-78-1-3-2-3	1	4	7	4	3	2	1	1	1	3	3
	IR29	1	1	8	4	5	4	3	2	4	-	4
	IR2061-464-2-4-4-6	1	5	7	4	6	4	3	1	1	4	4
	IR2061-522-6-9	1	4	8	4	5	4	4	2	3	5	7
	IR2070-414-3-9	1	3	7	5	6	5	4	3	1	7	4
	IR2071-586-5-6-3-4	1	1	6	5	8	4	4	3	1	7	7
	IR2071-588-3-2-6	1	1	7	4	8	4	4	2	1	7	4
B	IR34	1	3	8	8	5	4	7	2	4	4	3
	IR28	1	4	8	8	4	4	6	3	7	4	8
	IR2061-628-1-6-4-3	1	1	8	7	8	5	3	2	3	6	4
	IR3454-80-2-1	1	3	8	8	6	4	7	3	2	5	4
	IR3464-203-3-3	1	1	8	8	8	4	6	4	2	6	2
	IR3464-217-1-3	1	1	8	8	6	4	6	4	4	4	2
	IR3478-4-3-1	1	1	8	7	4	4	6	4	3	5	3
	IR4227-28-3-2	1	1	8	8	4	4	6	2	3	5	3
	IR4227-164-1-1	1	1	8	9	6	4	6	3	4	6	1
	IR4608-6-2	1	1	9	8	4	2	8	2	1	6	8
	IR4613-54-5	3	1	9	9	4	4	7	3	2	5	7
	IR5257-49-2	1	1	7	7	4	4	4	3	2	6	2
C	IR2823-101-6-3	1	3	7	4	4	4	6	3	5	5	2
	IR2823-295-3-2	1	3	8	4	4	4	6	4	2	3	1
REACTION TYPE: RSSS-RMSS-RSSM (IV)												
	Sigadis											
A	IR1529-680-3	1	9	8	6	8	4	8	4	1	7	7
	BRJ51-26-12	1	7	8	6	4	5	4	2	5	6	6
	IR4532-10045-3-2	3	7	8	7	9	6	3	5	1	9	9
	IR4534-10102-4-3	1	6	8	7	4	5	5	3	1	9	8
	IR9671-8-3-1-1	1	8	8	8	6	4	6	3	4	8	7
	IR3449-172-2-1	1	7	9	7	8	5	8	3	4	9	3
	IR3454-35-2-1	1	7	8	7	6	4	7	4	4	6	4
	IR3464-29-3-1	1	8	8	8	4	4	6	1	1	6	1
	IR3464-126-1-3	1	7	8	8	4	4	7	4	3	5	1
	IR3464-149-3-2	1	8	8	8	6	4	8	4	3	7	2

Table 2 (continued)

Line or variety		Reaction[b] to blast										
		Basic criteria						Secondary criteria				
		Philippines				Bumbong Lima Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
		IRRI		Leyte								
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
REACTION TYPE: RSSS-RMSS-RSSM (IV)												
A	IR4432-26-5	1	7	9	5	6	3	8	4	1	8	6
	IR4625-165-6	1	8	9	5	4	4	7	5	3	6	3
	IR5311-3-1	1	8	9	7	6	5	6	3	1	9	8
	IR3712-2	1	8	9	8	6	4	5	4	3	3	4
	IR3179-27	1	8	9	5	6	5	7	6	4	4	8
	IR1529-548-1-2	1	9	8	7	9	5	8	4	1	7	7
	IR9669-22-2-6	1	9	8	4	9	9	9	7	1	7	5
B	IR4531-10062-2-2	1	4	8	5	6	6	5	6	1	5	8
	IR9671-9-i-8-3	1	4	8	5	4	1	1	1	2	3	3
	IR3449-4-2-1	1	5	8	5	4	4	4	2	4	5	2
	IR3454-80-2-1	1	3	8	8	6	4	7	3	2	5	4
	IR5311-42-2	1	4	8	6	4	4	4	3	1	9	2
C	BRJ51-17-3	1	8	8	4	4	5	3	2	4	9	5
	BRJ51-196-2	1	7	8	4	5	5	3	2	4	8	5
	IR2071-588-5-4-3	1	7	8	4	4	8	5	3	1	9	7
	Milyang 30	1	8	6	4	4	4	1	1	4	9	6
REACTION TYPE: SMRR (V)												
	Dawn											
A	Dawn	6	4	1	1	3	2	2	1	6	2	7
	Basmati T 3	6	4	3	1	4	3	2	2	5	2	5
	CI7338-5	6	4	3	1	6	2	2	3	6	3	6
	DB-3	7	4	3	1	4	2	2	1	7	3	3
	DD-91	6	4	3	1	6	4	2	1	7	3	3
	DL-5	6	4	2	1	4	4	1	3	9	4	2
	DL-12	6	4	2	1	2	3	2	1	8	4	2
	DM-59	6	4	3	1	6	4	2	1	7	4	2
	DNJ-129	6	4	3	1	3	2	1	1	8	4	2
	Basmati 370	6	4	3	1	4	2	2	1	5	2	7
	N 32	6	3	4	1	4	2	3	1	9	3	2
	Unblatuzi Valley Sugar Co.	6	4	4	1	2	2	1	1	2	3	8
	B 52	6	6	4	3	4	2	1	2	9	3	1
	B 65	5	5	4	3	4	4	1	2	4	3	2
	BMT 53R 3540	6	4	4	1	4	4	2	2	5	-	5
	IR879-18-3-2	6	4	4	1	4	4	1	1	5	5	4
	Ctg 1516	6	5	4	1	6	4	2	1	7	3	2
B	RU369-7-2-1-4	7	4	3	1	9	2	4	3	1	6	4
	RC10 257-1-8-5-3-2	6	4	4	1	9	3	5	3	1	8	3
C	Dular	5	3	6	1	4	4	5	1	4	-	2
	Kanto 51	9	4	7	1	8	6	9	2	6	-	4
	Reference IR2070-423-2-5-6	5	4	7	4	4	4	6	3	1	8	4
REACTION TYPE: MR / R(M) (VI)												
	Sub-Dawn											
A	IR3271-PP134-68-3-1	6	1	1	1	4	3	1	1	4	3	3
	IR3271-758-1481	5	3	3	1	3	2	1	1	5	3	3
	IR3271-760-1482	6	1	4	2	4	2	1	1	4	3	3
	IR3271-746-1480	6	1	4	1	4	4	1	1	4	4	4

Table 2 (continued)

	Line or variety	Reaction[b] to blast										
		Basic criteria				Secondary criteria						
		Philippines				Bumbong Lima						
		IRRI		Leyte		Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
B	Amol I-82	5	1	6	1	9	9	1	2	2	3	1
	IR946-14-3-3-2-3	5	1	6	1	3	4	1	1	5	8	4
	IR1544-38-2-2	6	3	6	1	9	4	2	3	1	4	3
	Awini	4	1	7	1	4	4	3	1	3	5	3
	IR880-47-2-1-2	6	4	7	1	5	4	1	3	1	6	3
	IR930-2/IR822-432	6	1	6	1	6	4	1	1	3	3	4
C	IR2793-10-2	6	1	8	5	5	2	1	1	2	2	4
	IR2793-80-1	6	1	7	4	4	1	1	1	1	2	3
	IR4712-233-2	6	1	6	4	3	4	1	1	5	3	1
D	BW246-10	5	1	5	1	3	4	6	7	1	9	5
	TOS2513/7-7-16-5-B1	6	1	5	1	7	8	9	3	1	4	5
	TOS2578/7-4-2-3-B2	6	1	3	1	4	2	9	4	1	6	3
	TOS2581/7-4-2-5-2	6	1	3	1	4	3	6	5	3	5	2
REACTION TYPE: RSRR (VII)												
	TOS2259/7-3-2-9-B2	1	9	4	1	8	7	3	2	7	3	2
	Hang Yi 71	1	6	1	1	4	3	1	4	3	2	1
	Ca 902/B/2/2	1	9	1	1	1	3	2	1	7	5	3
REACTION TYPE: MRSS (VIII)												
	IR3478-97-2-3	6	1	8	7	4	4	5	2	3	4	3
	IR4432-29-6	5	1	8	7	7	4	9	3	1	4	7
	IR4432-43-3	5	1	9	8	7	3	7	5	1	7	8
	IR4432-52-6-4	5	1	8	8	6	3	4	5	1	6	8
REACTION TYPE: SSSR (IX)												
	HR693-123-2-6	5	6	7	1	8	9	3	3	2	6	7
	CI5309	8	5	5	1	9	9	3	2	7	2	8
	Chokoto	8	8	7	4	9	5	4	2	7	3	4
	Suweon 264	7	9	8	4	7	9	5	6	8	8	7
REACTION TYPE: SSSS (X)												
	BRJ51- -2	6	8	8	7	4	7	3	3	4	7	4
	IR20	7	7	8	8	4	5	7	3	3	9	6
	IR32	7	8	7	5	5	4	7	3	2	7	4
	Taichung T.C.W.C.	9	9	8	8	9	9	9	9	3	9	-
	Khao-teh-haeng 17	9	9	8	8	8	9	9	9	3	8	3
	IR1586-1-15-3-2	8	9	9	6	9	9	9	7	4	9	4
	IR26	8	8	9	8	9	8	6	8	5	9	8
	RP176-2 (74063)	7	8	9	6	9	7	4	7	4	9	9
	Peta	7	8	7	8	9	9	9	9	7	7	4
	Fanny	9	9	9	9	9	9	9	9	9	9	9

[a]Encircled figures indicate somewhat unusual score in a given group. [b]1976 Standard Evaluation System for Rice Scale of 1-9: 1 = none to small brown specks of pinhead size, 9 = about 100% of leaf area infected.

tentative subgroups showed more or less similar reaction in the Philippines, although there was still some heterogeneity among the components. Subgroup D seemed particularly different from others in respect to the reaction in Indonesia in 1976.

Groups VII, VIII, IX. Groups VII, VIII, and IX reveal very distinct differences in the Philippines, thus indicating their important role as differentials. The reactions in other countries suggest that there would be additional differences within each group. Only group VIII, which could be a segregant relating to Group IIIb, revealed relatively similar reaction outside the Philippines.

Group X. Group X had no significant resistance in the Philippines in 1976-77. It includes several varieties that have been nominated as components of previously proposed differentials. This implies that the varieties in this group may show significantly distinguishable reactions at other sites. However, it would not be easy to sort the different reactions under present circumstances in the Philippines.

IMPROVEMENT OF IRBN

A close look into the result of 2 years of IRBN reveals some interesting aspects of varietal resistance. For instance, one group of varieties such as Carreon, Ram Tulasi, and Raminad Str. 3 behaved similarly through many tests, with clear infection in Nepal, while a group like the Sigadis group showed a good level of resistance at the same site despite the generally narrow spectrum of their resistance.

The above fact is of particular interest. Carreon has been cited (Ou et al 1971) as a donor of *stable resistance* on which new pathogenic races would not likely build up.

The specific reaction of a group of varieties to certain races, as indicated above, greatly affects the breeding strategy. If varietal resistance is not simply measured by a linear scale from stable resistance to less stable, then diversification of types of resistance must be an important goal of each breeding program. Therefore, the present IRBN should be modified to measure the extent of specific resistance, in addition to identifying varieties that show stable resistance at many test sites.

Role of the present differentials in IRBN

Earlier differentials in IRBN were of five types -- those from the United States, Japan, Taiwan, and the Philippines, and the international differentials. Presently, only three sets (United States, Philippines, and international) are included (Table 1). Although each of the differentials, particularly the international ones, were established after tests against a number of races, they do not effectively sort out races that have been distinguished by various host reactions in the IRBN in the Philippines.

Of the international differentials, NP125, Dular, and Kanto 51 (Table 1) show reactions similar to those of the varieties in Group VI (Table 2). Raminad Str. 3 behaves like Carreon and Ram Tulasi. No variety may have the reaction type of Tetep, because Zenith is slightly different from Tetep (Bandong 1965).

Among the Philippine differentials, Kataktara DA-2 and Raminad Str. 3 behaved similarly, indicating that these two and Carreon and Ram Tulasi are closely related genotypes. None of the differential varieties seems to represent *O. nivara* type and Sigadis type, which are clearly distinguished as a major group in the Philippines (Table 2).

The drawback of the present differentials in IRBN can be summarized as follows:

- There is difficulty in increasing their seed because of their photoperiod-sensitivity or extremely early flowering, and their lack of resistance to major pests and diseases.
- There is lack of clear-cut response to the races, which are able to discriminate present breeding lines.
- They are irrelevant to presently prevailing genotypes of host resistance.

Developing differentials in IRBN

Developing a strategy through which a functional set of differentials can be found is more important than fixing some tentative set of differentials. But if some rigorous criteria for differentials are to be adopted as has been done for the latest differentials in Japan, so that each component should have a single major gene (Yamada et al 1976), it will be impossible, at the present level of knowledge, to develop a complete set of international differentials. It will be useful to have a tentative set of differentials, which are more functional than the present ones.

The principles in choosing the tentative differentials should be different from those used earlier. The present differentials were selected by testing a large number of races against a relatively small group of varieties. Although many races were identified there was no close look into the question of the kind of host resistance prevailing in breeding programs.

In contrast with the previous approach, the types of resistance actually working in breeding programs should first be identified. To represent each of the tentative groups of host resistance, about 20 varieties or breeding lines can be selected (Table 3). Many races would not clearly be distinguished by this set of differentials. Some error in the choice of the entries in Table 3 would also be due to ambiguous reaction in the blast nurseries.

Table 3. List of lines or varieties representing each group.

IRBN entry no. 77	Subgroup	Line or variety	Entries (no.) of each group	Reaction[1] to blast: Basic criteria, Philippines, IRRI '76	IRRI '77	Leyte '76	Leyte '77	Secondary criteria, Bumbong Lima Malaysia '76	Malaysia '77	Indonesia '76	Thailand '76	Nepal '76	Indonesia '77	Colombia '77
I		Major group	(81)											
	Tetep													
146	Ia	IR1905-81-3-1	49	1	1	1	2	2	1	1	1	1	3	3
	Zenith													
99	Ib	IR[illegible]547-6-2-5	10	1	1	1	1	1	2	1	1	5	3	3
	Carreon													
350	Ic	Colombia I	12	1	1	1	2	1	2	2	3	7	3	2
	M-302													
326	Id	IR946-33-2-2-2-2	6	1	1	1	3	4	5	5	5	5	7	4
	Miscellaneous		4											
II			(28)											
	O. nivara													
165	IIa	IR2588-2-3-3	25	1	1	8	1	5	2	1	1	1	2	5
415	IIb	74-5499 or	3	1	1	5	1	2	4	2	1	9	3	4
416	IIb	74-5507		1	1	6	1	4	4	1	1	9	3	4
III			(67)											
169	IIIa	IR2793-18-5	53	1	1	8	4	4	2	1	1	1	4	4
141	IIIb	IR34	12	1	3	8	8	5	4	7	2	4	4	3
	Unclassified		2											
IV			(26)											
332	[illegible]	IR152[illegible]-680-3	17	1	9	8	6	8	4	8	4	1	7	7
192	[illegible]vb	IR3454-80-2-1	5	1	3	8	8	6	4	7	3	2	5	4
161	IVc	IR2071-588-5-4-3	4	1	7	8	4	4	8	5	3	1	9	7
V		Minor group	(21)											
353	Va	Dawn	17	6	4	1	1	3	2	2	1	6	2	7
58	Vb	Ru 369-7-2-1-4	2	7	4	3	1	9	2	4	3	1	6	4
	Miscellaneous		2											
VI			(17)											
82	VIa	IR3271-PP134-68-3-1	4	6	1	1	1	4	3	1	1	4	3	3
333	VIb	IR1544-38-2-2	6	6	3	6	1	9	4	2	3	1	4	3
171	VIc	IR2793-80-1	3	6	1	7	4	4	1	1	1	1	2	3
269	VId	BW 246-10	4	5	1	5	1	3	4	6	7	1	9	5
VII			(3)											
60		TOS 2259/7-3-2-9-B2		1	9	4	1	8	7	3	2	7	3	2
293		Hahng Yi 71		1	6	1	1	4	3	1	4	3	2	1
VIII			(4)											
230		IR4432-29-6		5	1	8	7	7	4	9	3	1	4	7
IX			(4)											
306		C1 5309		8	5	5	1	9	9	3	2	7	2	8
X 137		IR26	(10)	8	8	9	8	9	8	6	8	5	9	8
		Total	261											

[1]1976 Standard Evaluation System for Rice scale 1-9: 1 = none to small brown specks of pinhead size; 9 = about 100% of leaf area infected.

Formulation of IRBN

Specificity of resistance in the IRBN as shown by Carreon in Nepal indicates the importance of selecting entries base' on their pattern of reaction over many sites rather than on average resistance. In other words, preservation of diverse types of resistance can be one of the objectives of the IRBN. Efforts toward this objective would make it possible to identify types of resistance for all new entries in the IRBN.

Therefore, it is necessary to include in the IRBN some entries that represent each of the tentative resistant types in Table 2. Because of possible error in grouping and environmental variation at each test site, it is desirable that at least five entries from each group be included. If the five entries representing each of the resistant types behave uniformly for several tests, one entry from each group can be selected for the final concise set of differentials. If the five entries show clear difference among them, or the group shows ambiguous reactions, the entries should be further tested for refining.

To identify the type of resistance, the basic policy for new entries to the IRBN should be as follows:

- entries showing clearly identical reactions to one of the known resistant types need not be tested further;
- entries should be retested if they do not show identical reactions to a known type; and
- entries should be retested if they show ambiguous reactions.

There should be a secondary policy to handle lines that show ambiguous reactions or those that should be recommended for a hybridization program.

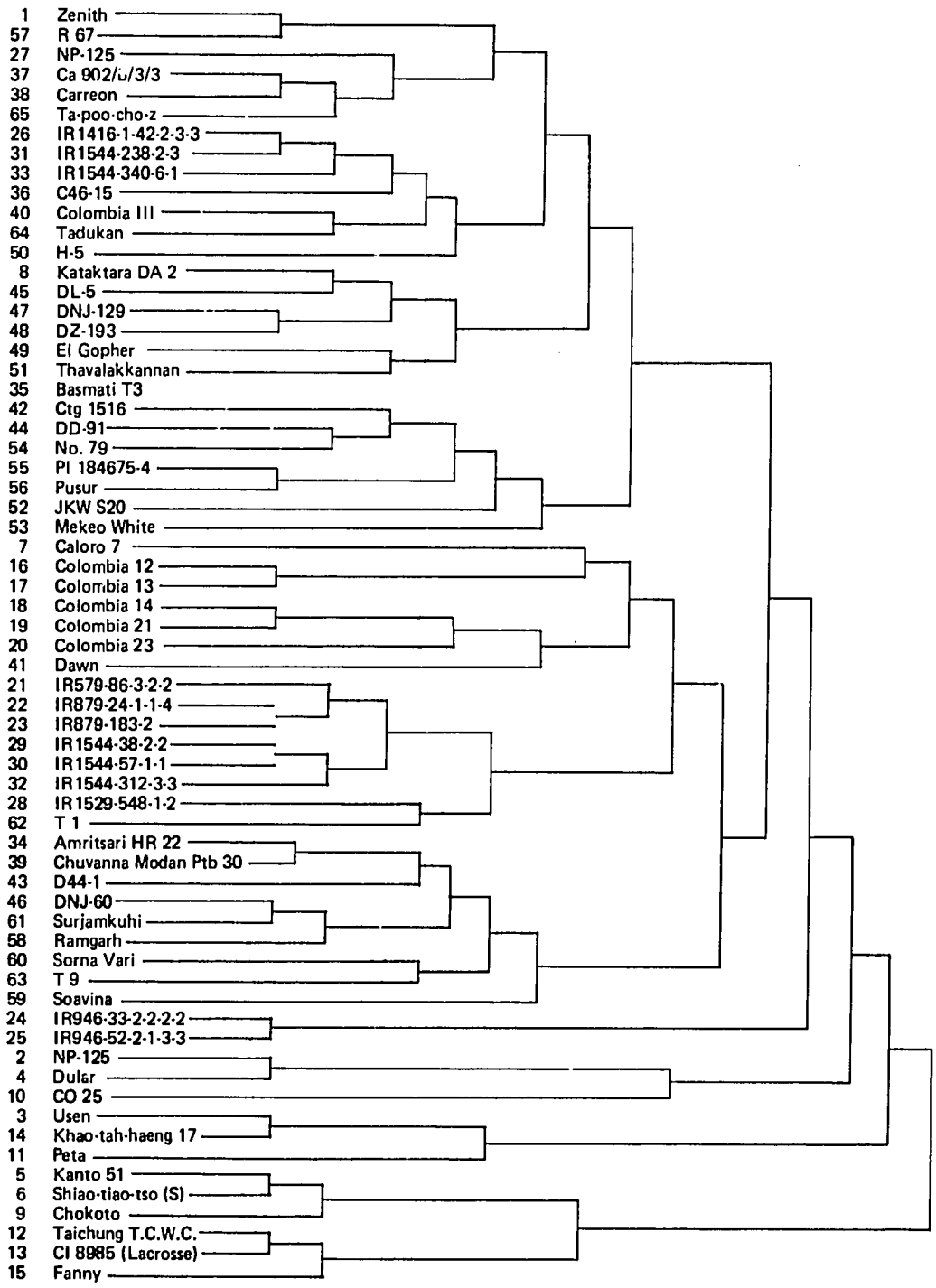

Fig. 2. An example of the numerical classification clustered by taxonomic distance.

At any rate, the core of formulating the IRBN consists of two steps:

1. maintaining and refining the representative lines or varieties from each of the resistance types to develop *differentials*; and

2. identifying type of resistance for new entries by the *differentials*.

This practice can be programmed with a computer by means of numerical classification. One such trial is given in Figure 2. This preliminary trial was, however, not successful because of the capacity of the computer program and the inadequacy of original data.

There is a good possibility that the grouping of the entries based on Philippine data would be different from that in other countries. It will not be easy to develop a rigid system of differentials and to identify the type of resistance of IRBN entries against many diverse races and resistant genes in the world. Use of a computer should be possible for such data processing.

One convenient solution is to leave a portion of IRBN for entries showing specific reactions in some countries. Or, some regional centers may add certain entries to reflect the regional specificity of the resistance type. On the other hand, if IRRI is to handle primary formulation of IRBN, then there is a need to test the IRBN at more sites in the Philippines to facilitate the initial classifications. The IRBN should also be further supplemented with laboratory tests of inoculation of certain races, which may differentiate some groups of resistance that cannot easily be separated by natural infection, such as those of Tetep and Zenith.

IMPLICATION OF IRBN DATA FOR GENETICS OF BLAST RESISTANCE

The four tests of IRBN in the Philippines have distinguished some resistance types; however, 34% of the entries remained unclassified because of their ambiguous reactions. But the recognition of these resistance groups provides an initial base for further genetic analysis of the resistance.

Genetic segregation of the different resistance types in a cross

Among the IRBN entries are cases where several lines from one cross were tested. In some crosses (Table 4), it is possible to observe distinct segregation among sister lines (Ikehashi and Khush 1979).

In the closely related sister lines of IR4547-6 and IR9559-PP889, there seem to be segregation between the Tetep group (I) and the *O. nivara* group (II). The same sort of segregation is found in IR2546. Further check of this segregation by such a race, as found in Leyte in 1976, may show that the difference between the two groups is controlled by a single gene.

Likewise, at Los Baños in 1976 segregation between subgroup IIIa and group VI was found in IR2793 and IR4712, but their reactions were fairly uniform at other sites. This suggests that the difference between the two is governed by a single gene. However, there remains the possibility of more than three types of segregation, which could have been missed through the selection of resistant types before testing them in IRBN.

A similar observation is possible regarding the segregation of IIIb and IV in IR2071 and IR3464, and that of IV and III in IR5311.

In other cases, two or three different types of reactions are found in the crosses, such as IR4432, IR2823, IR1544, and IR9669.

These observations are extremely important because they provide a base for further work, which could analyze genetic relationships among the reaction types.

A tentative system for search and naming of races at IRRI

There is a need to form a minimum differential system to collect and maintain the kind of races that appeared in the IRBN in 1976-77 and to distinguish prevailing types of resistance in the present breeding programs.

The four races that appeared in IRBN in the Philippines can theoretically be defined with two varieties (Table 5A). However, two of the distinct resistant groups that can discriminate the four are not found in the IRBN data. Therefore, the five resistant groups indicated in Table 5B can be used to find and classify the four races.

With these four races as tentative minimum differentials, many genotypes are still not discriminated. Apparently, the difference among the groups of Carreon, Tetep, and Zenith cannot be recognized with these races. Actually, Carreon and Tetep were used in IR5533 and IR9559, but the progeny seems to be close to Tetep in resistance (Table 2). The recognition of difference among the resistance donors will enable a breeder to avoid duplicated use of identical gene(s), to diversify the type of resistance, and to synthesize different types of resistances. It is important to search for a race that may distinguish the differences among the most resistant varieties and breeding lines. When such races are found, there will be a need to find several breeding lines or varieties that can designate the specific pathogenicity of the race.

In the absence of such a system, there is no way of synthesizing different types of resistance. Moreover, it is likely that different genes are identified as the same gene in the absence of the race that may distinguish different genotypes in the progeny from two resistant parents. Tetep and Zenith are thus reported to have an identical

Table 4. Segregation between different reaction types.

Type	Line or variety	Reaction[a] to blast										
		Basic criteria				Secondary criteria						
		Philippines				Bumbong Lima						
		IRRI		Leyte		Malaysia		Indonesia	Thailand	Nepal	Indonesia	Colombia
		'76	'77	'76	'77	'76	'77	'76	'76	'76	'77	'77
	I and II IR8*6/PK203/4/IR22/Tetep//IR22/*O. nivara*//IR3265											
II	IR4547-6-1-1	1	1	6	3	3	4	1	1	4	3	3
?	IR4547-6-1-2	1	1	4	1	1	4	1	1	1	3	3
II	IR4547-6-1-3	1	1	5	1	4	4	1	1	4	2	4
?	IR4547-6-1-3	3	1	4	3	4	4	3	1	2	2	4
I	IR4547-6-2-4	1	1	1	1	1	2	1	1	4	3	4
I	IR4547-6-2-5	1	1	1	1	1	2	1	1	5	3	3
I	IR4547-6-2-6	1	1	1	1	2	2	1	1	4	3	5
	IR1416-142-2-3-3/IR1487-194-3-4											
I	IR2546-23-2-2-2	1	1	1	3	2	2	5	1	3	3	6
II	IR2546-31-2-1-2	1	1	7	1	3	2	4	1	1	3	6
	IR8///IR8*2//IR1904/IR1905											
I	IR9559-PP889-1	1	1	3	1	1	2	1	1	1	3	3
II	IR9559-PP889-5-3	1	1	7	4	3	3	1	1	3	4	5
	IIIa and VI IR1416-131-5/IR1364-37-3-1//IR1514A-E666											
IIIa	IR2793-18-5	1	1	8	4	4	2	1	1	1	4	4
IIIa	IR2793-38-5	1	1	7	4	5	4	3	1	1	4	3
IIIa	IR2793-83-2	1	1	7	4	5	3	1	1	1	4	3
IIIa	IR2793-123-1	1	1	8	5	4	2	3	1	1	4	4
VI	IR2793-10-2	6	1	8	5	5	2	1	1	2	2	3
VI	IR2793-80-1	6	1	7	4	4	1	1	1	1	2	3
	IR1905-72-3-3/IR5//IR2061-213-2											
IIIa	IR4712-32-2	1	1	8	5	4	4	4	1	1	6	2
IIIa	IR4712-45-2	1	1	9	7	4	4	4	3	5	5	3
?	IR4712-228-1	3	1	8	4	2	2	1	1	5	4	1
VI	IR4712-233-2	6	1	6	4	3	4	1	1	5	3	1
	IIIb and IV IR1561-228-1-2///IR24//IR24*3/*O. nivara*											
IIIb	IR2071-588-3-2-6	1	1	7	4	8	4	4	2	1	7	4
IV	IR2071-588-5-4-3	1	7	4	8	4	8	5	3	1	9	7
IIIb	IR2071-588-6-2-8-4	1	1	8	4	9	4	5	3	1	7	4
IV	IR2071-625-1-252	4	6	7	5	4	5	7	4	1	9	6
	IR1628-68-3/IR84.-67-1-1-1//IR2061-213											
IV	IR3464-29-3-1	1	8	8	8	4	4	6	1	1	6	1
IV	IR3464-126-1-3	1	7	8	8	4	4	7	4	3	5	1
IV	IR3464-149-3-2	1	8	8	8	6	4	8	4	3	7	2
IIIb	IR3464-203-3-3	1	1	8	8	8	4	6	4	2	6	2
IIIb	IR3464-217-1-3	1	1	8	8	6	4	6	4	4	4	2
	IR2061-125-3[illegible] .R1820-52-2											
IV	IR5311-3-1	1	8	7	9	6	5	6	9	1	9	8
?	IR5311-42-2	1	4	8	6	4	4	4	3	1	5	2
III	IR5311-168-3	1	1	8	6	4	4	3	2	1	6	2
III	IR5311-295-3	1	1	8	5	4	2	1	1	1	4	3
	IIIb, IV, and VIII IR2061-125-37/CR94-32											
IV	IR4432-26-5	1	7	9	5	6	3	8	4	1	8	6
IIIb	IR4432-28-5	1	1	8	5	6	4	7	4	1	7	6
VIII	IR4432-29-6	5	1	8	7	7	4	9	3	1	5	7
?	IR4432-32-4	3	6	7	5	7	4	8	3	1	5	7
VIII	IR4432-38-6	4	1	7	5	6	3	4	3	1	5	8
VIII	IR4432-43-3	5	1	9	8	7	3	7	5	1	7	8
VIII	IR4432-52-6-4	5	1	8	8	6	3	4	5	1	6	8
?	IR4432-103-6-4	4	1	8	9	9	3	7	5	1	7	8

(continued on next page)

Table 4 (continued)

Type	Line or variety	Reaction[a] to blast: Basic criteria, Philippines, IRRI '76	IRRI '77	Leyte '76	Leyte '77	Secondary criteria, Bumbong Lima Malaysia '76	Malaysia '77	Indonesia '76	Thailand '76	Nepal '76	Indonesia '77	Colombia '77
	Double segregation undetectable in the Philippines											
	CR94-13/IR1529-680-3//IR24*3/*O. nivara*//IR1416-131-5											
	IR2823-101-6-3	1	3	7	4	4	4	6	3	5	3	1
	IR2823-271-4	1	1	7	1	4	2	1	1	5	3	3
	IR2823-295-3-2	1	3	8	4	4	4	6	4	2	9	1
	IR2823-399-5-6	1	3	8	5	4	4	1	1	3	9	3
	IR24/Tetep											
	IR24	8	-	9	-	9	-	8	9	3	-	-
	Tetep	1	1	4	1	2	1	2	1	1	2	2
	IR1544-38-2-2	6	3	6	1	9	4	2	3	1	2	8
	IR1544-57-1-1	5	4	5	1	8	4	3	1	1	2	8
	IR1544-181-1-1	1	1	4	4	3	2	1	1	5	3	4
	IR1544-238-2-3	4	1	6	4	4	2	1	1	1	3	4
	IR1544-312-3-3	4	4	6	1	7	3	3	1	1	4	4
	IR1544-340-6-1	1	1	5	4	4	2	4	1	1	2	3
	IR1544-414-3-1	5	3	4	1	4	3	3	1	1	3	5
	IR8/IR8*2/Carreon											
	IR8	8	-	8	-	9	-	8	8	3	-	-
	Carreon	1	1	1	2	1	2	2	1	6	4	2
	IR9669-PP830-1	1	1	1	1	1	2	1	1	1	2	4
	IR9669-PP836-1	1	1	1	1	1	2	1	1	1	9	4
	IR9669-PP846-1	1	1	3	1	1	2	1	3	1	9	5
	IR9669-PP823-1	1	1	7	4	2	2	4	1	1	6	4
	IR9669-PP827-1	1	4	7	4	4	2	6	3	1	7	4
	IR9669-22-2-6	1	9	8	4	9	9	9	7	1	7	5
	IR9669-23-12-7	1	4	7	4	2	2	6	1	2	7	4
	IR9669-27-4-8	1	4	7	4	3	2	4	3	3	5	4

[a]1976 Standard Evaluation System for Rice scale 1-9: 1 = none to small brown specks of pinhead size; 9 = about 100% of leaf area infected. Encircled figures indicate somewhat unusual score in a given group.

gene or to be allelic (Padmanabhan et al 1973), although there is evidence that they may have different resistant genes (Bandong 1965).

It is well known that each race would vary in pathogenicity. However, the extent of the variability is not yet fully recognized because measuring variability depends greatly on the nature of differentials and the way of defining the variability. In the absence of distinct difference in the types of resistance among differentials, the ambiguity of the reactions could lead to an overestimate of the variability. One such case in the international differentials has been reported (Veeraraghavan 1975).

With the tentative minimum differentials proposed in Table 5B, such ambiguous reaction is expected to be less frequent as distinctly different resistant types are adopted in it. There only remains one danger in misjudging: seed mixture in differential varieties.

The next step in genetic work is to hybridize among and within the resistance types. Testing of the progeny simultaneously against selected races should determine genes that differentiate the types of resistance.

Table 5. Standardization of race nomination for genetic analysis (tentative).

A. Required varietal reaction to designated 4 races (A-D) found in IRBN in the Philippines in 1976-77.

Variety[b]	Varietal reaction[a]: A IRRI 1976	B IRRI 1977	C Leyte 1976	D Leyte 1977
Va	R	R	S	S
Vb	R	S	R	S
or Vc	S	R	S	R

[a]R = resistant, S = susceptible. [b]IR34 can be useful as Va, but there is no variety which serves clearly as Vb. BW246-10 can be good Vc but its susceptibility is not distinct.

B. Tentative system of designating the races.

Race	Varietal reaction[a]				
	IR1905-81-3-3 (Tetep)	IR2588-2-3-3 (*O. nivara*)	IR34 (?)	IR1529-680-3 (Sigadis)	IR26
A	R	R	R	R	S
B	R	R	R	S	S
D	R	R	S	S	S
C	R	S	S	S	S

[a]R = resistant, S = susceptible. IR34 discriminates A and B from C and D. IR1529-680-3 distinguishes A from B, and IR2588-2-3-3 distinguishes C from D. IR1905-81-3-1 and IR26 are resistant and susceptible checks, respectively.

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