PART I
STUDIES ON THE PHYSIOLOGIC RACES OF THE RICE BLAST FUNGUS, *PIRICULARIA ORYZAE* CAV.[1]

C. C. CHIEN[2], S. Y. LIN[2], C. L. CHU[3], T. G. CHOU[4] and K. C. LIU[2]

Introduction

Since 1922-23, Sasaki (24) first reported the variation of pathogenicity in rice blast fungus, *Piricularia oryzae* Cav., many workers (13, 14, 17, 23, 25, 31) have studied the problems of physiologic specialization of the fungus in Japan. Classification of the fungus into physiologic types by comparing physiologic characteristics of isolates, and clarification of possible correlation between culture types and pathogenicity of the fungus were attempted (29, 30). Hemmi (16) intended to classify the fungus into strains by their pathogenicity to leaf and ear of rice. Suzuki (26) classified the races of the blast fungal isolates according to germination type of conidia and formation of appressoria. A joint study on the race problem under the leadership of Goto (8, 9, 10) was initiated in 1955, with five prefectural agricultural experiment stations participating.

In the United States, studies of different varietal reactions to the rice blast in separate geographic areas of the U.S. resulted in the discovery of physiologic races of *P. oryzae*, and the existence of at least two races of the fungus was reported (20). In further study, Latterel *et al.* (19) characterized fifteen physiologic races by their disease reactions on ten rice varieties. In 1963, they reported that 25 physiologic races had been characterized from the isolates obtained from 17 countries and from 5 rice growing areas of the United States on the basis of the differential reactions of 12 varieties of rice (18). Atkins (1, 3) reported the prevalence and distribution of physiologic races of *P. oryzae* in the U. S. and added one new race to the 15 existing races.

Field evidence indicating possible existence of physiologic races in Taiwan was first obtainted by Hashioka (11), who tested eight varieties for blast infection in seven locations and found a greater difference in varietal reaction due to locations than to yearly fluctuation. Li (21) observed differences in varietal reaction in blast nurseries established at four locations in 1956. This observation stimulated further research activities on the race problem. The study on physiologic race of the blast fungus was started in Taiwan Agricultural Research Institute in 1957, and in Academia Sinica, 1960. Hung *et al.* (12), using

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2. Associate Plant Pathologists.

3. Junior Plant Pathologist.

4. Research Assistant.

Department of Plant Pathology, Taiwan Agricultural Research Institute, Taipei, Taiwan, China.

16 differential rice varieties, recognized five pathogenic types among the seven isolates tested. Using the same set of differential varieties, tests were later made by Chien *et al.* with 67 isolates collected in 1960, 141 in 1961 and 146 in 1962. (6). They characterized these isolates into 19 physiologic races. These races were conveniently grouped into seven race groups characterized by their ability to infect certain groups of rice varieties. Successively six more races were identified by Chien and his co-workers (5). In Academia Sinica, another set of differentials was used for race characterization. In 1962, workers in Academia Sinica characterized 40 isolates into five physiologic races according to their virulence on the nine differentials (15).

Latterell *et al.* (18) suggested the need for superior differential varieties on an international basis and proposed 17 as possible candidates for a set of international differential varieties. In 1965 (4), a set of international differentials and nomenclature of races on an international basis by using the international differentials and standard techniques for uniform testing were proposed as the results of the United States-Japan Cooperative Rice Blast Project which was established in 1963.

In the course of cooperative efforts with the U.S.D.A., further characterization of races with isolates collected in Taiwan was made and the cultures of the blast races characterized by Chinese, Japanese and the U.S. workers were exchanged for investigation of their relationship. Several sets of differential rice varieties including U.S., Japanese differentials, 40 rice varieties from FAO, 24 tentative international differentials, 12 tentative international differentials, and 8 international differentials were tested as to their ability in differentiating isolates obtained in Taiwan, Japan and the U.S.

Materials and Methods

Isolation and maintenance of cultures

Isolations were made from the disease specimens collected during 1964-66 from the uniform blast nurseries. Pure cultures thus obtained were further subjected to single-spore transferring to yeast-starch agar slants. Stock cultures were maintained on rice straw medium in small test tubes and stored at 4° C.

Preparation of inoculum

Cultures to be tested for pathogenicity were first grown in 125 ml Erlenmeyer flasks containing 25 g water-soaked rice seeds and 10 ml water. After ten-day incubation at 28°C., the cultures were washed with sterilized water and removed to Petri dishes with their covers half open. Spores were produced abundantly in 3-6 days, depending on isolates. A second or third harvest of spores could be obtained by washing the cultures once or twice if they had not been contaminated.

Differential varieties

The 16 Taiwan differentials now in use for testing cultures of blast fungus and differentiating them into races are listed in Table 1. These include 11 varieties of the *japonica* type and five of the *indica* type. Of the *japonica* type, one was introduced from mainland China, three from Japan and seven were locally bred varieties. Of the *indica* type,

two are the upland rice and three the lowland rice (Table 1).

The U.S. differentials supplied by U.S. Army Biological Laboratory, Frederick, Maryland, the Japanese differentials by the Japan National Institute of Agricultural Science, the 40 rice varieties by FAO, the 24 tentative international differentials by IRRI and the 12 tentative international differentials by Dr. Atkins, U.S.D.A., the 8 international differentials by IRRI were used in the tests for their value in differentiating some representative Taiwan races of the blast fungus. The U.S. races kindly supplied by Dr. Atkins, and Japanese races by the Japan National Institute of Agricultural Science were used for testing their virulence to Taiwan differential varieties.

Table 1. Sixteen rice varieties employed at TARI as differentials for identification of physiologic races of *Piricularia oryzae* Cav.

Variety	Type	Origin
Kung-shan-wu-shen-ken	Japonica, lowland	Mainland, China
Taichung 65	〃	Taiwan
Pai-kan-tao	〃	〃
Taichung 171	〃	〃
Chianung 242	〃	〃
Kwang-fu 1	〃	〃
Chianung-yu 280	〃	〃
Taichung line 33	〃	〃
Kanto 51	〃	Japan
Norin 21	〃	〃
Sensho	〃	〃
Cutsugulcul	Indica, upland	Taiwan
Natala	〃	〃
Kao-chio-liu-chou	Indica, lowland	〃
Kaohsiung-ta-li-chen-yu	〃	〃
Taichung-ti-chio-wu-chien	〃	〃

Inoculation

The rice seeds sown for supplying test plants were treated with organic mercury fungicide and soaked in water for a few days at room temperature until they showed sign of germination. Plants were grown in paint-coated metal boxes (30cm×30cm×7.5cm in size), and placed on the greenhouse bench. Rice seedlings were top-dressed twice with 2% ammonium sulfate solution at the rate of 30 ml per box per application. Rice seedlings at the three to four-leaf stage were inoculated by spraying with spore suspension. Inoculated plants were incubated in a moist chamber of 20°-30°C for 24 hours before being removed to the greenhouse bench.

Recording of infection.

Five to seven days after inoculation, the inoculated plants were observed for reaction types which are classified as follows:

R (Resistant): Brown to dark brown small spots devoid of a grey center, usually 1 mm in diameter. The absence of lesion response also taken as R.

M (Moderately resistant): Brown to purple spots with grey center, about 2 mm in diameter.

S (Susceptible): Rapidly expanding lesions of medium to large size, usually with water-soaked appearance at first and a purplish brown border and a grey center later.

Experimental Results

1. Identification of races of P. oryzae Cav.

More than four hundred isolates of *P. oryzae* Cav. were obtained from the uniform blast nurseries in Ilan, Tungshu, Chiayi, Pingtung, Taitung, and Hualien areas during 1964-66, of which 293 isolates were tested on the 16 differential varieties and 19 races were characterized. Among them, 17 races showed the specialization pattern which had been previously detected (5). The addition of the two new races, races 26 and 27 increased the total number of races of the blast fungus to 27 races. These 27 races characterized during 1960-66 can be conveniently placed into seven race groups as follows:

Group A: Isolates of this group (race 1) were avirulent to the 16 differential varieties in greenhouse inoculation tests. They might have lost their pathogenicity during culturing, since most of them were originally isolated from leaf lesions of susceptible type.

Group K: Isolates of this race group (race 2 and 17) were characterized by their ability to infect KSWSK. In addition to their infectious ability to KSWSK, isolates of race 17 caused susceptible reaction on TC 65.

Group N: Isolates of this group (race 3) caused susceptible reaction on the *indica* variety Natala but resistant reaction on other differential varieties.

Group J: Four races (race 4, 5, 6, and 7) were included in this group. They were characterized by producing susceptible reactions on three *japonica type* varieties, (KT 51, NR 21 and SS). Reactions on other differential varieties were inconsistent.

Group I: This race group was composed of eight races (race 8, 9, 10, 11, 20, 21, 22, and 23). They were pathogenic to three local varieties of lowland *indica type* rice varieties.

Group P: Five races (race 12, 13, 14, 15, and 16) were placed under this group for their susceptible reaction on KSWSK and most of the locally developed *japonica* varieties. The variety Natala also gave susceptible reaction to the five races. Race 12 was the most virulent one among the 27 races so far characterized. It produced susceptible reaction on all 16 differential varieties.

Group T: Included in this race group were six races (race 18, 19, 24, 25, 26, and 27). This race group is characterized by its pathogenicity on KSWSK, TC 65 and

Natala.

The pattern of varietal reactions shown by the 27 races and the number of isolates obtained for each race during 1960–1966 are given in Table 2.

2. Prevalence and distribution of races of P. oryzae. Cav.

The distribution and frequency of occurrence of the 27 races of *P. oryzae* in Taiwan during 1964–66, together with those of 1960–63 are presented in Table 3 and Fig 1. Fig 2 gives the distribution of the blast races in Taiwan during 1960–66.

As shown in Table 3, races 24, 2 and 17 were the most predominant ones among 27 races during 1960–66. Race 13, the most predominant one during the years of 1960–63, and the major race in Tungshu and Chiayi areas, was not encountered during 1964–66, except one instance at Tungshu in 1966. On the other hand, only four isolates from four areas were designated as race 24 in 1963, however, it was encountered as many as 64 times during 1964–66. Races belonging to J group were not encountered in and after 1964. Races in P group, with the exception of race 12 which was encountered two times in 1964 and 3 times in 1965, of race 13 one time in 1966, and of race 16 one time in 1964, were not encountered in and after 1964. In I group, except race 9 which was characterized 3 times in 1965, and race 11, one time in 1964, all previously designated races before 1962 were not encountered in and after 1964. The rest of the races i. e., race 20, 21, 22 and 23 which were first designated in 1963 were encountered with steady frequencies during 1964–66.

There were fluctations in race appearances each year during the seven years period. The actual number of races detected was 13 races in 1960, 12 in 1961, 17 in 1962, 19 in 1963, 16 in 1964, 13 in 1965 and 14 in 1966.

In consideration of localities, 21 races were found in Ilan, 24 in Tungshu, 25 in Chiayi, 23 in Pintung, 25 in Taitung and 11 in Hualein. The distribution of the major races in the six areas were: Ilan, races 2, 14, 17 and 24; Tungshu, races 13 and 9; Chiayi, races 13, 17 and 2; Pintung, races 24, 17 and 2; Taitung, race 17 and Hualein, race 24. The patterns of race distribution in six localities where the uniform blast nurseries were located were quite similar. Among the 27 races so far characterized, 18 races were encountered over all the localities, except Hualein area, during the years of 1960–66.

Table 2. Physiologic races of *P. oryzae* characterized in Taiwan during 1960–1966.

Differential variety	Race designation																								Total no. of isolates	Total no. of races
	A	K		N	J				I								P					T						
	1	2	17	3	4	5	6	7	8	9	10	11	20	21	22	23	12	13	14	15	16	18	19	24	25	26	27	
Kung-shan-wu-snen-ken	R	S	S	R	S	S	S	S	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Taichung 65	R	R	S	R	R	Sm	S	R	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Pai-kan-tao	R	R	R	R	R	Mr	S	R	R	Rs	R	S	R	R	R	R	S	S	Sm	Sr	S	S	R	R	S	S	R		
Taichung 171	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	R	S	R	S	R	S		
Chianung 242	R	R	R	R	R	R	S	R	S	R	R	R	R	R	S	S	S	S	S	S	S	R	S	S	R	S	S		
Kwang-fu 1	R	R	R	R	R	R	S	R	S	R	R	R	R	R	S	S	S	S	S	S	S	R	S	R	R	S	S		
Chianung-yu 280	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	R	R	R	R	S	S		
Taichung-line 33	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	S	R	R	R	R	R	S		
Kanto 51	R	R	R	R	S	M	S	S	R	R	R	R	R	R	R	S	S	R	Sr	R	S	R	S	R	R	R	R		
Norin 21	R	R	R	R	S	M	S	S	S	R	R	R	R	R	R	S	S	R	S	R	S	R	R	R	R	R	R		
Sensho	R	R	R	R	S	M	S	S	S	R	S	S	R	R	R	R	S	R	Sm	M	S	R	R	R	R	R	R		
Cutsugucul	R	R	R	R	Sm	S	S	S	R	R	R	S	R	S	S	S	Sm	S	Sr	R	S	R	R	R	R	R	S		
Natala	R	R	R	S	S	S	S	S	Sm	S	S	R	R	S	S	S	Sm	Sm	S	S	S	Sm	Sm	S	S	S	S		
Kao-chio-liu-chou	R	R	R	R	R	Sm	S	Sm	S	Sr	S	S	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R		
Kaohsing-ta-li-chen-yu	R	R	R	R	R	M	S	Sm	S	S	S	S	S	S	S	S	S	S	Sr	R	R	R	R	R	R	R	R		
Taichung-ti-chio-wu-chien	R	R	R	R	Sm	R	Sm	Sm	S	S	S	S	S	S	S	S	S	S	M	R	R	S	R	R	R	R	R		
1960~1963	60	36	59	6	15	6	5	8	4	21	23	3	5	4	8	2	29	55	30	16	12	27	8	4	4			450	25
1964	24	16	20	5								1	3	5	3		2				1	1	9	36	3	18	4	151	16
1965	2	6	4	2						3			2	5	3	2	3							11		5	1	49	13
1966	9	11	8	13									8	10	6	2		1					1	17	1	2	4	93	14
Total	95	69	91	26	15	6	5	8	4	24	23	4	18	24	20	6	34	56	30	16	13	28	18	68	8	25	9	743	27

Table 3. Distribution and frequency of occurrence of physiologic races of *P. oryzae* characterized in Taiwan during 1960–1966.

Source	Year	Number of isolates																								Total no. of isolates	Total no. of races
		Group																									
		A	K		N	J				I									P					T					
		Race																									
		1	2	17	3	4	5	6	7	8	9	10	11	20	21	22	23	12	13	14	15	16	18	19	24	25	26	27		
Ilan	1960	1	1	1														1	1	2				1					8	7
	1	2	1	1		4						1							2	12			1						24	8
	2	10	2	1	1			2	2		2		1						1				3						25	10
	3	1	3	5		1									1	1							1		1				14	8
	4	4	4	3	2										1										9				23	6
	5		1	1							1				1										1		1		6	6
	6	1	4	2	4									1		2	1								3				18	8
	Total	19	16	14	7	5		2	2		3	1	1	1	3	3	1	1	4	14			5	1	14		1		118	21
Tungshu	1960	3	1	1		2				2	3	2						4	11			1							30	10
	1	1	1	1		2					9	5						3	6	5			7						40	10
	2					1		1	1		2	1						1	1				2						10	8
	3	7		1	1									1	2	1	1		3			1				2			20	10
	4	5	1	2											3	1		2				1	1	1	1		1		19	11
	5		1		2											1	1								3		1		9	6
	6	1		3	4									2					1						2	1			14	7
	Total	17	4	8	7	5		1	1	2	14	8		3	5	3	2	10	22	5	1	2	10	1	6	3	2		142	24

Chiayi	1960										2						2	3	1	1								9	5
	1	3	1	3													2	8	3			1						21	7
	2	4	6	3		2	1		1		1						2	6		1	6	5						38	12
	3	8	3	6	1				1		1			4	1	6	1	4	2		1		1	2	1	1			44	17
	4	8	4	4	1								1	3		1									7		12	1	42	10
	5	1													1	2		1							1			1	7	6
	6	2	2	1	1									1	2	1								1	1			1	13	10
	Total	26	16	17	3	2	1		2		1	3	1	8	4	10	1	11	19	4	3	6	7	3	10	1	12	3	174	25
Pintung	1960				1													2			3								6	3
	1	3	2	3							2	5						1	4	1	4			2					27	10
	2	6	5	8	1		3	1	2			4	2						1	2		1	2						38	13
	3	4	1	2																				2	1	1			11	6
	4	4	6	4	1																			2	12	1	1		31	8
	5		2	2							2			1	1			2							4		2		16	8
	6	2	3		1									3	4	1									5				19	7
	Total	19	19	19	4		3	1	2		4	9	2	4	5	1		5	5	3	7	1	2	6	22	2	3		148	23
Taitung	1960			8						2								2			1			1					14	5
	1	1	5	9							2	2						1	6	2			2						30	9
	2	3	2	5	1	3	2	1	1									4		2	4	4	2						34	13
	3	3	2	1																					1				7	4
	4	1		5	1										1	1								5	3		4	3	24	9
	5	1	1	1											1		1								1				6	6
	6	1		1	2									1	3	1	1								5			3	18	9
	Total	10	10	30	4	3	2	1	1	2	2	2		1	5	2	2	7	6	4	5	4	4	6	10		4	6	133	25
Hualein	1964	2	1	2																				1	4	2			12	6
	5		1											1	1										1		1		5	5
	6	2	2	1	1										1	1									1		2		11	8
	Total	4	4	3	1									1	2	1								1	6	2	3		28	11
Total		95	69	91	26	15	6	5	8	4	24	23	4	18	24	20	6	34	56	30	16	13	28	18	68	8	25	9	743	27

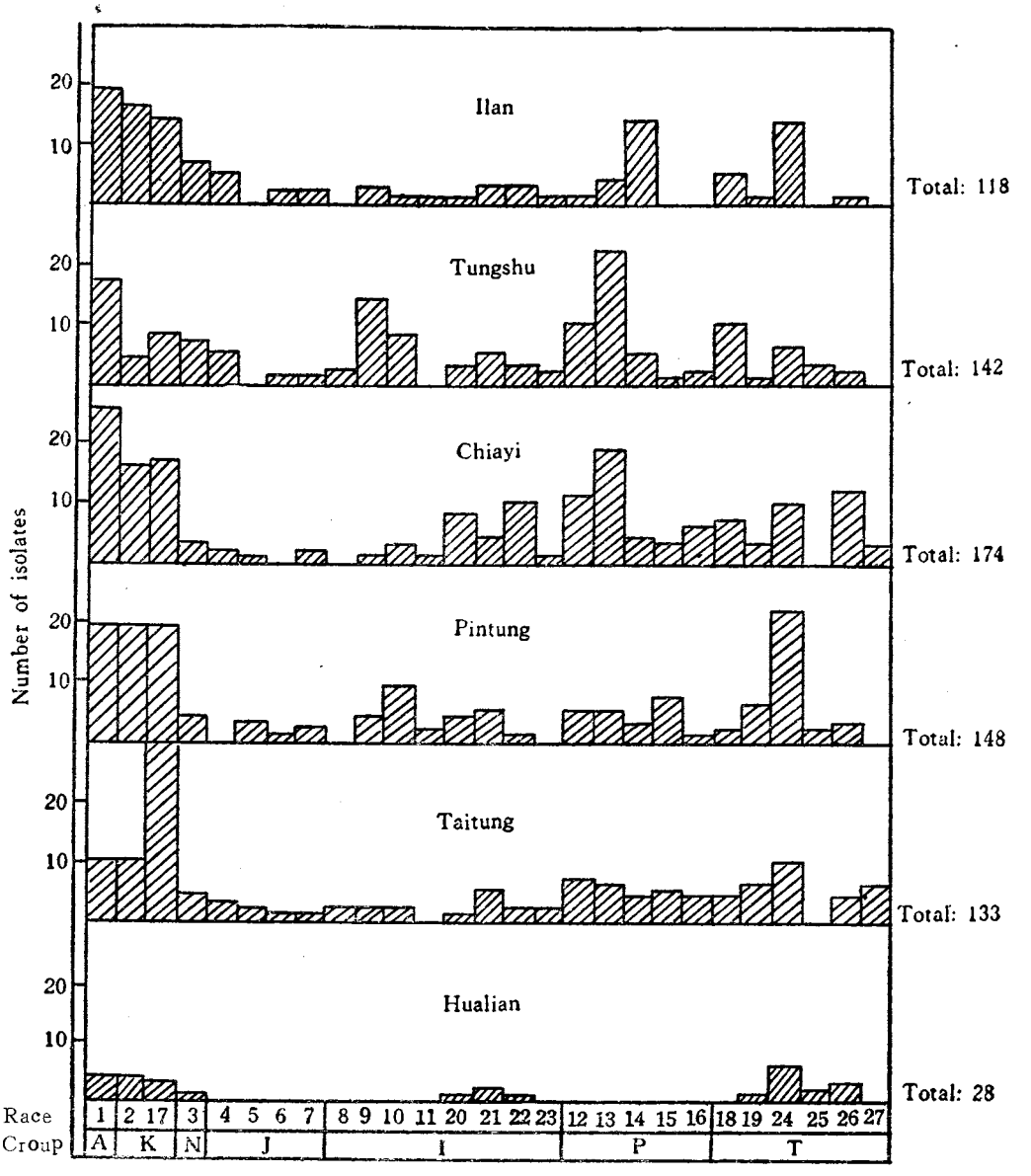
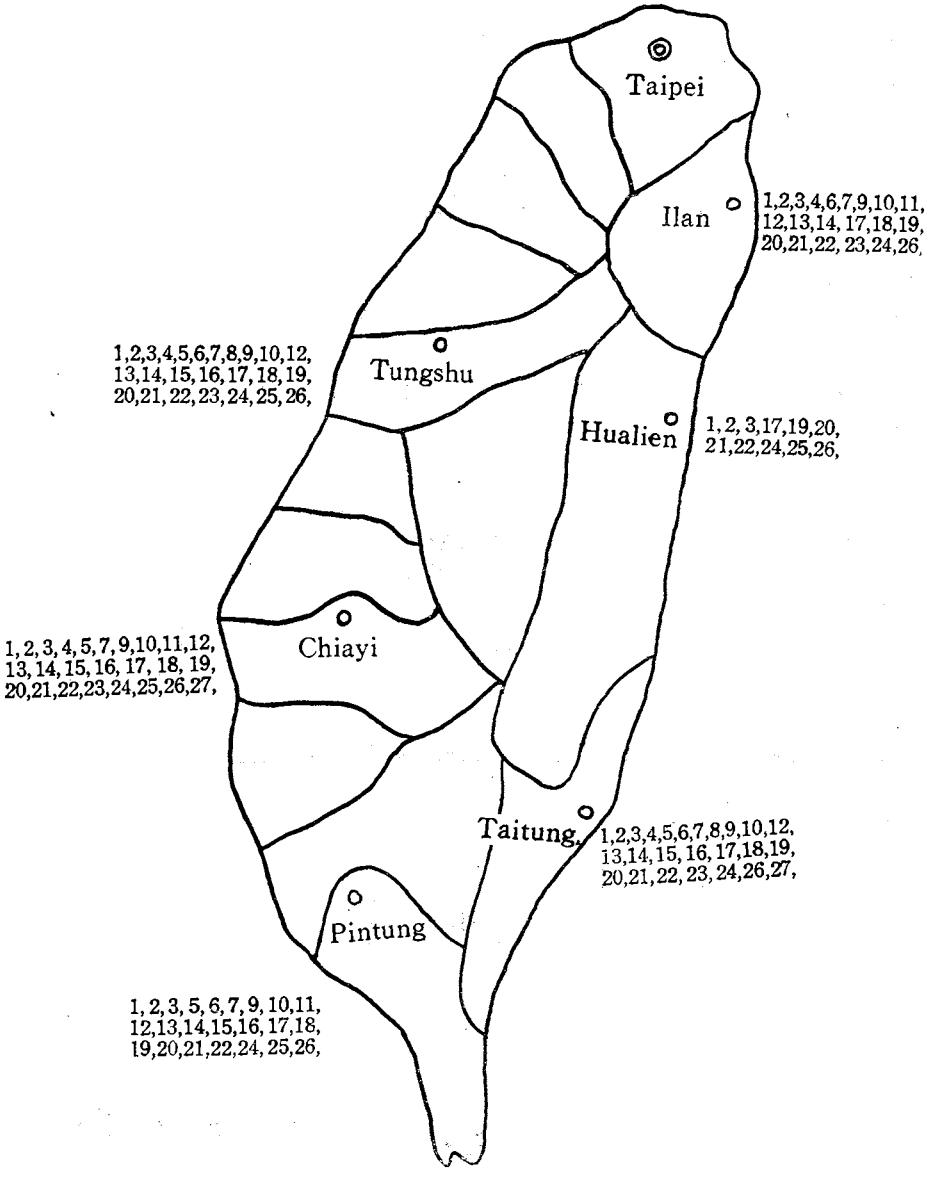


Fig 1. Distribution and frequency of occurrence of the 27 races of *P. oryzae* in Taiwan during 1960-66



Fig, 2. Geographic distribution of *Piricularia oryzae* races in Taiwan during 1960-1966

3. Reactions of the 16 Taiwan differential varieties to Japanese and U.S. races.

Eleven isolates representing eight Japanese races were tested for their pathogenicity on Taiwan differentials. The results are presented in Table 4.

Japanese race T-1 (Ken 53-33) could be included in P race group on Taiwan differentials. It infected all the 16 Taiwan differentials except CNY 280.

Japanese race T-2 did not show identical reactions for the two isolates (Ken 55-73 and Ken 62-88) when tested on the Taiwan differentials. Ken 55-73 gave a J race group reaction, while Ken 62-88 gave reaction similar to A race group, with susceptible lesions produced on KF-1 only.

Japanese race C-1 failed to give identical reactions for the two isolates (Ken 60-19 and ken 63-23) on the Taiwan differentials. Ken 60-19 gave the pathogenic pattern similar to Taiwan race 23. Ken 63-23 was less virulent than Ken 60-19.

Japanese race C-3 (Naga 87) gave a reaction similar to T race group on Taiwan differentials.

Japanese race N-1 (Hoku 373) gave the pathogenic pattern similar to Taiwan race 22 on Taiwan differentials. Taiwan race 22 gave the same reaction of N-1 on Japanese differentials as indicated in the later paragraph. It was believed that Japanese race N-1 was equavalent to Taiwan race 22.

Japanese race N-2 (Ai 62-22) gave the I race group reaction on Taiwan differentials.

Japanese race N-4 (Ina 168) behaved as Taiwan race 24 on Taiwan differentials. Yet Taiwan race 24 was not identical to Japanese N-4 on Japanese differentials.

Japanese race N-5 (Hoku 61-101) differed from any of the Taiwan races on Taiwan differentials. Naga 64-14, the other isolate in *Japanese race N*-5 gave the pathogenic reaction identical to Taiwan race 26 on Taiwan differentials. Yet Taiwan race 26 did not give the reaction pattern similar to the Japanese race N-5 on Japanese differentials.

Nine isolates representing six U.S. races were tested for their pathogenicity on the Taiwan differentials. The results are presented in Table 5.

U.S. Race 1, included two subraces, 1A and 1B. They were identical on the 16 differentials, if SM reactions were produced by race 1B on SS.

U.S. Race 3, produced SR and RS reactions respectively on KSWSK and TCTCWC. It gave resistant reaction on the rest of the varieties.

U.S. Race 4, caused RS reactions on KSWSK and KCLC, and R reaction on the rest of the varieties.

U.S. Race 5, included two subraces. Race 5A infected six varieties (KSWSK, NR 21, Nat., KCLC, KHTLC and TCTCWC), while race 5B infected five varieties (KSWSK, CNY 280, KCLC, KHTLC, and TCTCWC) of the Taiwan differentials.

U.S. Race 6, included two subraces, 6A and 6B. They were identical if RS reactions are produced on Cats by race 6B.

U.S. Race 7, caused S reactions on KSWSK, and RS reactions on three other varieties (KT 51, Nat., and KCLC).

Among the 16 Taiwan differntials, *indica type* varieties seemed more valuable as differentials than the *japonica type* varieties. Five *japonica type* varieties, i.e., TC 65 PKT, TC 171, CN 242, and KF 1 are not susceptible to any of the six U.S. races. Sucespitible reactions were produced on one *Japonica* type variety KSWSK by all the races.

Table 4. Reactions of Taiwan differential varieties to Japanese races of *P. oryzae*.

Variety	Japanese race										
	T-1	T-2	T-2	C-1	C-1	C-3	N-1	N-2	N-4	N-5	N-5
	Ken 53-33	Ken 55-73	Ken 62-88	Ken 60-19	Ken 63-23	Naga 87	Hoku 373	Ai 62-22	Ina 168	Hoku 61-101	Naga 61-14
Kung-shan-wu-shen-ken	S	S	R	S	S	S	S	S	S	S	S
Taichung 65	S	S	R	S	R	S	S	S	S	S	S
Pai-kan-tao	Sr	R	R	R	R	R	R	R	R	R	R
Taichung 171	Sr	R	R	S	R	R	S	R	R	Sr	S
Chianung 242	Sr	Sr	R	S	R	S	S	R	S	R	S
Kwang-fu 1	Sr	R	Sr	S	Sr	R	S	R	R	Sr	S
Chianung-yu 280	R	R	R	Sr	R	R	S	R	R	Sr	S
Taichung-line 33	Sr	R	R	S	R	R	S	R	R	R	R
Kanto 51	Sr	R	R	S	S	S	R	R	R	Sr	Sr
Norin 21	Sr	R	R	Mr	R	R	M	Sm	R	R	R
Sensho	Mr	R	R	R	R	R	R	Sr	R	R	R
Cutsugucul	S	R	R	S	Sr	R	S	R	R	R	R
Natala	S	R	R	S	Sr	S	S	S	S	R	S
Kao-chio-liu-chou	Mr	S	R	Sr	Sr	R	M	S	R	R	R
Kaohsing-ta-li-chen-yu	S	S	R	Sr	R	R	Ms	S	R	R	R
Taichung-ti-chio-wu-chien	S	S	R	Sr	R	R	Ms	S	R	R	R
Taiwan race equivalent				Ta.23			Ta.22?		Ta.24		Ta.26

Table 5. Reactions of Taiwan differential varieties to U.S. races of *P. oryzae*

Variety	U.S. race								
	1 A	1 B	3	4	5 A	5 B	6 A	6 B	7 A
Kung-shan-wu-shen-ken	S	S	SR	RS	S	S	S	S	S
Taichung 65	R	R	R	R	R	R	R	R	R
Pai-kan-tao	R	R	R	R	R	R	R	R	R
Taichung 171	R	R	R	R	R	R	R	R	R
Chianung 242	R	R	R	R	R	R	R	R	R
Kwang-fu 1	R	R	R	R	R	R	R	R	R
Chianung-yu 280	R	R	R	R	R	M	R	R	R
Taichung-line 33	R	R	R	R	S	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	RS
Norin 21	R	R	R	R	R	RS	R	R	R
Sensho	SM	R	R	R	R	R	R	R	R
Cutsugucul	R	R	R	R	R	R	RS	R	R
Natala	R	R	R	R	S	R	S	S	RS
Kao-chio-liu-chou	S	S	R	RS	S	S	S	S	RS
Kaohsing-ta-li-chen-yu	S	S	R	R	S	S	S	S	R
Taichung-ti-chio-wu-chien	S	S	RS	R	S	S	S	S	R

4. Reactions of the U.S. and Japanese differentials to Taiwan races

Table 6 gives the reactions of the Japanese and U.S. differentials, respectively, to representative isolates of certain Taiwan races of *P. oryzae*. Most of these isolates were sent to the United States and Japan for tests at Beltsville, Maryland and Tokyo in exchange of cultures for the cooperative research.

It seemed that the U.S. differentials did not provide a good differentiation for the Taiwan races. Races 9, 22 and 24 were indistinguishable on the U.S. differentials. The same reactions were also obtained for races 13 and 16, and for races 14, 17 and 19. But, rather satisfactory separation of these races was obtained with Japanese differentials.

Taiwan race 1 (3C-58G) lost their pathogenicity during culturing. None of the Taiwan, U.S. or Japanese differentials were infected by this isolate.

Taiwan race 2 (2T-74S) gave susceptible reaction only on KSWSK of the 16 Taiwan differentials. It infected CI 8970-P and Aichi-asahi of the U.S. and Japanese differentials, respectively.

Taiwan race 3 (2K-27S) infecting only Natala of the Taiwan differentials induced susceptible reactions on Rexoro and Taichung 65 of the U.S. differentials. However, Taich-

ung 65 when tested along with other Taiwan varieties showed resistant reaction to this isolate. Usen and Ishikari-shiroke in the Japanese differentials were found susceptible to this race.

Taiwan race 5 (2K-24S) belonging to J race group on Taiwan differentials was pathogenic to five varieties of the U.S. differentials, namely, Rexoro, Lacrose, Caloro, CI 8970-P and Taichung 65. It showed the same pathogenic pattern as U.S. race 6. However, U.S. race 6 did not give the Taiwan race 5 pattern on the Taiwan differentials. On the Japanese differentials, it was pathogenic to Usen, Ishikari-shiroke, Homare-nishiki, Aichi-asahi, Norin 20 and Pi No. 1.

Taiwan race 9 (3C-109M) seemed to be different from any of U.S. and Japanese races. It was highly pathogenic to the Japanese differentials. Of the U.S. differentials, only Caloro, CI 8970-P and Taichung 65 were found susceptible to this isolate.

Taiwan race 12 (2S-74S) infected all of the Taiwan differentials. On the U.S. differentials, it induced the pathogenic pattern similar to U.S. race 21. However, U.S. 21 did not show Taiwan race 12 pattern on the Taiwan differentials. It gave the same pathogenic pattern as Japanese race N-6, on the Japanese differentials.

Taiwan race 13 (2C-2124S) showed the highest virulence to both the U.S. and Japanese differentials. Te-tep, Tudukan, Chokoto and Yakeiko were the only varieties among the Japanese differentials which were resistant to this race. It differed from any of the Japanese races on the Japanese differentials. When tested on the U.S. differentials, Taiwan race 13 gave the reaction pattern identical to U.S. 17, yet U.S. rece 17 did not show the Taiwan race 13 pattern on the Taiwan differentials.

Taiwan race 14 (1I-29S) representing one of the most virulent races on the Taiwan differentials showed only moderate pathogenicity on the Japanese differentials and weak pathogenicity on the U.S. differentials. This isolate induced the pathogenic pattern similar to U.S. race 4 on the U.S. differentials. On the Japanese differentials, it showed the pathogenic pattern similar to Japanese N-2, if susceptible reaction was not obtained on Pi No. 1.

Taiwan race 16 (2C-86S) gave the same pathogenic pattern as U.S. race 17 on the U.S. differentials. It seemed to be different from any of the Japanese races.

Taiwan race 17 (2K-82S) gave the same pattern of Japanese N-2 on Japanese differentials. It behaved like U.S. race 2 on the U.S. differentials.

Taiwan race 19 (4K-18S) showed weak pathogenicity to both the U.S. and Japanese differentials. It gave susceptible reactions on Caloro and Taichung 65 in the U.S. differentials. Of the Japanese differentials, only Norin 20 and Norin 22 were infected.

Taiwan race 22 (4T-28S) showed rather strong pathogenicity to the Japanese differentials, but weak pathogenicity to the U.S. differentials. The pathogenic pattern of this race on the Japanese differentials was identical to the Japanese race N-1.

Taiwan race 24 (4C-25S) produced the same pathogenic pattern as Taiwan races 9 and 22 on the U.S. differentials.

Taiwan race 26 (4T-27Sb) seemed to be different form any of U.S. and Japanese races. It gave the pathogenic patterns similar to Taiwan races 9, 22 and 24, on the U.S. differentials.

Table 6. Reactions of U.S. and Japanese differential varieties to Taiwan races of *P. oryzae*.

Variety	Taiwau Race													
	1	2	3	5	9	12	13	14	16	17	19	22	24	26
	3C-58G	2T-74S	2K-27S	2K-24S	3C-102M	2S-74S	2C-2124S	1I-29S	2C-86S	2K-82S	4K-18S	4T-28S	4C-28S	4T-27Sb
U.S. differentials														
Zenith	R	R	R	R	R	R	S	R	S	R	R	R	R	R
Rexoro	R	R	Sr	S	R	S	S	R	S	R	R	R	R	R
Lacrosse	R	R	R	S	R	R	S	R	S	Rs	R	R	R	R
Caloro	R	R	R	S	S	S	S	S	S	S	S	S	S	S
CI 8970-P	R	S	R	S	S	S	S	R	S	R	R	S	S	S
CI 8970-S														
CI 5309	R	R	R	R	R	R	R	R	R	R	R	R	R	R
PI 180061	R	R	R	R	R	R	R	R	R	R	R	R	R	M
PI 201902	R	R	R	R	R	R	R	R	R	R	R	R	R	R
PI 231128	R	R	R	R	R	R	R	R	R	R	R	R	R	R
PI 231129	R	R	R	R	R	R	R	R	R	R	R	R	R	Sr
Taichung 65	R	R	Rs	S	S	S	S	S	S	S	Sr	Sr	S	M
Japanese differentials														
Te-tep	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Tadukan	R	R	R	R	R	S	R	R	R	R	R	R	R	R
Usen	R	R	S	S	S	R	S	Rs	S	R	R	R	R	R
Chokoto	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Yakeiko	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Kanto No.51	R	R	R	R	R	R	S	R	R	R	R	R	R	R
Ishikari Shiroke	R	R	S	S	S	S	S	R	S	R	R	S	S	S
Homare-nishiki	R	R	R	S	R	R	S	Rs	Rs	S	R	S	R	R
Ginga	R	R	R	R	S	R	S	S	Rs	S	R	S	S	S
Norin No.22	R	R	R	R	S	S	S	S	Rs	S	S	S	S	S
Aichi asahi	R	S	R	S	S	S	S	S	S	S	R	S	R	S
Norin No.20	R	R	R	S	S	S	S	S	S	S	S	S	R	S
Pi. No. 1	R	R	R	S	M	R	S	S	S	R	R	M	R	S
U.S. race equivalent	U.S. 10?			U.S. 6?		U.S. 21?	U.S. 17?	U.S. 4?	U.S. 17?	U.S. 2?				
Japanese race equivalent						N.6				N.2		N.1		

5. Reactions of the 12 tentative internat ional differentials supplied by J. G. Atkins, U.S.D.A. to Taiwan races of P. oryzae.

All varieties in groups 1 (Tadukan), 2 (Zenith and NP. 125), 3 (Usen), and 4 (C. I. 5309, Kanto 51, and Dular) gave resistant reactions to the eight races tested, with one exception that RS reaction was induced by race 16 on Usen, the only variety in group 3. On C.I. 8970-S, the variety in group 5, resistant reaction was caused by race 1, while susceptible reaction by races 16, 17, 22, and 26. SR or RS reactions were produced by races 3, 5, and 11 on this variety. Three varieties (Norin No. 20, Caloro, and Aichi asahi) in group 6 reacted resistantly to races 1 and 11 but susceptiblely to rece 22. Inconsistent reactions were shown on this variety group by the rest of the races. (Table 7)

Table 7. Reactions of the tentative international differentials supplied by J. G. Atkins. U.S.D.A. to Taiwan races of *P. oryzae*

Group no. and variety	Taiwan race							
	1	3	5	11	16	17	22	26
	3C-58G	2K-27S	2K-24S	2K-20S	2C-86S	2K-82S	4T-28S	4T-27Sa
Group 1								
Tadukan	R	R	R	R	R	R	R	R
Group 2								
Zenith	R	R	R	R	R	R	R	R
NP. 125	R	R	R	R	R	R	R	R
Raminad str.3								
Group 3								
Usen	R	R	R	R	R S	R	R	R
Group 4								
C.I. 5309	R	R	R	R	R	R	R	R
Kanto No. 51	R	R	R	R	R	R	R	R
Dular	R	R	R	R	R	R	R	R
Group 5								
C.I. 8970-S	R	S R	S R	R S	S	S	S	S
Group 6								
Norin No. 20	R	R	R	R	R	R S	S	S
Caloro	R	S R	S R	R	S	S R	S	S
Aichi asahi	R	R	R S	R	S	R	S	R

6. Reactions of the 24 tentative international differentials suupplied by IRRI to Taiwan races of P. oryzae.

Ten isolates representing ten races were tested for their pathogenicity to the 24 tentative international differentials. No pathogenic reactions were observed in all races on varieties of groups 1 (Te-tep and Tadukan), 2 (Zenith, Wag-wag, Raminad str. 3 and NP-125) and 4 (Chokoto, Yakeiko, G.I. 5309, Kanto 51 and Dular). Races 3, 13, 16, and 22 caused S-R reactions on varieties of group 3, while resistant reactions were given by races 1, 5, 11, 14, 17, and 26 on varieties of this group (Usen, Pi. No. 1, and Lacrosse). Varieties of group 5 (Ishikari-Shiroke, C. I. 8970-P, C. I. 8970-S, and Rexoro) gave resistant reaction to races 1, 5, 11, and 13. Only one or two varieties of this group gave RS or SR reaction to races 3, 17, 22, and 26. Race 16 is pathogenic to three varieties of this group. All varieties in Group 6 (Homare nishiki, Ginga, Taichung 65, Norin No. 22, Caloro, and Aichi asahi) reacted resistantly to race 1, but susceptiblely to race 22. Races 11, 16, 17, and 26 infected two varieties (Taichung 65 and Caloro) of the group, while races 3, 5, and 13 infected three varieties. (Table 8).

7. Reactions of 40 rice varieties supplied by FAO to Taiwan race of P. oryzae.

The 40 rice varieties from FAO were tested for their reactions to nine Taiwan races of *P. oryzae*. The results are presented in Table 9. All nine races caused resistant reaction on varieties of group 1, but susceptible reactions on varieties of group 6. Moderately resistant reactions were produced by races 12, 13, 17 and 22 on only one or two varieties of group 2. Varieties of group 3 seemed highly resistant to the races tested. Races 14, 17 and 18 all produced resistant reactions on this variety group; races 5, 13, and 22 each induced susceptible reaction only on one variety; races 9 and 12 induced susceptible reactions on two varieties among 8 varieties. Susceptible reactions were produced by race 3 on three varieties in the same group. Varieties of group 4 gave resistant reactions to races 3 and 13. Only one variety of this group gave susceptible reactions to races 5 or 18. Races 9 and 14 were pathogenic to two varieties of this group. Racec 12, 17 and 22 caused S-M reaction on four varieties of the group. Resistant reactions were produced by race 14 on all varieties of group 5. Race 17 and 18 caused MR and SR reactions respectively on Woo-Gen and T 141. The rest of the races are highly pathogenic to the varieties of this group.

8. Reactions of commercial rice varieties to Taiwan races of P. oryzae.

Twenty commercial rice varieties including two native Taiwan varieties i.e., Ai-Chueh-Chien and Taichung-native 1, and 18 *japonica* type varieties were tested for their reactions to eight Taiwan races of *P. oryzae*. Results are given in Table 10. Races 12, 13, and 16 are of the most pathogenic *ones* among the races tested. Of 20 varieties tested, only Taichung 186 Taichung-yu 184 were resistant to these races, while Taichung-native 1 resistant to races 12 and 13, but susceptible to race 16. Races 17, 24, and 26, the races of second pathogenic caused resistant reactions on the varieties of group 1 (Taichung 186 and Taichung-yu 184), but susceptible reactions on all varieties of group 2 (Taichung 65, Kaohsiung 24, Taipei 306 and Taipei 308) and group 3 (Tainan 1, Chianan 8, Kaohsinng 10, Kaohsiung 27, Kaohsiung

64, and Hsinchu 56). These three races induced S reaction on one or two varieties in group 4, and S-M-R reactions on some varieties of groups 5. Race 5 caused susceptible reactions on all varieties in group 5 (Taichung 178, Kaohsiung 122, Ai-Chueh-Chian, Taichung-native 1), and on two varieties in group 4 (Chianung 242 and Taipei 177). All varieties in groups 1 and 3 and two varieties in group 4 gave resistant reactions to the race. Race 1, the weakest in pathogenicity, caused resistant reactions on most of the verieties, a few varieties (Kaohsiung 24, Chianan 8, Kaohsiung 10, 64 and Hsinchu 56), however, showed RS reactions to the race.

Table 8. Reactions of the 24 tentative international differentials supplied by IRRI to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race									
	1	3	5	11	13	14	16	17	22	26
	3C-58G	2K-27S	2K-24S	2K-20S	2C-2124S	1I-29S	2C-86S	2K-82S	4T-28S	4T-27Sa
Group 1										
Te-tep	R	R	R	R	R	R	R	R	R	R
Tadukan	R	R	R	R	R	R	R	R	R	R
Group 2										
Zenith	R	R	R	R	R	R	R	R	R	R
Wag-wag	R	R	R	R	R	R	R	R	R	R
Raminad str. 3	R	R	R	R	R	R	R	R	R	R
NP-125	R	R	R	R	R	R	R	R	R	R
Group 3										
Usen	R	RS	R	R	RS	R	S	R	SR	R
Pi. No. 1	R	RS	R	R	RS	R	SR	R	R	R
Lacrosse	R	R	R	R	RS	R	S	R	SR	R
Group 4										
Chokoto	R	R	R	R	R	R	R	R	R	R
Yakeiko	R	R	R	R	R	R	R	R	R	R
C. I. 5309	R	R	R	R	R	R	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	R	R
Dular	R	R	R	R	R	R	R	R	R	R
Group 5										
Ishikari-shiroke	R	R	R	R	R	R	R	R	R	R
C. I. 9870-P	R	R	R	R	R	RS	S	RS	SR	R
C. I. 8970-G	R	RS	R	R	R	RS	S	R	S	RS
Rexoro	R	R	R	R	R	R	R	R	R	R

Group 6										
Homare-nishiki	R	R	RS	R	R	RS	R	R	S	R
Ginga	R	R	RS	R	R	RS	R	R	SR	R
Taichung 65	R	RS	SR	RS	S	S	S	S	S	S
Norin 22	R	R	R	R	R	S	R	R	S	R
Caloro	R	SR	SR	S	S	S	S	S	S	S
Aichi-asahi	R	SR	R	R	S	S	R	R	S	R

Table 9. Reactions of the 40 rice varieties supplied by FAO to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race								
	3	5	9	12	13	14	17	18	22
	2K-27S	2K-24S	3C-102M	2S-74S	2C-2124S	1I-29S	2K-82S	2S-17S	4T-28S
Group 1									
PI 180061	R	R	R	R	R	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	R
M-302	R	R	R	R	R	R	R	R	R
H-4	R	R	R	R	R	R	R	R	R
H-5	R	R	R	R	R	R	R	R	R
Murungakayan 302	R	R	R	R	R	R	R	R	R
Slo 15 (from 61A)	R	R	R	R	R	R	R	R	R
BR 7	R	R	R	R	R	R	R	R	R
Ninidhan	R	R	R	R	R	R	R	R	R
221/BCIV/I/178/3	R	R	R	R	R	R	R	R	R
221/BCIV/I/178/11	R	R	R	R	R	R	R	R	R
Hakkodo	R	R	R	R	R	R	R	R	R
G. B. 121	R	R	R	R	R	R	R	R	R
H-105	R	R	R	R	R	R	R	R	R
Samo Ran	R		R	R	R	R	R	R	R
Group 2									
Samo Trang	R	R	R	R	R	R	RM	R	R
FE 165	R	R	R	R	M	R	R	R	R
Tadukan	R	R	R	RM	M	R	R	R	R
Hybrid I	R	R	R	MR	R	R	R	R	M

Group 3									
Dud Kuning	R	R	S R		R	R	R	R	
Yakeiko	R	R	S R	R	R	R	R	R	R
Bengawan	S	R	R	R	R	R	R	R	R
D 25-4	S	R	R	R	R	R	R	R	R
Nepali Tulasi (Sel)	R	R	R	S	R	R	R	R	R
C 46-15	R	R	R	R	S	R	R	R	R
Hybrid II	R	R	R	S R	R	R	R	R	S
Fa-Yiu Tsai	S	S	R	R	R	R	R	R	R
Group 4									
A. C. 2250	R	R	R	RM	R	R	S R	R	S
Ginga	R	R	R	M	R	S	R	R	S
Nhta-6	R	R	S	S	R	R	RM	R	R
C 33-18	R	R	R	R	R	R	S R	S R	S R
T.K.M. 6	R	S R	S	R	R	R	R	R	S R
G.S. 336	R	R	R	S	R	R	S R	R	R
Group 5									
Tjere Mas	M	S R	M	R	R	R	R	R	RM
Woo-Gen	R	R	S R	S	R	R	MR	R	S
Patnai 23	S	S R	R	R	S	R	R	R	M
T 141	S	S	S R	R	S	R	R	S R	RM
M.T.U. 3	S	S	S	S	S	R	R	R	R
Group 6									
Usen	S	S	S R	S	S	S	S M	S	S
U.S.A. Caloro	S	S M	S	S	S	S	S R	S	S

Table 10. Reactions of commercial rice varieties to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race							
	1	5	12	13	16	17	24	26
	3C-58G	2K-24S	2S-74S	2C-2124S	2C-86S	2K-82S	4C-25S	4T-27Sa
Group 1								
Taichung 186	R	R	R	R	R	R	R	R
Taichung-yu 184	R	R	R	R	R	R	R	R

Group 2								
Taichung 65	R	R	S	S	S	S	S	S
Kaohsiung 24	RS(17:3)[a]	S	S	S	S	S	S	S
Taipei 306	R	S	S	S	S	S	S	S
Taipei 398	R	S	S	S	S	S	S	S
Group 3								
Tainan 1	R	R	S	S	S	S	S	S
Chianan 8	RS(18:2)	R	S	S	S	S	S	S
Kaohsiung 10	RS(18:2)	R	S	S	S	S	S	S
Kaohsiung 27	R	R	S	S	S	S	S	S
Kaohsiung 64	RS(17:3)	R	S	S	S	S	S	S
Hsinchu 56	RS(16:4)	R	S	S	S	S	S	S
Group 4								
Chianung 242	R	S	S	S	S	R	S	S
Taipei 177	R	S	S	S	S	S	R	S
Tainan 3	R	R	S	S	S	S	R	R
Hsinchu 61	R	R	S	S	S	R	R	R
Group 5								
Taichung 178	R	S	S	S	S	RM(16:4)	S	RS(15:4)
Kaohsiung 122	R	S	SR(13:7)	S	S	MR(12:8)	S	RM(17:3)
Ai-chueh-chien	R	S	RS(13:7)	S	S	RS(15:5)	R	R
Taichung-native 1	R	RS(13:7)	R	R	S	R	RM(10:7)	R

a. The number of leaves for different reactions.

9. **Physiologic races of P. oryzae characterized in one field block**

Thirty five isolates of *P. oryzae* were isolated from the disease specimens collected randomly from a blast nursery consisting of one rice variety Taichung 65. Cultures of *P. oryzae* were single-spore isolated and tested for their pathogenicity on the 16 differential varieties in the greenhouse.

The results presented in Table 11 indicate that there are several races of *P. oryzae* existing in one field block. The difference in frequency of occurrence was shown by the races. Fourteen isolates were identified as race 26, seven isolates as race 24, three isolates as race 21 and the other three isolates as race 1. Only one isolate was identified as race 20. There were 5 isolates showing the pathogenicity which did not belong to the existing race patterns.

These races can be further placed into four race groups. Race 1 belonged to A race group, race 17 to K race group, race 20 and 21 to I race group, and race 24 and 26 to T

race group. The rest of isolates comprising 14.3% of the total isolates did not belong to any race group. It was noticed from this experiment that the most prevalent race belonged to the T race group. No isolates were identified as races belonging to J or P race group, although the disease specimens were collected from *japonica* type rice variety.

Table 11. Physiologic races of *P. oryzae* Cav. characterized in one field block

Group	A	K	I		T		Isolates not included in the existing race
Race	1	17	20	21	24	26	
Number of isolate	3	2	1	3	7	14	5
Percentage of isolate in race group	8.5	5.8	11.4		60.0		14.3

10. Race characterization of P. oryzae Cav. by using the eight international differentials.

The eight international differential varieties were tested for their reactions to the isolates of *P. oryzae* which had been characterized with the U. S., Japanese or Taiwan set of differential varieties, and to some newly collected isolates of *P. oryzae* in Taiwan. The results are given in Table 12.

when the isolates of Japanese races were characterized with the international set of differentials, five former Japanese races T-1, T-2, C-1, C-3, N-1, would fall into IC-5, ID-10, IE-1, IF-2, IG-1 respectively. Former Japanese races N-2, N-4. and N-5 would be included in IH-1. Former U.S. races 1, 7, 3, 5B would fall into IB-5, IF-1, IG-1 and IG-2 respectively. Former U.S. raes 5A and 6B, and races 2 and 4 would be designated as ID-8 and IH-1 respectively. Former Taiwan races 3, 4, and 5 could be designated as ID-8, race 16 as IE-1, races 9, 12, 13, 20, 22, 24, 26, and 27 as IG-1, race 21 as IG-2, and races 2, 17, and 19 as IH-1. However, in the U.S.-Japanese Cooperative Study, former Japanese races T-1, and N-5 were designated as IC-1 and IG-1 respectively, and former U. S. races 5A, 6B and 7A were designated as ID-9, ID-8, and IB-2 or IB-4, respectively (4).

When, newly collected isolates in 1966 were tested on the international set of differentials, almost three fourths of the isolates were characterized into IG and IH race groups. Since the key varieties of these group, i.e., C.I. 8970 (S) and Caloro are susceptible to most races (4), the Taiwan isolates designated as IG or IH groups could be considered as the races of rather weak pathogenicity.

It was also noticed that the strains of *P. oryzae* designated by using the international differentials could be split into more different race groups when the Taiwan differential varieties were used for race characterization. For instance, isolates designated as IG-1 could be split into eight Taiwn races included in P, I, and T race groups.

Table 12. Pathogenic races and isolates characterized by the 8 international differential varieties

International race group	International race	Reaction per differential variety								Prior race			newly collected Taiwan isolate
		Raminad Str. 3	Zenith	NP-125	Usen	Dular	Kanto 51	CI. 8970 (S)	Caloro	US	Japan	Taiwan	
IB	5	R	S	R	R	S	R	S	R	1A			
IC	3	R	R	S	R	S	S	S	S				1
	5	R	R	S	R	R	S	S	S		T-1 (IC-1)		
ID	8	R	R	R	S	R	R	S	S	5A (ID-9)[a] 6B (ID-8)		3,4,5	2
	10	R	R	R	S	R	R	R	S		T-2		1
	11	R	R	R	S	R	R	R	R				
IE	1	R	R	R	R	S	S	S	S		C-1	16	3
	2	R	R	R	R	S	S	R	S				1
	3	R	R	R	R	S	R	S	S				3
	4	R	R	R	R	S	R	R	S				1
IF	1	R	R	R	R	R	S	S	S	7A(IB-2, IB-4)			4
	2	R	R	R	R	R	S	S	S		C-3		
IG	1	R	R	R	R	R	R	S	S	3	N-1	9,12,13,20, 22,24,26,27	24
	2	R	R	R	R	R	R	S	R	5B		21	15
IH	1	R	R	R	R	R	R	R	S	2,4	N-2 N-4 N-5 (IG-1)	2,17,19	14

a. The race designated by the U.S.-Japanese Cooperative Study.

Discussion and Conclusion

The prevailing races of the blast fungus varied from year to year. Among the 27 races so far characterized, races 17, 2 and 24 were the most predominant ones. Race 13, the most predominant one of 1960-1961, became less prevalent later in 1962 and 1963, and was not encountered during 1964-1965. Only one isolate collected from Tungshu was characterized as race 13 in 1966. The same trend was also observed with race 12. Races in J and P groups with a few exceptions, were not encountered in and after 1964. On the other hand, race 24 which was first designated with four isolates in 1963 was identified as many as 36 times in 1964. It has become the most predominant race since then.

Most races designated in and after 1964 belonged to race groups of K, N, I and T. Only a few isolates were designated as races in P race group. In I race group. only four out of 53 isolates characterized during 1964-66 fell into the existing race patterns designated before 1962, i. e., races 9 and 11. The rest of isolates fell into the race pattern of newly designated, i. e., races 20, 21, 22 and 23 which were encountered with steady frequencies since 1963. No isolates were designated as races in J race group since 1964.

The patterns of race distribution in six localities where the uniform blast nurseries were located were quite similar. Among 27 races so far characterized, 18 races were encountered over all the localities, except Hualein area, during the years of 1960-66, The rest of the races were encountered in some localities with minor prevalence. Apparently, there was no local peculiarity in race distribution within the island of Taiwan.

The relative prevalence of a given race could be expected to change with shifts in acreage of susceptible rice varieties (3). In the uniform blast nurseries, the varieties of rice planted were changed from year to year. Susceptible varieties were screened out and not planted in the following years. More resistant rice varieties were provided for commercial use, especially blast resistant varieties of Ponlai rice which were distributed for increasing acreage of planting this type of rice (22). Most of Ponlai rice varieties inherited the blast resistant quality of native rice. It is assumed that increasing acreage of planting Ponli rice varieties brings on the shifts of races of the blast fungus in Taiwan.

It was evident that no isolates collected in and after 1964 showed infectious ability to the varieties of Japanese origin, namely Kanto 51, Noring 21 and Sensho in Taiwan differential varieties, except a few isolates in race 12. However, Kanto 51 received from IRRI as one of the eight international differentials was susceptible to some newly collected isolates in 1966, which were designated as the races other than race 12. This phenomenon might be due to the different origins of seeds of Kanto 51 in the international differentials and those in Taiwan differentials. The susceptiblity of this rice variety to the blast fungus might change during the successive cultivation in the different localities. In order to compare research information on an international basis, the seeds for differential varieties should be distributed to the investigators by a certain organization every year.

Evaluations of the U.S. and Japanese differentials were made with several representative

isolates in Taiwan races. The U.S. differential varieties did not provide a satisfactory differentiation for the Taiwan races. They differentiated some race pairs that show a general similarity in host reaction. However, they failed to distinguish some other races; several Taiwan races showed identical pathogenic pattern on the U.S. differentials. The Japanese differential varieties provided unequivocal separation of Taiwan races. Fourteen isolates representing 14 Taiwan races were distinguished from one another on Japanese differentials.

The Taiwan differentials provided a satisfactory differentiation for Japanese races. The reactions obtained with certain Japanese isolates on Taiwan differentials agreed with those recorded in tests made in Tokyo (27). It was evident that isolates of the same race charact erized by Japanese workers could be further differentiated by the Taiwan differential varieties. Among the 16 Taiwan differentials, *indica* type varieties seemed more valuable as differentials for U.S. races, while *japonica* type rice varieties mostly showed resistant reactions.

According to Takasaka *et al.* (28), the major races in Taiwan may consist of Japanese N-group races and of the Philippines races. He indicated that Taiwan race 2 and 17 were identical to Japanese N-4 on Japanese differentials. Having tested the *P. oryzae* isolates from Taiwan on Japanese and U. S. differentials, Goto and Kozaka reported the presence of Japanese races N-3, N-4 and N-5, and U.S. races 4 and 18 in Taiwan (2). The evidences were also indicated by Latterell *et al.* (18). They reported that U.S. races 18 and 21 isolated from specimens received from Taiwan appeared to have the same affinities as Japanese N-5 and N-1. In tests conducted in Taiwan, Taiwan races 12, 7 and 22 gave pathogenic pattern identical to Japanese N-6, N-2 and N-1, respectively on Japanese differentials, and Japanese race C-1, N-1, N-4 and N-5 showed the pathogenic patterns identical to Taiwan races 23, 22, 24 and 26 respectively on Taiwan differentials. Taiwan races 5, 12, 14, 13 or 16 and 17 showed pathogenic pattern identical or similar to the U.S. races 6, 21, 4, 17 and 2, respectively on the U.S. differentials, and the U.S. races 3 and 4 showed the reaction similar to race pattern of Taiwan race 2 on Taiwan differentials. Among U.S. races, races 2, 3, 4 and 21 are equavalent to Japanese N race group in the international differentials (4). Further evidences were obtained when the Taiwan races were tested on the international differentials. Most Taiwan races could be designated as races in IG and IH groups in which all prior Japanese N races were assigned. It is not surprising that the main races in Japan are present in Taiwan, since *japonica* type rice varieties are widely cultivated here. These facts might suggest that Taiwan and Japan share the same main races, prior N-race group. However, the blast disease in Taiwan has seldom caused serious damage as compared with that happened in Japan. The phenomenon that rice in 1st crop is more susceptible to the blast disease than in 2nd crop, might be due to the environmental factors influencing the growth of rice, which in turn show the different susceptiblity to the blast fungus. Lower temperatures during the 1st crop, which prolong the growth period of rice make it susceptible to the blast fungus. The susceptible period of rice in Taiwan is shorter than in Japan, and rice varieties, especially most of Ponlai rice of present cultivation inherited

the blast resistant quality from the native rice. Therefore less damage by the rice blast disease in Taiwan could be expected.

On the whole, more complex race patterns were obtained with Taiwan differentials than with the U.S. and Japanese differentials. The great complexity of rice varietal composition in Taiwan and the number of differentials employed for race characterization are the factors responsible for the complex race patterns (7). In individual countries where the eight international differentials are not sufficient for established rice-breeding program, the use of local subsidiary varieties was suggested by the U.S.-Japanese cooperatiue study (4). Since the present 16 Taiwan differentials have given a complex race pattern, and since most of the isolates collected in Taiwan were characterized into IG and IH groups, it is of necessity to select a set of superior differentials as a subsidiary varieties in Taiwan. Among the 16 Taiwan differentials, varieties which showed definite resistant or susceptible reaction to most of the existing blast races could be selected as candidate for subsidiary differential varieties. Varieties of Kanto 51, Pai-kan-tao, Chianung 242, Kao-chio-liu-chou, Taichung 65, and Kung-shan-wu-shen-ken in Taiwan differentials seemed to show a good differentiating ability. If these varieties are utilized as a set of differentials, isolates so far collected in Taiwan could be characterized into 17 races instead of the present 27 races.

As previously stated, most isolates of Taiwan races and newly collected isolates in 1966 were assigned as IG and IH race groups when the international differential varieties were used. The rest of the isolates with a minor instances were assigned as IC, ID, IE and IF race groups. No isolates tested were assigned as races in IA or IB groups. Atkins *et al.* (4) indicated that IA group of races occurs in Asiatic countries including Taiwan. However, according to the results of our tests, no isolates have been designated as races in the IA group. Since isolates which showed the IA pattern was obtained by the U.S. workers from specimen provided by the Taiwanese workers, the occurrence of this race in Taiwan is probable.

Summary

1) Nineteen races of *Piricularia oryzae* Cav., were characterized from 293 isolates of the blast fungus obtained during 1964-1966. Among them, 17 races representing 259 isolates showed the pathogenic patterns which had already been detected. The two newly chara cterized races (races 26 and 27) showed T race group patterns. Race 24 was the most prevalent race in 1964, being encountered 64 times. Another prevalent races of the period were races 17, 2, 3, 26, and 21.

2) Nine isolates representing six U.S. races and eleven isolates representing eight Japanese races were tested for their pathogenicity on the Taiwan differentials. Among the 16 Taiwan differentials, *indica* type varieties seemed more valuable as the differentials for the U.S. races than the *japonica* type varieties. Isolates of the same Japanese races did not give identical reactions on the Taiwan differentials. The pathogenic patterns on the Taiwan differentials, induced by Japanese race C-1 (Ken 60-19), N-1 (Hoku 373), N-4 (Ina-168) and N-5 (Naga 61-14) were identical to those by Taiwan race 23,

22, 24 and 26, respectively.

3) Fourteen isolates representing 14 Taiwan races were tested on U.S. and Japanese differentials. It seemed that the U.S. differentials did not provide a satisfactory differentiation for the Taiwan races. They failed to distinguish between race 13 and 16, race 9 and 22 or 24, race 14 and 17 or 19. On U.S. differentials, Taiwan race 5, 12, 14, 13 or 16, and 17 showed identical or similar pattern of U.S. race 6, 21, 4, 17 and 2, respectively. The 14 Taiwan races were unequivocally separated from one another on the Japanese differentials. On Japanese differentials, Taiwan race 12, 17, and 22 showed identical pattern of Japanese N-6, N-2, and N-1, respectively.

4) Some representative Taiwan races were tested on the 12 and 24 tentative international differentials supplied by USDA and IRRI respectively. In general, Taiwan races showed rather weak pathogenicity to these differential varieties. These sets of differen tials seemed not to provide a satisfactory differentiation for the Taiwan races.

5) Nine isolates representing nine Taiwan races of *P. oryzae* were tested on the 40 rice varieties supplied by FAO. All test isolates induced resistant reaction on varieties of group 1. Most of the varieties in groups 2 and 3 showed R reactions to the test isolates. Varieties in groups 4 and 5 showed inconsistent reactions. S reaction was caused by all the isolates in varieties of group 6.

6) Twenty commercial rice varieties were tested for their reactions to eight Taiwan races of *P. oryzae*. Among these varieties, only Taichung 186 and Taichung-yu 184 are resistant to all the races tested. The rest of the varieties are susceptible to most of the test isolates.

7) Several races of *P. oryzae* were obtained from one paddy field block consisting of one rice variety-Taichung 65. Races belonging to T race group were found to be the most prevalent ones.

8) The eight international differential varieties were tested for their reactions to the isola tes of *P. oryzae* which had been characterized with U.S., Japanese or Taiwan set of differentials, and to new isolates of the pathogen from Taiwan. Most of the former Taiwan races and newly collected isolates were included in IG and IH groups. Prior and new nomenclature designations for the former US and Japanese races are: US 1A=IB-5; US 5A, and US 6B=ID-8; US 7A=IF-1; US 3=IG-1; US 5B=IG-2; US 2 and 4=IH-1; T-1=IC-5; T-2=ID-10; C-1=IE-1; C-3=IF-2; N-1=IG-1; N-2, N-4, and N-5=IH-1.

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