Proposal of a New Method for Differentiating Races of *Pyricularia oryzae* Cavara in Japan

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いもち病菌レース新判別法の提案

Many reports have been published in Japan on the pathogenic specialization of rice blast fungus, *Pyricularia oryzae*. Especially, Goto and his co-workers^{1, 2)} have established the method to identify blast fungus races.

Their differential varieties consist of 12 varieties belonging to the following 3 groups.

T group (varieties having rice blast resistance genes of *indica* rice)

Te-tep, Tadukan, and Usen

C group (varieties having resistance genes of Chinese varieties)

Chokoto, Yakeiko, and Kanto 51

N group (other common Japanese varieties)

Ishikari-shiroke, Homare-nishiki, Ginga, Norin 22, Aichi-asahi, and Norin 20

According to their method, blast fungus isolates found in Japan are classified into N, C, and T groups. N group races are defined as the races virulent only to N (Japanese) varieties in the differentials. C group races are virulent to C (Chinese), but not to T varieties in the differentials, irrespective of the virulence to N varieties. T group races are virulent to T (*indica*) varieties, irrespective of the virulence to C and N differentials. Then each race is numbered in the order of the identification in each race group, such as T-1 or C-3. With this procedure, 3 races of T, 9 races of C, and 6 races of N race group have been differentiated until now.

This procedure was adopted widely in Japan, and the situation of pathogenic specialization of rice blast fungus in Japan has been clarified¹⁻³⁾.

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1) Goto, K. et al. (1961). Plant disease and insect forecasting service Spec. Bull. 5, 89p.

(in Japanese) 2) Goto, K. et al. (1964). *ibid.* 18, 132p. (in Japanese) 3) Kozaka, T. et al.

(1972). *ibid.* 24, 296p. (in Japanese)

Kiyosawa and his co-workers conducted genetic studies on blast resistance of rice varieties on the basis of the results of race studies⁴⁾. In the course of their studies, it has been clarified that Goto and his co-workers' differential varieties are not always best⁵⁻⁷⁾. Sakurai and Toriyama⁶⁾ pointed out the defects of these differentials as follows:

- (1) Some important resistance genes are not included in these differentials.
- (2) Some differential varieties are very complicated with respect to resistance gene constitutions.
- (3) Some differential varieties have some unknown resistance genes, not included in Japanese commercial varieties.
- (4) Some differential varieties have the same resistance genes.

A committee was organized and discussed a new set of differentials and new nomenclature of races. After reviewing many workers' opinions and results of inoculation tests, the committee presents the following proposal.

Selection of new differential varieties

Selection of varieties was made according to the following criteria presented by Sakurai and Toriyama⁶⁾.

- (1) Each differential variety should have only one major true resistance gene which is effective to Japanese blast fungus races and is included in commercial varieties in Japan. These genes are desired to be confirmed by genetic analysis.
- (2) The differential varieties should be genetically pure, and their reactions against blast races should be stable.
- (3) The differential varieties should be of common *japonica* type, and their cultivation and seed collection should be easy, even though they are derived from foreign varieties.
- (4) The present standard and supplemental differential varieties should be included as far as possible.

The committee adopted the following 9 varieties which have singly different genes for true resistance according to the above-mentioned criteria.

Pi-k^s: Shin 2⁸⁾ *Pi-a*: Aichi-asahi⁹⁾ *Pi-i*: Ishikari-shiroke¹⁰⁾
Pi-k: Kanto 51¹⁰⁾ *Pi-m*: Tsuyuake¹¹⁾ *Pi-z*: Fukunishiki¹²⁾
Pi-ta: Yashiro-mochi¹³⁾ *Pi-ta²*: Pi No. 4¹³⁾ *Pi-z^t*: Toride 1¹⁴⁾

Shin 2 is susceptible to all Japanese blast races, but has a blast resistance gene *Pi-k^s*, which is active against a Philippine blast isolate Ken Ph-03⁸⁾, and not active against Japanese races. There are 2 kinds in Shin 2 type varieties. One has *Pi-k^s* and the other does not. Shin 2 belongs to the former. *Pi-m* gene was identified in variety Minehikari by Kiyosawa¹⁵⁾. Minehikari has *Pi-a* and *Pi-k* genes besides *Pi-m*¹⁵⁾, and Tsuyuake has *Pi-k* gene besides *Pi-m*¹¹⁾. Tsuyuake was adopted temporarily as a differential variety for *Pi-m*, but it should be replaced

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- 4) Kiyosawa, S. (1974). Misc. Publ. Natl. Inst. Agric. Sci., Ser. D.1 : 1-58. (in Japanese)
 - 5) — (1972). Japan. J. Breed. 22 : 119-123. (in Japanese)
 - 6) Sakurai, Y. and Toriyama, K. (1973). Kenkyu Seika (The results of researches) Agriculture, Forestry and Fisheries Research Council, Ministry of Agriculture and Forestry, Tokyo. 63 : 86-88. (in Japanese)
 - 7) Asaga, K. (1974). Nogyo Gijutsu 29 : 443-448. (in Japanese)
 - 8) Kiyosawa, S. (1969). Japan. J. Breed. 19 : 61-73.
 - 9) Kiyosawa, S. et al. (1967). *ibid.* 17 : 1-6
 - 10) Yamasaki, Y. and Kiyosawa, S. (1966). Bull. Natl. Inst. Agric. Sci., Ser. D. 14 : 39-68. (in Japanese)
 - 11) Ezuka, A. et al. (1969). Bull. Chugoku Agr. Exp. Sta., Ser. E. 4 : 1-31. (in Japanese)
 - 12) Kiyosawa, S. (1967). Japan. J. Breed. 17 : 99-107.
 - 13) — (1969). Agr. Hort. 44 : 407-408. (in Japanese)
 - 14) Yokoo, M. and Kiyosawa, S. (1970). Japan. J. Breed. 20 : 129-132.
 - 15) Kiyosawa, S. (1968). Japan. J. Breed. 18 : 193-205.

in future by another variety having *Pi-m* solely.

New nomenclature of the races

When a new set of differentials is adopted, the name of races should also be changed. If the races are numbered in the order of their discovery, the number will become very large, and it will be very difficult to understand virulence of races from their numbers. When some new resistance genes are introduced in future, some new differential varieties having them should be supplemented. Under such consideration, the committee adopted Gilmour's octal notation¹⁶⁾ according to Asaga's proposal⁷⁾.

First, 9 differential varieties are arranged in the order listed in Table 1, and code number is given to each resistance gene, and to each corresponding differential variety, as shown in Table 1. Code number 20 is for *Pi-m*. It is also for Tsuyuake having *Pi-m* and *Pi-k* genes, because we have no variety having *Pi-m* solely at present. The number of each race is the sum of code number of each resistance gene, accordingly of each differential variety, to which the race is virulent. For example, the race virulent only to Shin 2 (*Pi-k^s*) is 1, and the race virulent to Shin 2, Aichi-asahi (*Pi-a*), and Ishikari-shiroke (*Pi-i*) is 1+2+4=7. Furthermore, the race virulent to Fukunishiki (*Pi-z*), Yashiro-mochi (*Pi-ta*), and Pi No. 4 (*Pi-ta²*),

Table 1. The reaction of some isolates on the new differential varieties

Differential varieties	Shin2	Aichi-asahi	Ishikari-shiroke	Kanto 51	Tsuyuake	Fukunishiki	Yashiro-mochi	Pi No. 1	Toride 1	Current race number
Resistance gene	<i>Pi-k^s</i>	<i>Pi-a</i>	<i>Pi-i</i>	<i>Pi-k</i>	<i>Pi-m</i>	<i>Pi-z</i>	<i>Pi-ta</i>	<i>Pi-ta²</i>	<i>Pi-z^t</i>	
Code number	1	2	4	10	20	40	100	200	400	
Isolate										New race number
Ken 53-33	S	S	S	S	S	R	S	R	R	T-1 137
Hiro 63-20	S	S	R	R	R	R	S	S	R	T-2 303
Chu 65-673	S	S	R	R	R	R	S	R	R	T-2 103
Ken 64-52	S	S	S	R	R	R	S	R	R	T-3 107
Ken 60-19	S	S	S	S	S	R	R	R	R	C-1 037
Oita 65-114	S	S	S	S	R	R	R	R	R	C-1 017
Naga 87	S	R	R	S	S	R	S	R	R	C-3 131
Ina 72	S	R	R	S	S	R	R	R	R	C-3 031
Ken 61-14	S	S	S	S	R	R	R	R	R	C-5 017
Ken 66-25	S	S	S	S	R	R	R	R	R	C-6 017
Naga 64-8	S	S	R	S	S	R	R	R	R	C-8 033
Naga 65-386	S	R	S	S	S	R	R	R	R	C-9 035
Hoku 1	S	S	S	R	R	R	R	R	R	N-1 007
Ken 64-38	S	S	R	R	R	R	R	R	R	N-2 003
Ken 54-04	S	S	R	R	R	R	R	R	R	N-3 003
Ina 168	S	R	R	R	R	R	S	R	R	N-4 101
Naga 66-16	S	R	R	R	R	R	R	R	R	N-4 001
Naga 61-14	S	R	S	R	R	R	R	R	R	N-5 005

S : Susceptible reaction,

R : Resistant reaction

16) Gilmour, J. (1973). Nature 242 : 620.

in addition to the above-mentioned 3 varieties, is $1+2+4+40+100+200=347$. Conversely, in the case of race 347, the number can be decomposed into 1, 2, 4, 40, 100, and 200, from which we can understand that the race is virulent to those differential varieties, and to those resistance genes having those code numbers.

Some results of inoculation tests with new differentials are presented in Table 1. As shown in the Table, Ken 53-33, an isolate belonging to T-1 race according to the current differentiating procedure, belongs to race 137 in the new system, Ken 60-19 (C-1) to race 037, Ina 72 (C-3) to race 031, and Hoku 1 (N-1) to race 007.

It is desirable that already published results of researches on the distribution and the ecology of races will also be available even after the change of differentiating method. Then, some consideration was taken with arrangement of new differential varieties.

The Gilmour's notation system for races is characterized by triplets of differential varieties. Varieties having singly $Pi-k^s$, $Pi-a$, and $Pi-i$ genes were arranged in the first triplet in the new system. Isolates of N group races in the current system are virulent only to the differential varieties in the first triplet, with exception such as Ina 168 (N-4). So, N group races in the current system belong to new races with race number of one figure, 001 to 007, with a few exception.

For Kanto 51, N group races in the current system are all avirulent, but C group races are all virulent. All the tested isolates of T group races in the current system are virulent to Yashiro-mochi ($Pi-ta$), and the tested isolates of C or N group races are avirulent to it, with a few exception. In the new system, Kanto 51 was arranged at the top of the second triplet and code number 10 was given for it, and Yashiro-mochi was arranged at the top of the third triplet and code number 100 was given. Therefore, isolates of C group races in the current system belong to new races with race number of two figures except such cases as Naga 87 (C-3), and their tenth digit is odd. Isolates of T group races in the current system belong to new races with race number of three figures, and their hundredth digit is odd.

In a 168 (N-4) has virulence to Yashiro-mochi, which has the same gene ($Pi-ta$) as one in a line, K 1, derived from Tadukan, and belongs to the new race 101. Tadukan is one of the T group differentials in the current system, and Ina 168 is avirulent to Tadukan not due to $Pi-ta$, but to $Pi-a$, so it belongs to race N-4 with the narrowest virulence, in the current differentiating system. In case of Naga 87, the situation is similar.

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