

On "U.S.-Japan Cooperative Research on the International Pathogenic Races of the Rice Blast Fungus, *Piricularia oryzae* Cav., and their International Differentials"

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Background of the Cooperative Research

Study of races of rice blast fungus started in relation to the selection of disease resistant varieties for blast control. Existence of the race of this fungus was reported at first by R. Sasaki in Ehime Prefecture, Japan, in 1922 and 1923,* who confirmed by inoculation experiments that an isolate B collected in mountainous area can invade severely most of the rice varieties resistant to isolates belonging to A which are popular in low land areas. Soon after, a few workers confirmed other kind of races and after a while, many workers carried out the study, mainly under the support of Ministry of Agriculture and Forestry, but the progress of the study was not smooth due to unfortunate hazard of World War II and also due to scientific difficulty on their objective of the study. Consequently, the scheme to differentiate them was not successful. An authodox study based on the virulence of isolates of the pathogen was carried out during latest fifteen years. In this period, the problem of races of blast fungus was also required to be considered from the side of disease forecast, as there frequently occurred severe infection on the bred resistant varieties, as if they had entirely lost their resistance.

The recent study started in the National Institute of Agricultural Sciences in 1953, sti-

mulated by the fact that bred resistant rice varieties tend to be susceptible in Aichi Prefecture since several years, and five prefectural agricultural experiment stations and the National Institute of Agricultural Sciences started a joint study with the purpose of disease forecast in 1954. The results were concluded in 1965 that there are 3 race groups with 18 races in Japan, and that an epidemic outbreak of blast on bred resistant varieties is observed usually about 3 years after the first cultivation of a variety to the area where the variety had become very popular.

In the United States, Latterell *et al* reported pathogenic races of rice blast fungus in 1954, based on the fact that the variety Zenith was susceptible to blast in Florida but resistant in Arkansas. After their study, 25 races were characterized in 1965. In addition, U.S. Department of Agriculture also conducted a research program concerning identification of blast races prior to 1963.

The races of blast fungus have been studied also in Taiwan since 1957 and the existence of 27 races was proved by Chien *et al* in 1965. Similar study was carried out in Korea by Ahn and Chung, and Lee and Matsumoto, obtaining an evidence that at least 6 races were checked until 1966. Padmanabhan *et al* worked out similarly on the races of the same fungus in India since 1962, and proved existence of more than 4 races. In the Philippines 26 races were characterized similarly by the workers of IRRI in 1964.

* For literatures, refer please the complete account or preliminary report by the Cooperation Study, except for those given.

Initiation of the cooperative research

In all these cases, each country prepared one or more than one set of differential varieties, arranging usually suitable but special varieties for respective country. These must fairly adapt to the use within each country. But if the consideration is extended over the limit of one country, there has been no reliable basis of comparison of races, though international contact became more and more frequent through exchange of rice seed. The seed exchange eventually brings about the need to consider rice blast fungus based on its races rather than species, beside the problem of breeding resistant varieties. For there is always a danger of importation of new races, though the pathogen as species may exist already in the country.

In 1962, this international research on the races of rice blast was taken up as a project by the workers of U.S. and Japan, when international cooperation in science was planned between the two countries, and was adopted by the council, as a three year project beginning in 1963, involved in the first year group.

Selection of differential varieties

The study on the races of rice blast fungus is made on the basis of differential varieties. On the other hand selection of the differential varieties is based upon the reaction of the varieties of differently acting isolates of the fungus. Therefore, the isolates for study were collected from many rice growing countries as many as possible (154 isolates in all). For differential varieties, those from United States, Japan and Taiwan (39 in all) were tested, referring also those from other countries which reacted in a peculiar way, as all these have already been selected carefully by respective workers in respective countries. The varieties were selected based on easiness of inoculation, clearness of reaction, uniformity of individuals in a variety, easiness of growing seedlings and easiness of seed cultivation.

In regard to "pathogenic" race, there can

exist without doubt races based on other characteristics than virulence to living plants, viz. growth habit on agar media, nutritional requirement (Tamari 1966), etc.* As will be acquainted, a pathogenic race is a group of isolates with the same or quite similar reaction against their differential varieties. The term "race" has been understood as if a synonym of pathogenic races until recent times, since the sense of races was established on the parasitic pathogen which can be cultured only on the living host plant, never on the culture media. In the case of rice blast pathogen, however, it can be cultured in culture media as well as on the host plant. No remarkable correlation could be proved between the pathogenicity and cultural or physiologic characteristics on the culture media. Probably both may be inherent mostly independent of each other.

As regards the number of pathogenic races, it will rapidly increase with the increase of number of differential varieties in a set, and if one try to rank every isolate showing any distinction as a race, there will be created vast number of races. In the case of international races, too much detailed split, eventually creation of too many races will make the differentiation techniques laborious and difficult and will rather lessen the importance. In spite of this, all isolates of blast fungus collected in any rice growing country are desired to be grouped and arranged in a system. Therefore, the International Races were defined as races differentiated by rather small number of International Differential Varieties. Actually, 8 differential varieties, Raminad Str. 3, Zenith, NP-125, Usen, Dular, Kanto 51, Sha-tiao-tiao(S), and Caloro, were selected. Sometimes the International Races can be splitted into subraces further by adding of suitable subsidiary differential varieties, when

* For the pathogen of Bacterial Leaf Blight, Mizukami (1966) pointed out that "lyso-type" can be differentiated by the reaction to bacteriophage (phage races). This was introduced more clearly by Goto and Iwata (1965) based on Mizukami's own opinion. They seemed to be independent to the virulence.

Table 1. Pathogenic races of rice blast fungus characterized by the international differentials

International race	Reaction of races to differential variety									Corresponding		Locality, isolates were collected*
	Rami-nad Str. 3	Zenith	NP-125	Usen	Dular	Kanto 51	Sha-tiao-tsau(S)	Caloro	US races	Japan races		
IA 1	S	R	R	S	S	S	S	S				In
2	S	R	R	S	R	R	S	S				Ph, Th, Tw, Vn, Cy
3	S	R	R	S	R	R	S	R				Ph
IB 1	R	S	S	S	S	S	S	S				CR
2	R	S	R	S	S	S	S	S				El, US
3	R	S	R	S	R	R	R	S				Gu
4	R	S	R	R	S	S	S	S				US
5	R	S	R	R	S	R	S	R				US, El
6	R	S	R	R	R	R	S	S				Ja
IC 1	R	R	S	S	S	S	S	S				Ja, In, Ph, Ag
2	R	R	S	S	S	S	R	S				Th
3	R	R	S	R	S	S	S	S				US, In, Is, WP, Cy, Gu, Ok
4	R	R	S	R	S	S	R	S				Tw
5	R	R	S	R	R	S	S	S				Is
ID 1	R	R	R	S	S	S	S	S				US, In, Is, Bu, Gu
2	R	R	R	S	S	S	R	S				In
3	R	R	R	S	S	R	S	S				El, HK, Gu
4	R	R	R	S	S	R	S	R				In
5	R	R	R	S	S	R	R	S				HK
6	R	R	R	S	S	R	R	R				In
7	R	R	R	S	R	S	S	S				Ph
8	R	R	R	S	R	R	S	S				Ja, US, El, Ph, Is, Tw, Ko, Vn, Th
9	R	R	R	S	R	R	S	R				Ph, Is
10	R	R	R	S	R	R	R	S				Ja, Ko
11	R	R	R	S	R	R	R	R				Ph
IE 1	R	R	R	R	S	S	S	S				US, Ja, Tw, In, Is, Eg, Hu
2	R	R	R	R	S	S	R	S				Ja, Tw
IF 1	R	R	R	R	R	S	S	S				Ja, Tw, Hu
2	R	R	R	R	R	S	R	S				Ja
IG 1	R	R	R	R	R	R	S	S				US, Ja, Tw, Ko, Au, El, Ph, Hu, In
2	R	R	R	R	R	R	S	R				US, El
IH 1	R	R	R	R	R	R	R	S				US, El, Ja, Tw, Ko

* Abbreviation of locality where isolates were collected:

Ag: Argentine, Au: Australia, Bu: Burma, CR: Costa Rica, Cy: Ceylon, Eg: Egypt, El: El Salvador, Gu: Guinea, HK: Hong Kong, Hu: Hungary, In: India, Is: Indonesia, Ja: Japan, Ko: Korea, Ok: Okinawa, Ph: Philippines, Th: Thailand, Tw: Taiwan, US: United States of America, Vn: Vietnam, WP: West Pakistan.

one locality (country) needs to know about more details of the races there.

International Races

The International Races are determined and named as follows. All the races having virulence on Raminad Str. 3 is grouped in A prefixed with I (=international) and suffixed with race number (IA number). Similarly those virulent to Zenith, but innocuous to preceding differential variety, are grouped in B, and designated as IB number, and so on. Thus, International Races can be understood rather as a coarse grouping of isolates under test. The subraces are designated by suffixing in parentheses as IH 1 (locality abbreviation and number). For abbreviation of locality, the readers can refer the table in the footnote of table 1.

The result of cooperative research on the International Races is shown in Table 1.

In addition to the characteristics of each race, the table seems to show a tendency that some races distribute over many countries and may be called as cosmopolitan races (IC 3, ID 8, IE 1, IG 1), while some others have somewhat restricted distribution, though number of sample is not sufficiently large. Further, there is an indication that isolates of a certain race group are often found in a locality, as in the case of IB race group versus United States of America.

If the table is looked at more closely, one can find out that a race characterized by a series of differential varieties (for instance U.S. series, or Japan series) can be split into two by another series, viz. U.S. race 7 was split into IB 2 and IB 4, and Japan race C-1 into IE 1 and IF 1. In fact, the reason of these is inferred as there has not been respective variety (acting to split) in the series of differential varieties in question.

In spite of these discrepancies, important

role of the International Races (or International Differential Varieties) will be realized when consideration is extended over the limit of a country.

Techniques of race determination, etc.

For determination of the International Races, precise testing techniques are required. These were discussed as the first step of the cooperative research and a conclusion was drawn. Details are given in the report of the cooperative research, divided into spores, inoculum, plants, inoculation, incubation and ratings of varietal reaction.

The report was presented preliminarily at the International Rice Committee meeting held in United States in 1964, and then to Phytopathology. The detailed report was given in Annals of Phytopathological Society of Japan in 1967.

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